THE ECONOMIC IMPACT OF HEALTH CARE PROVISION: A CGE ASSESSMENT FOR THE UK

By

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ABSTRACT

This thesis seeks to determine the macro-economic impacts of changes in health care provision, whilst recognising the simultaneous effects of consequent changes in health on effective labour supplies and the resource claims made by the health care sector. The resource allocation issues have been explored in theory, by developing an extension of the standard Rybczynski theorem from a low-dimension Heckscher-Ohlin framework, and empirically, by developing a Computable General Equilibrium model, calibrated to a purpose-built dataset for the UK.

The theory predicts that, if the government is solely concerned with improving per capita income, a morally questionable policy of targeting health care provision towards skilled workers performs best. Furthermore, the impact of an expanding health sector on the outputs of non-health sectors is shown to depend on the sign and magnitude of a scale effect of increased effective labour supplies and a factor-bias effect of changes in the ratio of skilled to unskilled labour, although the latter effect dominates if effective labour supplies are relatively inelastic with respect to health care provision.

The theoretical predictions are not generally validated by the applied model due to added real-life complexities. The main findings are that a rise in NHS expenditures, the employment of foreign health care-specific skilled workers, and costless factor-neutral and skill-biased technical change in the UK health sector have a positive impact upon overall welfare via direct improvements in population well-being and indirect benefits from increased worker incomes. The study indicates that if an expansion of the health sector is financed from a reduction in state benefits, the non-working households and pensioners may require some compensation since they rely relatively heavily on these as a source of income.

The presence of health care-specific factors and rising pharmaceutical prices impact negatively upon the health sector and overall welfare, suggesting the importance of tackling rising input costs and structural rigidities. This may be achieved by the immigration policy, although since effects on domestic workers if their wages are not sustained, and on countries of origin faced by a 'brain-drain', are negative, in the long-term increasing the number of medical school places may be more desirable. Another suitable policy response is to purchase a more effective pharmaceutical product. Fairly small productivity gains in health care were shown to generate overall welfare gains. Finally, factor-neutral and skill-biased technical improvements yield significant welfare gains and cost-savings in the health sector. Such technical improvements may come in the form of improved medical procedures, which have been developed abroad yet are freely available or have been funded by charitable institutions, but also may reflect domestic policy which aims at reducing administrative overheads so that more resources can be devoted to front-line staff.

The sensitivity of the results to the elasticity of the waiting lists with respect to health care indicates the importance of ensuring that additional resources are effectively employed, attainable by the technical and administrative improvements in health care.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND TO THE RESEARCH PROBLEM

The interactions between health care, health and the remainder of the economy are multiple and complex. As early as the Basic Needs approach to development of the 1970s[1], which treats health care and other goods such as education, sanitation and housing as basic necessities, these linkages are in very general terms understood to be as follows. On the one hand, changes in income impact upon the consumption and/or provision of health care and other goods, which affects the health of populations in terms of mortality and morbidity (illness). On the other hand, changes in health impact upon the well-being of populations, with associated consequences for labour market participation, productivity and income. Such forward and backward linkages are important for developing and developed countries alike.

Many developing countries find themselves locked in a vicious circle leading from poverty to ill health and to poverty again. Health care systems in these countries are underdeveloped and many suffer from high prevalence rates for mainly communicable diseases, some incurable (such as AIDS) but the majority easily preventable by vaccination, so that the potential effects of improved health care systems on the labour market and the rest of the economy, especially in the long term, are considerable. Illustrative in this respect are the Commission for Macroeconomics and Health

[1] Streeten et al. (1981), Stewart (1985) and Afxentiou (1990).

(CMH)'s rough calculations that an additional investment by 2007 of $27 billion a year by rich countries (0.1% of donor GDP) and $35 billion a year by poor countries (1% of their GDP) would save 8 million lives a year by the end of the decade and yield worldwide economic benefits of $186 billion a year.[2]

In contrast, developed countries have much higher living standards and levels of health and so are thought to be on the "flat of the curve", where the marginal contribution of health care to health is minimal and other factors, like changes in diet, lifestyle (drinking and smoking), environment and education, seem more important in explaining variations in health.[3] The most common health problems in these countries concern non-communicable diseases related to diet and life style (themselves related to social class), such as cardiovascular diseases, diabetes and cancers, a fact which seems to corroborate this view. This being said, many former sceptics of the contribution of health care to health are now willing to accept that, even after allowing for diet and lifestyle, health care does make a difference for specific conditions, such as cardiovascular disease. According to David Cutler, an American aged 45 today will live 4.5 years longer than in 1950 because of a decline in cardiovascular disease, of which two-thirds can be attributed to better medical care and the remaining third to behavioural changes such as stopping with smoking. Apart from gains in longevity, medical care also enhances the quality of life through pain relief and increased mobility. The rise in medical costs

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2 "The Health of Nations", The Economist, 22 December 2001, p95-96. CMH (2001).

3 Folland et al. (2001, p108) on the production function of health.

partially reflects improvements in treatment quality enabling less drastic treatments and a more rapid recovery.[4]

The majority of developed country health care systems arguably fail to deliver specific medical services to a “satisfactory” standard, which is commonly attributed to limited financial means and an inefficient use of resources. In the UK pressures are visible, among others, in terms of poor health outcomes for some diseases (such as cancer), poor quality of services, including long waiting lists and waiting times for certain treatments, and inequities in access and health outcomes. These pose significant costs on society, in addition to the cost of health service provision. The Confederation of British Industry (2001) for example estimates that the direct cost of absence from work due to sickness for UK business amounts to nearly £11 billion a year, whereas total cost to society, including poorer quality services and products and the cost of increased welfare payments, nears £23 billion in total (approximately 2.3% of GDP in 2001). In future, health care costs, which have to be paid for somehow, are bound to rise with the prospect of an ageing population and advances in medical technology.

While the interdependencies between health care, health and the rest of the economy are now widely acknowledged, economic models which are used to assess these fail to incorporate the main channels through which interactions take place. The majority of empirical studies employ partial equilibrium techniques and/or econometric analyses and so conceal or ignore altogether differential effects of changes in health and health care across sectors, factors, households and their implications for the government

[4] These and other examples are reported by Paul Wallace in “The Health of Nations: A Survey of Health-Care Finance”, The Economist, 17 July 2004, p8.

budget. The small range of computable general equilibrium (CGE) models that does exist is diverse in application area. Health or health care has been modelled in a developing country context as one of many basic needs (Basic Needs models), as having an external effect on the labour market in the form of improved labour productivity (Externality models), or by analysing the disastrous consequences of epidemics (HIV/AIDS models). Though each of these strands of literature has its own merits, most of the reviewed models do not assess the endogenous impact of changes in health care provision on the health of the population, the labour force and its impact on production, income and welfare over time in a (developed country) CGE setting.[5]

Empirical studies typically fail to account for the main feature of rich and poor nations' health care systems, namely that they treat and (partially) cure people, i.e. improve their health, which not only makes them "feel better" but also enlarges the effective size of the working *and* non-working populations, further explained below. At the same time health care systems use factors of production including labour, which have to be paid for and reduce the effective supply of workers available to the rest of the economy. It is in addressing this caveat that this thesis seeks to make a contribution. By doing so, it is hoped to improve the understanding by the general public of the role of health care in the economy and to aid policy makers in their pursuance of improving the functioning of health care systems, the health of the population, welfare and economic growth.

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[5] An exception is Dixon et al.'s (2004) CGE model of the impact of the HIV/AIDS pandemic and health interventions on the Botswana economy. Whereas the pandemic and the mitigating effects of two health policies are endogenously modelled, other health expenditures are assumed not to impact on the health of the population, the labour force and welfare.

There are various ways in which an expansion of the health care sector enlarges the effective size of the working and non-working populations. A higher level of health care provision enlarges effective labour supply in the short term by augmenting the aggregate working time of current workers and reduced wastage by premature death. It does so in the longer term by reducing death rates among those young who are destined to enter the work force. However, one must bear in mind that it also increases the number of people who are not part of the work force, the young and the retired, through reduced deaths. These are an additional source of demand for health services (and other goods), so reducing the availability and/or level of treatment for the current work force and thus its effective size. Moreover, both groups of non-workers are usually recipients of transfers from the working population (e.g. state benefits for children, state pensions for the retired), with the associated distortions.

Although in principle a model of the economy which incorporates health care provision effects can be constructed for any country, the UK is taken as a case study. The UK is an archetype of a developed country health care system in which government provision and funding dominates. By funding health care from general taxation the UK government has been able to keep a tight lid on health care expenditures, whilst securing access to the majority of the population and reaching overall satisfactory health outcomes. The National Health Service (NHS) appears to be highly cost-effective relative to other industrialised countries[6]; however, many argue that excessive public control has led to systematic underfunding of and inefficiencies in health care provision, both of which the UK government seeks to address. Problems manifest themselves in

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[6] See Chapter 4 of this thesis.

various ways, but typically revolve around the issue of rationing, i.e. the conflict between potentially unlimited demands and limited financial means, and in this respect the UK does not differ from any other country. By focusing on the UK this study is able to model the impact of changes in health care policy and health care-related conditions which impinge upon the issue of rationing, either alleviating the rationing constraint or, in the case of the latter, straining it.

The analysis is novel in three respects. The first contribution is in terms of international trade theory, by developing an extension of the standard Rybczynski Theorem from a low-dimension Heckscher-Ohlin model which casts light on some of the resource allocation issues related to the provision of health care. While there is a strong literature on endogenous labour supply models[7], these have in the main been based on direct labour supply responses to higher wages. In this model, changes in the effective supply of skilled and unskilled labour come from changes in the size of the health care sector (which in this UK-centred example is largely determined by the government). The second contribution is in terms of data, by constructing a dataset for the UK for the year 2000, which is employed in the calibration of the CGE model. The dataset contains detailed information on health, health care use, income and benefit variables for individuals living in private households in Great Britain and is available for use in MS Access. The final contribution is in terms of empirics, by developing a CGE model for the UK with an extended health care component, the first of its kind, which analyses in greater detail the health care-related resource allocation issues.

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[7] E.g. Martin (1976) and Martin and Neary (1980).

1.2 PURPOSE AND RESEARCH OBJECTIVES

The purpose of this thesis is to determine the macro-economic impacts of changes in health care provision using a general equilibrium model of the UK economy, whilst recognising the simultaneous effects of consequent changes in health upon effective labour supplies and the resource claims made by the health care sector. The first part of the study uses a simple theoretical Heckscher-Ohlin model to assess the main interactions, whereas the second part employs an applied CGE model, calibrated to a purpose-built dataset for the UK. Within this general aim, the following research questions may be answered.

What is the impact of changes in health care policies and health care-related conditions on:

- non-health care sectors?
- production factors, especially skilled and unskilled labour?
- households?
- and overall welfare?

And, finally, how do policies aimed at alleviating rationing in public health care compare? In other words, which policy is more successful in improving household and overall welfare?

1.3 METHODOLOGY

This study employs a CGE model to analyse the interactions between health care and the remainder of the economy. Below follows a short introduction to this methodology and a motivation of why it is favoured to other research techniques.

A CGE model is derived from micro-economic optimisation behaviour under constraints of all agents in the economy and, unlike other partial equilibrium or macro-econometric approaches, is calibrated to a comprehensive set of consistent and balanced macroeconomic accounts, the Social Accounting Matrix (SAM).[8] This ensures that key behavioural and accounting constraints are satisfied and serves as a check on the 'reasonability' of the outcomes. A CGE model can be made sufficiently disaggregated, fit to the purpose of the study, and subsequently put to use in simulations of how changes in certain economic conditions are mediated through price and quantity adjustments in markets. Moreover, the CGE technique allows for counterfactual analysis, i.e. answering ‘what if’ questions, and is not just restricted to “learning from the past” like econometric studies are. A CGE model thus possesses strong theoretical foundations and mimics the functioning of the economy by capturing the interactions between the various sectors of the economy.

Naturally, a CGE model is not without limitations itself. First and foremost, unlike econometric studies, it is not possible to statistically validate the structure and underlying assumptions of the CGE model. As the SAM only reflects a 'snapshot' in time and does not contain detailed time series such as are used in econometric analyses, the direction of effects is more reliable than the magnitude. The more so since many of the parameters and elasticities are imposed rather than empirically estimated. CGE modellers address this issue by carrying out sensitivity analyses, which goes a long way to assessing the potential errors from using parameters not acquired through

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8 For an overview of CGE modelling see Bandara (1991), Blonigen et al. (1997), Devarajan et al. (1994, Chapters 1-3), Devarajan et al. (1997), Dixon and Parmenter (1996), Reinert and Roland-Holst (1997) on the use of SAMs, and Shoven and Whalley (1984, 1992).

econometric methods. Devarajan et al. (1994, p1-14) further comment on often heard, but contradicting and refutable, criticisms that CGE models are “too complicated”, “make too many assumptions”, “require too much data”, “give counter-intuitive results” (which is better considered as a complement), “tell us what we already know” and are “‘black boxes’ that cannot be understood by the uninitiated”. Nevertheless, as noted by Scarf and Shoven on the imperfections of CGE models, CGE models are superior in that *“there are no competing formulations that…provide the flexibility and conceptual wealth of the general equilibrium model”* (Scarf and Shoven, 1984).

Within the stated research objectives of this thesis, CGE modelling is preferred to other methods because of its theoretical tractability in terms of the behaviour of the agents in the economy and its ability to incorporate interdependencies and feedbacks. The linkages that are of interest are those between public and private health care, other product markets (including the main input suppliers to health care, such as pharmaceuticals and medical instruments), factor markets, especially for skilled and unskilled labour, government budget implications and household welfare effects of changes in health. Such linkage effects are concealed in econometric studies, whereas partial equilibrium models by nature (partially) leave these out.

Often heard rationalisations for the partial equilibrium approach include the relative smallness of the health care sector and the high degree of specialisation (i.e. intersectoral immobility) of highly skilled staff and high-tech capital. The UK’s NHS currently employs an approximate 1.3 million people, 4.3% of the total work force, which makes it the third biggest employer in the world after the Chinese Army and

Indian Railway[9] and suggests that health care is anything but small. The majority of health care staff, even those that are skilled, is in practice inter-sectorally mobile (managers and associated staff, laboratory technicians, ancillary workers) so that expansion or contraction of the health care sector will impact on other sectors. Furthermore, as was noted in the background to the research problem, there are other strong interactions with the rest of the economy and with policy-making, certainly in the longer term, so that it is arguable that general equilibrium modelling may be more appropriate for the analysis of some issues.

1.4 MEASUREMENT OF HEALTH AND CHANGES IN HEALTH

The explicit modelling of the impact of health care on the health of the population, first and foremost requires the definition of an appropriate measure of health. As is apparent from the vast amount of literature on health status measures and indicators of health, this proves to be a contentious issue.[10] Since this thesis is concerned with (labour) resource allocation issues of health care provisioning, health is explicitly measured in terms of the size of effective, i.e. ‘able to work’, labour endowments, thereby avoiding controversies surrounding the choice of a particular health indicator.

Specifically, it is postulated that the labour force is working if healthy and not working if ill and that a change in health has a parallel effect on effective labour endowments. Consequently, a decline in health is equivalent to a reduction in the number of people able to work (full-time and/or part-time) and so reduces effective labour endowments,

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[9] “NHS is world’s biggest employer after Indian rail and Chinese Army”, Sam Lister, Times Online, 20 March 2004.

[10] A literature review is outside the scope of this thesis, though a good starting point for the interested reader is the World Health Organization (2002) publication on Summary Measures of Population Health.

whereas an improvement in population health is equivalent to an increase in effective labour endowments available for use in the production sectors.

These changes in health come about through changes in the size of a non-tradable health care sector. The health care sector employs labour in the "production" of healthy people by treating the ill, i.e. health care adds value to the ill. Ill persons who are not yet (successfully) treated and therefore (partially or fully) unable to work are recorded in an artificial "waiting list" sector. The remaining part of the labour force that is healthy is by definition employed in one of the production sectors. Within this framework and given the initial waiting lists, the number of new ill and the quality/cost of treatments, a rise in the provision of health care in a given period increases the number of people treated and cured and thereby reduces the waiting lists and increases effective labour supplies.

There are limitations to modelling health and changes in health in this fashion. In the background to the research problem, the impact of an increase in the provision of health care on the size of the non-working population, i.e. children and pensioners, has been acknowledged. Although the CGE model accounts for these population groups, it does not model longer-term population processes (births, deaths, transitions from young to working and from working to retired), nor does it model the decomposition of those moving from young to working into skilled and unskilled. The obvious advantage of modelling in this way is its simplicity. The major disadvantage is that it requires the "translation" of the rather complex health transition from "ill" to "well" into a one-period model, yielding the previously mentioned limitations.

1.5 THESIS STRUCTURE

The remainder of this thesis is organised as follows. Chapter 2 analyses the interactions between health care and non-health care sectors in their simplest form, using a low-dimension Heckscher-Ohlin framework of a small open economy which is modelled on the UK. It captures changes in effective, i.e. able to work, labour endowments following a change in the provision of government-provided health care whilst recognising resource claims made on the labour market by the health care sector. Rybczynski-style predictions of an increase in health care expenditures on outputs are derived and subsequently assessed for sensitivity to key assumptions, most importantly the presence of health care-specific skilled labour. The results of an increase in health care expenditures are contrasted with those of changes in health care provision stemming from the immigration of foreign health care-specific skilled labour and productivity improvements in health care due to factor-neutral and skill-biased technical change respectively, *given* the size of the health care budget.

Chapter 3 reviews empirical literature applied to the economic effects of health and health care provision, focusing on CGE models. It identifies the major shortcomings in the literature, most notably the absence of the simultaneous impact of changes in health care provision on effective labour endowments and the health sector's demands for labour, which will be addressed in the CGE model of the UK economy developed in Chapter 6.

Chapter 4 gives an overview of the health care system and policy of the UK through time, illustrated by facts and figures, and highlights the pressures faced by the UK government (and many other developed countries) and the policy options it has in resolving these. It thereby not only provides the foundations of the UK-focused CGE model with health care provision effects developed in Chapter 6, but also gives the range of policy options and shocks that will be scrutinised using this applied model and, where possible, employing the theoretical framework of Chapter 2.

Chapter 5 presents the dataset, the UK 2000 SAM, to which the CGE model of Chapter 6 is calibrated, in tabular form. It contains economic data disaggregated by sector, which are predominantly taken from the UK Input-Output Supply and Use Tables for 2000 and are distributed over factors and households using data from the General Household Survey 2000-01. The latter dataset, readily available in MS Access, is a valuable source of information for a range of socio-economic characteristics of private households living in Great Britain, in the context of this thesis most notably health and health care use data, and so complements Chapter 4's portrayal of the UK's health care system and performance.

Chapter 6 outlines the CGE model for the UK with health care provision effects and presents simulation results which cover current issues in (developed country) health care systems and that of the UK in particular. Model experiments include increasing government expenditures on health care, a rise in the price of pharmaceuticals, the immigration of health care-specific skilled labour and productivity improvements in health care stemming from factor-neutral technical change, skill-biased technical change and technical change embodied in pharmaceuticals respectively. The applied nature of the CGE model allows for a more accurate and detailed representation of the UK economy, its health care system, health and welfare compared to the theoretical tool developed in Chapter 2. Specifically, the CGE model differentiates between eleven sectors (among which are health care and its main intermediate input suppliers), three factors (capital, skilled and unskilled labour), the government and five types of households (characterised by age and working status of its members), and separates public from private health care in consumption. More realism is also obtained in terms of the modelling of health care provision effects by incorporating direct increases in the 'well-being' of the population next to indirect improvements in health through increasing the size of effective, i.e. 'able to work', labour endowments. The added complexities ensure that the results of Chapter 6 (among others in terms of health, effective endowments, factor rewards, sectoral outputs, household income and welfare) complement those of Chapter 2 (mainly in terms of sectoral outputs), where the latter provides some insight into effects operating in the background of the former. The final chapter draws conclusions and outlines limitations and avenues for future research.

CHAPTER 2

HEALTH PROVISION EFFECTS IN A HECKSCHER-OHLIN FRAMEWORK

2.1 INTRODUCTION

This chapter presents a theoretical exposition of the interactions between government-provided health care and the outputs of non-health goods in a small open economy, via changes in the size of *effective* (i.e. 'able to work') labour endowments. In the theory of international trade, the Rybczynski (R) theorem predicts the repercussions of changes in endowments, such as labour and capital, on the structure and level of production. This theorem has its foundation in the Heckscher-Ohlin (HO) model of international trade, which therefore provides a natural starting point for assessing health provision effects. The standard exposition of the HO model treats factor supplies as fixed, which has led to the development of variable factor supply models (e.g. Martin, 1976, Martin and Neary, 1980). Whereas these models allow labour supply to respond to changes in real wages, in this chapter changes in effective labour supply come from changes in the size of health provision (which for the UK is largely determined by the government). A number of modifications to the HO model are considered in order to produce a model that is more representative of reality.

The rest of this chapter is organised as follows. Section 2.2 outlines the impact of labour endowment changes on outputs in the conventional HO model. Section 2.3 considers endowment changes which are health-related and conditioned on the output of a non-tradable health sector in the HO model that is adjusted accordingly. Section 2.4 gives a theoretical overview of the impact of health-conditioned changes in effective labour supply when alternative modifications are made to the HO model, most importantly the introduction of health care-specific skilled labour. This section includes an analysis of Rybczynski-type effects when the government allows foreign health care-specific skilled labour to enter the UK in order to alleviate the rationing of health care. The consequences of different types of technology shocks in the health sector on sectoral outputs are examined in Section 2.5. The final section concludes with a general overview.

2.2 CHANGES IN RELATIVE FACTOR SUPPLIES AND USE IN A LOW DIMENSION HECKSCHER-OHLIN MODEL

The low dimension HO model describes two regions, two factors and two goods. The two regions are the UK, which is modelled in detail, and the rest of the world (ROW). In line with the small country assumption the UK engages in world trade at a given set of world prices which will not be affected by its trading activities. In order to focus on the differential impact of changes in health provision across labour types, the two factors are skilled and unskilled labour. Factor endowments are exogenous and owned by a single representative household, who maximises utility subject to the income earned from the supply of these factors. It is assumed that households in the UK and ROW have identical homothetic utility functions. With respect to production there are two sectors (1 and 2), which compete for skilled and unskilled labour in the production of goods. Representative producers in these two sectors maximise profits by optimal employment of factors of production, using constant returns to scale (CRTS) production technologies which are sectorally identical across regions. Product and factor markets are perfectly competitive and factors of production are perfectly mobile between sectors, but not between countries.

In this framework the source of trade comes from differences in national factor endowments and factors used in the production of different goods, hence the label of the 'factor proportions' model of trade. The assumptions regarding national factor endowments and factor intensities in production are that: (1) The UK is relatively abundant in skilled labour, and (2); sector 1 is relatively intensive in skilled labour at any common factor price ratio (i.e. there are no factor intensity reversals). In order to specify the equations of the model, utility and production are described by linear homogeneous functional forms.[1]

On the consumption side, the representative household will seek to consume at levels which maximise utility subject to the budget constraint. This is formally described by:

Maximise $U = U(C_1, C_2)$

subject to $p_1 C_1 + p_2 C_2 = Y$

where U denotes the utility of the representative household, C_i the consumption of good i (i = 1,2), p_i the price of good i, Y the income of the representative household.

The solution to the utility maximisation problem is given by the Marshallian demand functions:

$$C_1 = C_1\left(P_1, P_2, Y\right) \qquad (2.1)$$

[1] Production and utility functions exhibit strictly convex technologies and preferences respectively so that the second order sufficient conditions are always satisfied.

$$C_2 = C_2\left(P_1, P_2, Y\right) \tag{2.2}$$

On the production side, the producer in industry *i* seeks to maximise profits in two stages. Firstly, producer *i* minimises production costs by choosing the optimal combination of factor inputs for a given output level. Subsequently, given the outcome of the first stage, the optimal, i.e. profit-maximising, level of output is established. The property of linear homogeneity of output levels in terms of factor inputs, i.e. CRTS technology in production, implies that the production function of sector *i* is fully described by the unit isoquant. All other isoquants are simply radial projections of the unit isoquant and, consequently, the cost-minimising relative factor input ratio is independent of the level of output. It is therefore convenient to formulate and solve the cost-minimisation problem faced by producer *i* in terms of unit output values, given by:

Minimise $\quad TC_i(1) = w_S a_{Si} + w_U a_{Ui}$

subject to $\quad f\left(a_{Si}, a_{Ui}\right) = 1$

where $TC_i(1)$ denotes costs of producing one unit of output in sector *i* (*i* = 1, 2), w_l the price of labour type *l* (*l* =*S*,*U*), and the input-output coefficients a_{Si} and a_{Ui} are defined as $a_{Si} = S_i / X_i$ and $a_{Ui} = U_i / X_i$, with S_i and U_i denoting the quantities of skilled and unskilled labour, respectively, employed by sector *i*, and X_i being the output of sector *i*. Also, sector 1 is assumed to use skilled labour relatively intensively, i.e. $S_1/U_1 > S_2/U_2$ or in terms of input-output coefficients $a_{S1}/a_{U1} > a_{S2}/a_{U2}$.

Solving the producer's cost minimisation problem for the production of one unit of output yields the following expressions for the unit factor demand equations:

$$a_{Si} = a_{Si}\left(w_S / w_U\right) \quad (2.3), (2.4)$$

$$a_{Ui} = a_{Ui}\left(w_S / w_U\right) \quad (2.5), (2.6)$$

Total factor demands of producer *i* are obtained by multiplying equations (2.3) to (2.6) by the output of sector *i*, X_i:

$$S_i = a_{Si} X_i \quad (2.7), (2.8)$$

$$U_i = a_{Ui} X_i \quad (2.9), (2.10)$$

Turning to the second stage of the producer optimisation problem, the profit maximisation problem of producer *i* becomes:

Maximise $\mu_i = p_i X_i - w_S S_i - w_U U_i = p_i X_i - w_S a_{Si} X_i - w_U a_{Ui} X_i$

where μ_i denotes the profit of producer *i*. This expression is linear in output X_i, so that the solution to the profit maximisation problem does not contain output levels. Instead, the following zero profit conditions (also referred to as unit price or unit cost equations) result:

$$p_i = w_S a_{Si} + w_U a_{Ui} \quad (2.11), (2.12)$$

The price (exogenous to the producer) received for one unit of output *i* equals the cost of producing one unit of output *i*. The result whereby profit maximisation of firms leads to zero profits follows from the assumptions of perfectly competitive markets and CRTS (Euler's theorem). This is, of course, also descriptive of the long-run equilibrium under perfect competition when there is freedom of entry and exit.

Supply and demand for goods resulting from the household's and producer's optimisation problems meet in product markets. Equilibrium in the product markets is obtained by adding the following market clearing conditions:

$$C_1 = X_1 - E_1 \qquad (2.13)$$

$$C_2 = X_2 + M_2 \qquad (2.14)$$

where E_1 and M_2 denote exports of good 1 and imports of good 2 respectively.[2]

Imports are bought and exports are sold at (exogenous) world prices, which requires a link between domestic and world prices. World prices are converted into domestic prices by introducing an exchange rate to the model:

$$p_i = p_i^w ER \qquad (2.15), (2.16)$$

where ER denotes the price of one unit of foreign currency measured in domestic currency, and p_i^w is the world price of good *i*.

2 Good 1 is exported and good 2 is imported due to the assumption that the UK is relatively abundant in skilled labour, which is relatively intensively used by sector 1.This result is known as the Heckscher-Ohlin theorem (for a proof of this theorem see for example Falvey (1994, pp. 18-19).

The exchange rate adjusts such that the trade balance is in equilibrium, represented by:

$$p_1 E_1 - p_2 M_2 = 0 \tag{2.17}$$

Similarly, factor markets clear through factor price adjustments. The full employment conditions are:

$$S_1 + S_2 = S \tag{2.18}$$

$$U_1 + U_2 = U \tag{2.19}$$

where S (U) denotes the fixed endowments of skilled (unskilled) labour.

The household derives income from participation in the two labour markets and receives an income of:

$$Y = w_S \left(S_1 + S_2 \right) + w_U \left(U_1 + U_2 \right) \tag{2.20}$$

The full set of equations of the HO model is displayed in Table 2.1.[3]

[3] The implementation of the HO model involves choosing a numeraire and making one market clearing equation redundant. The former, known as the normalisation procedure, is required as all the demand and supply equations of the model are homogeneous of degree 0 in prices, such that only relative prices can be established. The latter, known as Walras' Law, states that if n-1 markets are in equilibrium the nth market will automatically be in equilibrium.

Table 2.1 The Heckscher-Ohlin Model for a Small Open Economy

COMMODITY MARKETS		
Demand	$C_1 = C_1(P_1, P_2, Y)$	(2.1)
	$C_2 = C_2(P_1, P_2, Y)$	(2.2)
Unit price equations (*i*=1, 2)	$p_i = w_S a_{S_i} + w_U a_{U_i}$	(2.11), (2.12)
Market Clearing	$C_1 = X_1 - E_1$	(2.13)
	$C_2 = X_2 + M_2$	(2.14)
FACTOR MARKETS		
Demand (*i* = 1, 2)	$a_{S_i} = a_{S_i}(w_S / w_U)$	(2.3), (2.4)
	$S_i = a_{S_i} X_i$	(2.7), (2.8)
	$a_{U_i} = a_{U_i}(w_S / w_U)$	(2.5), (2.6)
	$U_i = a_{U_i} X_i$	(2.9), (2.10)
Market Clearing	$S_1 + S_2 = S$	(2.18)
	$U_1 + U_2 = U$	(2.19)
HOUSEHOLD INCOME		
	$Y = w_S(S_1 + S_2) + w_U(U_1 + U_2)$	(2.20)
FOREIGN SECTOR		
Price equations (*i*=1, 2)	$p_i = p_i^w ER$	(2.15), (2.16)
Balance of Payments constraint	$p_1 E_1 - p_2 M_2 = 0$	(2.17)
Endogenous variables:	C_1, C_2, X_1, X_2, S_1, S_2, U_1, U_2, a_{S1}, a_{S2}, a_{U1}, a_{U2}, P_1, P_2, w_S, w_U, Y, E_1, M_2, ER.	
Exogenous variables:	S, U, p_1^w, p_2^w.	

Source: Adapted from Dinwiddy and Teal (1988).

The impact of a shock to endowments on sectoral production in the HO model is given by the R theorem (Rybczynski, 1955). This theorem states that, at unchanged product prices, an increase in the endowment of one factor, while holding the endowment of the other factor constant, results in a more than proportionate increase in the production of the good using the growing factor intensively and an absolute decline in the production of the other good. Also following from the derivation of the R theorem is the result that increasing the endowments of both factors in the same proportion leads to an increase in the production of both goods in that proportion.[4]

Two particularly important features of the HO model for the derivation of these outcomes are that, from equations (2.3) to (2.6), the input-output coefficients are a function of relative factor prices only, while, from equations (2.11) and (2.12), factor prices solely depend on relative product prices. That is, if both products are produced in equilibrium, the zero profit conditions can be solved for factor prices, given product prices.[5]

The R theorem may be formally derived from the full employment conditions.[6] Equations (2.18) and (2.19) can be rewritten in terms of the input-output coefficients:

$$a_{S1}X_1 + a_{S2}X_2 = S \tag{2.21}$$

$$a_{U1}X_1 + a_{U2}X_2 = U \tag{2.22}$$

---

4 Another corollary is that increasing the factor endowments in a ratio equal to the factor ratio in one sector increases the output of that sector and leaves the output of the other sector unchanged.

5 The absence of product specialisation requires sufficiently similar relative factor endowments between the UK and the ROW (Falvey, 1994, pp. 16-17).

6 The derivation is usually associated with Jones (1965).

From equations (2.3) to (2.6) we have $a_{l_i} = a_{l_i}\left(w_S / w_U\right)$ for *l* = *S*, *U* and *i* = 1, 2 so that total differentiation of (2.21) yields:

$$da_{S1}X_1 + da_{S2}X_2 + a_{S1}dX_1 + a_{S2}dX_2 = dS \tag{2.23}$$

After further manipulation this expression can be written as:

$$\hat{a}_{S1}\lambda_{S1} + \hat{a}_{S2}\lambda_{S2} + \lambda_{S1}\hat{X}_1 + \lambda_{S2}\hat{X}_2 = \hat{S} \tag{2.24}$$

where a '^' denotes a proportionate change, $\lambda_{S_i} = S_i / S$ is the proportion of factor *S* used in sector *i*, and $\sum_i \lambda_{S_i} = 1$.

As commodity prices are unchanged due to the assumption that the UK is a small open economy, factor prices are constant such that $\hat{a}_{l_i} = 0$ for all *l*, *i*. Hence equation (2.24) can be simplified to:

$$\lambda_{S1}\hat{X}_1 + \lambda_{S2}\hat{X}_2 = \hat{S} \tag{2.25}$$

Repeating this derivation for unskilled labour results in:

$$\lambda_{U1}\hat{X}_1 + \lambda_{U2}\hat{X}_2 = \hat{U} \tag{2.26}$$

where $\lambda_{U_i} = U_i / U$ is the proportion of factor *U* used in sector *i*, and $\sum_i \lambda_{U_i} = 1$.

Solving for the proportional changes in output yields:

$$\hat{X}_1 = \frac{\lambda_{U2}\hat{S} - \lambda_{S2}\hat{U}}{|\lambda|} \tag{2.27}$$

$$\hat{X}_2 = \frac{\lambda_{S1}\hat{U} - \lambda_{U1}\hat{S}}{|\lambda|} \tag{2.28}$$

where $|\lambda| = \lambda_{S1}\lambda_{U2} - \lambda_{U1}\lambda_{S2} = \lambda_{S1} - \lambda_{U1} > 0$ under the assumption that sector 1 is relatively skill-intensive compared to sector 2.

If the economy's skilled/unskilled labour endowment ratio increases (i.e. $\hat{S} > \hat{U}$), equations (2.27) and (2.28) can be rewritten in terms of the following expressions:

$$\hat{X}_1 - \hat{S} = \frac{\lambda_{S2}\left(\hat{S} - \hat{U}\right)}{|\lambda|} > 0 \tag{2.29}$$

$$\hat{U} - \hat{X}_2 = \frac{\lambda_{U1}\left(\hat{S} - \hat{U}\right)}{|\lambda|} > 0 \tag{2.30}$$

The proportional change in the production of goods in increasing order of magnitude is thus captured by:

$$\hat{X}_1 > \hat{S} > \hat{U} > \hat{X}_2 \tag{2.31}$$

Conversely, a fall in the economy's skilled/unskilled endowment ratio (i.e. $\hat{U} > \hat{S}$) yields:

$$\hat{X}_2 > \hat{U} > \hat{S} > \hat{X}_1 \tag{2.32}$$

Finally, balanced growth in factor endowments (i.e. $\hat{S} = \hat{U}$) results in

$$\hat{X}_2 = \hat{U} = \hat{S} = \hat{X}_1 \qquad (2.33)$$

The R theorem identifies the special cases of a change in one factor endowment only, i.e. $\hat{S} > 0, \ \hat{U} = 0$ or $\hat{U} > 0, \ \hat{S} = 0$.

Expressions (2.31) and (2.32) demonstrate a "magnification effect" of factor endowments on product outputs occurs. If the pool of skilled (unskilled) labour expands more rapidly than the pool of unskilled (skilled) labour, the production of the skill- (unskilled-) intensive good grows at a higher rate than either factor, whereas the production of the other good grows (if at all) at a slower rate than either factor. Intuitively, if both sectors are to continue using unchanged input mixes, the only manner in which the additional skilled (unskilled) labour can be employed is by expanding production of the skilled- (unskilled-) intensive good and contracting the output of the unskilled- (skilled-) intensive good, the latter releasing the necessary unskilled (skilled) labour needed to increase the production of the skilled- (unskilled-) intensive good.

Figure 2.1, 2.2 and 2.3 illustrate the Rybczynski special cases of $\hat{S} > 0, \ \hat{U} = 0$, $\hat{U} > 0, \ \hat{S} = 0$ and balanced growth $\hat{S} = \hat{U}$ respectively.

Figure 2.1 Growth in skilled labour

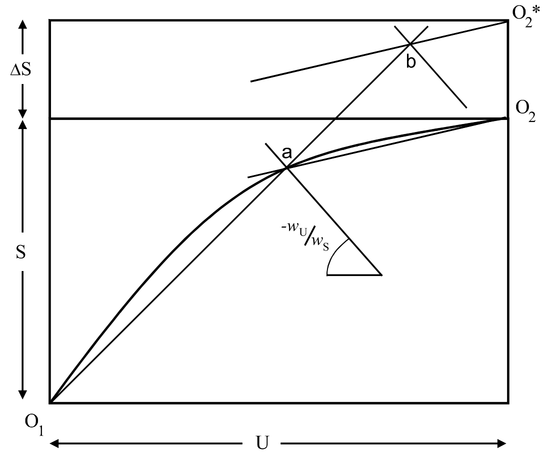


Figure 2.2 Growth in unskilled labour

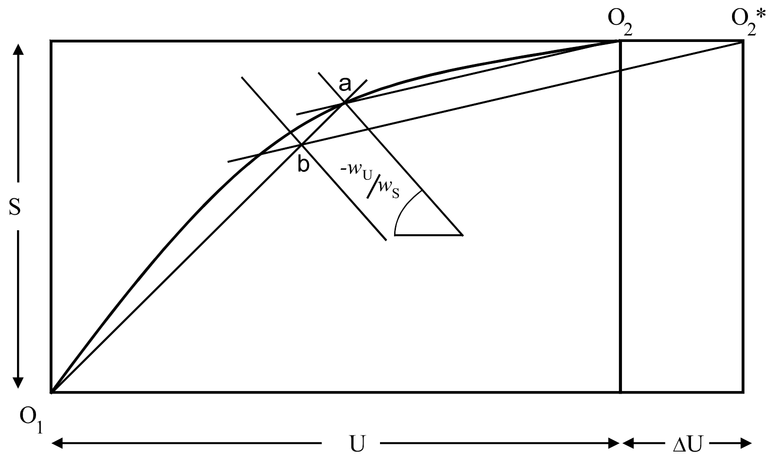
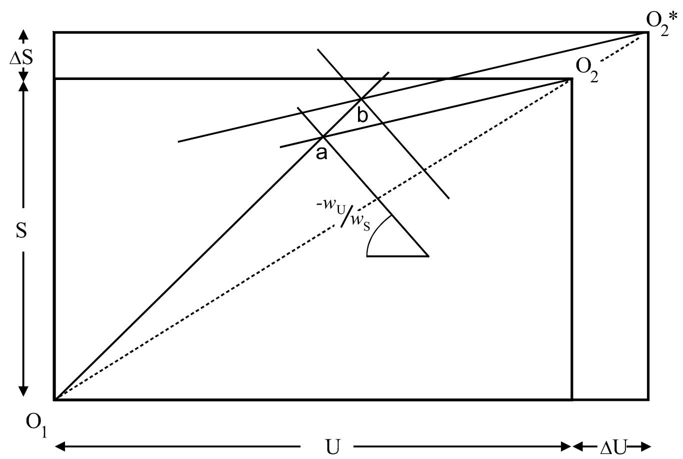


Figure 2.3 Balanced growth in labour endowments



The skilled-unskilled labour ratios in the production of good 1 and good 2 (measured from O_1 and O_2 respectively) remain constant at the given factor prices. Consequently, given that all factors are fully employed, the change in factor endowments alters the equilibrium combination of output from a to b, along the given skilled-unskilled labour ratio lines. In Figure 2.1 (Figure 2.2) the output of the S-intensive (U-intensive) good 1 (2) increases following a rise in skilled (unskilled) labour endowments, whereas the output of the U-intensive (S-intensive) good 2 (1) decreases. In Figure 2.3 the output of both goods increases by the common growth rate of the labour endowments.

2.3 EFFECTIVE LABOUR ENDOWMENTS, RESOURCE USE AND CHANGES IN HEALTH PROVISION

2.3.1 Introducing illness and health

The need for and existence of a health sector stems from the presence of people with ill health. Assuming that all people are working if healthy and not working if ill, a decline in population health caused by illness reduces the number of people able to work (full-time and/or part-time) and so reduces effective labour endowments, whereas an improvement in population health increases effective labour endowments available for use in the production sectors. Ignoring for the moment the cost and resource claims associated with reaching a particular level of health, and assuming that a health measure is agreed on, a change in health thus has a parallel effect on effective labour supply.

The repercussions of a change in the health of the population on the structure of output are analogous to those predicted by the R theorem following changes in relative factor endowments. If health improvements are equal across labour types, balanced growth, as in expression (2.33) and Figure 2.3, prevails. If, on the other hand, skilled (unskilled) labourers were to benefit more than unskilled (skilled) labour from a health improvement, the magnification effect, as in expression (2.31) (expression (2.32)), results. The latter includes the special cases identified by Rybczynski for which the health of only one labour type improves, given the health of the other labour type (Figure 2.1 and 2.2).

The analogy of the impact of a change in population health with the conventional HO model and R results breaks down with respect to per capita income. Whereas this analysis accounts for the presence of people potentially able to work but not working because of ill health, the conventional HO model excludes these by assuming that all factor endowments are fully employed and so the population is identical to the working population. Consequently, any change in factor endowments leads to a corresponding change in the value of total output and has a minor effect on per capita income for sufficiently similar factor endowment changes. In the extreme case where endowments change in the same proportion at given world prices, the output of each sector changes by the same proportion, so does its value and, given wages, so does the income of each factor. It follows that per capita real income (and the consumption of both goods) is unchanged.

In contrast, illness reduces effective labour endowments and thus reduces the total value of output. Given a rise in the number of people unable to work due to illness, and assuming a redistribution mechanism from the well (working) to the ill (not working, but still consuming), this results in a fall in per capita real income. In the example above, if an equal proportion of each labour type falls ill and so cannot work, the total value of output, factor income and hence real income per capita (and consumption) falls by the same proportion. [7]

The discrepancy between the standard R results and an analysis of health-related effective endowment changes with respect to per capita income may be formally derived by comparing two variables, per capita income of the working population and per capita income of the total population (working *and* non-working due to ill health).

In the initial equilibrium per capita income, I, of the working population (denoted by E) is:

$$I_E = \frac{w_S S_E + w_U U_E}{S_E + U_E} \tag{2.34}$$

where S_E and U_E denote effective, i.e. able to work, endowments of skilled and unskilled labour respectively.

Total differentiation of equation (2.34), given that $dw_S = dw_U = 0$, yields:

$$dI_E = I_E \left(\frac{w_S dS_E + w_U dU_E}{w_S S_E + w_U U_E} - \frac{dS_E + dU_E}{S_E + U_E} \right) \tag{2.35}$$

so that the proportionate change in per capita income of the working population equals:

$$\hat{I}_E = \left(\frac{w_S S_E \hat{S}_E + w_U U_E \hat{U}_E}{w_S S_E + w_U U_E} - \frac{S_E \hat{S}_E + U_E \hat{U}_E}{S_E + U_E} \right) \tag{2.36}$$

[7] Of course, if illness implies inevitable death there is no need to redistribute income and per capita income remains unchanged.

After further manipulation equation (2.36) yields:

$$\hat{I}_E = (\varpi - \gamma)\left(\hat{S}_E - \hat{U}_E\right) \tag{2.37}$$

where $\varpi = \dfrac{w_S S_E}{w_S S_E + w_U U_E}$ denotes the share of skilled labour in the total income of the working population and $\gamma = \dfrac{S_E}{S_E + U_E}$ denotes the share of skilled labour in total effective labour supply.

Developing the expression for $\varpi - \gamma$ yields:

$$\varpi - \gamma = \frac{\left(w_S - w_U\right) S_E U_E}{\left(w_S S_E + w_U U_E\right)\left(S_E + U_E\right)} \tag{2.38}$$

which is positive assuming that $w_S > w_U$, i.e. skilled workers earn a higher wage relative to unskilled workers.

From (2.37) an improvement in health for both types of workers if identical, i.e. $\hat{S}_E = \hat{U}_E > 0$, does not affect per capita income of the working population. Additionally, if the health improvement is higher for skilled (unskilled) labour relative to unskilled (skilled) labour, i.e. $\hat{S}_E > \hat{U}_E > 0$ ($\hat{U}_E > \hat{S}_E > 0$), per capita income of the working population will rise (fall). Thus if the government is solely concerned with maximising per capita income of the working population, equation (2.37) provides an argument for targeting government health policy in terms of the provision of treatments to skilled workers only (or worse, to deteriorate the health of the unskilled).

In the initial equilibrium per capita income of the total population, working and not working, is

$$I = \frac{w_S S_E + w_U U_E}{S + U} \tag{2.39}$$

Total differentiation of equation (2.39) yields:

$$dI = \frac{w_S dS_E + w_U dU_E}{S + U} \tag{2.40}$$

so that the proportionate change in per capita income of the population can be derived as:

$$\hat{I} = \varpi \hat{S}_E + (1 - \varpi)\hat{U}_E = \varpi\left(\hat{S}_E - \hat{U}_E\right) + \hat{U}_E \tag{2.41}$$

Given that the total population does not change (S and U are exogenous), $\hat{I}$ also represents the proportionate change in total income or GDP and, in the absence of intermediate inputs, the proportionate change in the total value of output at world prices.

From equation (2.41) an improvement in health for both labour types, $\hat{S}_E > 0$ and $\hat{U}_E > 0$, generates an increase in per capita income of the population even if health improvements are equal across labour types (i.e. $\hat{S}_E = \hat{U}_E > 0$). Nevertheless, for a given level of health improvement of the unskilled, $\hat{U}_E > 0$, the increase in per capita income will be higher the more the health of skilled labour is improved relative to the health of unskilled labour. Hence, if the government's prime objective is to maximise per capita income of the total population, equation (2.41) suggests a policy predicament of targeting treatments towards all skill types, but relatively more to skilled labour.

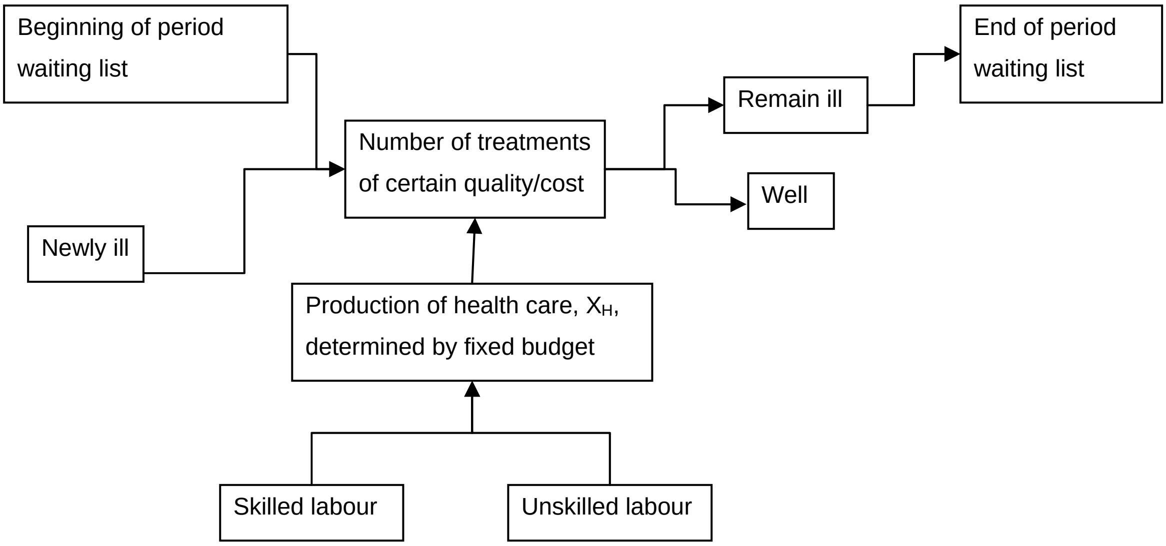
Bearing this in mind, in the following sections the change in the health of the population will be modelled on a non-traded health sector. Throughout the analysis it is assumed that health solely affects income, via its impact on labour market participation, and does not appear in the utility function. Any gains from changes in health are thus purely monetary.

2.3.2 Introducing health care

The improvement in health must be accounted for in terms of cost and resource use. It is assumed that the changes in health come about through changes in the size of a non-tradable health sector, *H*. Ethier (1972) assessed how the introduction of a non-traded good alters the Rybczynski result. In the presence of a non-traded good, an increase in the endowment of each factor will be partially absorbed by the production of the non-traded good, and so output changes in the remaining traded good sectors depend on the factor intensity in the non-traded sector and the characteristics of demand for the non-traded good. The analysis here differs in the respect that changes in effective labour endowments are conditioned upon changes in the production of a non-tradable health sector.

Health care is provided by the government, is free at the point of use, and its expenditure is determined politically and thus is exogenous to the model. The necessary finance for health care provision is obtained directly from households via a lump-sum transfer. The health sector employs skilled and unskilled labour in the ‘production’ of healthy people by treating the ill, i.e. health care adds value to the ill. Ill persons who are not (successfully) treated and therefore unable to work are recorded in an artificial waiting list sector, *W*.[8] The interrelations between the health sector and the waiting list sector in a one-period framework are depicted in Figure 2.4.

Figure 2.4 Public health care, demand rationing and the waiting list



In this framework health status is measured in terms of ability to work. The output of the health sector, 'well', is the number of people treated and 'cured' and thus able to work, the remainder being added to the waiting list.[9] Also following from Figure 2.4 is that the change in the size of the waiting list sector depends on the number of people who become ill (i.e. the number of people demanding treatment), the size of the health sector (i.e. the number of available treatments of a given quality and cost) and the effectiveness of health care in curing people (i.e. the effectiveness of treatments), the latter two determining the number of ill recovering from illness. Consequently, given

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8 In this UK-centred example, it is assumed that the given health budget is insufficient to treat all those presenting themselves as ill, such that the waiting list is positive.

9 An alternative interpretation, involving scaling in terms of worker-hours, is that it is the proportional reduction in the degree of illness of all, with the proportion of 'semi-cured' workers becoming an addition to the effective labour force.

the number of new ill and the quality/cost of treatments, a rise in the provision of health care, X_H, increases the number of people treated and cured, and thereby reduces the waiting list, *W*, that period.

The introduction of a health sector and an artificial waiting list sector alters the equations of the HO model developed previously.

Starting with the consumption of health care, health care demand is rationed such that:

$$C_H = X_H \tag{2.42}$$

where X_H denotes the amount of health care that the given health budget can purchase and C_H is the consumption of health care.[10]

Given the output of health care, X_H, a representative producer minimises the cost of production. Assuming CRTS in the production process this yields the equivalent of expressions (2.3) to (2.6) for the input-output coefficients for health care:

$$a_{SH} = a_{SH}\left(w_S / w_U\right) \tag{2.43}$$

$$a_{UH} = a_{UH}\left(w_S / w_U\right) \tag{2.44}$$

where the input-output coefficients a_{SH} and a_{UH} are defined as $a_{SH} = S_H / X_H$ and $a_{UH} = U_H / X_H$, S_H and U_H denote the quantities of skilled and unskilled labour,

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[10] The exogenous health budget is modelled via a lump-sum transfer by the representative household and consequently dealt with when discussing household income. If the health good had a price to the household then its introduction to the model would change the demand equations for good 1 and 2.

respectively, employed by the health sector and sector H is assumed to be the most skill-intensive of all sectors, $a_{SH}/a_{UH} > a_{S1}/a_{U1} > a_{S2}/a_{U2}$.[11]

Total demands for skilled and unskilled labour by the health sector follow from multiplication of the input-output coefficients by the output of the health sector:

$$S_H = a_{SH} X_H \tag{2.45}$$

$$U_H = a_{UH} X_H \tag{2.46}$$

The price of health care to the government is determined by the cost of producing one unit of health care, the equivalent of the zero-profit conditions (2.11) and (2.12) for health care:

$$p_H = w_S a_{SH} + w_U a_{UH} \tag{2.47}$$

where p_H denotes the price of health care.

Ignoring the loss of working time in undergoing treatment, the full employment conditions (2.18) and (2.19) are substituted by:

$$S_1 + S_2 + S_H = S_E \tag{2.48}$$

$$S_E = S - S_W \tag{2.49}$$

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[11] This is equivalent to $S_H/U_H > S_1/U_1 > S_2/U_2$, which is in contrast to the conventional HO models with a non-traded good that assume the factor-intensity of the non-traded good sector is in between those of the traded sectors. In this model health care is intrinsically non-tradable.

$$U_1 + U_2 + U_H = U_E \qquad (2.50)$$

$$U_E = U - U_W \qquad (2.51)$$

where S_E and U_E denote effective, i.e. able to work, endowments of skilled and unskilled labour respectively and S_W and U_W the amounts of skilled and unskilled labour, respectively, on the waiting list.

In agreement with the linkages displayed in Figure 2.4, the size of the waiting list for skilled and unskilled labour in a typical period depends on the size of the initial waiting list, the incidence of illness (number of new illness cases as a proportion of given total endowments) and the output of the health sector:

$$S_W = S_W\left(X_H; S_W^0, ir_S S\right) \qquad \partial S_W / \partial X_H = S_W^{'}\left(X_H; S_W^0, ir_S S\right) < 0 \qquad (2.52)$$

$$U_W = U_W\left(X_H; U_W^0, ir_U U\right) \qquad \partial U_W / \partial X_H = U_W^{'}\left(X_H; U_W^0, ir_U U\right) < 0 \qquad (2.53)$$

where S_W^0 and U_W^0 denote initial (given) waiting lists, and ir_S and ir_U the exogenous illness rates for skilled and unskilled labour respectively, and S_W and U_W are decreasing functions of health sector output.[12]

Finally, the household derives income from three sources of employment, the two tradables sectors and health care, such that equation (2.20) is replaced by:

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[12] The second-order derivative of the waiting lists with respect to health care is assumed positive, so that waiting lists are decreasing in health care but at a decreasing rate. Waiting lists can not become negative.

$$Y = w_S\left(S_1 + S_2 + S_H\right) + w_U\left(U_1 + U_2 + U_H\right) - T \qquad (2.54)$$

where T denotes the exogenous lump-sum transfer paid by households to finance the provision of health care, given by:

$$T = p_H X_H \qquad (2.55)$$

The full HO model with a non-tradable health sector is displayed in Table 2.2.

The formal derivation of the R theorem within the context of this model is identical to the standard procedure, with the difference that changes in effective labour supply are conditioned upon changes in health provision. Starting with the full employment conditions (2.48) to (2.51), rewritten in terms of the input-output coefficients:

$$a_{S1}X_1 + a_{S2}X_2 + a_{SH}X_H = S_E = S - S_W \qquad (2.56)$$

$$a_{U1}X_1 + a_{U2}X_2 + a_{UH}X_H = U_E = U - U_W \qquad (2.57)$$

where $a_{l_i} = a_{l_i}\left(w_S / w_U\right)$ for $l = S, U$ and i = 1, 2, H.

Total differentiation of (2.56) yields:

$$da_{S1}X_1 + da_{S2}X_2 + da_{SH}X_H + a_{S1}dX_1 + a_{S2}dX_2 + a_{SH}dX_H = dS_E \qquad (2.58)$$

Table 2.2 The Heckscher-Ohlin Model with Health Care

COMMODITY MARKETS		
Demand	$C_1 = C_1\left(P_1, P_2, Y\right)$	(2.1)
	$C_2 = C_2\left(P_1, P_2, Y\right)$	(2.2)
	$C_H = X_H$	(2.42)
Unit price equations (*i*=1, 2, H)	$p_i = w_S a_{Si} + w_U a_{Ui}$	(2.11), (2.12), (2.47)
Market Clearing	$C_1 = X_1 - E_1$	(2.13)
	$C_2 = X_2 + M_2$	(2.14)
FACTOR MARKETS		
Demand (*i* = 1, 2, H)	$a_{Si} = a_{Si}\left(w_S / w_U\right)$	(2.3), (2.4), (2.43)
	$S_i = a_{Si} X_i$	(2.7), (2.8), (2.45)
	$a_{Ui} = a_{Ui}\left(w_S / w_U\right)$	(2.5), (2.6), (2.44)
	$U_i = a_{Ui} X_i$	(2.9), (2.10), (2.46)
Market Clearing	$S_1 + S_2 + S_H = S_E$	(2.48)
	$S_E = S - S_W$	(2.49)
	$U_1 + U_2 + U_H = U_E$	(2.50)
	$U_E = U - U_W$	(2.51)
Waiting Lists	$S_W = S_W\left(X_H; S_W^0, ir_S S\right)$ $\partial S_W / \partial X_H = S_W^{'}\left(X_H; S_W^0, ir_S S\right) < 0$	(2.52)
	$U_W = U_W\left(X_H; U_W^0, ir_U U\right)$ $\partial U_W / \partial X_H = U_W^{'}\left(X_H; U_W^0, ir_U U\right) < 0$	(2.53)
HOUSEHOLD INCOME		
	$Y = w_S\left(S_1 + S_2 + S_H\right) + w_U\left(U_1 + U_2 + U_H\right) - T$	(2.54)
	$T = p_H X_H$	(2.55)

Table 2.2 Continued

FOREIGN SECTOR		
Price equations (i = 1, 2)	$p_i = p_i^w ER$	(2.15), (2.16)
Balance of Payments constraint	$p_1 E_1 - p_2 M_2 = 0$	(2.17)

Endogenous variables:	C_1, C_2, C_H, X_1, X_2, X_H, S_1, S_2, S_H, S_E, S_W, U_1, U_2, U_H, U_E, U_W, a_{S1}, a_{S2}, a_{SH}, a_{U1}, a_{U2}, a_{UH}, p_1, p_2, p_H, w_S, w_U, Y, E_1, M_2, ER.
Exogenous variables:	S, U, p_1^w, p_2^w, ir_S, ir_U, S_W^0, U_W^0, T.

Since total skilled labour endowments, *S*, the illness rate, *ir*, and initial waiting list for skilled labour, S_W^0, remain unchanged, the right-hand side of equation (2.58) may be rewritten as:

$$dS_E = dS - dS_W = 0 - \partial S_W / \partial X_H \, dX_H \qquad (2.59)$$

Manipulation of equation (2.58) yields:

$$\hat{a}_{S1}\lambda_{S1} + \hat{a}_{S2}\lambda_{S2} + \hat{a}_{SH}\lambda_{SH} + \lambda_{S1}\hat{X}_1 + \lambda_{S2}\hat{X}_2 + \lambda_{SH}\hat{X}_H = \hat{S}_E \qquad (2.60)$$

where, as before, a '^' denotes a proportionate change, while $\lambda_{Si} = S_i / S_E$ denotes the proportion of S_E employed in sector i, and $\sum_i \lambda_{Si} = 1$ for i = 1, 2, H.

Expression (2.59) can be rewritten as:

$$\hat{S}_E = \left| \varepsilon_{X_H}^{S_W} \right| \delta_{SW} \hat{X}_H \qquad (2.61)$$

where $\left|\varepsilon_{X_H}^{S_W}\right| = -\frac{\partial S_W}{\partial X_H}\frac{X_H}{S_W} = -S_W^{'}\left(X_H; S_W^0, ir_S S\right)\frac{X_H}{S_W} > 0$ denotes the absolute value of the elasticity of the waiting list for skilled labour with respect to the production of health care, and $\delta_{SW} = S_W / S_E > 0$ the ratio of skilled labour on the waiting list to effective skilled labour endowments, the "dependency ratio" for skilled labour.[13]

Combining (2.60) and (2.61), while substituting $\hat{a}_{Si} = 0$ for *i* = 1, 2, H (small country assumption) and $\hat{X}_H = \hat{T}$ (as $\hat{p}_H = 0$), yields:

$$\lambda_{S1}\hat{X}_1 + \lambda_{S2}\hat{X}_2 = \left(\delta_{SW}\left|\varepsilon_{X_H}^{S_W}\right| - \lambda_{SH}\right)\hat{T} \qquad (2.62)$$

Repeating this derivation for unskilled labour results in:

$$\lambda_{U1}\hat{X}_1 + \lambda_{U2}\hat{X}_2 = \left(\delta_{UW}\left|\varepsilon_{X_H}^{U_W}\right| - \lambda_{UH}\right)\hat{T} \qquad (2.63)$$

where $\lambda_{Ui} = U_i / U_E$ denotes the proportion of U_E employed in sector *i*, $\sum_i \lambda_{Ui} = 1$ for *i* = 1, 2, H, and $\delta_{UW} = U_W / U_E > 0$ the ratio of unskilled labour on the waiting list to effective unskilled labour endowments, the "dependency ratio" for unskilled labour. $\left|\varepsilon_{X_H}^{U_W}\right| = -\frac{\partial U_W}{\partial X_H}\frac{X_H}{U_W} = -U_W^{'}\left(X_H; U_W^0, ir_U U\right)\frac{X_H}{U_W} > 0$ denotes the absolute value of the elasticity of the waiting list for unskilled labour with respect to health care output.

[13] Note that this implies that the elasticity of effective skilled labour endowments with respect to the production of health care, $\hat{S}_E / \hat{X}_H$, is equal to $\left|\varepsilon_{X_H}^{S_W}\right| \cdot \delta_{SW}$.

Expressions (2.62) and (2.63) form a system of two equations in two unknowns, $\hat{X}_1$ and $\hat{X}_2$. Solving for the proportional changes in output yields:

$$\hat{X}_1 = \frac{\hat{T}}{|\lambda|}\left[\left(\lambda_{U2}\delta_{SW}\left|\varepsilon^{S_W}_{X_H}\right| - \lambda_{S2}\delta_{UW}\left|\varepsilon^{U_W}_{X_H}\right|\right) + \left(\lambda_{S2}\lambda_{UH} - \lambda_{U2}\lambda_{SH}\right)\right] \tag{2.64}$$

$$\hat{X}_2 = \frac{\hat{T}}{|\lambda|}\left[\left(\lambda_{S1}\delta_{UW}\left|\varepsilon^{U_W}_{X_H}\right| - \lambda_{U1}\delta_{SW}\left|\varepsilon^{S_W}_{X_H}\right|\right) + \left(\lambda_{U1}\lambda_{SH} - \lambda_{S1}\lambda_{UH}\right)\right] \tag{2.65}$$

where $|\lambda| = \lambda_{S1}\lambda_{U2} - \lambda_{U1}\lambda_{S2} > 0$ under the assumption that sector 1 is relatively skill-intensive compared to sector 2.

The extreme possibility of $\left|\varepsilon^{S_W}_{X_H}\right| = \left|\varepsilon^{U_W}_{X_H}\right| = 0$, implying the absence of any (positive) impact of health sector output on effective labour endowments, simplifies equations (2.64) and (2.65) to:

$$\hat{X}_1 = \frac{\hat{T}}{|\lambda|}\left[\lambda_{S2}\lambda_{UH} - \lambda_{SH}\lambda_{U2}\right] \tag{2.66}$$

$$\hat{X}_2 = \frac{\hat{T}}{|\lambda|}\left[\lambda_{U1}\lambda_{SH} - \lambda_{S1}\lambda_{UH}\right] \tag{2.67}$$

Expressions (2.66) and (2.67) reflect the proportionate changes in output of sectors 1 and 2 respectively following a change in government expenditures on health care, assuming the latter impacts the labour market *only* via the resource claims it makes. Since the skill-intensity of the health sector differs from the economy-wide effective endowment ratio, a change in the size of the health sector will affect the amount of skilled relative to unskilled labour available for use in the tradables sectors. Hence, the relationships depicted in (2.66) and (2.67) describe the “factor-bias effect” of a change in health care output. The remaining terms of equations (2.64) and (2.65) depict the “scale-effect” of a change in health care output, i.e. the impact of improved health on effective endowments of skilled and unskilled labour, which was investigated in section 2.3.1.[14] It is useful to consider the factor-bias effect in isolation first, before continuing with the overall impact, i.e. factor-bias plus scale effects, of an increase in the output of health care on the production of the non-health sectors.

2.3.3 Factor-bias effects

If government expenditure on health care increases ($\hat{T} > 0$), given that the health sector is the most skill-intensive sector, the skilled-unskilled effective labour endowment ratio for the rest of the economy must fall. On the basis of the R theorem, one expects the output of the relatively skill-intensive traded good (sector 1) to fall and the output of the other traded good (sector 2) to rise.[15] There are two cases to consider, depending on whether the middle-ranking sector (sector 1) has a skilled-unskilled labour ratio greater or less than the effective endowment ratio. Let $s_j = S_j / U_j$, where j = 1, 2, H or E (for the effective endowment ratio), then the two cases are as follows.[16]

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14 These terms resemble equations (2.27) and (2.28), but now with changes in effective labour supply conditioned upon the provision of health care.

15 In theory, the output of the other good (2) could fall as well, but this situation is precluded here as the health sector is assumed to be the most skill-intensive of all sectors. If this is not the case, the output of sector 2 would fall.

16 At least one sector must have a skilled-unskilled labour ratio greater than and at least one must have skilled-unskilled labour ratio less than the effective endowment ratio. If the skill-intensity of the health sector were to remain unspecified, there would be six possible outcomes depending on the ordering of skill intensities in the three sectors relative to the effective endowment ratio, being: (1) $s_H > s_1 > s_E > s_2$, (2) $s_H > s_E > s_1 > s_2$, (3) $s_1 > s_H > s_E > s_2$, (4) $s_1 > s_E > s_H > s_2$, (5) $s_1 > s_2 > s_E > s_H$, and (6) $s_1 > s_E > s_2 > s_H$.

Case 1: $s_H > s_1 > s_E > s_2$

The health sector is more skill-intensive than sector 2, so $\frac{\lambda_{SH}}{\lambda_{UH}} > \frac{\lambda_{S2}}{\lambda_{U2}}$, or $\lambda_{SH}\lambda_{U2} - \lambda_{S2}\lambda_{UH} > 0$, hence from equation (2.66) $\hat{X}_1 < 0$. Similarly, the health sector is more skill-intensive than sector 1, so $\lambda_{SH}\lambda_{U1} - \lambda_{S1}\lambda_{UH} > 0$, hence from equation (2.67) $\hat{X}_2 > 0$. In order to assess whether or not $\hat{T}$ exceeds $\hat{X}_2$, the latter is subtracted from the former, yielding:

$$\hat{T} - \hat{X}_2 = \hat{T}\left[\frac{\lambda_{S1}\left(\lambda_{UH} + \lambda_{U2}\right) - \lambda_{U1}\left(\lambda_{SH} + \lambda_{S2}\right)}{|\lambda|}\right] \tag{2.68}$$

Since $\lambda_{UH} + \lambda_{U2} = 1 - \lambda_{U1}$, $\lambda_{SH} + \lambda_{S2} = 1 - \lambda_{S1}$ this expression can be simplified to

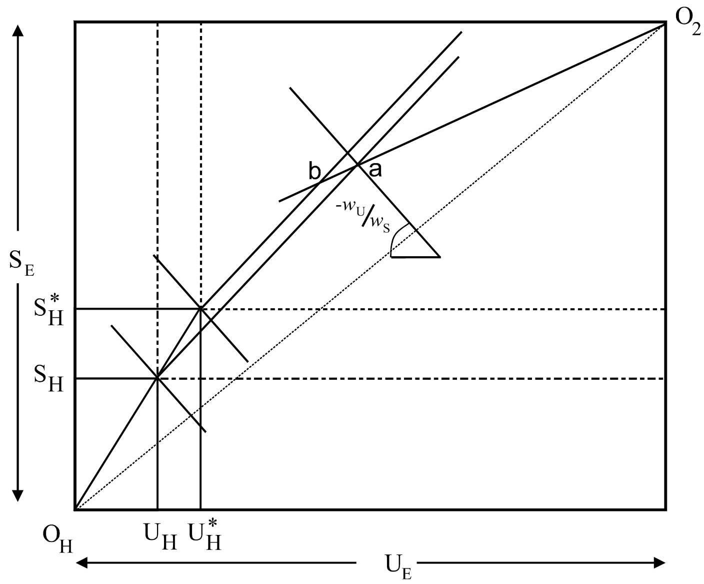
$$\hat{T} - \hat{X}_2 = \hat{T}\left[\frac{\lambda_{S1} - \lambda_{U1}}{|\lambda|}\right] \tag{2.69}$$

$s_1 > s_E$ implies $\lambda_{S1} - \lambda_{U1} > 0$, and therefore $\hat{T} > \hat{X}_2$.

Thus $s_H > s_1 > s_E > s_2$ implies $\hat{T} > \hat{X}_2 > 0 > \hat{X}_1$. Figure 2.5 illustrates.

The given government health budget, T, is allocated efficiently to purchase factors of production, S_H and U_H, at given factor prices and technology. The remaining factor inputs are allocated to sector 1 (measured from the south-west corner of the 'health box') and 2, giving equilibrium point a. As the government budget is increased, $\hat{T} > 0$, labour employed in health care increases to S_H^* and U_H^*, while the amount of labour, *and* the skilled-unskilled labour ratio, for the rest of the economy falls. Consequently, the output of the relatively skill-intensive good 1 decreases, whereas the output of good 2 rises, as indicated by b.

Figure 2.5 Factor-bias effects in the HO model - Case 1

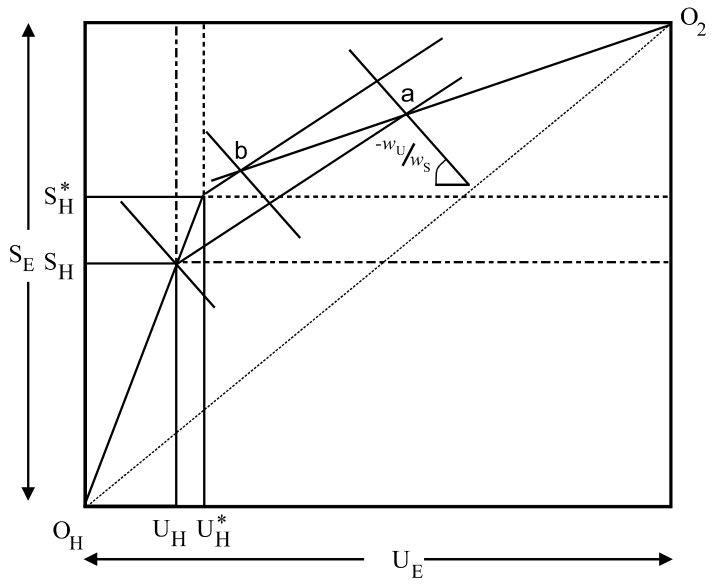


Case 2: $s_H > s_E > s_1 > s_2$

This situation is identical to case 1, except for the ordering of the middle-ranking sector 1 relative to the economy-wide endowment ratio. $s_E > s_1$ implies $\lambda_{S1} - \lambda_{U1} < 0$, so that $\hat{X}_2 > \hat{T}$, and the overall ordering of proportionate changes in sector output equals $\hat{X}_2 > \hat{T} > 0 > \hat{X}_1$. Figure 2.6 depicts this situation. [17]

[17] In Case 1 (Figure 2.5) sector 2's output expands proportionally less than the increase in the health budget, in Case 2 (Figure 2.6) by proportionally more.

Figure 2.6 Factor-bias effects in the HO model - Case 2



2.3.4 Factor-bias and scale effects: homogeneous health and treatments

Returning to equations (2.64) and (2.65) with positive waiting list elasticities, there are a myriad of possibilities, depending on the ordering of skill-intensities in each of the three sectors and the artificial waiting list, relative to the overall (effective) endowment ratio, and the waiting list elasticities for skilled and unskilled labour. To limit the number of possible outcomes of an expansion of the health sector, waiting lists are henceforth postulated as being homogeneous in ill health and, thus, in treatment across labour types. Equal proportions of each labour type fall ill from one type of illness, which affects labour types in the same way and requires a unique type of treatment, which needs the same amount of health provision and is equally effective across labour types.[18] Assuming that health care is allocated in proportion to the number of each labour type becoming ill – and so *not* targeted to any particular skill type, an increase in health provision, given initial waiting lists (which are, by assumption, proportionate to

[18] Evidence suggests that the incidence of illness is higher in low-income groups and that these groups consume less health care and are less efficient "producers" of health (i.e. respond less well to treatment), but for simplicity of exposition this is abstracted from.

total endowments of the respective labour types) and the incidence of illness, leads to identical proportionate reductions in the waiting lists of skilled and unskilled labour and thus an equi-proportionate rise in effective skilled and unskilled labour endowments. Hence, the expansion of the health budget induces balanced growth in effective labour endowments.

In terms of the specification of the HO model with health care, the assumption of homogeneity in terms of illness and treatment simplifies the waiting list equations so that $ir_S = ir_U$ and $S_W(\ )$ and $U_W(\ )$ are identical functions (see equations (2.52) and (2.53)). Furthermore, with respect to the R theorem derivation, $\left|\varepsilon_{X_H}^{S_W}\right| = \left|\varepsilon_{X_H}^{U_W}\right| = \varepsilon > 0$ and $\delta_{SW} = \delta_{UW} = \delta > 0$. Equations (2.64) and (2.65) thus become:

$$\hat{X}_1 = \frac{\hat{T}}{|\lambda|}\left[\delta\varepsilon\left(\lambda_{U2} - \lambda_{S2}\right) + \left(\lambda_{S2}\lambda_{UH} - \lambda_{U2}\lambda_{SH}\right)\right] \tag{2.70}$$

$$\hat{X}_2 = \frac{\hat{T}}{|\lambda|}\left[\delta\varepsilon\left(\lambda_{S1} - \lambda_{U1}\right) + \left(\lambda_{U1}\lambda_{SH} - \lambda_{S1}\lambda_{UH}\right)\right] \tag{2.71}$$

The scale effects of an expansion of the health budget for sector 1 and 2 are given by, respectively:

$$\hat{X}_1^S = \frac{\hat{T}}{|\lambda|}\left[\delta\varepsilon\left(\lambda_{U2} - \lambda_{S2}\right)\right] \tag{2.72}$$

$$\hat{X}_2^S = \frac{\hat{T}}{|\lambda|}\left[\delta\varepsilon\left(\lambda_{S1} - \lambda_{U1}\right)\right] \tag{2.73}$$

and the factor-bias effects for sector 1 and 2, respectively, are:

$$\hat{X}_1^F = \frac{\hat{T}}{|\lambda|}\left[\lambda_{S2}\lambda_{UH} - \lambda_{U2}\lambda_{SH}\right] \tag{2.74}$$

$$\hat{X}_2^F = \frac{\hat{T}}{|\lambda|}\left[\lambda_{U1}\lambda_{SH} - \lambda_{S1}\lambda_{UH}\right] \tag{2.75}$$

where $\hat{X}_1 = \hat{X}_1^F + \hat{X}_1^S$ and $\hat{X}_2 = \hat{X}_2^F + \hat{X}_2^S$.

Equations (2.70) and (2.71) can be further simplified using $\lambda_{UH} = 1 - \lambda_{U1} - \lambda_{U2}$ and $\lambda_{SH} = 1 - \lambda_{S1} - \lambda_{S2}$, which, after manipulating terms, yields:

$$\hat{X}_1 = \frac{\hat{T}}{|\lambda|}\left[(\delta\varepsilon - 1)\left(\lambda_{U2} - \lambda_{S2}\right) + |\lambda|\right] \tag{2.76}$$

$$\hat{X}_2 = \frac{\hat{T}}{|\lambda|}\left[(\delta\varepsilon - 1)\left(\lambda_{S1} - \lambda_{U1}\right) + |\lambda|\right] \tag{2.77}$$

Or, equivalently:

$$\hat{X}_1 = \frac{\hat{T}}{|\lambda|}(\delta\varepsilon - 1)\left(\lambda_{U2} - \lambda_{S2}\right) + \hat{T} \tag{2.78}$$

$$\hat{X}_2 = \frac{\hat{T}}{|\lambda|}(\delta\varepsilon - 1)\left(\lambda_{S1} - \lambda_{U1}\right) + \hat{T} \tag{2.79}$$

where $|\lambda| = \lambda_{S1}\lambda_{U2} - \lambda_{U1}\lambda_{S2} > 0$ under the assumption that sector 1 is relatively skill-intensive compared to sector 2.

If government expenditure on health care increases ($\hat{T} > 0$), given that the health sector is the most skill-intensive sector, the skilled-unskilled effective labour endowment ratio available to the rest of the economy falls, whereas, at the same time, both the skilled and unskilled effective (i.e. able to work) labour endowments rise in the same proportion for skilled and unskilled labour. Consequently, on the basis of the R theorem, the output of the skill-intensive good (sector 1) as well as the output of the other good (sector 2) may fall or rise, depending on the sign and magnitude of the factor-bias and scale effects. There are a total of seven cases to consider, depending on the magnitude of the elasticity of effective labour endowments with respect to health care, i.e. the waiting list elasticity times the dependency ratio and, as before, depending on whether the middle-ranking sector (sector 1) in terms of skill-intensities has a skilled-unskilled labour ratio greater or less than the effective endowment ratio. One case is illustrated below, whereas the other six possibilities are included in the appendix to Chapter 2, Section A1.

Case 1: $s_H > s_1 > s_E > s_2$ and $1 - \frac{|\lambda|}{\left(\lambda_{U2} - \lambda_{S2}\right)} = \frac{\lambda_{U2}\lambda_{SH} - \lambda_{S2}\lambda_{UH}}{\lambda_{U2} - \lambda_{S2}} < \delta\varepsilon < 1$[19]

According to the first part of the condition above, i.e. the ranking of the skill-intensities, the health sector is more skill-intensive than sector 2, so $\frac{\lambda_{SH}}{\lambda_{UH}} > \frac{\lambda_{S2}}{\lambda_{U2}}$, or $\lambda_{SH}\lambda_{U2} - \lambda_{S2}\lambda_{UH} > 0$, hence from equation (2.74) $\hat{X}_1^F < 0$. Since the health sector is also more skill-intensive than sector 1, $\lambda_{SH}\lambda_{U1} - \lambda_{S1}\lambda_{UH} > 0$, and hence from equation

[19] The lower boundary for $\delta\varepsilon$ can be derived from either equation (2.70) or equation (2.76) by setting $\hat{X}_1 > 0$. Notice that the value of the lower boundary is positive but less than 1, given that the health sector is more skill-intensive than sector 2, that sector 2's skill-intensity lies below the effective skilled-unskilled labour endowment ratio and that $|\lambda| > 0$.

(2.75) $\hat{X}_2^F > 0$. Sector 1 has a higher skilled-unskilled labour ratio compared to the effective endowment ratio, so that $\lambda_{S1} - \lambda_{U1} > 0$, and from equation (2.73) $\hat{X}_2^S > 0$ and hence $\hat{X}_2 = \hat{X}_2^F + \hat{X}_2^S > 0$. Similarly, sector 2 has a lower skilled-unskilled labour ratio compared to the effective endowment ratio, so that $\lambda_{U2} - \lambda_{S2} > 0$ and from equation (2.72) $\hat{X}_1^S > 0$. Therefore, using the first part of the condition for Case 1, sector 2's output rises, whereas sector 1's output will rise or fall depending on whether the scale effect outweighs the factor-bias effect. This, as well as the ranking of $\hat{T}$ compared to $\hat{X}_2$ (and $\hat{X}_1$, for $\hat{X}_1 > 0$), is determined by the magnitude of the elasticity of effective labour endowments with respect to health care, $\delta\varepsilon$, given by the second part of the condition for Case 1.

In order to assess whether or not $\hat{T}$ exceeds $\hat{X}_2$, the latter is subtracted from the former (using equation (2.79), yielding:

$$\hat{T} - \hat{X}_2 = \hat{T}\left[\frac{(1-\delta\varepsilon)(\lambda_{S1} - \lambda_{U1})}{|\lambda|}\right] \qquad (2.80)$$

Since $\lambda_{S1} - \lambda_{U1} > 0$ and $\delta\varepsilon < 1$, $\hat{T} - \hat{X}_2 > 0$.

Using equation (2.76), $\delta\varepsilon > 1 - \frac{|\lambda|}{(\lambda_{U2} - \lambda_{S2})}$ implies $\hat{X}_1 > 0$.[20]

The ranking of $\hat{X}_2$ and $\hat{X}_1$ is obtained from equations (2.78) and (2.79):

$$\hat{X}_2 - \hat{X}_1 = \frac{\hat{T}}{|\lambda|}(1-\delta\varepsilon)\left[\left(\lambda_{U2} - \lambda_{S2}\right) - \left(\lambda_{S1} - \lambda_{U1}\right)\right] \tag{2.81}$$

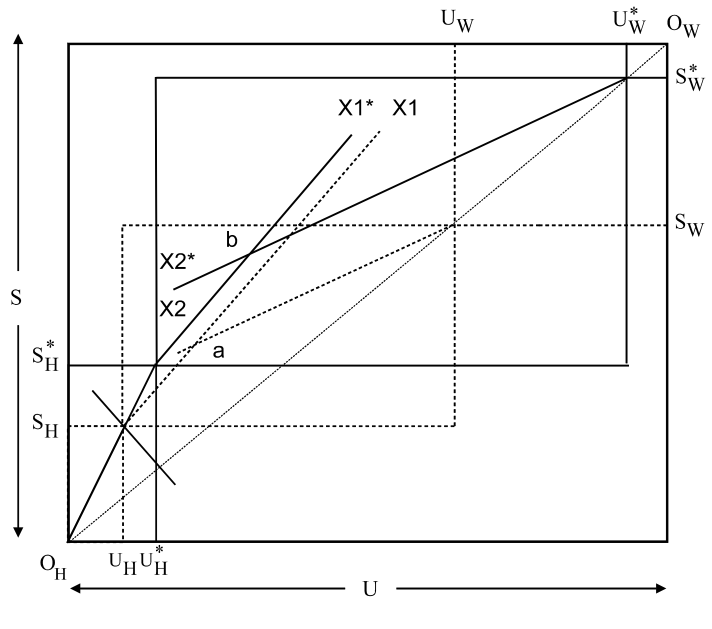
which, given $\lambda_{UH} = 1 - \lambda_{U1} - \lambda_{U2}$ and $\lambda_{SH} = 1 - \lambda_{S1} - \lambda_{S2}$, can be simplified to:

$$\hat{X}_2 - \hat{X}_1 = \frac{\hat{T}}{|\lambda|}(1-\delta\varepsilon)\left(\lambda_{SH} - \lambda_{UH}\right) \tag{2.82}$$

Since $s_H > s_E$, $\lambda_{SH} - \lambda_{UH} > 0$, so that, given $\delta\varepsilon < 1$, $\hat{X}_2 > \hat{X}_1$.

Thus $s_H > s_1 > s_E > s_2$ and $1 - \frac{|\lambda|}{\left(\lambda_{U2} - \lambda_{S2}\right)} = \frac{\lambda_{U2}\lambda_{SH} - \lambda_{S2}\lambda_{UH}}{\lambda_{U2} - \lambda_{S2}} < \delta\varepsilon < 1$ implies $\hat{T} > \hat{X}_2 > \hat{X}_1 > 0$. Figure 2.7 illustrates this situation.

Figure 2.7 Factor-bias and scale effects in the HO model - Case 1



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[20] The same result is achieved by combining equation (2.70) and $\delta\varepsilon > \frac{\lambda_{U2}\lambda_{SH} - \lambda_{S2}\lambda_{UH}}{\lambda_{U2} - \lambda_{S2}}$.

The maximum possible endowments[21] of skilled and unskilled labour are exogenous and equal to S and U. As before, inputs into the health sector are measured from O_H, while those unable to work and thus on the artificial waiting list are measured from O_W. At the original level of health provision, the number of potential skilled and unskilled workers remaining on the waiting list are S_W and U_W respectively (and by virtue of the previous assumptions are in the same proportion as the economy's endowment ratio). The inner box then gives the skilled and unskilled labour available to work in the two tradables sectors. Measuring inputs for sector 1 from the south-west corner of the 'health' box and inputs into the production of sector 2 from the north-east corner of the 'waiting list' box allows us to determine the equilibrium point at a.

As the government budget is increased, $\hat{T} > 0$, labour employed in health care increases to S_H^* and U_H^* while the provision of extra health care reduces the numbers on the waiting lists to S_W^* and U_W^*. The new equilibrium is given by b. Given the original waiting list size, the factor-bias effect, captured by the move from (U_H, S_H) to (U_H^*, S_H^*), increases the output of sector 2, whereas output of sector 1 is almost reduced to zero. Subsequently, given the new size of the health sector, the scale effect, reflected by the change in the waiting lists from (U_W, S_W) to (U_W^*, S_W^*), increases the output of both sectors. In Figure 2.7, the scale effect for sector 1 outweighs the factor-bias effect, such that the output of both sector 1 and 2 rises.

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[21] In the sense that there is no ill health, and hence no need for health provision.

Table 2.3 summarises the proportionate changes in output of non-health sectors if the health sector expands for all seven cases (Cases 2-6 are developed in the appendix to Chapter 2, Section A1).

Table 2.3 Output changes in the HO model following a rise in health expenditures

Relative factor intensities	Waiting list elasticity and dependency ratio assuming homogeneous health and treatment	Output changes for $\hat{T} > 0$
$s_H > s_1 > s_E > s_2$	Case 1. $1 - \frac{\lvert\lambda\rvert}{(\lambda_{U2} - \lambda_{S2})} = \frac{\lambda_{U2}\lambda_{SH} - \lambda_{S2}\lambda_{UH}}{\lambda_{U2} - \lambda_{S2}} < \delta\varepsilon < 1$	$\hat{T} > \hat{X}_2 > \hat{X}_1 > 0$
	Case 2. $0 < \delta\varepsilon < 1 - \frac{\lvert\lambda\rvert}{(\lambda_{U2} - \lambda_{S2})} = \frac{\lambda_{U2}\lambda_{SH} - \lambda_{S2}\lambda_{UH}}{\lambda_{U2} - \lambda_{S2}}$	$\hat{T} > \hat{X}_2 > 0 > \hat{X}_1$
	Case 3. $\delta\varepsilon > 1$	$\hat{X}_1 > \hat{X}_2 > \hat{T} > 0$
$s_H > s_E > s_1 > s_2$	Case 4. $\delta\varepsilon > 1 - \frac{\lvert\lambda\rvert}{(\lambda_{S1} - \lambda_{U1})} = \frac{\lambda_{S1}\lambda_{UH} - \lambda_{U1}\lambda_{SH}}{\lambda_{S1} - \lambda_{U1}}$	$\hat{X}_1 > \hat{T} > 0 > \hat{X}_2$
	Case 5. $1 < \delta\varepsilon < 1 - \frac{\lvert\lambda\rvert}{(\lambda_{S1} - \lambda_{U1})} = \frac{\lambda_{S1}\lambda_{UH} - \lambda_{U1}\lambda_{SH}}{\lambda_{S1} - \lambda_{U1}}$	$\hat{X}_1 > \hat{T} > \hat{X}_2 > 0$
	Case 6. $1 - \frac{\lvert\lambda\rvert}{(\lambda_{U2} - \lambda_{S2})} = \frac{\lambda_{U2}\lambda_{SH} - \lambda_{S2}\lambda_{UH}}{\lambda_{U2} - \lambda_{S2}} < \delta\varepsilon < 1$	$\hat{X}_2 > \hat{T} > \hat{X}_1 > 0$
	Case 7. $0 < \delta\varepsilon < 1 - \frac{\lvert\lambda\rvert}{(\lambda_{U2} - \lambda_{S2})} = \frac{\lambda_{U2}\lambda_{SH} - \lambda_{S2}\lambda_{UH}}{\lambda_{U2} - \lambda_{S2}}$	$\hat{X}_2 > \hat{T} > 0 > \hat{X}_1$

The rankings of relative output changes based on factor-bias effects alone (Section 2.3.3) are preserved only if the elasticity of effective labour supply with respect to health care, $\delta\varepsilon$, is ‘small enough’ (and less than one), which is illustrated by Case 2 and Case 7. In these cases, the output of the unskilled-intensive good 2 rises and the output of the other good falls. Gradually increasing $\delta\varepsilon$ leads to a rise in production of the skilled-intensive sector 1 as well, provided it is less than one (Cases 1 and 6). Improvements in $\delta\varepsilon$ thereafter makes the output rise for sector 1 stronger than that of sector 2 (Cases 3 and 5), which could in one particular situation lead to a fall in output for sector 2 (Case 4).

2.4 MODIFICATIONS TO THE HECKSCHER-OHLIN MODEL: INTRODUCING SPECIFIC FACTORS

The previous section illustrated the impact of health-related endowment changes, conditioned on the output of a non-tradable health sector, on the outputs of non-health goods in a simple, low-dimension HO model. Whereas this has led to important insights, it is unclear to what extent the results carry over to a more complex model. In the theory of international trade, a general body of theory has been developed to examine the generality of results of simple models. Whereas various modifications have been examined in detail elsewhere,[22] this section concentrates on one particular assumption which, if altered, is expected to have a significant impact upon the results. This is the assumption of perfectly mobile factors of production. Most of the value of health care output represents value-added in the form of wages to health care personnel, so that if part of the labour endowments is assumed specific to sectors, i.e. immobile, the output change of health care is restricted and, also, non-health outputs are less responsive to changes in endowments. The section includes an analysis of Rybczynski-type effects when the government allows the immigration of foreign health care-specific skilled labour in order to alleviate rationing of health care. Before proceeding with the introduction of specific factors, other possible extensions important to the HO model with health care are briefly addressed. These are: the use of intermediate products, the impact of removing the small country assumption and the issue of dimensionality.

2.4.1 Intermediate inputs, small country assumption and dimensionality

Intermediate inputs are of secondary importance compared to value added in the production of health care. Also, according to Falvey (1994), adding inter-industry flows

[22] Falvey (1994) provides a useful survey.

to the conventional HO model does not change its basic results. While there are two alternative measures of factor intensity - direct (value added only) and total (factor use in value added and intermediate inputs) - the ranking of products by either measure is the same. If the intermediate good is not also produced as a final product, the number of factors and products is unequal, which leads to dimensionality problems.

The small country assumption implies that prices are fixed on world markets. Allowing for a ‘large country’ in the sense that it can influence the terms of trade implies that product prices and thus factor prices are not constant anymore in the analysis of health conditioned labour endowment changes. The theory of immiserising growth (Bhagwati,1958) suggests that growth in the country’s more abundant factor - here skilled labour, where the growth would be caused by an improvement in health, may reduce welfare by turning the terms of trade against its exports and so reduce the real income of the growing country.

Ethier (1984) and more recently Falvey (1994) investigate the impact of changing the (relative) dimension of the model from a 2 x 2 to an n x m HO model with n products and m factors. The R theorem derived from the simple HO model carries over to a higher dimension HO model as correlation, provided that $n \geq m$. There is a tendency for an increase in those outputs using intensively those factors whose endowments have risen and a decline for the others. If endowments of one factor rise, it can be shown that there exists at least one sector for which the relative output change exceeds the relative endowment change and at least one sector for which the relative output change is negative. In between these two extremes, the more (less) intensive a good is in the expanding factor, the higher (lower) the relative output change.

2.4.2 Specific factors

The existence of specific factors is often cited as a reason why the impact of changes in factor endowments on domestic outputs may be smaller in reality that that predicted by the R theorem. The Specific-Factors (SF) model (also known as Ricardo-Viner, or Jones-Neary model) assumes that a factor in each sector, usually capital, is specific to the sector and hence immobile across sectors, whereas the other factor, labour, can move freely between the sectors. As a consequence, in the conventional HO model there are two rental rates for the capital stock in each sector next to a uniform wage rate.

The SF model arose in reaction to the inability of conventional trade models to explain factor-owner reactions to international trade policies. While the R theorem predicts that factor returns remain unaffected by changes in endowments, in reality a policy such as liberalisation of immigration restrictions leading to a rise in labour supply is strongly opposed by workers and much favoured by capital owners, which seems at odds with the theory. The SF model reconciles such real world phenomena with conventional trade theory by showing that in the short-run some factors are temporarily locked in, so that factor rewards change in response to external shocks, whereas in the long run initially locked-in factors will become mobile, and respond to differences in sectoral factor rewards, so that gradual adjustment to long-run equilibrium can take place. The SF model can thus be interpreted as a short term version of the conventional HO model.[23]

[23] Examples are Mayer (1974), Neary (1978) and Neary (1996). Another version regards the SF model as a generalisation of the Ricardian model. The capital stocks in the two sectors are treated as two different types of factors so as to encompass factors that are always immobile between sectors (e.g. land in one sector and capital in the other). This implies a 3-factor, 2-sector model. See for example Jones (1971) and Caves et al. (1999, Chapter 6).

The conventional SF model with two sectors and three factors, labour and two types of sector-specific capital, arrives at different conclusions regarding the impact of factor endowment changes on factor returns and the composition of outputs compared to the conventional HO model. With respect to factor returns, the SF model predicts that growth in labour supply lowers the wage and increases rents to both types of sector-specific capital, whereas growth in either capital type improves wages and reduces rents. Specific factors therefore share a common interest contradicting that of the mobile factor, which is to welcome any policy that leads to a rise in the supply of the mobile factor labour and to disapprove of those leading to an increase in either type of specific capital.

In terms of output changes, the SF model shows that the outputs of both sectors rise following an increase in the supply of the mobile factor, irrespective of factor intensities, but remains inconclusive about the ordering of these relative changes.[24] An increase in the supply of a specific capital type would lead to a less than proportionate rise in the output of its sector of employment (which invalidates the magnification effect of the standard R theorem), but would still result in a fall in the output of the other sector as the supply of its specific factor is fixed and some of the mobile factor has been drawn into the expanding sector.

The specific factor introduced into the HO model with health care is skilled labour. Compared to the tradable good sectors 1 and 2 the health sector is the sector in which skills are mostly specific. In order to keep the number of modifications to a minimum,

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[24] The ranking of relative output changes is influenced not only by relative factor intensities, but also by the relative magnitudes of the elasticities of (factor) substitution in both sectors.

while still addressing the question of how factor-specificity alters the results, the specificity of skilled labour is narrowed down to health care only. The remainder of skilled labour endowments is non health care-specific, or tradables-specific, and can move freely between sector 1 and 2. Unskilled labour remains perfectly mobile. In terms of the HO model with a non-tradable health sector (Table 2.2) this implies the following changes.

Firstly, there are two types of skilled labour, health care-specific skilled labour and tradables-specific skilled labour. Each of these types of labour has exogenously fixed total (potential) labour endowments and is assigned a separate waiting list. The market clearing equations for skilled labour, (2.48) and (2.49), thus become:

$$S_1 + S_2 = S_E^T \tag{2.83}$$

$$S_E^T = S^T - S_W^T \tag{2.84}$$

$$S_H = S_E^H \tag{2.85}$$

$$S_E^H = S^H - S_W^H \tag{2.86}$$

where S^T and S^H denote total potential (and exogenous) skilled labour endowments specific to tradables and health care respectively, S_E^T and S_E^H effective, i.e. able to work, skilled labour endowments specific to tradables and health care respectively and S_W^T and S_W^H the number of tradables- and health care-specific skilled workers on the waiting list respectively. S_1 and S_2 represent the quantities of (tradables-specific) skilled labour employed by sectors 1 and 2 respectively and S_H is the amount of (health care-specific) skilled labour employed in the health sector.

The waiting list equation for skilled labour (2.52) is replaced by:

$$S_W^T = S_W^T\left(X_H; S_W^{T0}, ir_S^T S^T\right) \quad \partial S_W^T / \partial X_H = S_W^{T'}\left(X_H; S_W^{T0}, ir_S^T S^T\right) < 0 \qquad (2.87)$$

$$S_W^H = S_W^H\left(X_H; S_W^{H0}, ir_S^H S^H\right) \quad \partial S_W^H / \partial X_H = S_W^{H'}\left(X_H; S_W^{H0}, ir_S^H S^H\right) < 0 \qquad (2.88)$$

where S_W^{T0} and S_W^{H0} denote the initial (beginning of period) waiting lists for tradables-specific and health care-specific skilled labour respectively, ir_S^T and ir_S^H the exogenous illness rates for tradables-specific and health care-specific skilled labour respectively and S_W^T and S_W^H are decreasing functions of health output.

Secondly, instead of a uniform wage, w_S, the two types of skilled labour earn a sector-specific wage, w_S^T in the tradables sectors and w_S^H in the health sector. Household income, as displayed in equation (2.54), changes as follows:

$$Y = w_S^T\left(S_1 + S_2\right) + w_S^H S_H + w_U\left(U_1 + U_2 + U_H\right) - T \qquad (2.89)$$

The unit factor demand equations for sector *i*, *i* = 1,2, equations (2.3) to (2.6), are substituted by:

$$a_{Si} = a_{Si}\left(w_S^T / w_U\right) \qquad (2.90), (2.91)$$

$$a_{Ui} = a_{Ui}\left(w_S^T / w_U\right) \qquad (2.92), (2.93)$$

Unit factor demands for health care, equations (2.43) and (2.44), are replaced by:

$$a_{SH} = a_{SH}\left(w_S^H / w_U\right) \tag{2.94}$$

$$a_{UH} = a_{UH}\left(w_S^H / w_U\right) \tag{2.95}$$

Finally, the unit price equations (2.11), (2.12) and (2.47) are adjusted so that they incorporate the health care- and tradables-specific wages:

$$p_H = w_S^H a_{SH} + w_U a_{UH} \tag{2.96}$$

$$p_i = w_S^T a_{Si} + w_U a_{Ui} \qquad \text{(2.97),(2.98)}$$

where i = 1, 2.

The full set of equations of the model with health care adjusted for health care-specific (and tradables-specific) skilled labour is displayed in Table 2.4.

The formal derivation of the R theorem for the SF model with health care is identical to the standard procedure, with the difference that changes in effective labour supply are conditioned upon changes in health provision *and* that, while the prices of tradables, unskilled labour and tradables-specific skilled labour remain the same, the price of health care and health care-specific skilled labour may change.

Table 2.4 The Specific-Factors Model with Health Care

COMMODITY MARKETS		
Demand	$C_1 = C_1\left(P_1, P_2, Y\right)$	(2.1)
	$C_2 = C_2\left(P_1, P_2, Y\right)$	(2.2)
	$C_H = X_H$	(2.42)
Unit price equations (*i*=1, 2)	$p_i = w_S^T a_{S\,i} + w_U a_{U\,i}$	(2.97), (2.98)
	$p_H = w_S^H a_{S\,H} + w_U a_{U\,H}$	(2.96)
Market Clearing	$C_1 = X_1 - E_1$	(2.13)
	$C_2 = X_2 + M_2$	(2.14)
FACTOR MARKETS		
Demand (*i* = 1, 2)	$a_{S\,i} = a_{S\,i}\left(w_S^T / w_U\right)$	(2.90), (2.91)
	$a_{S\,H} = a_{S\,H}\left(w_S^H / w_U\right)$	(2.94)
i = 1, 2, H	$S_i = a_{S\,i} X_i$	(2.7), (2.8), (2.45)
i = 1, 2	$a_{U\,i} = a_{U\,i}\left(w_S^T / w_U\right)$	(2.92), (2.93)
	$a_{U\,H} = a_{U\,H}\left(w_S^H / w_U\right)$	(2.95)
i = 1, 2, H	$U_i = a_{U\,i} X_i$	(2.9), (2.10), (2.46)
Market Clearing	$S_1 + S_2 = S_E^T$	(2.83)
	$S_E^T = S^T - S_W^T$	(2.84)
	$S_H = S_E^H$	(2.85)
	$S_E^H = S^H - S_W^H$	(2.86)
	$U_1 + U_2 + U_H = U_E$	(2.50)
	$U_E = U - U_W$	(2.51)
Waiting Lists	$S_W^T = S_W^T\left(X_H; S_W^{T0}, ir_S^T S^T\right)$	(2.87)
	$\partial S_W^T / \partial X_H = S_W^{T'}\left(X_H; S_W^{T0}, ir_S^T S^T\right) < 0$	

Table 2.4 Continued

	$S_W^H = S_W^H\left(X_H; S_W^{H0}, ir_S^H S^H\right)$	(2.88)
	$\partial S_W^H / \partial X_H = S_W^{H'}\left(X_H; S_W^{H0}, ir_S^H S^H\right) < 0$	
	$U_W = U_W\left(X_H; U_W^0, ir_U U\right)$	(2.53)
	$\partial U_W / \partial X_H = U_W^{'}\left(X_H; U_W^0, ir_U U\right) < 0$	
HOUSEHOLD INCOME		
	$Y = w_S^T\left(S_1 + S_2\right) + w_S^H S_H + w_U\left(U_1 + U_2 + U_H\right) - T$	(2.89)
	$T = p_H X_H$	(2.55)
FOREIGN SECTOR		
Price equations (i = 1, 2)	$p_i = p_i^w ER$	(2.15), (2.16)
Balance of Payments constraint	$p_1 E_1 - p_2 M_2 = 0$	(2.17)

Endogenous variables:	C_1, C_2, C_H, X_1, X_2, X_H, S_1, S_2, S_H, S_E^T, S_E^H, S_W^T, S_W^H, U_1, U_2, U_H, U_E, U_W, a_{S1}, a_{S2}, a_{SH}, a_{U1}, a_{U2}, a_{UH}, p_1, p_2, p_H, w_S^T, w_S^H, w_U, Y, E_1, M_2, ER.
Exogenous variables:	S^T, S^H, U, p_1^w, p_2^w, ir_S^T, ir_S^H, ir_U, S_W^{T0}, S_W^{H0}, U_W^0, T.

The following equations summarise the relative output, input, factor price and output price changes following a change in the size of the health budget in the SF model, using the assumption that waiting lists are homogeneous in ill health and, thus, in treatment across labour types (for a full derivation see the appendix to Chapter 2, Section A2).[25]

$$\hat{X}_1 = \frac{\sigma\theta_{UH}\hat{T}}{\left(\left(1-\delta\varepsilon\right)\theta_{SH} + \sigma\theta_{UH}\right)}\left[\delta\varepsilon + \frac{2\lambda_{S_2^T}\phi\left(1-\delta\varepsilon\right)}{\left(\lambda_{U_2^T} - \lambda_{S_2^T}\right)}\right] \qquad (2.99)$$

[25] Note that those factor prices and output prices which are not mentioned do not change in value.

$$\hat{X}_2 = \frac{\sigma\theta_{UH}\hat{T}}{\left((1-\delta\varepsilon)\theta_{SH} + \sigma\theta_{UH}\right)}\left[\delta\varepsilon + \frac{2\lambda_{S_1^T}\phi(\delta\varepsilon - 1)}{\left(\lambda_{S_1^T} - \lambda_{U_1^T}\right)}\right] \tag{2.100}$$

$$\hat{X}_H = \sigma\theta_{UH}\hat{T}\Big/\left((1-\delta\varepsilon)\theta_{SH} + \sigma\theta_{UH}\right) \tag{2.101}$$

$$\hat{p}_H = (1-\delta\varepsilon)\theta_{SH}\hat{T}\Big/\left((1-\delta\varepsilon)\theta_{SH} + \sigma\theta_{UH}\right) \tag{2.102}$$

$$\hat{w}_S^H = (1-\delta\varepsilon)\hat{T}\Big/\left((1-\delta\varepsilon)\theta_{SH} + \sigma\theta_{UH}\right) \tag{2.103}$$

$$\hat{a}_{SH} = -\sigma\theta_{UH}(1-\delta\varepsilon)\hat{T}\Big/\left((1-\delta\varepsilon)\theta_{SH} + \sigma\theta_{UH}\right) \tag{2.104}$$

$$\hat{a}_{UH} = \sigma\theta_{UH}(1-\delta\varepsilon)\hat{T}\Big/\left((1-\delta\varepsilon)\theta_{SH} + \sigma\theta_{UH}\right) \tag{2.105}$$

where $\lambda_{S_i^T} = S_i \big/ S_E^T$ denotes the proportion of tradables-specific skilled labour employed in sector i, with $\sum_i \lambda_{S_i^T} = 1$ for i = 1, 2, and $\lambda_{U_i^T} = U_i \big/ U_E^T$ denotes the ratio of unskilled labour employed in sector i to total unskilled labour employed in the tradables sectors, with $\sum_i \lambda_{U_i^T} = 1$ for $i = 1, 2$ and $|\lambda| = \lambda_{S_1^T}\lambda_{U_2^T} - \lambda_{U_1^T}\lambda_{S_2^T} = \lambda_{S_1^T} - \lambda_{U_1^T} = \lambda_{U_2^T} - \lambda_{S_2^T} > 0$ under the assumption that sector 1 is relatively skill-intensive compared to sector 2.

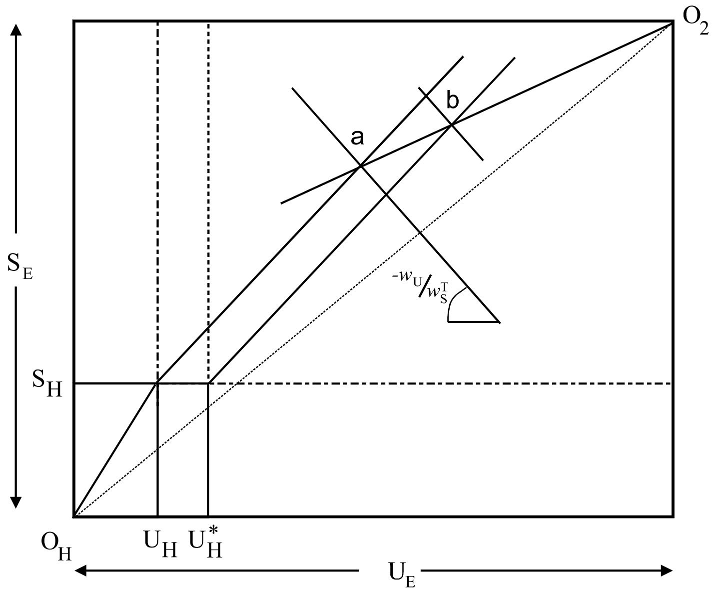
Compared to the HO model the following new terms appear: $\theta_{SH} = a_{SH} w_S^H \big/ p_H$ ($\theta_{UH} = a_{UH} w_U \big/ p_H$) represents the cost share of health care-specific skilled labour (unskilled labour) in the output of health care, so that $\theta_{UH} + \theta_{SH} = 1$. σ denotes the elasticity of substitution between health care-specific skilled labour and unskilled labour in health care, defined as $\sigma = \left(\hat{a}_{UH} - \hat{a}_{SH}\right) / \left(\hat{w}_S^H - \hat{w}_U\right)$, and $\phi = U_H / U_E^T$ is the ratio of unskilled labour employed in health care to total unskilled labour employed in the tradables sectors. The latter parameter appears as, due to the sector-specificity of skilled labour, the tradables sectors now compete with the non-tradable health care sector only in terms of unskilled labour, with an expansion in health care initially reducing the supply of effective unskilled labour available to sectors 1 and 2.

The additional parameters complicate the effect of a rise in health care expenditures, $\hat{T} > 0$, on changes in outputs (and prices) compared to the HO model. Since the proportionate changes in outputs of the tradables sectors lend themselves for comparison with the outcomes of the HO model, they are considered first.

Factor-bias effects:

In the absence of scale effects ($\varepsilon = 0$), $\delta\varepsilon = 0$, so that given $\lambda_{S_1^T} - \lambda_{U_1^T} = \lambda_{U_2^T} - \lambda_{S_2^T} > 0$, $\theta_{lH} > 0$ for $l = S,U$, $\phi > 0$, and a positive substitution elasticity in health care, $\sigma > 0$, from equation (2.99) $\hat{X}_1 = \hat{X}_1^F > 0$ and from equation (2.100) $\hat{X}_2 = \hat{X}_2^F < 0$. The expansion of the health care sector reduces supply of unskilled labour available to the tradables sectors so that, conforming with the R theorem, the output of the unskilled-intensive good, sector 2, must fall and the output of the other good, sector 1, must rise, thereby reversing the rankings of the HO model with health care (see section 2.3.3). Due to the specificity of skilled labour to health care (and the remainder to tradables) the supply and hence use of this factor in health care does not change. Figure 2.8 illustrates.

Figure 2.8 Factor-bias effects in the SF model



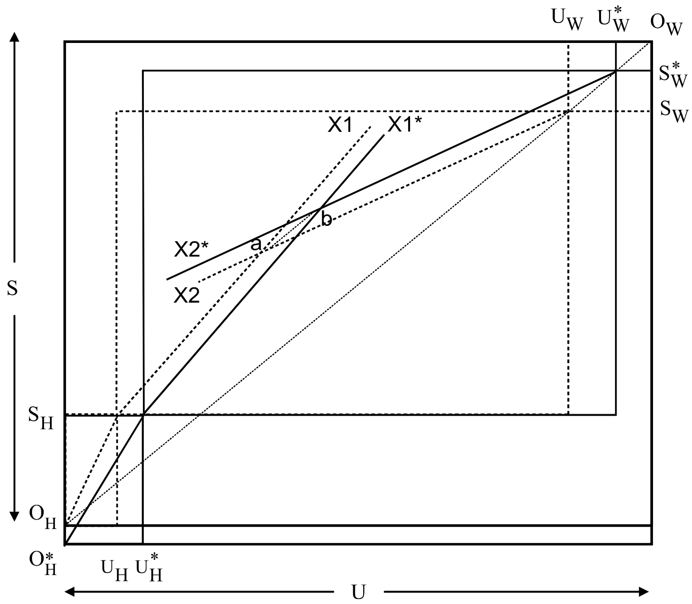
Factor-bias and scale effects:

Using equations (2.99) and (2.100), the difference in the proportionate change in outputs of sectors 1 and 2 for a given positive substitution elasticity σ and positive $\delta\varepsilon$, yields:

$$\hat{X}_1 - \hat{X}_2 = \frac{2\phi\sigma\theta_{UH}\left(1-\delta\varepsilon\right)\hat{T}}{\left(\left(1-\delta\varepsilon\right)\theta_{SH} + \sigma\theta_{UH}\right)\left(\lambda_{U_2^T} - \lambda_{S_2^T}\right)} \tag{2.106}$$

Limiting the range for the elasticity of effective labour supply with respect to health care, $\delta\varepsilon$, to $0 < \delta\varepsilon < 1$, given $\lambda_{U_2^T} - \lambda_{S_2^T} > 0$, $\theta_{lH} > 0$ for $l = S,U$, and $\phi > 0$, yields $\hat{X}_1 - \hat{X}_2 > 0$. Also, from (2.99) $\hat{X}_1 > 0$, whereas from (2.100) the sign of $\hat{X}_2$ is indeterminate and depending on the health sector's use of unskilled labour relative to the tradables sectors (ϕ): the higher the value of this parameter, the more the positive health effect of an increase in health expenditures is counteracted by a reduction in the availability of unskilled labour, which for the unskilled intensive sector implies that a contraction is more likely. Hence, $0 < \delta\varepsilon < 1$ and $\sigma > 0$ implies $\hat{X}_1 > 0$, $\hat{X}_1 > \hat{X}_2$, but with $\hat{X}_2 > 0$ or $\hat{X}_2 < 0$, depending on ϕ. Again, compared to the HO model, the ranking of the proportionate changes in outputs of sector 1 and 2 is reversed. Figure 2.9 illustrates the boundary case for which $\hat{X}_2 = 0$, which is given by $\phi = \delta\varepsilon\left(\lambda_{S_1^T} - \lambda_{U_1^T}\right) / 2\lambda_{S_1^T}\left(1 - \delta\varepsilon\right) > 0$. As the waiting list for health care-specific labour falls, effective supply and hence the use of this factor changes (in the same proportion as effective supply of tradables-specific skilled and unskilled labour).

Figure 2.9 Factor-bias and scale effects in the SF model - $0 < \delta\varepsilon < 1$**,** $\hat{X}_2 = 0$



The ranking of the remaining variables, for $0 \le \delta\varepsilon < 1$ and $0 < \sigma < \infty$, can be derived as: $\hat{T} > \hat{X}_H > 0$, $\hat{w}_S^H > \hat{p}_H > 0$ and $\hat{a}_{UH} > 0 > \hat{a}_{SH}$. In the presence of health care-specific skilled labour, part of the increase in the expenditures on health care is absorbed by a wage increase, resulting in a rise in the price of health care, where $\hat{w}_S^H > \hat{p}_H > 0$ (a magnification effect). The output of the health sector thus increases, but by less than the rise in expenditures on health care: $\hat{T} > \hat{X}_H > 0$. Due to the rise in the relative wage of health care-specific skilled labour, substitution towards relatively cheaper unskilled labour is observed: $\hat{a}_{SH} < 0$, $\hat{a}_{UH} > 0$.

The boundary case of $\delta\varepsilon = 1$ (and $\sigma > 0$) yields proportionate changes in outputs of $\hat{X}_1 = \hat{X}_2 = \hat{X}_H = \hat{T} > 0$, which replicates the rankings of the HO model, with proportionate changes in the input-output coefficients and prices reduced to zero: $\hat{a}_{SH} = \hat{a}_{UH} = \hat{w}_S^H = \hat{p}_H = 0$. In this situation, an increase in government expenditures on health care is fully absorbed by a change in health care production since the relative change in the latter is matched by a change in the effective supply of all labour types. Consequently, the prices of health care and health care-specific skilled labour remain the same and input-output coefficients do not change.

For $\delta\varepsilon > 1$ the proportionate changes cannot be determined without imposing further restrictions on ϕ and σ (see Table 2.5). If factor substitution in health care is limited (σ small), the additional effective supply of all labour, especially health-care specific skilled labour, cannot be absorbed by the health sector so that this sector contracts. Given the rise in the health care budget, the unit cost of health care and so the price of health care-specific skilled labour must rise, generating limited factor substitution in favour of unskilled labour. Also, waiting lists rise and effective endowments of all labour types fall. The effects on tradables' outputs depend on the health sector's reliance on unskilled labour relative to that of tradables (ϕ). For a large ϕ, the tradables sectors are less dependent on unskilled labour - but sector 2 relatively more so than sector 1 - so that following the fall in effective labour supplies, sector 1 expands and sector 2 contracts. For a small ϕ, the tradables sectors are relatively more dependent on unskilled labour relative to the health sector, so that both sectors contract.

For a high σ, the additional supply of health-care specific skilled (and unskilled) labour can easily be absorbed by the health sector so that this sector expands. The unit cost of health care provision and the health care-specific skilled wage fall, generating factor substitution in favour of this relatively cheaper factor of production. Also, waiting lists fall and effective endowments of all labour types rise. For a large (small) ϕ, the tradables sectors are less (more) dependent on unskilled labour - but sector 2 relatively more so than sector 1 - so that following the rise in effective labour supplies, sector 2 expands and sector 1 contracts (expands).

Table 2.5 Output changes in the SF model following a rise in health expenditures

Constraints on parameters assuming homogeneous health and treatment			Output changes for $\hat{T} > 0$
Waiting list elasticity and dependency ratio	Substitution elasticity health care	The health sector's use of unskilled labour relative to the tradables sectors	
$0 < \delta\varepsilon < 1$	$\sigma > 0 \Leftrightarrow \hat{X}_H > 0$	$0 < \phi < \dfrac{\delta\varepsilon\left(\lambda_{S_1^T} - \lambda_{U_1^T}\right)}{2\lambda_{S_1^T}\left(1-\delta\varepsilon\right)}$	$\hat{X}_1 > \hat{X}_2 > 0$
		$\phi > \dfrac{\delta\varepsilon\left(\lambda_{S_1^T} - \lambda_{U_1^T}\right)}{2\lambda_{S_1^T}\left(1-\delta\varepsilon\right)}$	$\hat{X}_1 > 0 > \hat{X}_2$
$\delta\varepsilon > 1$	$0 < \sigma < \dfrac{\theta_{SH}\left(\delta\varepsilon - 1\right)}{\theta_{UH}}$ $\Leftrightarrow \hat{X}_H < 0$	$0 < \phi < \dfrac{\delta\varepsilon\left(\lambda_{U_2^T} - \lambda_{S_2^T}\right)}{2\lambda_{S_2^T}\left(\delta\varepsilon - 1\right)}$	$0 > \hat{X}_1 > \hat{X}_2$
		$\phi > \dfrac{\delta\varepsilon\left(\lambda_{U_2^T} - \lambda_{S_2^T}\right)}{2\lambda_{S_2^T}\left(\delta\varepsilon - 1\right)}$	$\hat{X}_1 > 0 > \hat{X}_2$
	$\sigma > \dfrac{\theta_{SH}\left(\delta\varepsilon - 1\right)}{\theta_{UH}}$ $\Leftrightarrow \hat{X}_H > 0$	$0 < \phi < \dfrac{\delta\varepsilon\left(\lambda_{U_2^T} - \lambda_{S_2^T}\right)}{2\lambda_{S_2^T}\left(\delta\varepsilon - 1\right)}$	$\hat{X}_2 > \hat{X}_1 > 0$
		$\phi > \dfrac{\delta\varepsilon\left(\lambda_{U_2^T} - \lambda_{S_2^T}\right)}{2\lambda_{S_2^T}\left(\delta\varepsilon - 1\right)}$	$\hat{X}_2 > 0 > \hat{X}_1$

Table 2.5 summarises the proportionate changes in output of the non-health sectors if the health sector expands in the SF model. In contrast with the HO model (Table 2.3), the results hold independently of the skill-intensity of the tradables sectors relative to the health sector (only the relative use of unskilled labour matters), while factor substitution in the health sector comes into play.

Table 2.6 summarises the proportionate changes in outputs, unit factor demands and prices for three conventional values for the elasticity of substitution between health care-specific skilled labour and unskilled labour in health care: $\sigma = 0$ (Leontief production technology), $\sigma = 1$ (Cobb-Douglas production technology) and $\sigma \to \infty$ (perfect substitutability between factors of production) respectively.

Table 2.6 Sensitivity of SF results for factor substitution in health care

$\sigma \to$	0	1	∞
$\hat{X}_1 =$	0	$\frac{\theta_{UH}\hat{T}}{(1-\delta\varepsilon\theta_{SH})}\left[\delta\varepsilon + \frac{2\lambda_{S_2^T}\phi(1-\delta\varepsilon)}{(\lambda_{U_2^T}-\lambda_{S_2^T})}\right]$	$\hat{T}\left[\delta\varepsilon + \frac{2\lambda_{S_2^T}\phi(1-\delta\varepsilon)}{(\lambda_{U_2^T}-\lambda_{S_2^T})}\right]$
$\hat{X}_2 =$	0	$\frac{\theta_{UH}\hat{T}}{(1-\delta\varepsilon\theta_{SH})}\left[\delta\varepsilon + \frac{2\lambda_{S_1^T}\phi(\delta\varepsilon-1)}{(\lambda_{S_1^T}-\lambda_{U_1^T})}\right]$	$\hat{T}\left[\delta\varepsilon + \frac{2\lambda_{S_1^T}\phi(\delta\varepsilon-1)}{(\lambda_{S_1^T}-\lambda_{U_1^T})}\right]$
$\hat{X}_H =$	0	$\hat{T}\theta_{UH}/(1-\delta\varepsilon\theta_{SH})$	$\hat{T}$
$\hat{a}_{SH} =$	0	$-\theta_{UH}(1-\delta\varepsilon)\hat{T}/(1-\delta\varepsilon\theta_{SH})$	0
$\hat{a}_{UH} =$	0	$\theta_{UH}(1-\delta\varepsilon)\hat{T}/(1-\delta\varepsilon\theta_{SH})$	0
$\hat{w}_S^H =$	$\hat{T}/\theta_{SH}$	$(1-\delta\varepsilon)\hat{T}/(1-\delta\varepsilon\theta_{SH})$	0
$\hat{p}_H =$	$\hat{T}$	$(1-\delta\varepsilon)\theta_{SH}\hat{T}/(1-\delta\varepsilon\theta_{SH})$	0

Typically, when factors employed in health care are perfectly substitutable (fourth column), all adjustment to an increase in the health care budget takes place via the production of health care (and other goods), whereas in the absence of factor substitution in health care (second column) all adjustment takes place via the price of health care and the wage of health care-specific skilled labour. The intermediate case of unitary elasticity of substitution in health care is displayed in the third column.

2.4.3 Immigration of health care-specific skilled labour in the SF model

In a rationed public health care system such as the UK's National Health Service, the government may consider importing foreign skilled workers to the health care sector so as to alleviate the rationing constraint. The model developed in the previous subsection is suited to analysing the Rybczynski-type effects of such a policy change.

The following equations summarise the relative output and factor supply changes in the SF model following immigration of health care-specific skilled labour, $\hat{S}^H > 0$, whilst maintaining the size of the health budget to its original value, $\hat{T} = 0$. As before, it is assumed that waiting lists are homogeneous in ill health and, thus, in treatment across labour types, and in addition that the income generated by the additional foreign workers remains within the economy, so that the trade balance is unaffected (for a full derivation see the appendix to Chapter 2, Section A3).

$$\hat{X}_1 = \frac{(1+\delta)\theta_{SH}\hat{S}^H}{(1-\delta\varepsilon)\theta_{SH} + \sigma\theta_{UH}} \left[\delta\varepsilon + \frac{\lambda_{S_2^T}\phi\left(1-\delta\varepsilon-\sigma\left(\theta_{UH}/\theta_{SH}\right)\right)}{\left(\lambda_{U_2^T} - \lambda_{S_2^T}\right)} \right] \qquad (2.107)$$

$$\hat{X}_2 = \frac{(1+\delta)\theta_{SH}\hat{S}^H}{(1-\delta\varepsilon)\theta_{SH}+\sigma\theta_{UH}}\left[\delta\varepsilon - \frac{\lambda_{S_1^T}\phi\left(1-\delta\varepsilon-\sigma\left(\theta_{UH}/\theta_{SH}\right)\right)}{\left(\lambda_{S_1^T}-\lambda_{U_1^T}\right)}\right] \quad (2.108)$$

$$\hat{X}_H = \frac{(1+\delta)\theta_{SH}\hat{S}^H}{(1-\delta\varepsilon)\theta_{SH}+\sigma\theta_{UH}} \quad (2.109)$$

$$\hat{p}_H = -\frac{(1+\delta)\theta_{SH}\hat{S}^H}{(1-\delta\varepsilon)\theta_{SH}+\sigma\theta_{UH}} \quad (2.110)$$

$$\hat{w}_S^H = -\frac{(1+\delta)\hat{S}^H}{(1-\delta\varepsilon)\theta_{SH}+\sigma\theta_{UH}} \quad (2.111)$$

$$\hat{a}_{SH} = \frac{\sigma\theta_{UH}(1+\delta)\hat{S}^H}{(1-\delta\varepsilon)\theta_{SH}+\sigma\theta_{UH}} \quad (2.112)$$

$$\hat{a}_{UH} = -\frac{\sigma\theta_{UH}(1+\delta)\hat{S}^H}{(1-\delta\varepsilon)\theta_{SH}+\sigma\theta_{UH}} \quad (2.113)$$

where the difference in the proportionate changes in tradables' outputs is given by:

$$\hat{X}_1 - \hat{X}_2 = \frac{(1+\delta)\theta_{SH}\hat{S}^H\phi\left(1-\delta\varepsilon-\sigma\left(\theta_{UH}/\theta_{SH}\right)\right)}{\left(\lambda_{U_2^T}-\lambda_{S_2^T}\right)\left((1-\delta\varepsilon)\theta_{SH}+\sigma\theta_{UH}\right)} \quad (2.114)$$

Factor-bias effects:

In the absence of health effects ($\varepsilon = 0$), $\delta\varepsilon = 0$, so that given $\lambda_{S_1^T} - \lambda_{U_1^T} = \lambda_{U_2^T} - \lambda_{S_2^T} > 0$ and $\theta_{lH} > 0$ for $l = S,U$ and $\phi > 0$, and with a positive substitution elasticity in health care, $\sigma > 0$, immigration of health care-specific skilled labour, $\hat{S}^H > 0$, leads to a fall in health care-specific skilled wages, a fall in the unit cost of health care provision and hence, given the health care budget, a rise in health care output, $\hat{X}_H > 0$. For $\sigma < \theta_{SH}/\theta_{UH}$, the fall in health care-specific skilled wages induces limited substitution of health care-specific skilled labour for unskilled labour so that overall employment of unskilled labour in health care rises and thus the relative supply of unskilled labour available for the tradables sectors falls: $\hat{X}_1 = \hat{X}_1^F > 0$ and $\hat{X}_2 = \hat{X}_2^F < 0$. In contrast, for $\sigma > \theta_{SH}/\theta_{UH}$, so much of the unskilled labour is substituted by skilled labour in health care that the employment of unskilled labour in health care falls, and the effective supply of unskilled labour for the rest of the economy rises, despite the expansion of the health sector, so that $\hat{X}_1 = \hat{X}_1^F < 0$ and $\hat{X}_2 = \hat{X}_2^F > 0$. Figures 2.10 and 2.11 illustrate.

Figure 2.10 Factor-bias effects of skilled labour migration in health care - $\sigma < \theta_{SH}/\theta_{UH}$

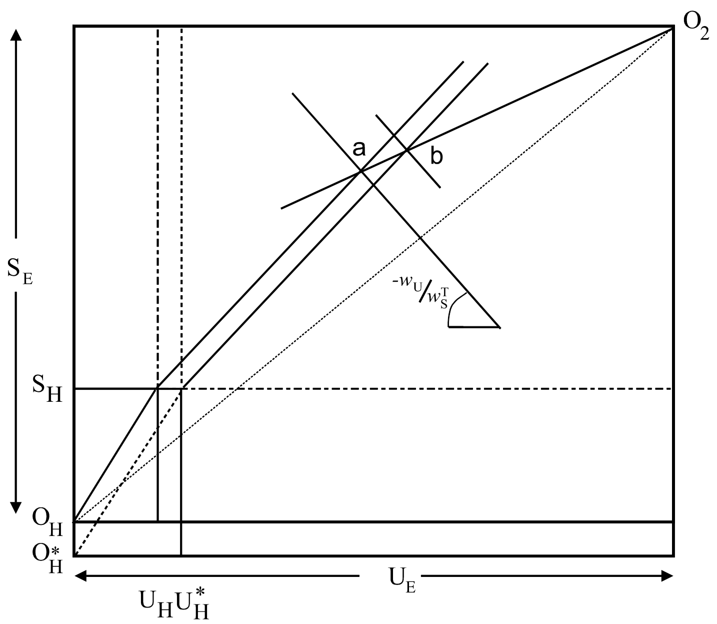
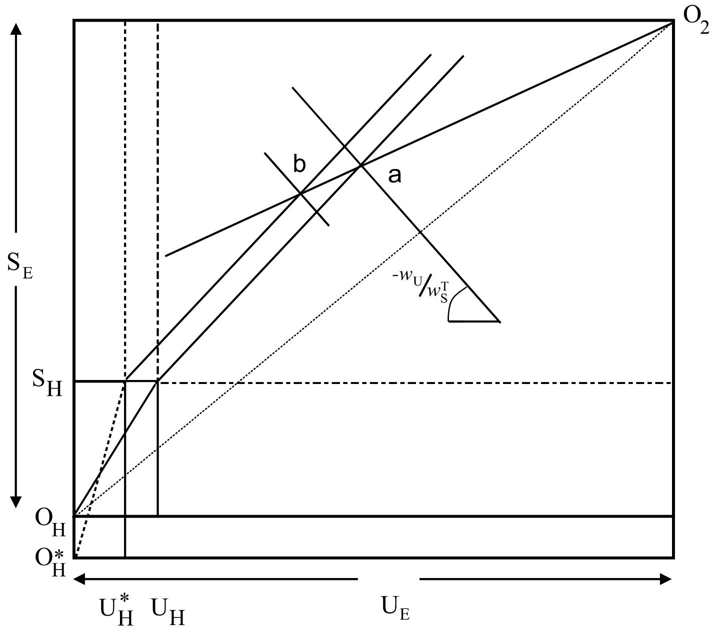


Figure 2.11 Factor-bias effects of skilled labour migration in health care - $\sigma > \theta_{SH} / \theta_{UH}$



Factor-bias and scale effects:

For positive health effects, $\delta\varepsilon > 0$, the effects of a rise in health care-specific skilled labour, $\hat{S}^H > 0$, on changes in outputs (and prices) become more complicated. The results are nevertheless similar to the SF model results in Table 2.6. *Ceteris paribus*, for a 'small' elasticity of effective endowments with respect to health care the factor-bias results pertain, though the formerly contracting sector may now expand, depending on the reliance of health care on unskilled labour relative to tradables (for lower values of ϕ). For a 'large' $\delta\varepsilon$ the signs of the proportionate changes cannot be determined without imposing further restrictions on ϕ and σ: for low (high) levels of factor substitution in health care, i.e. σ small (large), immigration of health care-specific skilled labour and effective labour supply changes cannot (can) be absorbed by the health sector so that this sector contracts (expands), with associated effects on prices, factor demands and outputs as obtained for the SF model.

2.5 TECHNICAL CHANGE IN THE HEALTH SECTOR

There are generally two opposing views on the origins of the many problems that health care systems face nowadays, both supported by a large body of evidence (see Chapter 4). On the one hand, one may argue that insufficient resources have been devoted to health care, whereas on the other hand one may trace back the problems to inefficiencies in the provision of health care. The impact of an increase in health care expenditures across sectors and factors, given production technologies, has been assessed in previous sections. This section departs from previous analyses in that health improvements do not originate from an increase in the use of health care inputs, but from an improvement in productivity of those inputs - i.e. the more efficient use of existing health care resources. Productivity improvements in health care are modelled via technical change, which can be either factor-neutral (Hicks-neutral) or skill-biased. Factor-neutral technical change (FNTC) increases the productivity of both labour types, whereas skill-biased technical change (SBTC) increases the productivity of skilled relative to unskilled labour. There are various ways of defining and implementing these types of technical change (see for example Barro and Sala-i-Martin (1999, p32-33)). This section adopts the approach of Jones (1965) in using the proportionate changes in input-output coefficients as a measure of technical change, which generally may be decomposed into an effect due to factor price changes at given technology and an effect of a change in technology at given factor prices. The requirement for adoption of a new technology, in which case it is technical *progress*, is that unit costs must fall at current factor prices. This condition will be tested for both FNTC and SBTC. The HO model with health care is taken as point of departure; technical change in the SF version of the model is considered in the appendix to Chapter 2, sections A4 and A5.

2.5.1 Factor-neutral technical change in health care using the HO model

FNTC increases productivity of skilled and unskilled labour without altering the ratio of marginal products for a given skilled to unskilled labour ratio. In terms of the production function for health care this type of technological progress, using Jones (1965), implies that $\hat{a}_{SH} = \hat{a}_{UH} = \hat{a} < 0$ (and $\hat{a}_{li} = 0$ for *l* = *S*, *U* and *i* = 1, 2). Per unit of output of health care, less inputs of skilled and unskilled labour are required, so that unit factor demands fall in identical proportions.

The new technology will be adopted if the unit cost of health care at current factor prices falls. At *unchanged* factor prices, total differentiation of the unit cost equation for health care (2.47) yields:

$$\hat{p}_H = \theta_{SH}\hat{a}_{SH} + \theta_{UH}\hat{a}_{UH} \qquad (2.115)$$

where $\theta_{SH} = a_{SH}w_S / p_H$ and $\theta_{UH} = a_{UH}w_U / p_H$ are the cost shares of skilled and unskilled labour in the output of health care respectively, and $\theta_{SH} + \theta_{UH} = 1$ by definition. Substituting $\hat{a}_{SH} = \hat{a}_{UH} = \hat{a} < 0$ in equation (2.115) gives $\hat{p}_H = \hat{a} < 0$, so that unit cost of health care falls and the new technology will be adopted.

Since the health budget, $T = p_H X_H$, is unchanged, the proportionate change in the output of health care can be derived as $\hat{X}_H = -\hat{a} > 0$. This information is used to derive the proportionate changes in outputs of sector 1 and 2.

Substitution of $\hat{a}_{SH} = \hat{a}_{UH} = \hat{a} < 0$ and $\hat{X}_H = -\hat{a} > 0$ in equation (2.58) and (2.59) yields after further manipulation:

$$\lambda_{S1}\hat{X}_1 + \lambda_{S2}\hat{X}_2 = -\delta_{SW}\left|\varepsilon_{X_H}^{S_W}\right|\hat{a} \tag{2.116}$$

Repeating this derivation for unskilled labour results in:

$$\lambda_{U1}\hat{X}_1 + \lambda_{U2}\hat{X}_2 = -\delta_{UW}\left|\varepsilon_{X_H}^{U_W}\right|\hat{a} \tag{2.117}$$

Equation (2.116) and (2.117) resemble equation (2.62) and (2.63), but with $\hat{T}$ replaced by $-\hat{a}$, and λ_{lH} for $l = S,U$ disappearing from the term in brackets.

Solving for the proportional changes in output:

$$\hat{X}_1 = \frac{-\hat{a}}{|\lambda|}\left[\lambda_{U2}\delta_{SW}\left|\varepsilon_{X_H}^{S_W}\right| - \lambda_{S2}\delta_{UW}\left|\varepsilon_{X_H}^{U_W}\right|\right] \tag{2.118}$$

$$\hat{X}_2 = \frac{-\hat{a}}{|\lambda|}\left[\lambda_{S1}\delta_{UW}\left|\varepsilon_{X_H}^{U_W}\right| - \lambda_{U1}\delta_{SW}\left|\varepsilon_{X_H}^{S_W}\right|\right] \tag{2.119}$$

which, using the assumption of homogeneous health and treatments across labour types, gives:

$$\hat{X}_1 = \frac{-\hat{a}\delta\varepsilon}{|\lambda|}\left[\lambda_{U2} - \lambda_{S2}\right] \tag{2.120}$$

$$\hat{X}_2 = \frac{-\hat{a}\delta\varepsilon}{|\lambda|}\left[\lambda_{S1} - \lambda_{U1}\right] \tag{2.121}$$

Comparison of the solution values for the proportionate changes in outputs in a model in which the increase in health care production stems from FNTC, $\hat{X}_H = -\hat{a} > 0$, with those of the model where the production increase was induced by an increase in expenditures on health care, $\hat{X}_H = \hat{T}$, reveals that the former model only yields scale effects. This is due to the technological improvement being neutral across factors, thereby eliminating factor-bias effects (the proportionate change in health care employment equals $\hat{L}_H = \hat{a}_{lH} + \hat{X}_H = \hat{a} - \hat{a} = 0$, for $L = S,U$). Since only scale effects matter, FNTC in health care of magnitude $\hat{a}$ results in proportionate output changes, as shown in Table 2.7.

Table 2.7 Output changes in the HO model following FNTC in health care

Relative factor intensities	Waiting list elasticity and dependency ratio assuming homogeneous health and treatment	Output changes for $\hat{X}_H = -\hat{a} > 0$
$s_H > s_1 > s_E > s_2$	Case 1. $0 < \delta\varepsilon < \frac{\lvert\lambda\rvert}{(\lambda_{U2} - \lambda_{S2})}$	$\hat{X}_H > \hat{X}_1 > \hat{X}_2 > 0$
	Case 2. $\frac{\lvert\lambda\rvert}{(\lambda_{U2} - \lambda_{S2})} < \delta\varepsilon < \frac{\lvert\lambda\rvert}{(\lambda_{S1} - \lambda_{U1})}$	$\hat{X}_1 > \hat{X}_H > \hat{X}_2 > 0$
	Case 3. $\delta\varepsilon > \frac{\lvert\lambda\rvert}{(\lambda_{S1} - \lambda_{U1})}$	$\hat{X}_1 > \hat{X}_2 > \hat{X}_H > 0$
$s_H > s_E > s_1 > s_2$	Case 4. $0 < \delta\varepsilon < \frac{\lvert\lambda\rvert}{(\lambda_{U2} - \lambda_{S2})}$	$\hat{X}_H > \hat{X}_1 > 0 > \hat{X}_2$
	Case 5. $\delta\varepsilon > \frac{\lvert\lambda\rvert}{(\lambda_{U2} - \lambda_{S2})}$	$\hat{X}_1 > \hat{X}_H > 0 > \hat{X}_2$

How do the results of the HO model with FNTC-induced changes in health care output compare to those of the HO model in which health care output rose due to an increase in expenditures on health care?

In the absence of factor-bias effects the change in output for sector 1 cannot be negative (as in Cases 2 and 7 of Table 2.3). If the skill intensity of sector 1 exceeds the effective endowment ratio, the outputs of sector 1 and 2 rise, and the output change in the former exceeds that of the latter. If the skill-intensity of sector 1 is smaller than the effective endowment ratio, the output of sector 1 rises whereas the output of sector 2 falls. The role of the magnitude of the elasticity of effective labour supply with respect to health care is to change the relative position of the change in health care output (i.e. the size of FNTC). The larger is this elasticity, the larger the magnitude of the changes in outputs of non-health sectors, i.e. the more likely that there is a magnification effect.

2.5.2 Skill-biased technical change in health care using the HO model

SBTC increases the productivity of skilled labour only, while leaving the productivity of unskilled labour unchanged.[26] Following Jones (1965) this type of technological progress implies that $\hat{a}_{SH} < 0$, $\hat{a}_{UH} = 0$ and $\hat{a}_{li} = 0$ for l = S, U and i = 1, 2. Skilled labour in health care is more productive so that less input of skilled labour is required per unit of output of health care.[27]

The new technology will be adopted if the unit cost of health care at current factor prices falls. From equation (2.115), $\hat{p}_H = \theta_{SH}\hat{a}_{SH} < 0$, so that the new technology will be adopted.

Given the health budget, $T = p_H X_H$, the proportionate change in the output of health care can be derived as $\hat{X}_H = -\hat{p}_H = -\theta_{SH}\hat{a}_{SH} > 0$. Using this result in the derivation for the proportionate changes in outputs of sector 1 and 2 yields:

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[26] Each skilled worker can so to speak treat more patients. Note that the technological improvement pertains to the health sector only, in contrast to some trade economists who use factor augmentation as applying to the factor in *all* sectors. In that case technical change is equivalent to an endowment change of the relevant factor.

[27] It can be shown that this type of technical change falls in the category of “unskilled labour using” (“skilled labour saving”) technical progress, which occurs when, at constant relative wages, the ratio

$$\hat{X}_1 = \frac{-\hat{a}_{SH}}{|\lambda|}\begin{bmatrix} \theta_{SH}\left(\lambda_{U2}\delta_{SW}\left|\varepsilon_{X_H}^{S_W}\right| - \lambda_{S2}\delta_{UW}\left|\varepsilon_{X_H}^{U_W}\right|\right) \\ +\theta_{SH}\left(\lambda_{S2}\lambda_{UH} - \lambda_{U2}\lambda_{SH}\right) + \lambda_{U2}\lambda_{SH} \end{bmatrix} \quad (2.122)$$

$$\hat{X}_2 = \frac{-\hat{a}_{SH}}{|\lambda|}\begin{bmatrix} \theta_{SH}\left(\lambda_{S1}\delta_{UW}\left|\varepsilon_{X_H}^{U_W}\right| - \lambda_{U1}\delta_{SW}\left|\varepsilon_{X_H}^{S_W}\right|\right) \\ +\theta_{SH}\left(\lambda_{U1}\lambda_{SH} - \lambda_{S1}\lambda_{UH}\right) - \lambda_{U1}\lambda_{SH} \end{bmatrix} \quad (2.123)$$

which, using the assumption of homogeneous health and treatments across labour types, gives:

$$\hat{X}_1 = \frac{-\hat{a}_{SH}}{|\lambda|}\left[\theta_{SH}\delta\varepsilon\left(\lambda_{U2} - \lambda_{S2}\right) + \theta_{SH}\left(\lambda_{S2}\lambda_{UH} - \lambda_{U2}\lambda_{SH}\right) + \lambda_{U2}\lambda_{SH}\right] \quad (2.124)$$

$$\hat{X}_2 = \frac{-\hat{a}_{SH}}{|\lambda|}\left[\theta_{SH}\delta\varepsilon\left(\lambda_{S1} - \lambda_{U1}\right) + \theta_{SH}\left(\lambda_{U1}\lambda_{SH} - \lambda_{S1}\lambda_{UH}\right) - \lambda_{U1}\lambda_{SH}\right] \quad (2.125)$$

where $|\lambda| = \lambda_{S1}\lambda_{U2} - \lambda_{U1}\lambda_{S2} > 0$ under the assumption that sector 1 is relatively skill-intensive compared to sector 2 (and health care is the most skill-intensive sector of all). As with improvements in health induced by an increase in expenditures, the term involving $\delta\varepsilon$ is the scale effect, whereas the remainder represents the factor-bias effect.

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of skilled to unskilled labour employed in health care falls. See for example, Findlay and Grubert (1959)'s analysis of technical change which uses capital and labour as factors of production.

Factor-bias effects:

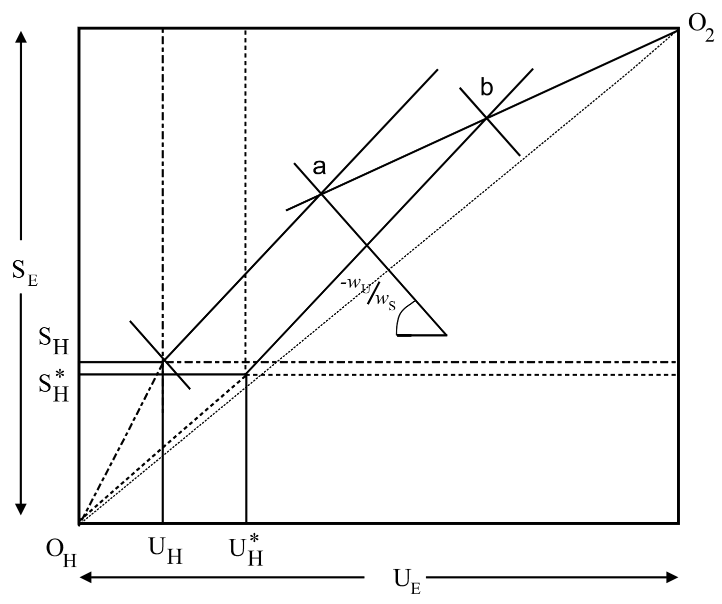
In the absence of scale effects ($\varepsilon = 0$) and given $|\lambda| > 0$, $-\hat{a}_{SH} > 0$ and $0 < \theta_{SH} < 1$:

$$\hat{X}_1 = \hat{X}_1^F = \frac{-\hat{a}_{SH}}{|\lambda|}\left[\lambda_{U2}\lambda_{SH}(1-\theta_{SH}) + \theta_{SH}\lambda_{S2}\lambda_{UH}\right] > 0$$

$$\hat{X}_2 = \hat{X}_2^F = \frac{-\hat{a}_{SH}}{|\lambda|}\left[\left(\theta_{SH} - 1\right)\lambda_{U1}\lambda_{SH} - \theta_{SH}\lambda_{S1}\lambda_{UH}\right] < 0$$

so that more (less) of skilled and unskilled labour is employed in sector 1 (2). In health care, production and thus employment of unskilled labour rises by $\hat{X}_H = -\theta_{SH}\hat{a}_{SH} > 0$.[28] Employment of skilled labour in health care falls by $\left(1-\theta_{SH}\right)\hat{a}_{SH} < 0$ since the fixed health care budget constrains the output expansion.

Figure 2.12 Factor-bias effects of SBTC in the HO model



28 The reader can verify that $\hat{X}_1 > \hat{X}_H$ further requires $0 < \theta_{SH} < \lambda_{U2}\lambda_{SH} / \left(\lambda_{U2} - \lambda_{S2}\right)$.

Furthermore, compared to an expenditure-induced expansion of the health sector, the factor-bias effects of SBTC in health care have the reverse sign: the innovation benefits the skilled-intensive sector and harms the unskilled-intensive sector by saving on the use of skilled labour, thereby making it relatively more abundant in the rest of the economy. Figure 2.12 illustrates.

Factor-bias and scale effects:

The proportionate changes in outputs of sector 1 and 2 can be conveniently rewritten as:

$$\hat{X}_1 = \frac{-\hat{a}_{SH}}{|\lambda|}\left[\theta_{SH}(\delta\varepsilon - 1)(\lambda_{U2} - \lambda_{S2}) + \theta_{SH}|\lambda| + \lambda_{U2}\lambda_{SH}\right] \qquad (2.126)$$

$$\hat{X}_2 = \frac{-\hat{a}_{SH}}{|\lambda|}\left[\theta_{SH}(\delta\varepsilon - 1)(\lambda_{S1} - \lambda_{U1}) + \theta_{SH}|\lambda| - \lambda_{U1}\lambda_{SH}\right] \qquad (2.127)$$

so that the difference in the proportionate changes in tradables outputs is:

$$\hat{X}_1 - \hat{X}_2 = \frac{-\hat{a}_{SH}}{|\lambda|}\left[\theta_{SH}(\delta\varepsilon - 1)(\lambda_{SH} - \lambda_{UH}) + (1 - \lambda_{UH})\lambda_{SH}\right] \qquad (2.128)$$

For positive health effects, $\delta\varepsilon > 0$, the effects of SBTC on changes in outputs become more complicated in that they depend on the rankings of skill-intensities relative to the overall effective endowment ratio, the cost-share of skilled labour in health care and the size of the elasticity of effective endowments with respect to health care. In order to avoid the development of all feasible rankings, the following patterns are derived.

From (2.126) and given $\lambda_{U2} - \lambda_{S2} > 0$, $\partial\hat{X}_1 / \partial(\delta\varepsilon) = -\hat{a}_{SH}\theta_{SH}(\lambda_{U2} - \lambda_{S2}) / |\lambda| > 0$ so that for a higher scale effect the relatively skill-intensive sector expands more.

Similarly, from (2.127), $\partial \hat{X}_2 / \partial(\delta\varepsilon) = -\hat{a}_{SH}\theta_{SH}\left(\lambda_{S1} - \lambda_{U1}\right)/|\lambda|$, which is positive (negative) if the middle ranking sector has a greater (smaller) skill-intensity than the overall effective endowment ratio, i.e. for $s_H > s_1 > s_E > s_2$ ($s_H > s_E > s_1 > s_2$). Thus, a higher elasticity of effective labour supply with respect to health care intensifies the factor-bias effect in sector 1 and, depending on the relative rankings of skill-intensities, reinforces or mitigates the factor-bias effect in sector 2. Despite the latter ambiguity, the gap between the output change of sector 1 and sector 2 is increasing in $\delta\varepsilon$, since given that health care is the most skill-intensive sector, $\lambda_{SH} - \lambda_{UH} > 0$, so that: $\partial\left(\hat{X}_1 - \hat{X}_2\right)/\partial(\delta\varepsilon) = -\hat{a}_{SH}\theta_{SH}\left(\lambda_{SH} - \lambda_{UH}\right)/|\lambda| > 0$.

2.6 OVERVIEW

This chapter has examined the impact of endowment changes on sectoral outputs using a low-dimension Heckscher-Ohlin (HO) framework, where endowment changes originate from a non-traded, government-provided health sector. Below follows an overview and interpretation of the main findings, and the implications for the likely effects of expanding health care provision in the UK. In doing so, frequent references are made to the remaining chapters of this thesis.

In international trade theory the impact of endowment changes on sectoral outputs is described by the Rybczynski (R) theorem. Using a conventional HO model with two factors (skilled and unskilled labour) and two goods (differentiated by skill-intensity) the R results predict that an increase in the relative endowment of skilled (unskilled) labour results in a more than proportionate increase in the production of the skill-intensive (unskilled-intensive) good, and a less than proportionate increase (if at all) of the other good.

If endowment changes originate from a change in health, where an improvement (reduction) in health is assumed to have a parallel effect on effective, i.e. able to work, labour endowments, the correspondence with the conventional R results ceases to hold with respect to per capita income, which includes people who are unable to work due to ill health. Typically, an identical improvement in health for skilled and unskilled labour does not affect the per capita income of the working population, whereas the per capita income of the total population rises. Also, if the health improvement is relatively higher for skilled (unskilled) labour, per capita income of the working population will rise (fall), whereas per capita income of the total population always rises. Setting aside other considerations such as well-being and equity, both indicators favour a government policy of health care provision biased towards skilled workers.

If a change in health derives from a change in government provision of non-traded health care which is free at the point of use, the R predictions are altered. The concept of a waiting list is introduced for both skill types which records ill persons who are not (successfully) treated and therefore unable to work. The remainder of the skilled and unskilled labour endowments is by assumption employed in either health care or the tradables sectors. Consequently, an increase in the production of health care, *ceteris paribus*, reduces the waiting list of skilled and unskilled workers and thus increases their effective endowments.

The change in effective labour endowments following a change in health care provision is shown to consist of three multiplicative factors - the dependency ratio, the absolute value of the waiting list elasticity and the proportionate change in the output of health care - where the first two factors combined represent the elasticity of the effective labour supply with respect to health care provision. The dependency ratio measures the proportion of ill on the waiting list relative to effective labour endowments, i.e. the ratio of non-working to working. The waiting list elasticity measures the proportionate reduction in the waiting list in response to a one percent rise in the production of health care.

According to the aforementioned relationship, the impact of an increase in health care provision on effective endowments, i.e. the improvement in health of a particular labour type, is greater: (1) the greater the dependency ratio, (2) the greater the waiting list elasticity, and (3) the greater the proportionate change in health care provision.

The first is a so-called ‘leverage’ effect of a change in health care provision, since *ceteris paribus* a higher dependency ratio implies that more people are benefiting from an increase in health provision. The second effect shows that the greater the effectiveness of a change in health provision in treating and curing people, the more a given increase in health care output, given the dependency ratio, reduces the waiting list. The third effect is trivial, since given the waiting list and dependency ratio, a bigger increase in health care output reduces the waiting list by more.

Unequivocal determination of values for the waiting list elasticity and the dependency ratio and thereby explicitly pinpointing the elasticity of effective labour endowments with respect to health care proves to be a complicated task.[29] Evidence presented elsewhere in this thesis[30] suggests that whereas unskilled workers generally have poorer

[29] See also Section 6.4.4 for the calibration of waiting list parameters for the UK focused Computable General Equilibrium (CGE) model.

[30] See for example Section 3.2.3, 4.3.6, 5.3.2 and 6.4.4.

health, skilled workers are thought to be more effective users of and responders to health care so the dependency ratio and the waiting list elasticity (in absolute value) are likely to be respectively higher and lower for unskilled relative to skilled workers. Due to the counteracting effects of a higher (lower) dependency ratio and lower (higher) waiting list elasticity for unskilled (skilled) labour, the true size of the elasticity of effective endowments of unskilled and skilled labour with respect to health care remains unclear. One may also argue that if health inequalities across labour types exist, the government may want to correct these by targeting health expenditures at those with poorer health outcomes (effectively the third factor mentioned). This then equalises the impact of health care provision on effective labour endowments.

Consequently, in this theoretical framework and after presenting the general outcomes of an increase in the provision of health care on non-health outputs, the magnitudes of the dependency ratio and the waiting list elasticity are for simplicity assumed identical for both skill types by employing the homogeneity assumption.[31] This assumption posits that labour types are homogeneous, i.e. equal, in terms of illnesses incurred, treatments needed, health care resources used, effectiveness of treatments and thus health. Assuming that health care is indeed allocated in proportion to the number of each labour type becoming ill - and so not targeted to any particular skill type, an increase in health care provision thus leads to identical proportionate reductions in the waiting lists and thus to an equi-proportionate rise in effective skilled and unskilled labour endowments. Hence, postulating homogeneity in terms of health across labour types implies that the

[31] Based on empirical evidence, these parameters are calibrated differently across labour types in the CGE model of Chapter 6, so that the impact of an expansion of the health sector on effective labour endowments differs.

expansion of the health care budget induces balanced growth in effective labour endowments (and a rise in per capita income of the total population).

The impact of an increase in health expenditures on the outputs of non-health sectors may be decomposed into a factor-bias effect and a scale effect. The former measures the impact of the health sector on effective endowments remaining for tradables in terms of the resource claims it makes, whereas the latter measures the health improvement following the expansion of the health sector which by virtue of the homogeneity assumption is in proportion to the overall endowment ratio.

Postulating homogeneity and assuming that the health sector is the most skill-intensive sector[32], the factor-bias effect is negative for the relatively skill-intensive good and positive for the relatively unskilled-intensive good. That is, an expansion of the health sector, given that it is the most skill-intensive good, reduces the skilled-unskilled effective labour endowment ratio for the rest of the economy so that, on the basis of the R theorem the output of the relatively skill-intensive traded good must fall and the output of the other good must rise. The scale effect is always positive for the skill-intensive good, but may be negative for the unskilled-intensive good, depending on the ordering of the skill-intensity of the middle ranking (skill-intensive) sector relative to the overall effective endowment ratio. The borderline case, where the skill-intensity of aforementioned sector equals the overall effective endowment ratio, replicates the R corollary that increasing the effective endowments in the same proportion as the factor ratio in one sector, increases the output of that sector and leaves the output of the other sector unchanged.

Whether or not the outputs of the tradable good sectors rise or fall following an increase in health expenditures thus depends on the sign and relative magnitude of each sector's factor-bias and scale effects. The analysis establishes that the rankings based on factor-bias effects alone are preserved when scale effects are added, provided that the elasticity of effective labour supply with respect to health care, i.e. the waiting list elasticity and dependency ratio combined, is small enough (and less than one). Gradually increasing the elasticity leads to a rise in the production of both the unskilled-intensive *and* skill-intensive goods provided it is less than one, whereas for improvements in the elasticity beyond one the output rise for the skill-intensive good exceeds that of the unskilled-intensive good, which could in one particular situation even show a decline.

Which of these situations is likely to prevail in the UK? Despite the uncertainty about the magnitude of the elasticity of effective labour supply with respect to health care for skilled relative to unskilled labour, one may safely argue that, at least for developed countries, the elasticity lies well below the value of one.[33] Consequently, given the aforementioned assumptions an exogenous increase in health expenditures is expected to benefit the unskilled-intensive sector and harm or possibly slightly benefit the skilled-intensive sector.

The remainder of the chapter is concerned with extensions to the HO model and repercussions for the HO-based results. The main modification considered is the presence of specific factors, being skilled labour in health care and skilled labour employed in the tradables sectors. Health care-specific skilled labour earns a health

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[32] This is in line with the data presented in Chapter 5 (Section 5.3.3).

[33] See also Chapter 6 Section 6.4.4, where the elasticities are close to 0.1.

care-specific skilled wage and has its own waiting list, different from, respectively, the wage and waiting list of tradables-specific skilled labour. The health care-specific skilled wage adjusts in response to changing demands on this specific factor and so factor substitution takes place. Furthermore, due to the specificity of skilled labour the reliance of health care on unskilled labour relative to tradables sectors plays a role in the determination of the impact of an increase in health expenditures on non-health outputs.

Allowing for specific factors is shown to reverse the factor-bias effects of an increase in health expenditures, as an expansion of the health sector reduces the supply of unskilled labour remaining for tradables, so that, on the basis of the R theorem, the output of the unskilled-intensive good falls and the output of the other good rises. An assessment of the total, i.e. factor-bias *and* scale, effects is not straightforward since scale effects depend on the elasticity of effective labour supply with respect to health care, the substitution elasticity in health care and the dependence of the health sector on unskilled labour relative to the tradables sectors. Restricting the former parameter to a likely value of below one (and assuming some substitution between health care staff) allows the reproduction of the factor-bias effects, although the output of the unskilled-intensive good may now rise if health care is relatively less reliant on the use of unskilled labour.

The Specific-Factors (SF) model has also been subjected to a shock in total health care-specific skilled labour endowments via the immigration of foreign skilled labour. Such a policy may be motivated by the desire to alleviate the rationing constraint imposed by the exogenous health budget and the presence of specific factors. In the absence of remittances, the increased supply of health care-specific skilled labour from abroad lowers its wage and the unit cost of health care, which - given the fixed health budget -

results in an increase in health care provision. For limited (considerable) factor substitution in health care in favour of skilled labour, factor-bias effects are found to be positive (negative) for the skill-intensive good and negative (positive) for the unskilled-intensive good, since overall employment of unskilled labour in health care rises (falls) and so the relative supply of unskilled labour available for tradables sectors falls (rises). The incorporation of scale effects and limiting the range of the elasticity of effective endowments with respect to health care, alter these results in a similar fashion as for an increase in the health budget. Specifically, the factor-bias effects continue to hold, although the contracting sector may now expand if health care is relatively less reliant on unskilled labour.

A final modelling exercise that has been carried out is to let the expansion in the health sector originate from an improvement in the productivity of labour rather than an increase in the health care budget, again to alleviate the constraint imposed by the exogenous health care budget. Productivity improvements in health care are modelled via technical change, which can be factor-neutral or skill-biased by respectively increasing the productivity of skilled and unskilled labour or increasing the productivity of skilled labour only.

If technical change is neutral across factors, factor-bias effects are removed so that in line with the aforementioned scale effects, the relatively skill-intensive tradable sector expands, whereas the unskilled-intensive tradable sector may or may not contract depending on the ordering of the skill-intensity of the middle ranking (skill-intensive) sector relative to the overall effective endowment ratio. Factor-neutral technical change applied to the SF version also yields scale effects only, although due to the homogeneity assumption (and limiting the elasticity of effective endowments with respect to health care to a value between zero and one) tradables-specific skilled labour and unskilled labour grow in the same proportion, which yields balanced growth in tradables outputs.

If technical change is skill-biased, the health sector saves on the employment of skilled labour so that factor-bias effects reappear and, in line with the R theorem, benefit the skilled-intensive good and harm the unskilled-intensive good. The inclusion of scale effects is shown to intensify the factor-bias effect in sector 1 and, depending on the relative rankings of skill-intensities, either reinforces or mitigates the factor-bias effect in sector 2, whilst magnifying the gap between the outputs of the two tradables sectors. Skill-biased technical change applied to the SF model yields similar factor-bias effects, since health care expands and needs more unskilled labour, thereby reducing the amount of unskilled labour available to the rest of the economy and making skilled labour relatively more abundant. When allowing for scale effects (and limiting the elasticity of effective endowments with respect to health care to a value between zero and one), factor-bias effects are maintained, though if health care is relatively less reliant on the use of unskilled labour the formerly contracting unskilled-intensive sector may now expand.

In conclusion, this chapter has analysed the economic impact of an expanding health sector in a simple, low-dimension general equilibrium framework. In applied models with added complexities, such as many of the models reviewed in Chapter 3 and the applied model of Chapter 6, the foregoing predictions are most unlikely to be wholly true. Nevertheless, these effects will still operate in the background and thus give a useful guide to the interpretation of the outcomes of such a model.

CHAPTER 3

LITERATURE REVIEW

3.1 INTRODUCTION

Various strands of empirical literature on the economic effects of health and health care provision have emerged. These can be divided into health economics literature, econometric studies and Computable General Equilibrium (CGE) models (although the first two strands are overlapping).

In the health economics literature the contribution of health care to improving health has received a vast amount of attention.[1] At the macro level the contribution of health care to the health status of the population is typically summarised by a health production function, assuming that an agreement can be made on the measurement of the output health. It is typically assumed that health status is a function of health care (health inputs) and other factors (such as diet, lifestyle, environment, education, human biology and technology) which shift the production function up or down, and that it exhibits the law of diminishing marginal returns. Empirical medical historical studies and econometric studies have been employed respectively to assess the validity of the production function throughout history and to estimate the function, and in particular the elasticity of population health to health care expenditure. In respect of the former, medical historians find that the contribution of health care to historical downward trends in population mortality rates had probably been negligible until well into the twentieth

[1] This section is based on Folland et al. (2001), Chapters 5 and 6.

century. Improved health had most probably to do with public health measures (such as immunisation programs and improved sanitary and sewage systems), an increase in knowledge through education on the sources of diseases, and improved nutrition through increased supply of food stuffs.[2] A central conclusion from econometric studies is that, whereas the marginal contribution of health care to health - measured by mortality rates and illness indicators such as working days lost due to illness, or other physiological measures like blood pressure and cholesterol levels - is significant, the marginal effect on health in developed countries is small, suggesting that we are almost "on the flat of the curve." Other factors, like changes in diet, lifestyle (alcohol and cigarette consumption), environment (pollution) and education, seem more important in explaining variations in health. The macro-oriented focus of these empirical studies conceals important differences with respect to the effectiveness of different types of health care (such as prenatal care) for different population groups (effects are shown to differ for example across ethnic groups). Furthermore, by focusing purely on the partial question of the impact of health care on health, feedback effects to resource allocation issues which bear on health care (and hence health) as well are ignored.

At the micro level the Grossman model of health demand[3] provides the theoretical starting point for much subsequent empirical work. Grossman uses human capital theory to explain the demand for health. In this approach health is a form of durable (human) capital that produces an output of healthy time, which can subsequently be employed in income-enhancing activities. This is equivalent to the standard human capital theory, in

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2 However, the former two factors have themselves most probably been fuelled by advances in medical research.

3 See for example Grossman (1972, 1999).

which knowledge capital (narrowly defining human capital) enhances productivity, wages and thus provides an incentive for individuals to invest in education and training. Each person inherits an initial stock of health, which depreciates with age and can be augmented by investment. Health investments are produced by time invested in health-improving activities and money spent on health inputs, such as medical goods. The demand for health care goods is thus a derived demand for inputs into the production of the health commodity. The demand for this commodity stems from its dual nature of making people ‘feel better’, i.e. by entering a person’s utility function as a consumption good, and of increasing the number of healthy days available for income-augmenting activities as an investment good. By describing the behaviour of individuals in terms of allocation of time and money between health and non-health activities, Grossman is able to show how the demand for health and health care arises and how the resulting allocation is affected by changes in factors such as age and level of education. Theoretical predictions derived from the Grossman model have been the subject of research in a wide variety of empirical studies.[4] Although the Grossman model of health capital yields important insights into the determinants of health, health care demand, and resource allocation towards health and non-health activities, it operates at the individual level, which calls into question its theoretical and empirical applicability at a macro level. With respect to the former, in many countries, such as the UK, health care provision depends on the availability of government-rationed public health care (below demand levels) such that an investment model of health (care) demand is simply not applicable. Furthermore, and related to the previous argument, the partial nature of the Grossman model precludes the inclusion of important general equilibrium effects such

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[4] Folland et al. (2001, Chapter 6, pp.131-133).

as links between the demand and supply side of health care, labour markets and the government budget. Finally, in terms of empirics, measurement problems which are persistent at the micro level are exacerbated at the macro level by aggregation issues and by lack of data at the national level.

Econometric models of economic effects of health and health care focus on multiple linkages between health, health expenditures, human capital, productivity, wages, income and economic growth in an attempt to establish the direction and magnitude of effects.[5] Apart from their common theme, these studies differ vastly in terms of estimation technique (e.g. time series, cross-section and panel data analysis), level of application (micro, macro), country or countries of application (developed, developing) and results. With respect to the latter the consensus that emerges is that effects work both ways. A major drawback of this literature is its highly aggregated nature, such that differential effects across for example sectors, labour types and household types cannot be distinguished, nor are the general equilibrium effects (such as linkages with the government budget) explicit.

This chapter surveys studies that employ CGE models. Applied literature focusing on general equilibrium effects of changes in health and health care provisioning on the economy is small but diverse in terms of application area. The few CGE studies that exist are arranged into three groups to show the diversity in research themes; they are, in chronological order, models of health or health care as a basic need (Basic Needs

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[5] Illustrative of this type of literature are: Bhargava et al. (2001), Bloom and Canning (2000), Bloom et al. (2001), Bloom et al. (2004), Crémieux et al. (1999), Ettner (1996), Hamoudi and Sachs (1999), Hitiris and Posnett (1992), Jamison et al. (2003), Knowles and Owen (1997), Mayer (2001a,b), Pritchett and Summers (1996), Strauss and Thomas (1998), Stronks et al. (1997) and Thomas (2001).

models), CGE analyses of health care as having an external effect (Externality models) and studies of epidemics (HIV/AIDS models). The models are discussed in three self-contained sections, each with separate introductory paragraphs and a summary of the model structures and results.

Two related groups of models not covered in this literature review are general equilibrium studies applied exclusively to health care sectors (Health Sector models) and CGE models of health insurance (Health Insurance models). These studies focus on the medical care market of developed countries, such as The Netherlands and the United States, and consequently share a common concern for issues of cost-containment, efficiency and equity in provisioning of health care and health insurance. The former type of studies[6] claim to be of the general equilibrium type, but since the model domain spans health care markets only and abstracts from the "rest of the world", they are truly partial in nature. Although the detailed level of analysis of medical care[7] may represent a constructive addition to the CGE studies surveyed in this chapter, the partial equilibrium character of such models precludes general equilibrium aspects such as the resource claims of health care (i.e. competition for scarce factors of production such as capital and labour), government budget implications and the impact on effective labour supply of improved health, which are crucial for our understanding of the economic

6 Chatterji and Paelinck (1991) develop a purely theoretical general equilibrium model. Canton and Westerhout (1999a, b) and Folmer et al. (1997) construct a model applied to the Dutch pharmaceutical and health care market respectively, which are employed to analyse financial reform measures.

7 The models typically feature the behaviour of patients, general practitioners, medical specialists, pharmacists, drug producers (brand name and generic), parallel importers, insurance companies and hospitals and the various interrelationships between them. Special attention is devoted to the presence of market failures such as information asymmetries between patients, physicians and pharmacists (principal-agency problems) and imperfect competition in the market for pharmaceuticals enabled by patenting.

impact of health care provision. The latter category[8] focuses on health insurance which, although the financial side of health care is important for determining its economy-wide effects and will feature in some fashion in the CGE model, is not the prime focus of this thesis. Finally, the literature review excludes global assessments of changes in health which concentrate on the uncertainty following a disease outbreak and consequent reductions in international travel, foreign direct investment and economic performance.[9]

3.2 BASIC NEEDS MODELS

3.2.1 Introduction

Basic needs models are the earliest type of models that recognise the economy-wide effects of improved health. Basic needs models attempt to incorporate the basic needs approach to development into a general equilibrium framework.[10] This review covers two archetypal basic needs models, which are illustrative of their development over time.[11] The basic needs approach arose in reaction to earlier views on development and integrates many of their elements and policy recommendations into a comprehensive framework aimed at the goal of basic needs satisfaction. The basic needs approach as such was treated completely for the first time at the 1976 Tripartite World Conference

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8 Ballard and Goddeeris (1999) study the efficiency and equity effects of financing universal health insurance coverage, using a computational general equilibrium model of the US for 1991. Johansson's (2001) overlapping generations model investigates macro-economic effects of different types of health insurance for the elderly in the context of an ageing population demanding more health services. Finally, Bednarek and Pecchenino (2002) employ an overlapping generations general equilibrium model of the US for 1998 to examine the effect of the tax-benefit system underlying the US health care system on the well-being of different age and socio-economic groups as well as overall welfare.

9 An example is Lee and McKibbin's (2003) study of the global economic effects of SARS based on the G-Cubed (Asia Pacific) model.

10 See Streeten et al. (1981), Stewart (1985) and Afxentiou (1990) for a comprehensive discussion of the basic needs approach.

11 These are Vianen and Waardenburg (1975) and Kouwenaar (1986). Another example, not covered by this review, is Van der Hoeven (1987, 1988).

on Employment, Income Distribution and Social Progress and the International Division of Labour of the International Labour Organization (ILO).

3.2.2 The basic needs approach

The basic needs approach to development concentrates on the fulfilment of basic needs of all, but especially of, the poor. Basic needs refer to certain standards of nutrition (food, water), living conditions (housing, sanitation and clothing), universal provision of health and education and participation in the decision-making processes geared towards basic needs satisfaction. At the heart of the approach (Kouwenaar, 1986, p6 and further) lies the belief that by an initial investment (redistribution) the sectoral structure of supply (demand) can be altered in favour of small-scale, labour-intensive sectors, which produce commodities demanded especially by low-income groups.[12] The latter thus benefit in terms of employment, income *and* consumption. A virtuous circle of growth that is (income-) equalising is set into motion, which via improved consumption of the poor benefits their health. The latter effect can be interpreted as an investment in human capital or as inducing labour-augmenting technological progress in the sector of employment. The role of the government is accommodating, and so is one of formulating goals, policies, monitoring the results, adapting policies accordingly and channelling information to the relevant parties, in dialogue with the people involved.

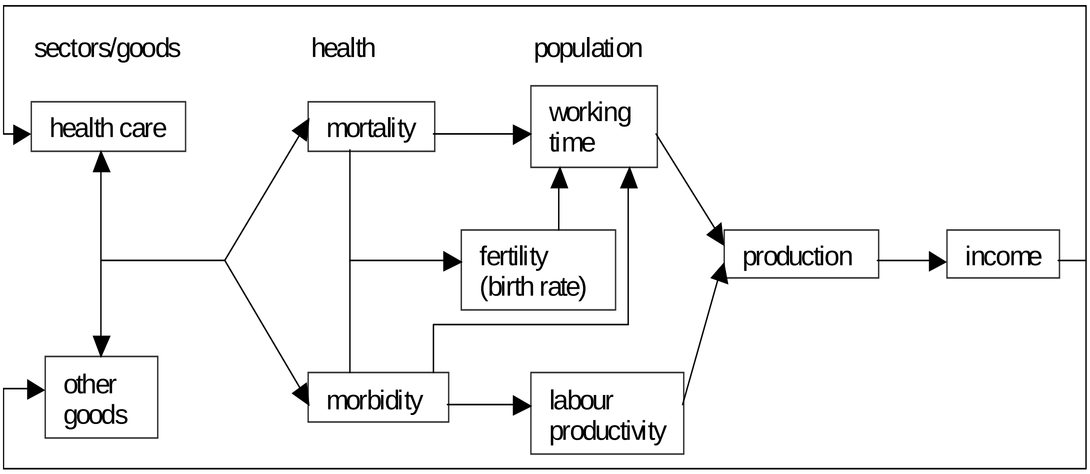
The chief disadvantage of the basic needs approach is that, despite the nobility of purpose, translation of the idea of basic needs satisfaction into policy is not trivial. The basic needs approach as an all-embracing development strategy is often accused of being “rather vague”, “arbitrary”, “intellectually clumsy” and to “suffer from political

[12] In practice this is achieved by the introduction of price distorting measures and/or the removal of existing ones, such as sector-specific tariffs.

unreality". Streeten et al. (1981, p8) comment: "*While there is virtually universal agreement on the objective, there is much disagreement on its precise interpretation and on the most effective way of achieving it.*"

A recurrent question in the basic needs literature, and indeed the source of much criticism, is whether a trade-off exists between economic growth and expenditures on basic needs.[13] This debate is much older than the basic needs literature itself and has been explored in the human capital literature. In the short term attention to basic needs fuels expenditures on social sectors which, given outlays on other goods and income, curbs savings, investments, capital accumulation and hence growth. A counterargument in support of the basic needs approach is that consumption of basic goods and services may in the long run increase labour productivity and growth by virtue of being an investment in human capital. The latter hinges upon the conjecture that investments in human capital are more productive than are alternative physical investments.

Figure 3.1 Health in a basic needs framework



[13] See Streeten et al. (1981) and Afxentiou (1990) for an elaborate discussion of the growth-basic needs trade-off. The general equilibrium models that find a trade-off between growth and basic needs impose rather pessimistic assumptions of "…unimpeded flow of exports to developed countries, … ever-present population pressures and … that the economic restructuring required for the satisfaction of basic needs is unlikely to take place…." (Afxentiou 1990, p253).

3.2.3 Health as a basic need

The role of health and health care implicit in basic needs models is summarised in Figure 3.1. From left to right the first linkage flows from health care (and other goods) to health, arguably the most difficult component of the modelling exercise. Frances (1985, p17) labels this the “meta-production function”. This production function translates household consumption of health care and other basic needs into so-called “full life indicators”, in this case health achievements such as mortality and morbidity[14] reductions at the individual level. The transformation requires two steps: an allotment of household consumption among individual members of the family and a conversion of consumption per person into “life achievements” at the individual level.

Improved health affects the well-being of working and non-working populations, of which the former may augment effective labour supply. The effect of better health on labour is two-fold. Lower mortality and/or morbidity allows a labourer to work longer, the quantity or working time effect, and he or she may witness a rise in the amount of work per time-unit, the labour productivity effect. In the basic needs models emphasis is on the second consequence, often referred to as the human capital effect, which is put forward as the principal argument against the existence of a basic needs-growth trade-off.[15] The working-time and labour productivity effects augment effective labour supply and, if that additional labour is employed, raise the quantity of production in the economy. Consequently higher income levels (depending on the participation in the labour market and alterations in the wage structure) enable households to spend more on

14 Morbidity is defined as the incidence (number of new cases) or prevalence (number of existing cases) of a particular disease or of all diseases in a defined population, within a given time period.

15 The absence of any working time effect of improved health presumes the beneficiary decides to work less by the amount of the working time gained.

goods and services, which can be devoted to elevating their health status. The realisation of the latter depends on the preference structure of the actors, the availability of goods and price levels.

The presence of linkages between health care and other goods is conceived to be crucial in basic needs modelling and has repercussions for costs, results and design of policies.[16] A well-known example is the relationship between health care and education. Better-educated individuals are more likely to look after personal hygiene, which enhances their health status and that of others by minimising health risks and, vice versa, healthier individuals have a greater capacity and incentive to learn.[17]

A final element of Figure 3.1 is the effect of improved health on population growth. Higher levels of health and other basic needs indicators lower mortality, morbidity and influence fertility and birth rates[18], which has implications for poverty and growth. This issue dates back to the work of Thomas Malthus, who predicted that policies that improve health would reduce mortality rates and, given birth rates, raise population growth to rates above the level of growth of food supply. “Positive checks”, such as famines, would be unavoidable unless people set in motion “preventive checks”, i.e.

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16 For example Streeten et al. (1981, p47-51).

17 See for example Grossman (1972, 1999) who posits that educated people are more efficient “producers” of health and are greater consumers of health care (i.e. are more effective responders to treatment and have a greater taste for health).

18 Fertility, i.e. the ability of women to give birth to children, rises, which in turn affects the choice of number of children, measured by the crude birth rate.

have fewer children.[19] The question of whether or not improved health lowers birth rates is heavily debated in the basic needs literature.[20]

3.2.4 Vianen and Waardenburg's Tanzanian model

Vianen and Waardenburg's (1975) multi-sector model is a basic needs model in nature as it focuses on developing countries in general and Tanzania specifically, and incorporates health care as a basic need, although it was published a year before the ILO's formulation of the basic needs approach to development.

The model is "structuralist" as opposed to "neoclassical" in viewing the world as institutionally and behaviourally rigid and relying heavily on government intervention, rather than seeing the world as smoothly-adjusting, relying on the price mechanism, which stems from its developing country focus. Furthermore, all equations are linear, have constant coefficients, and are not derived from micro-economic optimisation. Hence the approach to modelling health care in a general equilibrium framework is rather ad hoc. Overall the model appears to have few general equilibrium features, but due to its inclusion of economy-wide health care linkages it is discussed here.

The model is large (1255 equations and variables), is calibrated to data from 1969 and is recursively dynamic in that, once the time path of the exogenous variables is known as are starting values for lagged endogenous variables, one can solve for the values of the remaining endogenous variables. The focus on health care is apparent from the detail on

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19 Verschoor (2000, chapter 4) provides an overview of the work of Malthus, the demographic transition, and of the literature on fertility decisions.

20 For a critical appraisal of the relationship between basic needs and population growth see Afxentiou (1990).

health care sectors (six), age groups (five), disease categories (seven) and types of labour in health care and other sectors (four).

Vianen and Waardenburg make a distinction between an economic and a health component, each containing several sectors. The health component relies on economic sectors in terms of intermediate inputs and education of its skilled labour inputs (ratio of skills from medical education is assumed to be fixed). Conversely, health care produces healthy or semi-healthy people who work and consume. Total consumption and savings depend on the size and composition of the population, which in turn is also affected by health care.

The economic component is centred on the input-output approach by employing fixed coefficient Leontief production functions. Final demand is endogenously dependent on income and population of each age group, save for exogenously given government and private consumption of health care.[21] One type of capital is produced by the construction sector. The labour markets for some skill types are segmented by sector of employment or age. These markets are characterised by lack of substitution and, in the absence of an equilibrating price mechanism, unemployment.

When a person falls ill he or she needs and thus demands health care. Remaining demand comes from a referral system, by which patients are referred to specific types of care. The authors assume that the need for treatments will never be smaller than the supply of treatments and that substitution of capacity to meet demand is not possible.

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[21] Exogenously given private and government expenditures on health care determine the value of production and supply of medical treatments, which is not necessarily sufficient to equalise need for and provision of treatments.

The total capacity of each institution is expressed in terms of total cost, not in terms of value of output as that ignores externalities. The number of people recovering is a function of the numbers treated per institution and independent of treatment type. Moreover, some patients recover spontaneously without treatment. One type of care, public health care, is preventive and influences the number of ill in the current year. The effect of public health expenditures on the number of ill is approximated by the inverse of preventive cost per person multiplied by the total amount of public health expenditure, based on estimates of other studies.

The authors introduce a labour productivity effect of health care by special treatment of disabled people. In contrast to optimally recovered healthy people who are able to work just as before they incurred an illness, there is a number of disabled people multiplied by some coefficient (<1) representing the proportion of time they can do their job as if healthy.

The study presents a numerical exercise for only one period, 1970, using a “shifting system” which simulates a change in size and age composition of the population by accounting for births, deaths and movements between age cohorts, all influenced by the health care system. The authors report on changes in size and composition of the population (population grows by 2.55%, with considerable growth in the <1 age cohort and the cohort of 1-4 years old declining) but emphasize the weakness of the statistical data and therefore potentially unreliable results.

Vianen and Waardenburg acknowledge the data deficiencies of their research, by and large explained by the limited data availability and the computational capacity of that era. They propose a sensitivity analysis for certain coefficients and exogenous variables and to expand the time frame of simulations, so as to analyse the effects over time of improved health care on health and economic growth. Other items on their research agenda are to create an evaluation function (i.e. a welfare function) for appraising policies and subsequently to employ the model as a programming tool. With the latter the authors imply adding endogenous variables to the model, which would become feasible after the creation of additional degrees of freedom.

Other improvements pertaining to the latter are to incorporate more general equilibrium features. Firstly, a government budget constraint would restrict government expenditures on, for example, health care. Secondly, the establishment of markets for some variables with prices as equilibrating variables would do justice to the fact that (some) markets do clear through price adjustments. Furthermore, the assumption of a segmented labour market (by skill type and for some skill types by age and sector of employment) is rather rigid. Allowing for different degrees of substitutability between labour types would be a more realistic alternative.[22] Finally, the use of non-linear behavioural equations derived from micro-optimisation processes would remove the ad hoc character of the model and replace it with consistent behaviour firmly grounded in economic theory.

3.2.5 Kouwenaar's basic needs policy model for Ecuador

Kouwenaar's (1986) model with special reference to Ecuador is the only Social Accounting Matrix (SAM) based, neoclassical basic needs model, as opposed to the

[22] Evidence suggests for example that some higher skilled labour types (such as doctors) are less mobile across sectors compared to low skilled labour (such as ancillary workers), due to their highly specialised knowledge related to the sector they are employed in. On the other hand, some basic tasks performed by highly skilled workers can easily be carried out by lower skilled workers (for example nurses taking over some of the responsibilities of doctors).

previously discussed structuralist model. It thus includes prices and their effect on resource allocation, income and demand, though Kouwenaar does incorporate certain market imperfections, such as imperfect competition in commodity markets, imperfect substitutability between domestic and traded goods, credit and labour rationing, segmentation of the labour market and short run immobility of capital, characteristic for structuralist models.

The model is designed to assess policies aimed at basic needs satisfaction in the medium to long term. The model is recursive dynamic and consists of a main iteration, which produces the equilibrium for the current year, and an updating iteration in which the exogenous variables of the main iteration are adjusted. Updating is either carried out endogenously, via functions of the equilibrium solution of the previous period, or exogenously, e.g. according to historical growth rates.

The model is structured upon a detailed classification of, among others, sectors (48), consumption categories (27), occupation groups (10), institutions (10) and households (9). Kouwenaar abandons the rather ad hoc approach to modelling of the structuralist models, and their frequent use of simple linear equations, by deriving behavioural equations of producers and consumers from micro-optimisation using more sophisticated production and utility functions, such as Constant Elasticity of Substitution (CES) functions. The nominal exchange rate is chosen as the numéraire. The closure is savings-driven, with fixed foreign savings and all other savings being determined residually, although alternative closure rules are experimented with. Dynamic adjustments occur via capital accumulation, population growth, labour supply changes and adjustments in basic needs.

Health, as one of the basic needs, is measured in terms of the 'output' life expectancy as a function of 'input' indicators such as the adult illiteracy rate, per capita public health expenditures and per capita disposable income. Several linear and non-linear equations using these variables are fitted either from cross-country data or estimated at the country level for Ecuador. The author constructs a composite index of human well-being, as a weighted average of individual basic needs indicators and monetary variables.

Basic needs in general and health specifically affect population and labour supply growth. Specifying the link from basic needs to population growth is an option within the model. If the option is applied, birth and mortality rates are decreasing non-linear functions of average per capita disposable income (Kouwenaar 1986, p202). Additionally, health affects sector productivities in the longer-term. Specifically, the constant term for labour (the share parameter) in each CES production function is a function of average life expectancy and years of schooling. The technical specification assumes labour augmenting technological progress[23], and is described by: $L^* = L \cdot E^{\alpha} \cdot S^{\beta}$ where L^* and L represent sector employment in efficiency units and person years respectively. E and S are indices of average life expectancy and of schooling of the employed labour force in a sector (Kouwenaar 1986, p267).

Kouwenaar uses the model for a variety of static, one-year and dynamic, five-year policy simulations aimed at basic needs satisfaction, of which the latter type is only of interest as it incorporates feedback effects between the economy and basic needs such as health. Counterfactual simulations include an increase in direct taxes accompanied by a fixed subsidy on basic food products, a reduction in wage disparities, land reform

[23] This type of technological progress coexists with factor neutral technical change.

(redistribution of land) and more equal access to credit and government services. The results are compared to a base time path. Although the repercussions of changes in health (care) on the economy are not directly apparent (as this is not the main focus of the model), favourable effects observed in static simulations are strengthened in the dynamic counterparts and seem to confirm the self-reinforcing processes between production, employment and productivity, income and basic needs, and the absence of a trade-off between basic needs and growth. This is for example illustrated by the final simulation, in which the redistributive effect of improving access for the poor is strengthened by the labour-augmenting productivity increase following from government investments in services.

3.2.6 Summary

Basic needs models are the earliest type of models to recognise the economy-wide effects of improved health. These recursive dynamic CGE models are designed to implement the basic needs approach to development current in the 1970s into a comprehensive modelling framework. Health and health policy fulfil only a minor role, and it has proved virtually impossible to disentangle the effect of improved health (care) within the counterfactual simulations. Nevertheless it seems that the positive feedback effects of basic needs into the economy via population and labour market linkages counteract the negative short-term effects on growth, supporting the view that a trade-off between basic needs and growth is absent.

The application to developing countries implies that the modellers not only face data problems but also implement rigidities in the model and abstract from various general equilibrium elements. The structuralist model of Vianen and Waardenburg (1975) is demand-driven and characterised by the absence of prices. The approach to modelling economic behaviour is rather ad hoc as behavioural equations are linear, have constant coefficients, and are not derived from micro optimisation. Kouwenaar's (1987) model has more neoclassical general equilibrium features by including prices and behavioural equations of producers and consumers derived from micro-optimisation using more sophisticated non-linear production and utility functions.

Kouwenaar (1986) models the effect of health on population growth and incorporates labour augmenting technological progress brought about by changes in health and education. The working-time effects of health, other than those caused by changes in demographic variables, are only included in the health-focused model of Vianen and Waardenburg (1975). In this model the number of people recovering is a function of the number of treatments, apart from those who recover spontaneously without treatment.

3.3 EXTERNALITY MODELS

3.3.1 Introduction

The general class of externality studies formulates CGE models, which explicitly account for the presence of external effects, such as changes in health, education and the environment. These models have the dual purpose of quantifying the effects of policies aimed at reducing (encouraging) the negative (positive) externality and of assessing how inclusion of an externality alters well-established results of economic policies such as trade liberalisation. The most known type of all externality models is concerned with economic-environmental linkages, so-called environmental models. As a by-product, these models may quantify health effects of environmental degradation, usually greenhouse gas emissions, on labour supply and productivity via changes in mortality and morbidity, and their repercussions on associated medical expenditures and welfare.[24]

Health externality studies account for the positive effect of improved health on the economy. This type of research has its origins in the human capital literature, which studies the link between human capital formation (especially education), productivity and growth, and the body of literature focusing on the importance of adjusting trade policy models for market imperfections.[25]

3.3.2 Health as an externality

Externalities arise if a consumer (producer) is affected by the actions of another consumer (producer) without some form of compensation being paid or received. Hence there is no market and thus no price for the externality (Johansson 1991, p64-66). In the case of positive externalities, such as improved health, this leads to underproduction of the externality and a welfare loss to society. In the CGE modelling literature on health externalities this definition is not entirely appropriate as the positive effects of improved health spill over to the labour market and are internalised in the price of labour via supply and productivity effects. There is thus a market and a price for the externality in which its value is realised.

3.3.3 Savard and Adjovi's CGE model of Benin with externalities

Savard and Adjovi's (1997) model for Benin is the sole CGE model including health as an externality. The authors assess the economy-wide effects of economic, fiscal and

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[24] A selection of environmental CGE models featuring side effects on health are: Beghin et al. (1999), Bruvoll et al. (1999), Garbaccio et al. (2000), Li (2002), Mayeres and Van Regemorter (2003), Resosudarmo (2003) and Vennemo (1997).

[25] See for example Corden (1997).

public sector reform measures adopted under the Structural Adjustment Programs (SAP) of the late 1980s, early 1990s using a static CGE model of Benin with health and education externalities. CGE models based on classical assumptions predict (small) economic benefits from trade liberalisation. The authors' purpose is to verify whether these results still hold in the presence of positive health and education externalities.

Savard and Adjovi impose for education both a labour-augmenting and a factor-neutral externality and for health a labour-augmenting externality. The labour-augmenting externality increases the productivity of labour, whereas the factor-neutral externality enhances the productivity of both factors, labour and capital, in a similar fashion. In contrast to factor-neutral externalities, the labour-augmenting externality changes the cost-minimising combination of inputs because, at constant factor prices, producers will have an incentive to use more of the increasingly productive factor labour. In concordance with the Basic Needs literature, the authors give a two-fold interpretation to the labour-augmenting health externality, it being both a productivity effect of improved physical condition and a longevity effect, according to which a healthier population lives longer, resulting in a higher ratio of older, more experienced and more productive workers relative to young labourers.

The magnitude of externalities differs by sector. Sectoral value added is a CES function of a labour composite and capital. The constant term, the shift parameter, of this function is multiplied by the neutral education externality. The labour composite is a CES function of informal and formal labour demand. For each of these factors the share parameters are multiplied by the education and health externalities. The externality parameters take the form of a constant elasticity function. For the labour-augmenting health externality by sector i (Ω_i) we have: $\Omega_i = \left(\frac{G_{health}}{G_{0\,health}} \right)^{\varsigma_i}$. G_{health} and $G_{0health}$ represent government expenditures on health in the current and base year respectively, and ς_i is the sector-specific health expenditure elasticity for labour. Its value lies between zero and one (like all other externality elasticities), implying a decreasing marginal external effect.[26]

The authors acknowledge that their treatment of externalities suffers from a serious shortcoming, which is the lack of endogenous effects on labour supply. In the case of education, making the choice of more education will reduce the supply of labour at least in the short run. Improved health in the long run induces people to work more hours, whereas the income effect of the rise in productivity will encourage them to work less and take more leisure time. The absence of working time effects other than changes in longevity implies that income and substitution effects of improved health cancel out in total.

The actors in the model are the government, firms, the rest of the world and three households (urban poor, rural poor, and non-poor). The sector structure distinguishes between public sectors (health, education, other administrative services) and seven private sectors (with further disaggregation of agricultural sectors). Factors of production are capital and labour.

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[26] The authors assume that health impacts most on agriculture, less on manufacturing and least on services. For education, the reverse order is postulated. In absolute terms, the externality values chosen are relatively low (in the range of 0.003 to 0.06).

Savard and Adjovi model the labour market in great detail to reflect stylised facts for Benin. Standing out is the notion of “déflatés” (Savard and Adjovi 1997, p8), referring to laid-off former pubic sector employees. This labour type is in a state of “waiting unemployment” and coexists with informal labour, modern labour and bureaucrats (civil servants). For the latter two categories, the demand side determines the market and wages are fixed. This demand is always satisfied from the pool of unemployed and informal labourers. Wages of informal labour are flexible and adjust to absorb déflatés or adjust to changes in hiring in the modern sector or civil service. Déflatés choose to remain in a state of unemployment or opt for the informal sector based on changes in their wage relative to the base year.

The model is parameterised using a nested Leontief-CES structure for production and nested Linear Expenditure System (LES) - Cobb Douglas (CD) structure for utility. Foreign trade is modelled using the Armington assumption of imperfect substitutability between domestic and imported goods and the small country assumption. Welfare is evaluated using the Equivalent Variation (EV). To avoid free lunches foreign savings are fixed and the exchange rate is the equilibrating variable. Total investments are fixed and determine savings such that government deficits are financed from domestic private savings. The marginal propensity to save by household is endogenous. The consumer price index is chosen as the numéraire.

The authors perform essentially one simulation, a 10% reduction in import duties, and subsequently impose several scenarios targeted at keeping the government budget balanced. These involve cutting various categories of government expenditures.[27]

The first simulation shows that trade liberalisation enhances production in some sectors, household income and welfare, and GDP (growth of 0.53%). Due to a loss of tariff revenue the government deficit rises. When accompanied by a reduction in government expenditures, the authors find that the presence of externalities may invert the results of economic and financial liberalisation as a cut in government expenditure has negative spillover effects on domestic product and public sector employment. Lay-offs in the public sector increase unemployment and put pressure on informal wages, which has a negative influence on income, especially of poor households. Savard and Adjovi therefore conclude that "…*it may be much more beneficial to reduce civil service salaries and to remove the constraints on wages in the modern sector in order to relieve the pressures on the government's budget.*" (Savard and Adjovi 1997, p18).

The authors make several suggestions on improvements to their analysis. These include endogenising tax evasion, incorporating public goods in the utility function and modelling the production of education and health care in more detail by explicit treatment of the endogenous labour supply effects of improved health and education. An additional shortcoming of the model is that it is static and thereby not capable of capturing the long run effects of externalities and the time-path of adjustment towards a new equilibrium. Also, the authors do not explicitly consider people who are not

[27] Tax increases are ruled out in the presence of a relatively big informal sector and the danger of tax evasion.

working, i.e. age groups such as children and pensioners, or the unemployed. These population groups claim resources, financed by other households with working members and/or the government, such that an increase in their health accompanied by additional resource claims has repercussions for the welfare of remaining population groups. Once these aspects are accounted for, the model could be employed to assess the overall repercussions of changes in health on the size and composition of the population, the labour force and its feed back effects on the economy in terms of production, income and welfare.

3.3.4 Summary

Externality models account for the presence of external effects, such as health, education and environmental effects, in a CGE framework. Only one CGE model on health (and education) externalities presently exists, namely Savard and Adjovi (1997). This type of work originates from human capital theory and trade policy models adjusted for market imperfections. In line with the former type of literature, Savard and Adjovi focus on the labour productivity effect of improved health according to which health externalities, as a constant elasticity function of public health expenditures, are incorporated using labour augmenting technological progress in production. The health externality thereby influences the optimal combination of inputs in production and relative wages. Hence, the pure externality definition, in which the absence of compensation is crucial, does not cover such spillover effects to the labour market.

Following the second body of literature, Savard and Adjovi verify whether the standard CGE results of (small) economic benefits from trade liberalisation still hold in the presence of positive health and education externalities. The authors find that the occurrence of externalities may invert the results of economic and financial liberalisation as a cut in government expenditure on health and education, aimed at maintaining the government deficit, has negative spillover effects on domestic product and public sector employment, household income and welfare.

The main shortcomings of Savard and Adjovi (1997) are a lack of dynamic effects, no distinction between working and non-working or age groups, and absence of endogenous labour supply effects (i.e. the impact of better health on working time) and utility gains from improved health.

3.4 HIV/AIDS MODELS

3.4.1 Introduction

HIV/AIDS models assess the economic impact of HIV (Human Immunodeficiency Virus) and AIDS (Acquired Immune Deficiency Syndrome) using CGE analysis. The virus HIV that causes AIDS was first isolated in 1983. Estimates show that in 2003 almost five million new infections with HIV occurred and almost three million people died of HIV/AIDS related causes, bringing the total of people currently living with HIV/AIDS worldwide to 38 million, 1.1% of the world's adult population. By far the most affected region is Sub-Saharan Africa, which accounts for approximately 70% of worldwide HIV/AIDS cases and has a prevalence rate of at least seven times the world prevalence rate (UNAIDS, 2004). It comes to no surprise therefore that most empirical models of the macroeconomic implications of the HIV/AIDS pandemic are applied to Sub-Saharan Africa.[28]

[28] This is not to say that HIV/AIDS does not pose a threat to other countries and/or regions. For example, countries in Eastern Europe and the Commonwealth of Independent States (CIS), despite recording relatively low prevalence rates, are witnessing some of the fastest growing rates of HIV/AIDS infection in the world.

3.4.2 The economic impact of HIV/AIDS

Dixon et al. (2002) succinctly enumerate the main effects of HIV/AIDS on the African economy, namely reduced labour supply, reduced labour productivity and a worsening of the balance of payments. Labour supply falls through increased mortality and morbidity, and the impact may differ across sectors depending on relative skill intensities and difference in incidence across skill types. The long duration of the illness lowers labour productivity, which in turn reduces competitiveness, profits and hence government's tax earning ability. The latter effect combined with the pressure on government spending to mitigate the impact of HIV/AIDS increases the potential for fiscal crises. Finally, a fall in productivity lowers exports while at the same time HIV/AIDS sufferers usually require expensive imports of health care goods. The deterioration of the trade balance may lead to defaults on debts and an appeal for international assistance.

As noted by Arndt (2003) and Arndt and Wobst (2002), the basic consensus of the early literature on the macroeconomic impact of HIV/AIDS that appeared in the early nineties was that AIDS had little net (negative) macroeconomic impact measured in terms of per capita GDP.[29] Conclusions reached by more recent studies are considerably less sanguine and show more often than not a strong negative association between HIV prevalence and per capita GDP.[30] This change in tone stems from the explicit recognition of the long term, dynamic nature of the pandemic, accompanied by improved data. Given the disease's long incubation period, relatively small but

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29 Kambou et al. (1992)'s CGE model for Cameroon and Cuddington's (1993) econometric model for Tanzania are examples of earlier studies.

30 CGE examples are: Arndt and Lewis (2000), Arndt and Lewis (2001), Arndt and Wobst (2002), and Arndt (2003). The latter three models focus more on the implications for labour markets and human capital accumulation. An example of a recent econometric study is Dixon et al. (2001a).

sustained negative impacts on rates of accumulation, be it of physical or human capital, and technological progress are sufficient to bring about a significant fall in growth in the long term.

The discrepancy between short run and long run effects of the HIV/AIDS epidemic is particularly apparent from the manner in which the pandemic affects human capital formation. Whereas in the short run a fall in labour supply may increase per capita GDP as more capital and land are available per worker in production, in the long term a decline in the rate of human capital accumulation may negatively influence growth and levels of per capita income. Hamoudi and Birdsall (2002) explore four ways in which the epidemic is likely to affect the rate of human capital formation and the productivity of the existing human capital stock in Africa, most of which feature in some form in the CGE studies discussed later. Firstly, the loss of adults, among which many teachers, affects Africa's ability to supply education. Evidence shows not only that AIDS disproportionally affects adults of working age but also that, at least in the first wave of the epidemic, HIV was much more likely to infect the relatively well-educated workers, making the teacher profession relatively vulnerable to the epidemic.[31]

Also, given a drastic fall in life expectancy, the time horizon over which to reap returns to education is shortened, which lowers the willingness to invest in and thus demand for schooling. Arndt and Wobst (2002) argue that children whose parents die from AIDS-related causes are less likely to go to school as the need for children, or indeed orphans, to work becomes more pressing, thereby further depressing the demand for education.

[31] Equally alarming is the relatively high HIV/AIDS prevalence rate of 20% among health care nurses in South Africa reported in Dixon et al. (2002).

Moreover, the loss of skilled people of working age negatively affects productivity of those who remain behind in the presence of increasing marginal returns or positive externalities to human capital. Hamoudi and Birdsall (2002) argue that an agglomeration of skilled workers is much more effective than an equal amount of workers each acting on their own. The stylised fact of "brain drain", whereby skilled labour migrates to relatively skill abundant places to increase its income, is used in support of this line of reasoning. Arndt and Wobst (2002) similarly reason that the decline in productivity of the workforce is a reflection of the replacement of more experienced workers (who die from AIDS related causes) by relatively inexperienced workers (who are of school age but forced to work), who are less productive and are less likely to innovate.

Finally, insofar as human and physical capital are complementary inputs in production, a loss of physical capital reduces the ability of skilled workers to contribute to production and thus their productivity.[32] The erosion of the physical capital stock is attributable to a reduction in domestic savings, via a shortening of time horizons and large, sustained outlays for medical care,[33] and a fall in attractiveness to foreign investments.

Economists have two methods of quantifying the overall effect of HIV/AIDS prevalence on the economy, as measured by GDP per capita, these being an econometric modelling framework and a computable general equilibrium analysis. CGE

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[32] The loss in productivity stemming from externality or complementarity issues may further magnify the slowdown in human capital accumulation by lowering the returns to education.

[33] Medical costs include purchases of treatments by households and delivery of treatments by the government, but also refer to medical expenses of firms on medical insurance, death benefits and spouse's and disability pensions, cost of absenteeism and even funeral costs.

studies are being reviewed here.[34] Econometric analyses[35] use calibrated neo-classical growth models and similar to the CGE studies, hypothesise that changes in per capita income are determined by changes in physical and human capital accumulation and productivity. A priori, the effect of the pandemic on the growth rate and level of income is indeterminate.[36] An increase in the prevalence of HIV/AIDS lowers productivity and leads to a fall in the savings rate and population growth. The former two effects reduce the ratio of capital to labour and income per capita over time. The latter effect works in the opposite direction by raising the capital-labour ratio and per capita income over time. The overall impact depends on which of these effects predominate and therefore remains an empirical question.

The prime disadvantage of growth models compared to CGE models is that they fail to capture the differential impact of the epidemic across sectors, factors and the population and the various interactions between different parts of the economy, such that it is unclear how the overall result comes about. Dixon et al. (2002) add that, due to the explicit incorporation of inter-sectoral differences with respect to loss of labour, of which the relatively skilled and sector-specific types may be difficult to replace, CGE studies generally predict a relatively greater negative economic impact of HIV/AIDS.

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34 The review discusses five CGE models applied to the HIV/AIDS pandemic, which are exemplary of their development over time. Excluded are Shombi Sharp's 2002 model for the Russian Federation, used by the UNDP (2004), and the Centre for International Economics' model for Papua New Guinea, used by AusAID (2002).

35 Dixon et al. (2002) is a good source of references for econometric work on HIV/AIDS.

36 See Dixon et al. (2001a, pp.412-414) and Cuddington (1993, pp.178-182).

3.4.3 Kambou, Devarajan and Over's Cameroon model

Kambou et al.'s (1992) model for Cameroon is the first CGE model to assess the economy-wide impact of the HIV/AIDS pandemic. The authors presume that the epidemic affects the economy solely via exogenous reductions in labour supply and abstract from increases in public and private health expenditures. The research is motivated by epidemiological evidence of a highly unequal distribution of HIV infection, biased towards highly skilled urban workers, which could have severe consequences for economic growth, per capita income and overall welfare: "*Indeed, were it not for the fact that AIDS kills the skilled population in disproportionate amounts, some may argue that the macroeconomic impact of the disease in Sub-Saharan Africa is unimportant. Africa's population is growing so rapidly, the argument goes, that the additional deaths due to AIDS will hardly be noticeable in the aggregate statistics.*" (Kambou et al. (1992, p111).

The model (see Table 3.1) is employed in static and recursive dynamic simulations of a skill-neutral reduction in overall supply of rural, urban skilled and urban unskilled labour, representing a total of 30,000 workers per year (0.8% of the labour force), and skill-biased reductions in supply of each labour category of 10,000 a year, holding other skill categories constant. The base run, which serves as a reference case against which the effects of reduced labour supply are measured, reflects status-quo assumptions of no changes in the internal and external environments within which the economy operates.

In the static simulations a skill-neutral reduction of labour supply leads to a rise in wages, which translates into higher production costs and higher prices, especially for sectors with labour-intensive production processes. An increase in the cost of production, combined with a fall in investment demand due to a sharp reduction in government savings, reduces output and employment. The rise in domestic prices brings about a deterioration of the trade balance as exports decrease and imports rise due to a fall in international competitiveness. The contraction of the external sector has negative consequences for government savings since tariff revenues fall. The fall in especially government savings exacerbates the contraction of the economy in the dynamic skill-neutral simulations by depressing investments and average real GDP growth falls by approximately 50% (two percentage points) relative to the base run.

The skill-biased experiments reveal that sectors contract, the extent depending on relative factor proportions in each sector. Shortages of rural labour lead to an agricultural output decrease proportionally larger than the decrease in output of other goods, whereas in the case of a fall in urban labour, manufacturing and service sectors show relatively large production decreases (Rybczynski type effects). The authors note that, although HIV/AIDS brings an overall loss to the economy, some sectors may gain depending on relative price changes. For example, the food sector expands following a fall in the supply of urban skilled labour as this makes rural labour relatively cheap. In aggregate though, the contraction of manufacturing and construction is relatively more pronounced. A fall in supply of urban skilled labour hits the economy hardest, with sharpest reductions in output experienced by manufacturing and construction sectors. The assumed growth rate of 1% for urban skilled labour is insufficient to absorb the loss of 6% of urban skilled labour, in contrast with rural labour which still grows in the presence of HIV/AIDS, causing the economy to contract and GDP growth rates to fall by relatively more.

Kambou et al.'s main result is thus that, when evenly distributed across the population, HIV/AIDS approximately halves the average growth rate of real GDP, a reduction of two percentage points, and that most of this impact comes from the loss of urban skilled labour. Such a heavy loss of Cameroon's most skilled and productive type of labour signifies a decline in the rate of return to human capital investments, productivity and growth. This leads Kambou et al. (1992) to conclude that: "… a *people-centred development approach is bound to fail.*" and that the impact of alternative government (and household) responses to HIV/AIDS needs to be assessed (Kambou et al. 1992, p123).

3.4.4 Arndt and Lewis's South African model

Arndt and Lewis (2000, 2001) advance the analysis of Kambou et al. (1992). The authors not only model the demographic effects of HIV/AIDS, but also account for behavioural effects, through government and household responses to mitigate the negative consequences of the disease. Arndt and Lewis find a substantially greater impact compared to Kambou et al. (1992) due to improved demographic estimates of the magnitude of the epidemic, which is substantially larger than originally thought, as well as an explicit account of the long duration of the pandemic such that negative effects cumulate.[37] The results are published in two separate articles, a study addressing the macro-economic implications of HIV/AIDS (Arndt and Lewis, 2000) and a paper concentrating on sectoral impacts and unemployment (Arndt and Lewis, 2001).[38]

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[37] Analyses are carried out for ten instead of five years. Additionally, Kambou et al. (1992) did not contain a time dimension. They use the period of 1987 to 1991 to compare scenarios and report results in terms of average annual growth rate differences.

[38] Unless stated otherwise the reported results are from both papers.

Arndt and Lewis's model is relatively more sophisticated in terms of aggregation, functional forms and market structure (see Table 3.1). The authors employ a translog production function for capital and labour inputs, which permits different substitution elasticities between pairs of inputs. This functional form emulates South Africa's reality of marked differences in factor utilisation featuring the simultaneous existence of high unemployment of unskilled and full employment of professional labour. A novel feature of government behaviour is that government consumption expenditure as a share of total absorption (private consumption, government consumption and investments) is exogenous but across the seven spending categories can accommodate a variety of allocation rules, including increased health spending at the cost of other goods or deficit spending at the cost of savings, which crowds out investment. The latter crowding-out mechanism is incorporated in the AIDS scenario. Finally, to conform to reality, real wages for unskilled, skilled and informal labour are set institutionally above market clearing levels, such that the level of employment becomes the equilibrating variable. Levels of unemployment result from simple subtraction of employment from labour supply. The wage for professional labour is set in the market.

Arndt and Lewis compare a hypothetical No-AIDS scenario with an AIDS scenario to distil the differential impact of the HIV/AIDS epidemic. Features of the AIDS scenario are: a slow-down in population and labour force growth by skill category (unskilled labour is taxed relatively heavily); a fall in labour productivity (effective labour input by skill type is reduced proportionally with the projected AIDS deaths one period hence); total factor productivity growth drops by up to one half of the No-Aids rate at the height of the epidemic (reflecting among others cost of hiring, training adjustments, absenteeism and slow-down in technical progress); households struck by AIDS reduce savings and increase health spending to 10 to 15% of total spending at a cost of non-food items; and finally the health share in government expenditures rises from 15% in 1997 to 26% in 2010 by augmenting the deficit (the share of non-AIDS related spending is assumed constant). Only the first effect was considered by Kambou et al. (1992).

Against the backdrop of these assumptions the AIDS scenario lowers economic growth compared to the No-AIDS scenario, at a maximum of 2.6 percentage points in 2008. As a result, the overall size of the economy measured in terms of real GDP is considerably lower, in 2010 by about 17%, relative to a situation without the HIV/AIDS epidemic. This welfare measure is biased upwards due to stark increases in health and related expenditures to fight AIDS, which do not signify a welfare improvement in this model.[39] Therefore, the authors employ absorption excluding AIDS-related expenditures and private expenditures on food as an alternative welfare indicator. The difference in this real absorption measure is 22% in 2010.[40] Arndt and Lewis argue that further information on per capita GDP and absorption is required, as the slowdown in population growth may leave welfare per capita unaffected or may indeed lead to an improvement per capita. Whereas in Kambou et al. (1992) per capita income remains approximately constant, Arndt and Lewis find a fall in GDP and absorption per capita. Specifically, in 2010 per capita GDP is 8% lower and absorption per capita is lower by 13%, indicating that the decline takes place disproportionally in non-health, non-food expenditures. Decomposition of the total effect on real GDP in 2010 reveals that the

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[39] A deficiency in Arndt and Lewis's analysis is that it does not include a measure of health status in the utility function such that improvements in well-being of the ill are not positively valued.

[40] These figures are from Arndt and Lewis (2000). Arndt and Lewis (2001), although based on the same model and assumptions, report slightly higher estimates: real GDP is about 20% lower in 2010 compared to the No-AIDS scenario, real absorption is 24% lower.

change in total factor productivity and government spending (reducing savings and investments) account for the major part of the GDP decrease, 34% and 45% respectively.[41] Finally, although Arndt and Lewis (2000) expected to find a fall in unemployment for the high-unemployment unskilled labour category in South Africa, as AIDS impacts on this category more than others, the model results suggest the contrary. The unemployment rate for unskilled labour actually increases marginally relative to the No-AIDS scenario, because the HIV/AIDS pandemic not only reduces labour supply growth (labour supply is 17% smaller in 2010 in the AIDS scenario) but also slows down production growth and thus labour demand. This issue is further elaborated in Arndt and Lewis (2001).

The authors label the high unemployment of unskilled and semi-skilled labour in South Africa as an employment problem.[42] The data suggest that job creation performance over the past thirty years for this category has been dismal relative to other skill types. Formal sector employment failed to grow in line with unskilled and semi-skilled labour supply in the 1970s and actually declined in the 80s and 90s, leaving total employment for lower skilled labourers in 1999 at 92% of its level in 1970. Although the authors recognise the complexity of South Africa's history, they attribute this phenomenon to a single factor, namely the neo-classical explanation that the lower-skilled labour types have systematically priced themselves out of the market. A combination of institutional

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41 Decomposition of the change in real GDP is implemented via progressive elimination of effects. This method is subject to path dependency. The authors use the following order of elimination: total factor productivity is eliminated first, followed by government deficit spending (replaced by displacement of government expenditures on other goods), factor-specific productivity declines and reductions in labour supply. The latter two account for the remaining 8% and 13% respectively.

42 Rather confusingly, Arndt and Lewis (2001) suddenly change the labour classification in their analysis from informal, unskilled, skilled and professional labour types to unskilled, semi-skilled, skilled and highly skilled labour categories. Consequently, labour market results are reported in terms of the latter typology.

factors such as labour unions, wage bargaining councils and labour legislation have led to the creation of a relatively rigid wage for lower skilled labour types that is set well above market-clearing levels. Their hypothesis is supported by data on real remuneration trends across labour classes. Evidence shows that real wages for semi- and unskilled labour has grown by up to 250% of the 1970 level, whereas for highly skilled and skilled labour these have remained relatively close to the 1970 level (at 90% and 110% respectively).[43]

Arndt and Lewis (2001) put forward two additional factors, apart from the slow-down in growth explanation, to motivate the fact that the unemployment rates of unskilled and semi-skilled are largely unaffected by the HIV/AIDS epidemic. These stem from changes in the structure of the economy caused by the differential impact of the pandemic across sectors. Firstly, a fall in savings (associated with the pandemic) brings about a fall in investment demand and lowers the production of investment goods by the construction and equipment sectors. These sectors use unskilled and semi-skilled labour relatively intensively and take up a significant share of total wage payments to these categories (approximately 16%). Additionally, AIDS-induced morbidity effects on unskilled and semi-skilled labour lower the output of sectors using these labour types relatively intensively even more, exacerbating the negative effects on employment.

In the light of the above, Arndt and Lewis (2001) advocate a policy of real wage moderation (or even decline) for unskilled and semi-skilled labour to stimulate

[43] The growth paths of real remuneration for labour in the model simulations (reported in Arndt and Lewis 2001 only) are set conservatively relative to the evidence. Specifically, real wages for the lower skill types grow at 2% (less than the average annual growth rate of 3.5% over 1970-1999). Real remuneration for skilled labour remains constant and remuneration for highly skilled labour is formed in the labour market.

employment, especially in equipment and construction sectors that use these factors intensively, investment and growth. This would palliate the negative economic consequences of the HIV/AIDS pandemic and reduce unemployment rates. They assess the effect of this policy by comparing different growth paths of real wages with the original scenario. The model results show that constant real wages for semi-skilled and unskilled labour improve GDP growth by 0.5 percentage points annually relative to the No-AIDS scenario, whereas a fall of 1% annually increases GDP growth by approximately 1 percentage point. This change in growth performance stems from improvements in employment and is further encouraged by a rise in investments. For example, an annual decrease in real wages for semi-skilled and unskilled labour of 1% reduces the unemployment rate to a level of 17 percentage points below the level in the base case, which at 41% is still high.

Arndt and Lewis (2001) recognise that the distributional effects of this policy across households with employed members who prefer a real wage rise, versus households with unemployed members who rather see real wages fall, are not trivial and should be investigated in more detail in future. Nevertheless, as a first indication, the authors find that the real value of total factor payments to unskilled and semi-skilled labour remains constant. This suggests that the reduction in wages offsets the increase in payments to the newly employed and has no adverse distributional effects across households. Another avenue for future research listed by Arndt and Lewis (2000) is to improve the empirical basis of the effects of the HIV/AIDS pandemic. Alternative intervention policies aimed at mitigating the impact of the pandemic, next to a policy of wage moderation, need further scrutiny. Finally, currently not modelled are dynamic implications over time of the HIV/AIDS pandemic, such as the impact of a reduction in education spending on skill accumulation and growth of labour supply by skill type.

3.4.5 Arndt and Wobst's Tanzanian model

Arndt and Wobst (2002) zoom in on an under-investigated element of Arndt and Lewis's (2001, 2002) analysis of the potential economic implications of the HIV/AIDS pandemic via its effect on labour markets and human capital accumulation. The central hypothesis of Arndt and Wobst is that in poor countries such as Tanzania, where the stock of human capital is small, not the death of skilled people but the impact of HIV/AIDS on growth in the human capital stock, i.e. rates of human capital accumulation, matters more for economic performance in the long term. Evidence points to a strong relationship between educational attainment, productivity and technological progress, and earnings, such that higher education levels may enhance economic growth significantly. A CGE model of Tanzania addressing the implications of skills upgrading is the last of three analyses undertaken by the authors to scrutinise this research question. The authors commence with a labour force survey (LFS) analysis and a study of rates of human capital accumulation using education transition matrices (ETMs) for the 1990s of which results are used to derive tentative conclusions on the economic impact of HIV/AIDS via changes in skill upgrading.

A comparison of the 2000/01 LFS with the 1990/1991 LFS shows that the age structure of the Tanzanian labour force has changed in favour of the young and less experienced. The shares of children of 10-14 years old and juveniles of 15-19 years old in the work force have increased relative to the share of medium age employees of 20-34 years old. This pattern agrees with the loss of educational capacity, due to teachers dying from AIDS, and a fall in education demand by children, forced to work to compensate for the loss in income of AIDS stricken parents of prime-age and, to a lesser extent, older age. Moreover, in line with the LFS results, the authors find a sharp fall in the share of the school age population of 5-14 years old enrolled in primary education. The trends in school enrolments in Tanzania are deciphered in more detail using the novel approach of estimating ETMs at provincial, regional and national level.

An ETM captures the way in which children move through the education system. For a given education level a child has three options for the following year, which are to progress to the next educational level, to remain in the same educational level and to exit the education system and enter the labour force. The probabilities of each of these outcomes for all education levels are put into one comprehensive transition matrix, *T*. Reading row-wise the diagonal entries represent the probability of repeating the same educational level and the following entry to the right of the diagonal represents the probability of progressing to the next educational level. Exit probabilities for each education level are put in the matrix by adding an additional column. All other entries are zero by assumption and rows add up to one such that all choices are accounted for. If E_t is the enrolment in year t, with the entry for grade 1 positive and all other entries zero, then the number of individuals at each educational level, *S*, at t+1 equals: $T^{'} \cdot S_t + E_t$.[44] Using a minimum cross-entropy approach, the authors estimate non-stationary ETMs, which permit transition probabilities to evolve over time according to a linear trend, and stationary ETMs, in which probabilities are constant.[45] Arndt and Wobst find that trends in secondary school enrolment, which is relatively small in size,

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44 Enrolment in first educational level is supplied exogenously, such that probability of repeating grade 1 is set to zero.

45 For more information the reader is referred to Appendix B of Arndt and Wobst (2002).

have been positive. More importantly, trends in primary school enrolments are negative from grade 4 onwards and especially so for boys. For grades 4 to 7 exit probabilities are increasing, which is in line with the large increase in the share of 10-14 year olds in the labour force.

The final part of Arndt and Wobst (2002) is a CGE analysis of the implications of skill upgrading (defined as a reduction of the share of the low-skilled and an increase the share of the medium and high skilled in the labour force) using a static CGE model for Tanzania. A salient feature of the Tanzanian model (see Table 3.1) is that it accounts for the presences of large wedges between producer and consumer prices, such that households may opt to produce entirely for own consumption (home consumption). Another distinguishing feature is that factors of production are mobile, but only to a certain degree, which is activity and/or scenario related. Capital employed in (non-) agricultural sectors can only move freely across (non-) agricultural sectors. Labour is mobile if rural-urban migration is permitted, but made specific to agriculture and non-agricultural sectors when it is not, in which case (non-) agricultural labour mobility is restricted to (non-) agricultural sectors only. Finally, land is only employed in agriculture and perfectly mobile within sub-sectors.

Skill upgrading is simulated by transferring 2% of low-skilled to medium skilled workers and 1% of the medium skilled to the high skilled category, given the total number of agricultural and non-agricultural workers. Two scenarios are used, which either allow or forbid rural-urban migration. In the migration-permitting scenario agricultural labour of a certain skill type can migrate and change into non-agricultural labour of the same skill class (and vice versa). Migration is a function of relative agricultural/non-agricultural wages, which are maintained at a constant level by labour flows between the categories. In the scenario which prohibits migration total agricultural and non-agricultural labour is fixed. In this set-up, migration is ultimately governed by low demand elasticities for agricultural products combined with larger opportunities for skilled workers in urban areas. Consequently, when migration is allowed, skill upgrading entails larger increases in the medium and high skilled workforce in non-agricultural sectors compared to their agricultural counterparts.

The authors find that skill upgrading with migration leads to a higher real GDP relative to the scenario in which migration is prohibited (increases by 0.42% compared to 0.35% without migration). Not only do workers move to a higher and more productive skill class, but also from agricultural to more productive non-agricultural jobs. Secondly, in the absence of migration agricultural GDP improves by relatively more from skill upgrading. This results from a rise in productivity of more skilled agricultural workers and the large number of (low skilled) workers involved in skill upgrading. Nevertheless, the cost to the agricultural sector of migration is relatively small compared to the gains to the non-agricultural sector due to productivity differences and the fact that the agricultural sector cannot easily absorb highly skilled workers. The latter factor, combined with strong reductions in marginal product following an increase in the size of the highly skilled labour class, ensures that real wages of highly skilled labour in agriculture decline when migration is not permitted and logically, when migration is allowed, these workers have the highest propensity to migrate.

Arndt and Wobst conclude that the observed patterns of skill upgrading agree with a development strategy which enhances agricultural production. This improves demand by the majority of the population for non-agricultural products and permits migration from rural to urban areas without significant cost to agricultural sectors. The slowdown in skill upgrading observed in the LFS and ETM analyses, of which HIV/AIDS is likely to be a contributing factor, would diminish such positive processes. The authors also note the negative effects of the strong shift in age structure towards younger, inexperienced workers who are less productive and less likely to innovate.

Although certain aspects of Arndt and Wobst (2002) are innovative, especially the use of ETMs, one could criticise their work on several points. Firstly, the model is static and not dynamic and therefore does not capture adjustment processes over time. Secondly, their analysis of the impact of HIV/AIDS on the economy via changes in the rate of skill accumulation is essentially qualitative. Three separate studies were carried out, and the results of the LFS study and ETM analyses are not directly incorporated in the CGE model simulations in the form of 'No-AIDS' versus 'AIDS' scenarios. The latter procedure is fairly common in CGE models of the economic impact of HIV/AIDS (see for example Kambou et al., 1992 and Arndt and Lewis, 2000, 2001). Instead, the authors argue that they "*… do not know and cannot know what educational and labour force trends would have prevailed in the absence of the pandemic.*" (Arndt and Wobst, 2002, footnote p39). Hence, no guesstimates of the likely impact of the HIV/AIDS pandemic on the education and labour market are implemented in the CGE simulations and no quantitative but only tentative conclusions are derived.

3.4.6 Arndt's Mozambique model

Arndt (2003) is a development of Arndt and Lewis (2000, 2001). He complements their CGE analyses with the results of Arndt and Wobst (2002) for Tanzania and thereby addresses the caveats of the latter.

The author develops the ETM of Arndt and Wobst (2002) into an education and skill transition matrix (ESTM), which governs transition between various scholastic levels (lower and upper primary, secondary and tertiary) *and* workforce skill levels (unskilled, skilled and highly skilled). People who are not working and not in school (infants) and those who retire from the labour force or die are incorporated as a first and last class in the matrix respectively. The ESTM for Mozambique is estimated over the years 1996 to 1999, a period in which effects of the HIV/AIDS pandemic were minor, and which is therefore assumed to reflect a 'No-AIDS' situation. The effects of HIV/AIDS are derived from available demographic projections and trends in transition probabilities estimated by Arndt and Wobst (2002) for Tanzania over a period containing a substantial number of AIDS-related deaths. Typically, AIDS increases the death rates; increases the probability of moving from a lower level of schooling to the unskilled workforce; reduces the likelihood of moving from secondary to tertiary education; increases the probability of changing from tertiary education to the skilled labour force (as opposed to highly skilled); and, at each level of educational attainment, reduces the chance of remaining in school.

The resulting ESTMs with and without AIDS are subsequently employed in CGE simulations of a base 'AIDS' scenario and a 'No-AIDS' scenario. A second AIDS scenario, 'Education' is imposed, which looks at the effect of education policy in the presence of the pandemic. The 'Education' scenario maintains the transition probabilities of the 'No-AIDS' scenarios while the demographic effects of AIDS, i.e. increases in the death rates and proportional reductions in the probability of remaining in a category, still obtain. Education policy is hypothesised to cost 25% and 50% of base funding levels in the first two years of the simulation period (1% of GDP approximately), after which an increase of 3% per annum in terms of real foreign currency takes effect for the remainder of the simulation period. Incremental expenditures on education are funded through direct taxation of urban households.

The three scenarios have different implications for labour force projections. Without the HIV/AIDS pandemic the skilled and highly skilled labour categories grow rapidly, while the AIDS scenario depresses skill upgrading to lower, albeit still positive, rates of growth for the two skilled labour types. The pool of unskilled labour is larger in the ‘AIDS’ scenario than in the ‘No-AIDS’ scenario due to a rise in school drop-out rates. When the education policy is put in place, growth of the higher skilled labour categories is only marginally affected by the epidemic, which stems from the relative smallness of the highly skilled labour segment compared to the large pool of unskilled labour, i.e. the potential new entrants into the educational system. This implies that the indirect effects of the pandemic on transition probabilities are more important than the direct effects on death rates, and signifies the importance of maintaining the flow of new entrants into the skilled segments of the workforce to preserve future stocks of (highly) skilled labour.

The alternative labour force projections, together with assumptions on productivity growth and physical capital accumulation, are fed into a recursive dynamic CGE model for Mozambique (see Table 3.1). The productivity of each factor is assumed to decline proportionally with the share of the relevant adult population that has AIDS. Physical capital accumulation across sectors is governed by profit rate differentials. They are financed by government, foreign and private (firms and households) savings, of which the latter two may vary across scenarios. In the ‘AIDS’ scenario foreign savings and private savings rates are assumed fixed, whereas in the ‘No-AIDS’ scenario a slight degree of responsiveness (elasticities below 0.5) to rates of return to capital is permitted.

Results indicate that the economic repercussions of HIV/AIDS are potentially sizeable. Arndt finds a relatively large decline in the growth rate of real GDP compared to earlier studies. Real GDP growth falls by between 2.8% and 4.3% in 2010, leading to a reduction in real GDP in 2010 of 14% to 20%. On a per capita basis the growth rate is between 0.3% and 1% lower in 2010, leading to a per capita GDP of about 4% to 12% less compared to the ‘No-AIDS’ scenario. A decomposition of the effects of AIDS show that reduced population growth and human capital accumulation (24%), reduced physical capital accumulation (35%) and most importantly reduced productivity growth (41%) are the main drivers of the reduction in growth rates. Moreover, sectors that produce investment goods (other manufacturing and construction) are particularly hard hit, whereas agricultural sectors are not so much affected. Given the labour force projections of the ‘AIDS’ scenario relative to the ‘No-AIDS’ scenario, the pandemic reduces output of sectors that intensively use highly skilled and skilled labour and capital, whereas sectors that use unskilled labour intensively tend to expand as a share of GDP (Rybczynski type effects). The former factors happen to have relatively high productivity growth rates compared to the latter, which magnifies the differences in GDP growth rates. The assumption of technical change biased towards human and physical capital, in stark contrast to earlier studies, such as Arndt and Lewis (2000, 2001), which impose Hicks-neutral technological progress, is key in explaining the growth differential. If Hicks-neutral technical change is imposed, the growth differential falls to 2.5%, slightly below the estimate of Arndt and Lewis (2000). Output per worker and wages differ significantly in the ‘Education’ scenario compared to the base ‘AIDS’ scenario, whereas total real GDP is approximately the same for the entire simulation period. Labour supply in the 'Education' scenario is relatively low due to the policy of maintaining school enrolment rates. Greater stocks of human capital and a larger amount of capital per worker imply higher output per worker (11% higher in 2010 compared to the base 'AIDS' scenario). A reduction in the amount of unskilled labour implies an increase in unskilled wages (by 14% in 2010), but as the value added share in GDP rises, education instead of working as an unskilled labourer overall generates a higher payoff. Growth rates in the two 'AIDS' scenarios also differ substantially. In the early stages education policy slows down economic performance as taking people out of the labour force reduces the contribution of otherwise working individuals to the economy, but later such a policy pays off in terms of higher growth rates. By 2010 real GDP growth is 0.6 percentage points higher in 'Education' compared to the base 'AIDS' scenario, due to more rapid human capital accumulation, i.e. enhanced productivity of a more skilled labour force.

In spite of a high degree of uncertainty around the results,[46] the long but finite duration and severity of the impact of the pandemic suggests that effective mitigating policies, such as the education policy, and preventive policies, aimed at reducing HIV infections, implemented today may have a high pay-off in the long term. Arndt (2003) illustrates this by net present value (NPV) calculations of successful education and preventive policies. He finds that, assuming that the growth enhancement of 0.6% of education policy persists up to 2020, additional education expenditures in the order of 5% of GDP

[46] For example, Arndt (2003) stresses that the productivity impact of AIDS is speculative because of a thin empirical base, which makes estimates of technical change and the impact of AIDS thereon highly implausible.

per year from 2002 to 2010 are justified. Similarly, if effective preventive policies reduce AIDS deaths and result in a per capita growth benefit of 0.3%, additional preventive expenditures of 2.5% of GDP from 2002 to 2007 are warranted, based on a per capita GDP measure of evaluating preventive policy only. The assumption that the pandemic is severe, long-lasting but nevertheless finite is critical and signifies a departure from Kambou et al. (1992), whose viewpoint was that a people-centred development approach (such as investments in human capital) would be fruitless as AIDS reduces the life expectancy of educated people. Instead Arndt assumes that over time a vaccine is likely to become available and that together with behavioural changes and changes in human biology this will eventually cut back HIV/AIDS prevalence rates. Until that time, policies that aim at reducing the impact of HIV/AIDS and the duration of the pandemic are justified.

Arndt (2003) is sophisticated compared to the previous HIV/AIDS models in simultaneously considering the consequences of HIV/AIDS for labour, physical and human capital accumulation and the rate of - human and physical capital biased - technological change, and in assessing the potential of preventive and mitigating policies (such as education policy) in a recursive dynamic CGE setting. Nevertheless, the reliability of data and thus results remains a problem (indeed in all studies), which can only be ameliorated in due time when more is known on the effect of HIV/AIDS on productivity growth and labour supply by skill type. Furthermore, Arndt (2003) does not address the issue of resource allocation, which needs to change considerably and raises questions about feasibility if policy recommendations were to be carried out. Priority setting amongst the most cost-effective government responses, which is much needed but can lead to controversial outcomes, may therefore not be carried out.

Instead, the author's objective is to show that proposed policies are likely to have a high payoff such that (Arndt, 2003, page iv): "… *imaginative initiatives, including costly ones, can be considered.*"

3.4.7 Dixon, McDonald and Roberts' Botswana model

Dixon et al. (2004) report preliminary results of the effects of health care interventions aimed at reducing the impact of the HIV/AIDS pandemic on the Botswana economy. It is the first of its kind in explicitly modelling health policies which target the pandemic directly and thereby represents a marked improvement upon previous analyses, which, at best, examined indirect (e.g. labour market and education) policies aimed at mitigating the effects of the pandemic on the economy or, in the case of Arndt (2003), evaluated the impact of preventive policies using NPV calculations based on GDP per capita only (not endogenously modelled in the CGE framework). Two types of health care interventions are considered: reductions in other sexually transmitted diseases (STD) which reduces the probability of HIV transmission and a health education programme (EDU) which focuses on prevention by reducing the number of newly formed sexual relationships.

The analyses are carried out in a recursive dynamic CGE model for Botswana (see also Table 3.1) with an embedded "compartmental" epidemiological model. The latter endogenises the impact of the epidemic on labour supply via changes in mortality. It distinguishes high risk and low risk populations, which are each subdivided into those who are currently infected and those who may become infected. Changes over time are then derived from population numbers in the previous period plus a series of transmission parameters.

The policy interventions are modelled endogenously in the sense that they impose costs in terms of material and skilled labour (in the economic component of the CGE model) and benefits in terms of the preservation of life (in the epidemiological component). A total of five shocks/policies are modelled incrementally which describe the impact of:

- AIDS, modelled on HIV/AIDS prevalence estimates of UNAIDS;
- AIDS and the associated rise in government expenditures on health care (HE), assuming that real health care provision quadruples over 1994-2020;
- AIDS with HE and an STD policy intervention which reduces the chance of HIV transmission through sex between high risk partners by 50% and by 30% if at least one low-risk partner is involved, and costs US$ 0.39 per capita;
- AIDS with HE and an EDU policy that yields fewer new sexual partnerships (25% across all risks) and costs US$ 0.35 per capita;
- and AIDS with HE, STD and EDU policies combined.

The results of each of these scenarios are presented in terms of macroeconomic indicators relative to the population in the base period (due to lack of data on household numbers and size) and are reported relative to the ‘No-AIDS’ baseline.

The AIDS pandemic is shown to increase ‘per capita’ GDP relative to the baseline, whereas interventions reduce it. The closure rule of maintaining the capital-labour ratio is responsible for this counterintuitive result: the AIDS scenario produces the lowest workforce, i.e. highest capital/labour ratio (and so GDP per capita) and interventions yield a higher workforce, thereby reducing capital/labour ratio (and GDP per capita).

In contrast, private consumption ‘per capita’ rises until 2010 and subsequently falls in a scenario in which the government responds to the AIDS pandemic with increased health expenditures. The EDU policy which reduces the number of new sexual partners is not sufficient to avert a fall in per capita private consumption, whereas the STD policy (and STD and EDU policy combined) is. The AIDS scenario alone at first yields a growth path of private consumption per capita above the baseline, but after 2014 below the baseline in agreement with diminishing returns to input substitution.

Given the pattern of per capita consumption and fixed absorption shares destined for investments, government consumption ‘per capita’ must rise considerably and at an increasing rate to yield the rise in per capita GDP. The results confirm that this is the case, even with STD and EDU policy interventions in place. Also as expected, the AIDS pandemic, combined with increased health care expenditures, significantly reduces ‘per capita’ disposable income for each household type (by up to 50% in 2020 compared to the baseline). The STD and EDU interventions are shown to mitigate these effects by more than half. Effects differ across households and factors, but the picture is far from clear and more research is needed into interpreting these results. In general, the AIDS pandemic yields higher capital-labour ratios and thus higher wages, whereas interventions will lower this effect.

Overall, Dixon et al.’s (2004) preliminary paper on the AIDS pandemic in Botswana clearly advances previous CGE analyses by assessing the impact of various health policies. Nevertheless, as the authors recognise, ‘much remains to be done’. The authors mention three model refinements currently underway in order to ‘provide estimates of greater reliance to policy makers’. These are the inclusion of morbidity (productivity and absences from work) effects associated with HIV infection, disaggregation by household of epidemiological consequences and the inclusion of a third type of health policy in the form of Anti-Retroviral Treatment (ART), which has become a viable policy option (the price for ART drugs has fallen considerably) and delays the onset of the disease.

Further improvements are needed in terms of the CGE model itself. For example, the paper does not address the impact of the epidemic on human capital accumulation, the importance of which was demonstrated by Arndt and Wobst (2002) and Arndt (2003). The changes in asset ownership are not considered and results seem to hinge upon the assumption of maintaining capital stocks, which may prove difficult for a country hit by the AIDS pandemic.

In addition, from the point of the reader not all model assumptions are clear from the paper (e.g. What is the numéraire? How is consumption demand modelled? What is the closure rule with respect to the trade balance? What are the welfare effects and how are they modelled?). The same is true for the impact of the epidemic and interventions on sectors, which are not reported either. Finally, Dixon et al. distinguish government expenditures on health care from those related to the specific STD and EDU health interventions. This suggests that the former type of expenditures does not yield benefits in terms of saved human lives. Nor do health expenditures in general and the specific STD and EDU policies enhance utility, so that people do not 'feel better' if the effects of illness are reduced. It is not clear what government expenditures on health care comprise and it may be that they overlap with the STD and EDU health interventions.

3.4.8 Summary

HIV/AIDS models assess the economic impact of HIV/AIDS using CGE analysis. Most empirical models of the macroeconomic implications of the HIV/AIDS pandemic are applied to Sub-Saharan Africa, where the pandemic is at its worst. Kambou et al.'s

(1992) model for Cameroon is the first CGE model to assess the economy-wide impact of the HIV/AIDS pandemic in a series of static and recursive dynamic simulations. The authors presume that the epidemic affects the economy solely via exogenous reductions in labour supply. Kambou et al. (1992) find that HIV/AIDS approximately halves the average growth rate of real GDP, a reduction of two percentage points, and that per capita income remains approximately constant. Arndt and Lewis's (2000, 2001) recursive dynamic model for South Africa not only models the demographic effects of HIV/AIDS, but also accounts for behavioural effects, through government and household responses to mitigate the negative consequences of the disease. In stark contrast with Kambou et al. (1992), per capita GDP and absorption are 8% and 12% lower in the 'AIDS' scenario compared to the 'No-AIDS' scenario and the growth difference is much larger (at a maximum of 2.6%). Improved demographic estimates of the magnitude of the epidemic, as well as an acknowledgement of its long term dynamic nature are explanatory factors of the differences in results. Arndt and Lewis (2000, 2001) show that, given the long incubation period of AIDS, relatively small but sustained negative impacts on rates of growth of labour supply, physical capital and (Hicks-neutral) technological progress produce a significant fall in growth in the long term. Arndt and Wobst (2002) and Arndt (2003) assess the impact of the HIV/AIDS pandemic on the *rate* of human capital accumulation and (future) stocks of labour supply by skill type. Given the evidence of a strong link between educational attainment as measured by skill level, productivity and technological progress, and earnings, the HIV/AIDS pandemic may lead to a less-educated, less-skilled work force and significant reductions in economic growth. In AIDS-stricken countries the education sector typically contracts from the supply side due to teachers dying from AIDS and from the demand side as children are forced to work to compensate for the loss in income of AIDS-stricken parents. The result is a simultaneous increase in the share of young, unskilled people in the workforce and fall in the share of the school age population enrolled in primary education. Using Education Transition Matrices, which capture the way in which children move through the education system, Arndt and Wobst (2002) find negative trends in (primary) school enrolments for Tanzania. A static CGE analysis of skill upgrading of the labour force, which shows that real GDP improves, forms the basis of the qualitative conclusion that the observed slowdown in skill upgrading caused by HIV/AIDS generates negative effects on the economy. This would be further exacerbated by the strong shift in age structure towards younger, inexperienced workers who are less productive and less likely to innovate. Arndt (2003) explicitly incorporates an Education *and* Skill Transition Matrix, which governs transition between various scholastic levels *and* workforce skill levels, into a recursive dynamic CGE model for Mozambique and, using trends in transition probabilities from Arndt and Wobst (2002), derives quantitative conclusions on the effects of the HIV/AIDS pandemic (although careful interpretation is still required due to the weak empirical basis). Arndt (2003) finds a relatively large negative economic impact compared to earlier studies, which is largely explained by the assumption of technological change biased towards human and physical capital. The HIV/AIDS pandemic results in a reduction in real GDP growth of 2.8% to 4.3% at most and, although population and labour supply growth fall as well, per capita GDP falls by about 4% to 12% compared to a ‘No-AIDS’ scenario. Arndt (2003) also assesses the impact of a mitigating education policy, which maintains transition probabilities while demographic effects of the AIDS pandemic take place. In the later stages such a policy enhances growth rates by 0.6% compared to the base ‘AIDS’ scenario, due to the enhanced productivity of a more skilled labour force. The author supports other mitigating policies and preventive policies which, implemented today, may have a high pay off in the long term, because of the long, but finite, duration and severity of the impact of the pandemic. This is a departure from Kambou et al. (1992), who described a people-centred development approach (such as investments in education) as fruitless because of the shortened lifespan of educated people. Nevertheless, issues of resource allocation and priority setting among policies are ignored. Dixon et al. (2004) are the first to model endogenously the impact of the AIDS pandemic and two possible health interventions to mitigate its impact (an STD policy and an education policy aimed at reducing the number of new sexual partnerships) using a recursive dynamic CGE model of the Botswana economy with an embedded epidemiological model. The simulations illustrate the severe consequences of the pandemic, which up to halves disposable household incomes per capita by 2020, and the significance of health interventions, which reduce the adverse effects by more than half. The results are nevertheless preliminary (the model is being refined in terms of household disaggregation, morbidity effects of HIV/AIDS and modelling Ant-Retroviral Treatment), and the authors realise that much remains to be improved, especially with respect to physical and human capital accumulation (being respectively ‘overly optimistic’ and not modelled at all). From a reader’s point of view model assumptions and results are not clear, nor is the definition of government expenditures on health care, as opposed to those related to specific STD and education policies.

Table 3.1 HIV/AIDS models: summary of model structure

Study	Country	Time period	Aggregation	Functional forms	Market Closure	Dynamics*
Kambou et al. (1992)	Cameroon	Calibration: 1979-1980.5 Simulation: 1987-1991	11 sectors (agriculture, manufacturing, services) 4 factors (rural, urban unskilled and urban skilled labour (mobile), sector-specific capital) 1 representative household	Production: Leontief, Cobb Douglas, CES Utility: Cobb Douglas Trade: Armington assumption	Capital: fixed in the short run Imports: small country assumption Exports: market power Macro closure: savings driven Government expenditures: fixed Foreign savings: exogenous Exchange rate: flexible Numéraire: world import price	R: rural, urban unskilled and urban skilled labour supply grows by 2%, 3% and 1% Capital stock updated by investment (shares are function of profit rate differentials)
Arndt and Lewis (2000, 2001)	South Africa	Calibration: 1997-2000 Simulation: 2001-2010	14 sectors (3 services: social, government, and health) 5 factors (professional, skilled, unskilled, and informal labour, capital) 5 households (income quintiles) 7 government consumption, 3 government investment types corporate account	Production: translog, Leontief Utility: Cobb Douglas Trade: Armington assumption Investment demand: activity specific capital coefficient matrix	Sectoral factor market distortions by fixing sector to average return Wage informal, unskilled and skilled labour fixed relative to numéraire Trade: small country assumption Macro closure: savings driven Government expenditure shares: fixed Foreign savings: exogenous Exchange rate: flexible Numéraire: producer price index	R: unskilled, skilled and professional labour grows by 3.05%, 1.6% and 3.1% up to 2001, afterwards rates vary Exogenous growth trajectory real wages informal, unskilled and skilled labour Capital stock updated by investment (as function of profit rate differentials) Total factor productivity grows exogenously
Arndt and Wobst (2002)	Tanzania	Calibration: 1998	12 activities (4 agricultural) 12 commodities 9 factors (3 agricultural and 3 non-agricultural labour types with different education level) 12 households (rural and urban)	Production: CES in value added, Leontief in intermediate inputs Utility: LES Trade: Armington assumption	Factors: fully employed, segmented markets Trade: small country assumption Macro closure: savings driven Investment and government spending: fixed shares Foreign savings: exogenous Exchange rate: flexible Numéraire: consumer price index Explicit modelling of marketing margins and home consumption	S

* R = recursive dynamic; I = intertemporal optimisation; S = static. Reported growth rates correspond to a ‘No-AIDS’ scenario.

Table 3.1 continued

Study	Country	Time period	Aggregation	Functional forms	Market Closure	Dynamics*
Arndt (2003)	Mozambique	Calibration: 1997 Simulation: 1998-2010	19 productive sectors 6 factors (highly skilled, skilled and unskilled non-agricultural labour; skilled and unskilled agricultural labour; physical capital) 2 households (rural and urban)	Production: translog Utility: Cobb Douglas Trade: Armington assumption	Rural-urban migration: wage differentials (elasticity of 0.2%) Sector-specific capital Government deficit: fixed nominally Government consumption by commodity: fixed share of total endogenous government consumption Macro closure: savings driven Foreign savings: exogenous Trade: small country assumption Exchange rate: flexible Numéraire: consumer price index	R: exogenous population growth Labour supply growth: trends transition matrix Exogenous productivity growth highly skilled, skilled, unskilled labour, capital of 4%, 3%,, 2% and 3% respectively (agrees with total factor productivity growth of 2.7%) Capital stock updated by investment (function of profit rate differentials) Foreign savings, domestic savings rates function of rate of return to capital in 'No-AIDS' scenario (elasticities of 0.5 and 0.25 respectively), fixed in 'AIDS' scenario
Dixon et al. (2004)	Botswana	Calibration: 1993/94 Simulation: 1994-2020	41 multi-product sectors, 54 commodities 12 factors (land, capital, labour by: skill, citizen / non citizen, social class) 5 households (rural/urban employed/self-employed, non-citizen)	Production: CES Trade: Armington assumption Transport and marketing margins (endogenous function of efficiency marketing services)	Factor: no full employment in general Baseline: efficiency parameters production, investment shares total absorption and real volume of government expenditures vary In scenarios these are fixed: implies optimistic view in the sense that physical capital accumulation is maintained	R: no-AIDS baseline 1994-2020 using univariate ARIMA time series forecasts for real GDP, imports, exports, real gross domestic investments and population based on 1960-1993. Availability of each labour type grows with workforce

* R = recursive dynamic; I = intertemporal optimisation; S = static. Reported growth rates correspond to a 'No-AIDS' scenario.

3.5 OVERVIEW

The applied literature focusing on the general equilibrium effects of changes in health and health care on the economy is small but diverse in terms of application area. The earliest type of models that acknowledge the economy-wide effects of improved health, Basic Needs models, were designed to implement the basic needs approach to development of the 1970s in a comprehensive framework, with its overarching goal of basic needs satisfaction. Improved health features in terms of demographic variables, working time and labour productivity effects. Nevertheless, health and health policy fulfil only a minor role, and it has proven virtually impossible to disentangle the effect of improved health within counterfactual simulations. Furthermore, Basic Needs models typically are recursive dynamic and applied to developing countries, and by virtue of the latter suffer from lack of data, a rather ad hoc approach to modelling of economic behaviour (not based on microeconomic optimisation behaviour) and abstraction from several general equilibrium elements (such as the endogeneity of prices and the government budget).

Externality models account for the presence of external effects, such as changes in health, education and environmental effects, in a Computable General Equilibrium (CGE) framework. To this date only one CGE model of health externalities exists, that of Savard and Adjovi (1997). Health improvements appear endogenously in the form of improved labour productivity as a function of government expenditures on health (relative to the base year), which influences the optimal combination of inputs in production and relative wages. The main aim of the model, and indeed of most externality models, is to assess whether the standard CGE result of (small) economic benefits from trade liberalisation holds in the presence of positive health and education externalities. The conclusion is negative, as cuts in government expenditure on health and education, aimed at maintaining the government deficit, have negative spill-over effects on domestic product and public sector employment, household income and welfare. A major benefit compared with the Basic Needs literature is that this model is a ‘pure’ CGE model, i.e. firmly grounded in microeconomic optimisation behaviour, and accounts for various inter-sectoral linkages. However, it too is applied to developing country issues in which health is only of secondary importance. Further caveats are a lack of dynamic effects, no distinction between working and non-working or age groups, and absence of endogenous labour supply effects (i.e. the impact of better health on working time) and utility gains from improved health.

The recent class of models of HIV/AIDS assesses the economic impact of HIV (Human Immunodeficiency Virus) and AIDS (Acquired Immune Deficiency Syndrome) using (recursive) dynamic CGE analysis. Generally, this literature models the negative health consequences of the pandemic by imposing exogenous demographic and behavioural scenarios on the economy. Typical features of the pandemic are that it reduces labour supply by skill type, lowers factor productivity and increases household and government expenditures on health care at the cost of expenditures on other goods (like education) and savings. Under these assumptions the literature’s main conclusion is that the slow-down in physical capital accumulation (due to lower savings and investments), productivity growth, population growth and human capital accumulation (due to a fall in supply and demand for education) reduces economic growth and results in a fall in per capita income in the long term compared to a “No-AIDS” scenario.

HIV/AIDS models share with the foregoing strands of literature the application to developing countries and associated data problems. They are relatively more sophisticated though, modelling the impact of changes in health in greatest possible detail and focusing solely on this issue as opposed to more broad development issues. As with Externality models, HIV/AIDS studies incorporate changes in productivity, and as do Basic Needs models, they consider changes in the size and composition of the population and labour force. These negative health effects are, with the exception of Dixon et al.'s (2004) preliminary paper, imposed on the economy in *exogenous* scenarios of the likely impact of HIV/AIDS on a variety of model parameters. HIV/AIDS models generally do not assess *endogenously* the effects of government health policies (or household spending) on the health of the population and labour supply, most likely, due to the incurable nature of the disease. This is illustrated by Arndt (2003), which considers the modelling of a health policy in the form of a massive HAART (Highly Active Anti-Retroviral Therapy) approach. This is not implemented, as treatment and distribution costs are found to be prohibitive and effectiveness would be relatively low, a finding contradicted by Dixon et al. (2004). Nevertheless, in the latter study other government expenditures on health care do not affect health and welfare. Expenditures on health care in the HIV/AIDS literature are thus generally seen as a consequence of the disease - which is not curable up to this date – and therefore have no positive health and welfare impact whatsoever, and instead crowd out other expenditures (like education, which negatively affects skill accumulation) or reduce savings, investments and hence growth.

From the foregoing analysis one may conclude that, although the labour productivity effect of improved health is well-established, most of the reviewed models do not endogenously assess the impact of changes in health care provision on the size and composition of the population, the labour force and its impact on production, income and welfare over time in a (developed country) CGE setting. This thesis attempts to address this caveat by modelling the endogenous labour supply, i.e. working time, effect by skill type of changes in health care provision, whilst recognising the resource claims made by the health care sector in terms of capital and, more importantly, labour inputs, using a CGE model for the UK.

CHAPTER 4

THE UK HEALTH CARE SYSTEM: PAST, PRESENT AND FUTURE

4.1 INTRODUCTION

This chapter gives an overview of the UK health care system and policy. It provides the foundations for the UK-focused model with health provision effects developed in Chapters 5 and 6 and sets the scene for the range of policy options that will be scrutinised. Rather than giving a full-fledged historical account of all aspects of UK health care (as in Rivett, 1998), the UK health care system is described from a policy perspective (following the approach of Klein, 2001), with priority areas discussed in more detail. A policy-oriented approach is justifiable on the grounds that the UK health care system is highly politicised (for example, from the 1980s - when waiting lists became sizeable, "doing something about waiting lists" became a *sine qua non* of electoral programmes of all political parties). Most of health care in the UK is in fact provided publicly through the National Health Service (NHS) and so, more than in any other country in Europe, changes are largely politically motivated.

Section 4.2 outlines the evolution of the UK's health care system up to its present state, supported by some facts and figures in section 4.3. Section 4.4 highlights the pressures in UK health care and those policy options the government has in resolving these that can be handled in a Computable General Equilibrium (CGE) framework. The challenges faced by the health care system in the UK, and in other countries around the world, typically revolve around the issue of rationing.

4.2 THE EVOLUTION OF UK HEALTH CARE

The UK health system approaches a so-called 'command model' of health care provision, which uses central planning to finance, produce and allocate health care according to some predetermined criteria. In the UK, the criterion of equity (fairness) has been the single most important influence in the development of the NHS (Office of Health Economics, 2002, p10). How did this system come about? This section provides an account of the development of the health care sector in the UK over time, dominated by NHS provision.[1] The analysis is narrowed down geographically to England as, encouraged by devolution, health service provision differs from that in Scotland, Northern Ireland and Wales.[2]

4.2.1 Pre-1948: the inheritance of the NHS

Early 20th century health care was provided predominantly by family or general practitioners (GPs), voluntary hospitals and municipal (local authority) hospitals. General practice was almost invariably a business run by one man single-handedly. GP care was free of charge for low-paid workers under Lloyd George's National Insurance Act of 1911, but not for their wives and families and not for those workers with a higher standard of living, whose demands were curtailed by fees-for service. Voluntary hospitals, financed by voluntary contributions and income from their investments, were often founded for the benefit of the sick poor by philanthropists and social reformers (such as William Marsden's Royal Free Hospital) or by citizens "*proud of their towns and anxious to perpetuate their names*" (Rivett, 1998, p7). They were the most

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1 It follows the policy-oriented approach towards the history of UK health care of Klein (2001), supplemented with elements of the more factual account of Rivett (1998).

2 The European Observatory on Health Care Systems (1999) is a good reference for health care developments in the UK constituencies of England, Scotland, Wales and Northern Ireland.

prestigious type of hospitals, were responsible only to themselves, and aimed to provide quality care to a limited number of patients, usually excluding the elderly and chronically ill. Although well-managed, the reliance on voluntary contributions meant that ‘voluntaries’ struggled to fulfil their duties. The 1929 Local Government Act allowed local authorities to develop Poor Law institutions (‘workhouses’) into municipal hospitals. Institutional funding came from local taxation (the ‘poor rate’) and, although being proper hospitals, most kept their Poor Law functions by providing social as much as medical care. They mostly focused on diseases with a high external cost to society (infectious diseases like tuberculosis and smallpox) and functioned as a ‘dumping ground’ for cases that were not likely to improve with treatments and so were transferred to them by the voluntaries (i.e. the elderly and chronically ill).

The Pre-NHS system, being largely a private system with limited access for the poor and minimal private insurance, led to extensive unmet need of those unable to pay, high morbidity and mortality and low expectations: *“Pain and discomfort were accepted as part of life to be endured with stoicism. The family doctor had to be tough to get on with his many interesting and rewarding tasks….Working class people did not expect to be comfortable. Most went hungry…Many were miserably cold in winter…Successful treatment by the family doctor was accepted with gratitude and the many failures were tolerated without rancour or recrimination.”* (Rivett, 1998, p2).

The supply of health care was poorly co-ordinated (the relationship between the municipal and voluntary hospitals was strained due to the regular dumping of chronic cases onto the municipal sector) and unequal across regions (suppliers were located in the more prosperous areas).

Finally, by the mid-1930s, the system was no longer financially viable. While advances in medical knowledge, medicines and technology drove up costs of provisioning, charitable giving and local taxation were not yielding nearly enough funding to support hospital activities.

The inadequacies of the health system set the stage for change. But while observers agreed that the health care system required improvements, there was disagreement as to how the health care system should be organised in the future. In the late 1930s and early 1940s three visions emerged: (a) extending National Insurance (supported by the British Medical Association and adopted post-war by many European countries), (b) establishing health care as a local government service (as subsequently adopted in Scandinavia) or (c) creating an independent, centralised service supported by public funds. The last choice, of nationalisation, was favoured by the experience of communal action and the increased sense of social solidarity during the Second World War. The war had, in effect, nationalised the health system already: for example, a National Blood Transfusion Service had been set up for treatment of military and civilian casualties, and an Emergency Medical Service to provide care in emergency situations. An important political factor enhancing the “command” model’s prospects for adoption was the election of a post-war Labour government by one of the largest majorities in British history. The Attlee government was explicitly committed to a programme of public ownership and had Aneurin Bevan, a radical and passionate proponent of the NHS, as Minister of Health.

The creation of the NHS in 1948 was the result of a great many compromises (Klein, 2001, p9, discusses these as dilemmas) on party-political differences, interests of central versus local government and of government versus the various care suppliers, and on the extent of coverage (inclusion of mental illness and dental care), many of which remained unresolved until well after the implementation.

4.2.2 The 1948 NHS framework

The 1946 NHS Act envisaged (citation from Klein, 2001, p1): *"…a comprehensive health service designed to secure improvement in the physical and mental health of the people of England and Wales and the prevention, diagnosis and treatment of illness, and for that purpose to provide or secure the effective provision of services."*

The service was comprehensive in scope (provision of care 'from cradle to grave'; no health care area was excluded), available to all (irrespective of contribution) and free at the point of need. The creation of the NHS brought 1,143 voluntary and 1,545 municipal hospitals (amounting to nearly 500,000 beds) into public ownership with negligible additional resources, but what did change was that the poor now had access to medical services, i.e. 'the masses joined the middle classes'. In order to make sure that finite resources were employed where they were most needed, Bevan introduced some organisational changes.

The hospital service was administered by centrally-appointed (rather than elected) bodies and all recurrent spending was financed by the central government (H.M. Treasury) through general taxation. Administrative powers and funding were devolved to local regions on the basis of requirements for service delivery. Health regions typically differed from history-based local government regions. However, local authorities retained their health functions of providing community care.

It was originally envisaged that all medical personnel would become salaried state employees. But GPs insisted on retaining their independence, which forced Bevan to compromise. Whereas specialists received salaries, subject to negotiable terms of service and the right to treat private patients in NHS hospitals, GPs who joined the NHS continued to be paid on a capitation basis (seen as a "defence against the perils of state servitude" Rivett, 1998, p30). Since people were free to register on a GP's list and GPs were being contracted to provide care for those on their lists at established fees and allowances (so-called responsibility fees), a GP's income would depend on his/her list size, services offered and revenues from other, non-NHS, activities.

Despite many reforms, especially those in the 1990s, much of the basic structure of the 1948 NHS remains in place today.

4.2.3 Emerging problems: from meeting needs to rationing

Instead of being a unified system, the NHS was polarised into GP, local authority (community) and hospital (i.e. regional) care, which continued to create administrative problems for years. More substantial, however, were the financial problems caused by escalating expenditures in response to rising demands, compounded by growing inefficiencies.

<u>Rising expenditures</u>

The cost of the NHS far exceeded initial projections, which were based on presumptions that pre-war health care expenditure trends were appropriate predictors of future trends and that health care expenditure would be 'self-liquidating' by improving population health. With the benefit of hindsight, these presumptions were clearly wrong. Firstly, medical practice is intrinsically expansive due to technological advances, which raise expectations and demands for new and often more expensive drugs and treatments.[3] Secondly, providing a free service in itself encourages demand. Thirdly, improved health tends to enhance health care demand rather than reducing it. Generally, people feel they would benefit from some form of health care (even if health improvements are marginal). More important in this respect though is the impact of ageing: improvements in life expectancy imply that people live longer and so demand further health care, which is generally more expensive because of the 'survival of the unfit' (Rivett, 1998, p111), meaning that curing people of simple, cheap diseases enables them to fall ill from more complex and expensive diseases.[4]

Inefficiencies: supplier-induced demand and pay disputes

The early NHS had a built-in institutional inefficiency, which was the demand generated by the professional providers of the service, a problem known as supplier-induced demand. The GPs were the so-called 'gatekeepers' of the health care system, which meant that patients could only access the system via an appointment with the GP (or practice nurse), who could then, if necessary, effect immediate treatment or direct the patient to the 'right' specialist. Whilst this system is in itself efficiency enhancing,

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3 Technical progress which reduces the unit production cost may increase the total cost of health care as the fall in price is likely to cause a rise in demand. If the technical improvement is purely quality enhancing, demand (including demand of those previously deemed untreatable) at any price goes up. However, once adjustments for improvements in health outcomes are carried out, for example in terms of preventing more serious conditions from developing and increasing the length of life, the cost may well fall rather than rise. The presence of insurance further enhances cost by inducing patients and/or doctors to choose higher cost treatments as they are reimbursed anyway (moral hazard). See Folland et al. (2001, p310-313).

4 See Emmerson et al. (2000, Section 7) for more on the impact of ageing on health care costs in the UK. The authors report on evidence which suggests that the greatest proportion of health care spending amongst the elderly tends to be incurred in the final stages of one's life so that it is not age or longevity *per se* that matters for per capita health care costs, but remaining length of life. Longevity is not a problem as long as people live longer in a healthy state. Accordingly, the differences in health spending across age groups would be explained by differences in the composition of the age groups in terms of decedents (costly) and survivors (less costly) and the positive impact of ageing on future health care spending would be much less than predicted.

by for example reducing search costs and curbing frivolous demands, it places financial control at the discretion of GPs and specialists. Since their incomes were only loosely related to the number of patients treated (specialists' salaries, GPs' responsibility fees) and costs were covered by the NHS, doctors were primarily concerned with improving patient welfare without regard to any financial constraints. If doctors prescribed more and/or more costly medicines, there was little anyone could do.

Another source of cost escalation was the increased pressure exerted by the medical profession for increases in their pay. Since the private sector was virtually non-existent, the NHS effectively had a monopoly of employment of medical labour. It determined not only demand, but also supply (by determining the number of medical school places) and indirectly set an upper limit on labour payments via its system of capped budgets, introduced in the 1950s, from which all health care costs, including labour, had to be met. Wages were essentially fixed in bilateral bargaining rounds between the Department of Health (DoH) and the medical profession, in which the latter fared particularly poorly in the 1950s. Consequently, the NHS had been able to depress the incomes of the medical profession, to the dismay of the latter: for example, whereas average incomes in the period 1950-59 rose by 20%, the average income of GPs and health administrators had fallen by the same percentage.[5] However, since the 1950s periodic reviews of remuneration throughout the NHS have been carried out. The outcome of the consequent bilateral bargaining between the Minister of Health (constrained by the Treasury) and the medical profession (represented by the British

5 Next to the GP as 'gatekeeper', this was the second efficiency-enhancing measure incorporated in the original NHS. The so-called 'pool' system for GPs was abolished in 1966, when a basic allowance (i.e. salary element) was introduced in the calculation of GP earnings.

Medical Association and other unions) - the latter threatening strike action and withdrawal from the NHS - usually recommended increases in remuneration.

Potential solutions: the role of user charges and rationing

In the early 1950s, changing the system of NHS finance in favour of an insurance-based system was deemed undesirable by Bevan for reasons of equity, i.e. fairness in the distribution of resources (Klein, 2001, p29). With respect to health care provision, it was argued that the allocation of health care ought not to depend on the contribution made but on needs. On the funding side, a progressive tax system could achieve a more equal distribution of income. Moreover, and particularly relevant for later governments, the political cost of doing so would be very high. By 1958, despite the many (mainly financial) problems and controversies (mainly about introducing charges, discussed below) there was a consensus on the NHS amongst all parties involved: "*As an institution the NHS ranked next to the monarchy as an unchallenged landmark in the political landscape of Britain*" (Klein, 2001, p25). Ever since, it has been virtually impossible for governments to attack the NHS (they simply had to work with it) and resulted in political parties competing to become the NHS's 'best friend'.

The unwillingness of the Attlee and subsequent governments to change the system of health care funding meant that the NHS was compelled to compete with other government departments for general tax revenues, further compounding the financial problems.[6] For example, in the 1950s the NHS's reputation as a 'penitent financial sinner' - Bevan talked about the 'cascades of medicine' pouring down British throats

[6] At the same time this financial constraint led to the 'advantage' of keeping the NHS cheap by international standards.

(Klein, 2001, p31) - meant that expenditures on the NHS rose only marginally, despite a period of economic growth, with detrimental effects on, for example, hospital provision.

Not surprisingly, politicians reverted to a policy of charging user fees, the absence of which had led to excess demand in the first place; in 1952 a 5d prescription charge was introduced, as was a flat rate of £1 for ordinary dental treatment. However, pricing policy - although regularly surfacing throughout the history of the NHS[7] - never played a major role in NHS revenue generation and demand management. According to Bevan, nominal charges would only marginally affect demand and revenue. If charges were to be substantial, one would have to introduce exemptions for the least well-off to protect equity, which would increase administrative costs, bring back the means test into the health service and reduce revenue (most health care demand derives from poorer people so that most of health care demand would be charge exempt).[8] Moreover, introducing charges could prevent people with middle incomes but genuinely in need from seeking access to health care and could compromise the doctor-patient relationship.

The financial crisis of the late 1940s and early 1950s - caused by the incompatibility between ever expanding demands and limited resources - led to the recognition that the provision of an adequate health service was utopian. Consequently, the NHS rather than being an instrument for meeting needs, as originally intended, became an instrument for rationing scarce resources. The "bottom-up" approach for allocating budgets was replaced by a "top-down" approach, in which capped budgets were determined for local

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[7] Like 'hotel' charges to hospital patients in the 1950s, prescription charges in the 1960s and thereafter, and consultation charges for primary care in the 1990s.

[8] A means test would impose payment for services according to ability to pay. While ensuring access to the poorest, a means test was considered morally wrong as it implies identification of a 'sub-class' of payers, which runs against the principle of providing free health care irrespective of contribution.

authorities, which had discretionary power over how to allocate expenditures within the centrally determined limit. This implied increased professional autonomy, but at the same time increased conflicts between the centre (the government), unable to control clinical autonomy of the NHS providers ("policy making through exhortation", Klein 2001, p39), and the periphery (local authorities, the medical profession, etc.), forced to work within centrally imposed budgetary limits.

Geographical inequities in health care

The increased focus on cost control resulted in the neglect of the distribution of health care, which deteriorated significantly in the 1950s. Given the overall constraints on the health budget, basing the distribution of capital on historic inheritances which favoured the southeast of England (London) was politically most appealing.[9] The 1962 Hospital Plan of Enoch Powell was the first attempt to allocate resources to needs according to centrally determined criteria based on national norms for the appropriate number of beds for each region. These, and other plans to increase hospital size, were only partially carried out, primarily for political reasons: (1) politicians as vote-maximisers favour negative action (such as avoiding hospital closure) over positive action (which, except for pay increases, offers hardly any political gains); (2) in fact, whatever action was undertaken, the size of the waiting lists remained constant, around 600,000, due to the feed back of improved services to increased referrals by GPs; (3) politicians largely work for the benefit of the next government due to the time-lag between policy design and implementation; (4) labour in the NHS is well organised as an interest group (via BMA, trade unions) and so governments favoured current spending (including wage

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[9] Although, in terms of labour, the measure of restricting access of new entry GPs to well-endowed areas seemed successful in improving geographic distribution.

payments) over capital spending; and (5) consumers of health care, who would favour increased availability of hospital services, lacked institutional representation to voice their concerns (Klein 2001, p59).

Practical difficulties resulting from uncertainty about the future size and composition of the population and its geographical diversity further complicated central planning. Consequently, governments gradually abandoned planning through norms on the desirable level of provision in favour of an equitable distribution of resources across regions. The 1976 Resource Allocation Working Party (RAWP) rationed available resources according to needs by weighting the population by age, gender and mortality factors. This formula, as any other, could not guarantee equity in access, so geographical differences in access (possibly motivated by spatial variations in health outcomes and so needs) could well, and in fact did, arise (so-called ‘postcode rationing’). Also, the RAWP was based on growth; regions which were relatively underprovided simply received a relatively rapid annual increment of growth so that no region was made worse off. In periods of recession, as became apparent in the 1980s, this could not be sustained.

4.2.4 The 1991 Reforms: introducing the internal market

Since 1948, the NHS has been subject to numerous changes and reforms. The most radical of these, however, were those outlined in the 1989 White Paper “Working for Patients” of the Conservative Thatcher Government, which passed into law in 1990 as the NHS and Community Care Act.

Despite the many successes (rising number of nurses, doctors, dentists, more treatments, fall in waiting times, reduced regional inequalities, etc.) there were continuous, and increasing pressures, both external (e.g. media published scare stories on the NHS on a daily basis) and internal (the medical profession's discontent with the NHS) on subsequent governments to change the health service. These demands ultimately originated from the government's inability to resolve the widening gap between demands and resources, which had been present ever since the establishment of the NHS in 1948, but which had grown worse in the periods of economic crisis of the 1970s and 80s.

There was disagreement as to what drove the increased excess demand: was the NHS under-funded or were resources simply used inefficiently? The former view, held by the medical profession (the so-called 'inputters'), demanded increased cash injections and supported a move towards health insurance to secure extra funding.[10] The latter opinion, held by the Thatcher government (the 'outputters'), saw the solution in improvements in efficiency (which principally referred to productivity: squeeze more outputs out of available inputs) by changing the incentive structure on the supply side.[11] Since conclusive evidence supporting either position was absent, the political debate turned into a 'dialogue of the deaf' (Klein 2001, p151). It demonstrated once more that there was no agreed way of measuring the 'adequacy' of health care expenditures.

The drastic proposals of "Working for Patients" were prepared and implemented in haste by a Thatcher government which was aspiring to, and indeed secured, another term in office in 1992. The consultation process borrowed ideas from North America's

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[10] For reasons explained before, user charges to curb demands and recover costs never really came off the ground.

[11] Besides productive efficiency, allocative efficiency (supplying the types and quantities of health care that consumers want) had to be improved.

health care reforms, put forward by leading expert Alain Enthoven (Rivett, 1998, p360), and lessons learnt from reforms in education (Klein, 2001, p161), and excluded the medical profession, in the presence of which consensus was deemed impossible.

Working for patients

The White Paper contained amongst others, two major changes, which together created the internal, mimic, market. Firstly, purchasers (Health Authorities - HAs) were separated from providers (Hospitals and Community Health Services). The former received funds from the government with which to purchase health services required by their populations on a weighted capitation basis (prohibiting the cross-boundary flows allowed under the RAWP). The latter were transformed into independent NHS Trusts, which had to compete (along with private providers) for contracts with purchasers of health care. Secondly, the 1991 reforms introduced the concept of GP fundholding. GPs who entered the scheme were allocated a budget, based on their list size, with which to purchase health services for their patients from NHS Trusts (and also the private sector). The GP budget covered most costs of treatments, including staff costs, prescription medicines and a range of hospital services, and any remaining surplus could be reinvested in the GP's practice[12], so encouraging the efficient use of resources (in line with the idea of the GP as gatekeeper). Conversely, if GPs failed to keep within budgets (and if NHS Trusts made losses) their independent status would be revoked. Fundholding was implemented gradually and voluntarily, and those who did not join the scheme continued to be controlled by HAs. By allowing consumers to switch between

12 NHS trusts making a profit from sales to GPs were also allowed to retain (and accumulate) these funds for discretionary use.

GPs if unhappy about the services they provided, the GPs were to be made more responsive to consumer demand.

The internal market in practice

Within five years, virtually all hospitals had become NHS Trusts and approximately 50% of GPs had opted to become fundholders. Hence, in the 1990s effectively two NHS models were running in parallel (fundholding and non-fundholding).

It seems probable that fundholding led to efficiency gains in some areas. For example, with respect to prescription behaviour, a GP fundholder who trades off a budget surplus with patient health from prescribing would prescribe less items per patient and substitute cheaper, generic drugs, compared to a non fundholder, who seeks perfect patient health only (which can never be optimal given diminishing marginal returns).[13]

It remains nonetheless unclear whether overall efficiency in health care improved, due to sharp rises in management costs and some features of the internal market that did not work in practice (see also Klein, 2001, p174 and p194 and further). Firstly, money did not seem to follow patients. For example, people did not readily change GPs in practice and so responsiveness of GPs to consumer demand was rather weak. Similarly, HAs were dependent on NHS Trusts for the provision of health care for their populations, Trusts being relatively better informed about health services, and were reluctant to change providers as this could endanger the stability of service provision. Their focus on building long-term relationships with NHS Trusts reduced competition and consumer choice. Secondly, the notion of an internal market was unrealistic as the NHS

[13] See for example Whynes et al. (1997a, b).

consisted of a collection of different types of markets, some monopolistic (such as ambulance and accident and emergency services, and the medical profession itself with its restricted competition among its members), others highly competitive (such as elective surgery). Competition varied across regions, with the London area being relatively more competitive compared to other regions and having been hit relatively hard by the 1991 reforms. Consequently, government intervention to smooth the impact of the reforms on the capital was required, thereby enhancing costs. Government policy to allow mergers between NHS Trusts for the sake of slimming down the NHS also ran contrary to the aim of promoting competition.

The record with respect to equity was also mixed. Critics of the internal market feared that hospitals and GPs would refuse expensive treatments and select only the healthiest patients who were less costly to treat ('cream skimming') so as to safeguard their budgets. Whereas these fears proved unfounded, the introduction of the internal market did seem to create a 'two-tier health system': there was evidence that NHS Trusts, in competing for patients from the fundholding sector, treated fundholders' patients more quickly than non-fundholders' patients, which ran counter to the stated objective of fair and equal access for all.

The detrimental equity consequences, together with inefficiencies arising from, for example, increased bureaucracy, are likely to have led to the abolition of the internal market by the Labour government in 1999.[14]

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14 See also Koen (2000), Docteur and Hoxley (2003, p37-39), Propper (2001, p174-176) and Smee (2000) for an assessment of the UK's reform experience.

4.2.5 1997 and onwards: Politics of the Third Way

In 1997 the Labour party, led by Tony Blair, came to power in a landslide victory and brought with it new politics (referred to as the "Third Way") and a new approach to health care provision. It was keen to avoid the mistakes made by previous Conservative governments *and* Labour governments ('Old Labour'), but at the same time aimed to build on what had worked previously. It laid out its vision for the future of the NHS in the White Paper "The New NHS: Modern-Dependable".

The New NHS: Modern-Dependable

As regards the NHS organisation, the Labour government partially rolled back some of the features introduced by the Conservative government. The competition of the internal market was replaced by cooperation (partnership) between organisations (including the private sector), with a greater role for primary care providers (local GPs and nurses) in the provision of health services. Firstly, the internal market was abolished, while retaining the split between purchasers and providers. And secondly, fundholding was discarded and replaced by Primary Care Groups (PCGs). The creation of the latter institutions essentially implied the universalisation of fundholding. PCGs simply combined all GPs and other primary care providers in a given geographical area. Initially, PCGs were formally part of HAs, with devolved responsibilities for managing the budget for the health care of their patients. Over time, they were intended to become freestanding Primary Care Trusts (PCTs), still accountable to HAs but with the additional task of providing community health services. PCGs would operate within a 'single cash limited envelope' (Klein, 2001, p205), which covered their population's share of all NHS services (which, as in GP fundholding, included prescribing).

Beyond organisational reforms, the Labour government targeted the following areas of health care provisioning for improvements, which it identified from past experience. Firstly, it placed greater emphasis on improving public health (apparent from, for example, the decisions to appoint a Minister for Public Health and to ban tobacco advertising) and reducing inequalities in health. This focus arose from the recognition that health care is only one of the many factors influencing population health, and hence that health care policy aimed at reducing ill health and inequalities in health should be part of a broader policy framework, including education, housing, and so on. Secondly, it concentrated on the development of instruments for promoting efficiency and quality. Having discarded the internal market, a new mechanism had to be put in place to ensure that both the efficiency and the quality of health care were promoted. Improved performance measurement (by Performance Indicators[15]), supported by the threat of central interventions if providers underachieved, was seen as the way forward. Moreover, it created several institutions, among them the National Institute for Clinical Excellence (NICE),[16] which regulated the medical profession.[17] Both of these measures were part of a stated aim to renew the NHS as a genuinely national service, offering fair access to health care of consistently high quality, in which postcode rationing was no

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15 Performance Indicators (PIs) actually date back from the early and mid-1980s but were in those days of minimal importance. The use of PIs to achieve efficient provision is not without problems: as ‘sticks’ (punishments if providers underperform) PIs may increase rather than reduce pressure on providers thereby frustrating efforts to perform well, whereas as ‘carrots’ (subsidies to reduce inefficiencies) PIs may create perverse incentives by rewarding providers who fail to meet targets and could lead to focus on dimensions of performance subject to financial incentives at the expense of performance in unaffected areas.

16 The main purpose of NICE is to give guidance to patients, health professionals and the public on current “best practice” in terms of individual health technologies (including medicines, medical devices, diagnostic techniques, and procedures) and the clinical management of specific conditions. Using both clinical and economic evidence, NICE recommends treatments for use in the NHS if they are deemed cost-effective (providing good value for money). See also NICE (2003).

17 See Klein (2001, p209-211) and Rivett’s update on Quality at http://www.nhshistory.net [13 July 2004] for the multiple forms of regulations and audits created by the Labour government in recent years.

longer acceptable. The government was determined to enhance confidence in the NHS as a public service which should be responsive to needs and wishes of carers and patients.

The new NHS in practice: the re-emergence of rationing

Labour's election promises of 1997 in the sphere of health care included, amongst others, to reduce the waiting list by 100,000 people by the time of the next election, to reduce waiting times for hospital inpatient admission to a maximum of 18 months, to end waiting for cancer surgery and to set high quality standards for hospitals. These improvements were to be funded by cutting management costs (as preceding Conservative governments had pledged) by £1 billion. The original policy of fiscal austerity as part of the campaign to get rid of its 'tax and spend' image was relaxed somewhat with respect to the NHS, and eventually abolished altogether in 2000 (made possible by a favourable global environment), when the government conceded that the NHS had been systematically under-funded, with too few doctors and nurses. Blair announced that spending on the NHS would rise from 6.7% in 2000 to 8% of GDP in 2006, equal to the EU average. Since then, frequent announcements of additional funding for the NHS and organisational reforms have been made in a number of White Papers, starting with *The NHS Plan* (DoH, 2000a).[18]

The government's commitment to explicit targets and its stress on performance measurement made the NHS a more and more transparent organisation and its

[18] For a detailed factual analysis of recent developments in UK health care policy and the role of successive Secretaries of State for Health - Frank Dobson (1997-1999), Alan Milburn (1999-2003) and John Reid (1993-) - therein, see the updates of Rivett (1998) available from http://www.nhshistory.net. For the NHS plan and progress made since, see http://www.nhs.uk/nationalplan/ and http://www.publications.dh.gov.uk/nhsplan/ [13 July 2004].

shortcomings accordingly became increasingly visible to the public, a problem further compounded by heightened media attention to the service. Amongst many other examples, the case of ‘Child B’ in 1995 (denied potentially lifesaving but expensive treatment for leukaemia), variations in access to and quality of services across regions (postcode rationing), and comparisons between the UK and Western European health care systems (in which the UK particularly faired badly) brought negative publicity for the NHS; the health care system appeared to be in ‘perpetual crisis’ (Klein, 2001, p224). At the heart of these shortcomings lay the ever-present gap between virtually limitless demands and finite resources. Scarcity required rationing, defined as decision-making about the allocation of scarce resources over competing needs, for which the government was increasingly held responsible.[19] The issue of rationing, made apparent by the presence of waiting lists, and the challenges this poses for future governments is further explored in section 4.4.

4.3 UK HEALTH CARE IN 2004: SOME FACTS AND FIGURES

This section gives a global picture of the current situation of health services in the UK in terms of provision, finance and performance, which result from the political reforms described previously.

4.3.1 Service delivery and coverage: public versus private care

The UK health system is dominated by the state provision, via the NHS, to which every person normally resident in the UK is entitled. With the arrival of the NHS in 1948 the private sector was virtually eliminated overnight. In the 1970s and 1980s private health care provision increased dramatically, primarily as the result of the growth of

[19] The establishment of NICE should be seen as the government’s response to it no longer being able to diffuse blame onto the medical profession for controversial rationing decisions.

employment-based insurance schemes. Since the 1990s private health insurance coverage and the share of private in total health care expenditure have remained fairly constant at around 11.5% and 16% respectively.[20] Over two thirds of private health insurance is employer-provided, and coverage is skewed towards the higher socioeconomic groups. Private health care use is not confined to the insured but also includes patients (approximately 20% of private patients) who pay for treatment themselves.[21] Private provision is mostly of secondary (hospital) care, but dominates in the sector of tertiary (social) care, which offers long-term care in residential and nursing homes to the mentally ill, people with learning difficulties and the elderly, together with a range of domiciliary services provided to people in their own homes. Private primary care is very small.[22]

The distinction between public and private health care becomes increasingly blurred by the hiring of skills and facilities from the state sector by private providers and vice versa.[23] For example, all NHS medics working in the secondary sector have contracts that allow them to provide private treatment, about two thirds doing so[24], and many

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[20] The former is likely to be the result of the economic recession and sharp increases in insurance premia (European Observatory on Health Care Systems, 1999, p43). The latter is largely due to the government's commitment to increase public health expenditure (see for example DoH, 2000a).

[21] Emmerson et al. (2000, Section 5), King's Fund (2001a, Chapter 2), European Observatory on Health Care Systems (2002), King and Mossialos (2002).

[22] European Observatory on Health Care Systems (1999, 2002), Smee (2000), King's Fund (2001a, Chapter 2), National Audit Office (2003a).

[23] King's Fund (2001a, Chapter 4) further explores public-private boundaries in UK health care, the way they are shifting and become obscure, and the government's stance on these.

[24] King's Fund (2001a, p85). Consultants working full-time are permitted to earn up to 10% of their gross income from private practice, those working part-time may engage in private practice without restriction by giving up payment for one NHS session per week (King's Fund, 2001a, p83-89; European Observatory on Health Care Systems, 2002, p107).

NHS facilities are available for hire by private providers (e.g. NHS pay beds[25]). Conversely, the Secretary of State for Health signed a Concordat with the private sector in November 2000 which allows renting of spare operating theatres from the private sector for hip operations and other elective surgery by NHS doctors and nurses.[26] The government also seeks cooperation with the private sector to fund the building of acute hospital facilities through the so-called Private Finance Initiative (PFI), though their ownership remains in the public domain. One of the latest moves towards a more private, i.e. market, approach is the introduction of Foundation Trusts which, compared to the normal NHS Trusts, are allowed greater financial and managerial autonomy, although remaining part of the NHS.[27]

The increased use of private alternatives to the NHS is often regarded as proof that the public is increasingly dissatisfied with the quality of NHS provision, especially with long waiting times. Evidence shows, however, that private health care users also use public health care, suggesting that, in spite of increasing dissatisfaction with the NHS, people using private health care do support the concept of public provision (they regard private health care as 'quicker' but not necessarily 'better').[28]

Long waiting times for treatments and rising incomes combined with tight constraints on NHS funding might be expected to increase demand for private insurance. The

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25 These are beds in NHS hospitals which consultants may use for private patients. King's Fund (2001a, p53-54 and p80-83).

26 King's Fund (2001c).

27 See the pages on Secretaries of State for Health, Alan Milburn and John Reid available at http://www.nhshistory.net/ for more information on Foundation Trusts.

28 European Observatory on Health Care Systems (1999, p45), King's Fund (2001a, p90), Propper (2000).

impact of an expansion of the private sector on the NHS remains unclear however. On the one hand, growth in private health care could reduce pressures on the NHS by, for example, reducing waiting lists and times in the NHS. On the other hand, NHS service provision could deteriorate as staff move into private health care, so that effectively a two-tier health system arises in which the NHS functions as a ‘poor service for the poor’.[29] While NHS waiting lists fall if patients are diverted to the private sector, waiting times in the NHS could well rise as the private sector (using NHS staff) treats patients almost immediately.[30]

4.3.2 Workforce

The NHS workforce has risen by an impressive 224200 persons (21%) since 1997 and currently accounts for 1.3 million people. This amounts to approximately 24% of the public sector labour force, 4.3% of the total labour force, and makes it the world’s third biggest employer, after the Chinese Army and the Indian State Railways.[31]

As shown in Figure 4.1, the majority of NHS workers, approximately 84%, are directly involved in patient care, which includes doctors (109000), nurses (386400), scientific, therapeutic and technical staff (122100), ambulance staff (16000) and support staff in each of these areas (360700 in total), as well as GP practice staff (88400). The remaining 16% (199800) provides infrastructure support, which comprises clerical and

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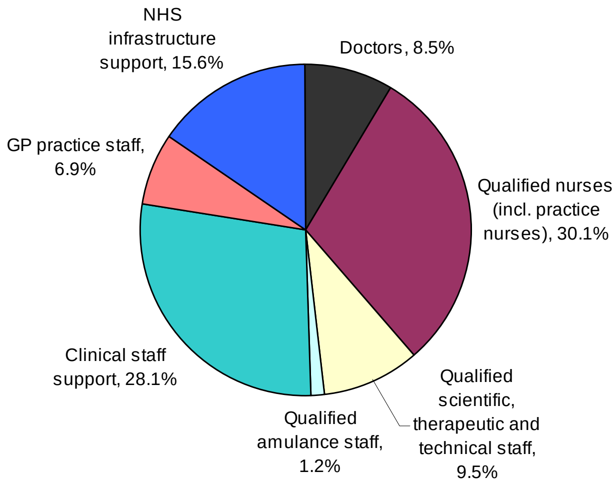
29 Propper (2000, p856).

30 Emmerson et al. (2000, Section 5), Propper (2000; 2001, Section 8) and King and Mossialos (2002) discuss the interactions between public and private health care provision in more detail. The balance of evidence suggests that dual practice is detrimental to NHS waiting times (Jacobs et al., 2003).

31 “NHS is world’s biggest employer after Indian rail and Chinese Army”, Sam Lister, The Times, 20 March 2004.

administrative staff in central functions and hotel, property and estates and managers.[32] The latter takes up only about 3% of total NHS staff (35300), a fact used by the government to contradict the myth that nearly everyone working in the NHS is a bureaucrat or manager and to show that extra money is spent efficiently.[33] Even so, growth figures by staff category are in favour of critics of the government and show that over the period 2002-2003 the number of managers has risen faster than the number of doctors and nurses (9.4%, compared to 5.1% and 5.5% on the previous year respectively).

Figure 4.1 NHS workforce categories September 2003



Source: DoH (2003c)

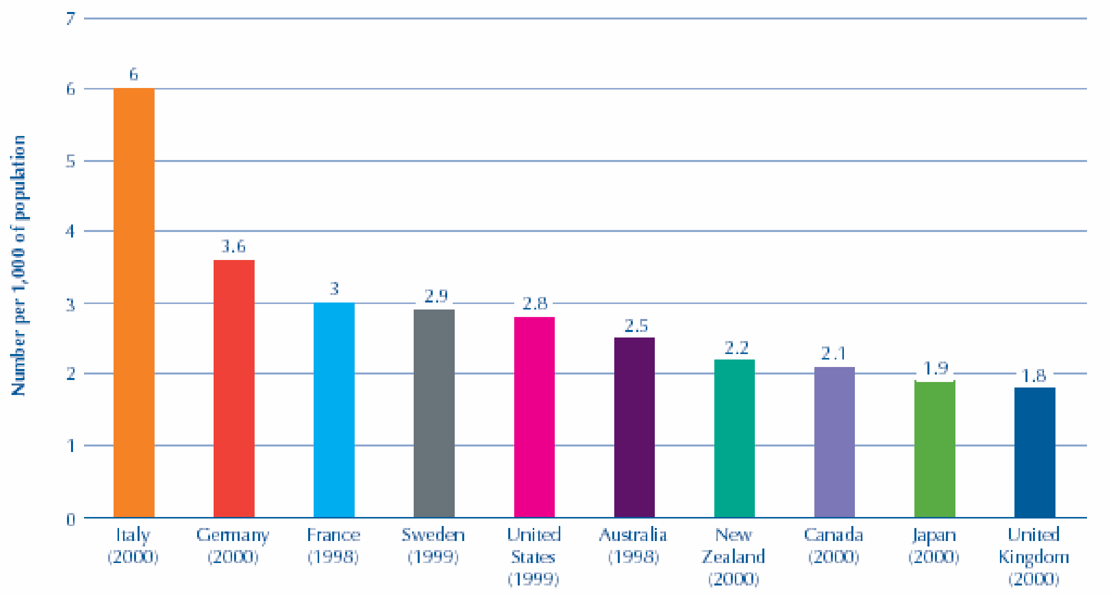
Although the NHS employs over 1 million people, there are shortages of GPs, nurses, midwives and other health care staff such as physiotherapists and radiographers, which

32 Figure 4.1 excludes opticians, dentists and pharmacists as they may work in the NHS or private sector. The number of doctors includes 32600 GPs (excluding retainers, i.e. qualified doctors who are - for the time being - unable to work in full time general practice usually for family or personal reasons, but wish to maintain their GP skills by working a limited number of hours).

33 See for example Audit Commission (2002, p14-15).

the government seeks to correct by, for example, improving employment conditions (including pay) to retain existing staff, investing in training and recruiting from abroad.[34] Staff shortages are apparent from international comparisons.

Figure 4.2 Number of practicing physicians



Source: National Audit Office (2003a, Figure 7).

Over the past 20 years the number of physicians in the UK has risen steadily, by 40% in total; however other countries have generally reported even higher growth rates. Consequently, the number of doctors in the UK per 1000 population is the lowest of all 10 comparator countries shown in Figure 4.2 (G7 plus Australia, New Zealand and Sweden). In terms of practising nurses, the UK is second lowest (Figure 4.3).[35]

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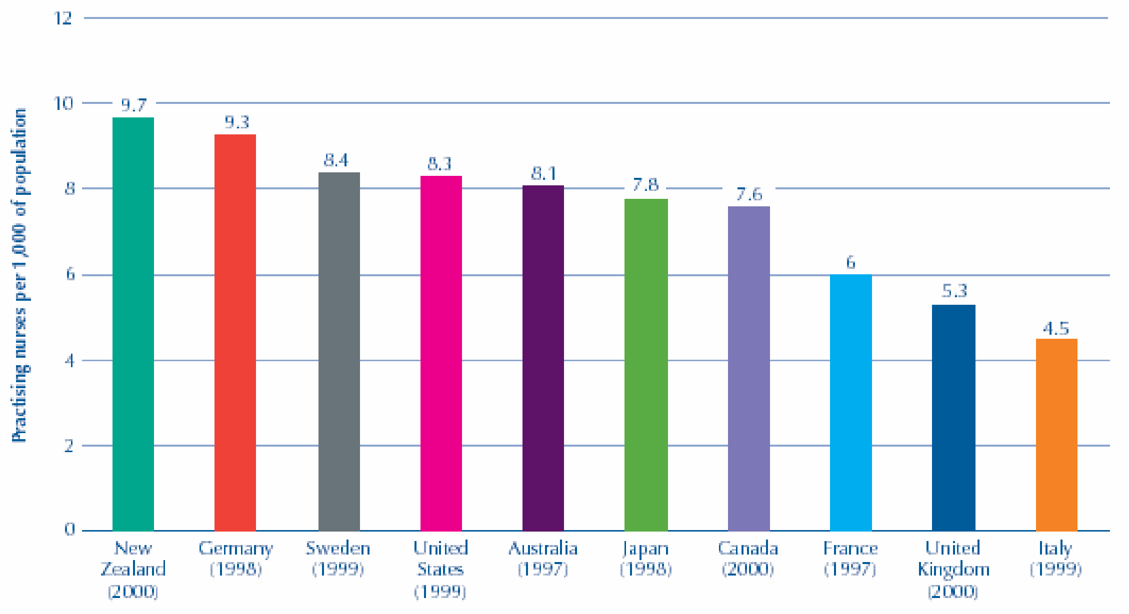
34 See for example King's Fund (2001d), National Audit Office (2001), Audit Commission (2002). Ironically, staff shortages are exacerbated by a relatively high rate of sickness absence: 4.9% across all NHS trusts compared to an average of 3.7% in the public sector (National Audit Office, 2003b, p1).

35 All data represented in this section need careful interpretation due to definitional differences across countries and other sources may report different figures. With respect to the UK data, the reported number of doctors and nurses are for the NHS only and, for nurses, are full-time equivalents. Private sector nurses account for approximately 25% of all qualified nurses.

Figure 4.3 Number of practicing nurses



Source: National Audit Office (2003a, Figure 9)

The Organisation for Economic Co-operation and Development (OECD, 2003) reports 8.8 practicing nurses per 1000 population, in line with the EU average and slightly above the OECD average of 8.1, and 2 practising physicians per 1000 population. Using these data, the UK has a relatively high nurse to physician ratio of 4.4 which questions which of the countries adopts the 'appropriate' skill-mix in health service delivery.

Figures 4.2 and 4.3 conceal differences in the pattern of health service provision across countries. For example, the number of acute admissions and average length of stay are relatively low for the UK (147 per 1000 of population and 6.2 respectively in 2000[36]), so that the UK performs better once the data are standardised for these variables, as shown in Figure 4.4 and 4.5 for the number of nurses.[37]

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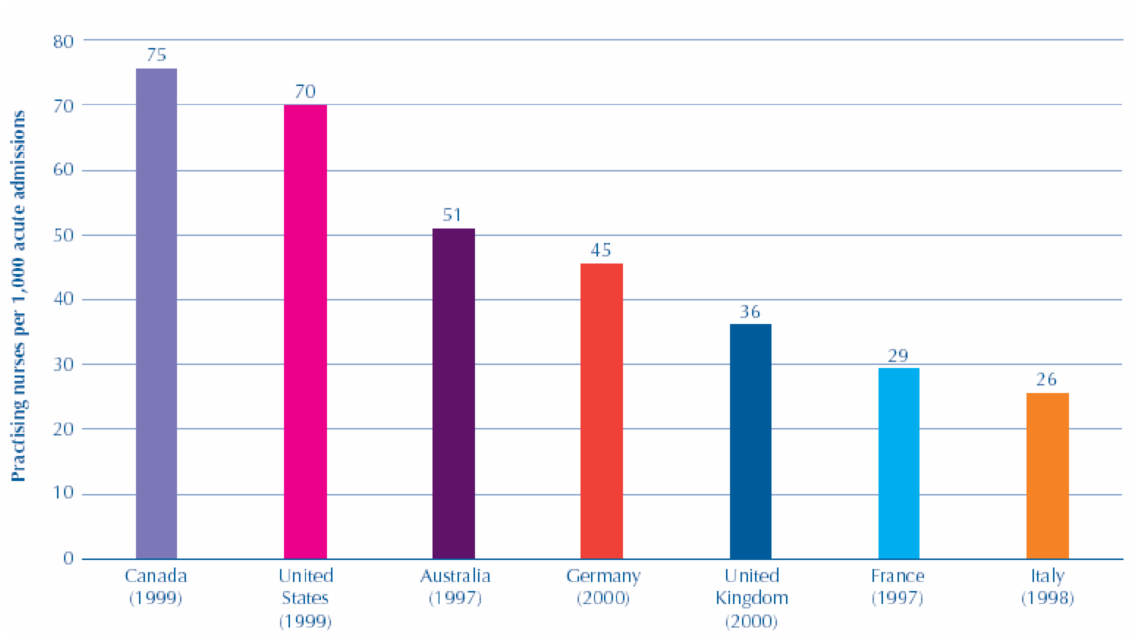
36 See Figure 4.20. OECD (2003) reports an average length of stay of 6.9 days.

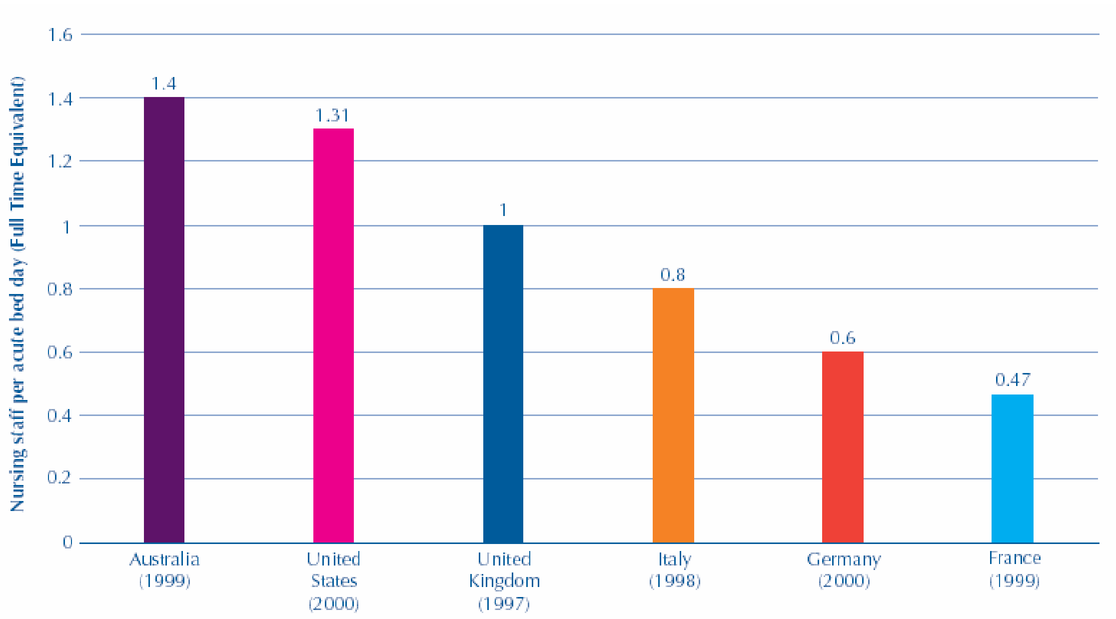
37 Acute care is health care required for a brief but severe period of illness, for conditions resulting from disease or trauma, and recovery from surgery.

Figure 4.4 Practicing nurses per 1000 acute admissions



Source: National Audit Office (2003a, Figure 11)

Figure 4.5 Practicing nurses per acute bed day



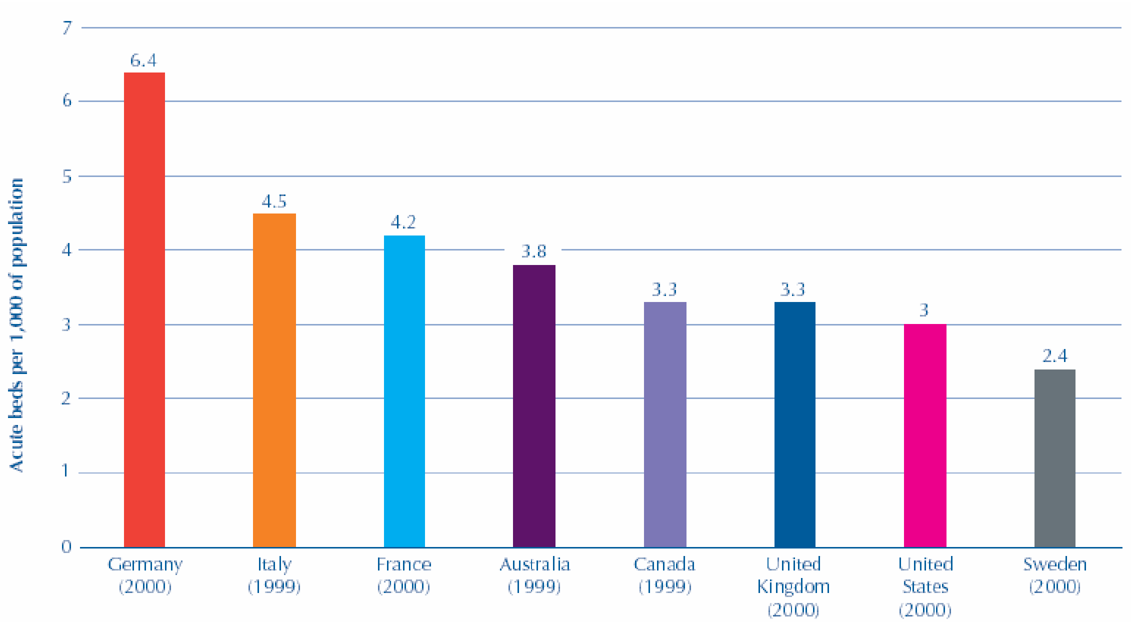
Source: National Audit Office (2003a, Figure 12)

4.3.3 Capacity

Since the establishment of the NHS in 1948, the number of hospital beds in Great Britain has fallen due to a switch from social care in hospital to care in the community, shorter lengths of stay and an increase in the use of day surgery. The decline has now come to an end as the government aims to increase the acute bed availability in order to reduce bed blockages (King's Fund, 2001b; OECD, 2003).

The UK ranks relatively low in terms of bed numbers (Figure 4.6) and available Magnetic Resonance Imaging (MRI) units (Figure 4.7). The latter is an indication of the level of investment in new technology and how advanced medical equipment is (National Audit Office, 2003a, p14).[38] Again, these comparisons may be misleading as they conceal variations in, for example, utilisation. Figure 4.8 shows that the UK has the highest acute bed occupancy of all comparator countries for which information is available.

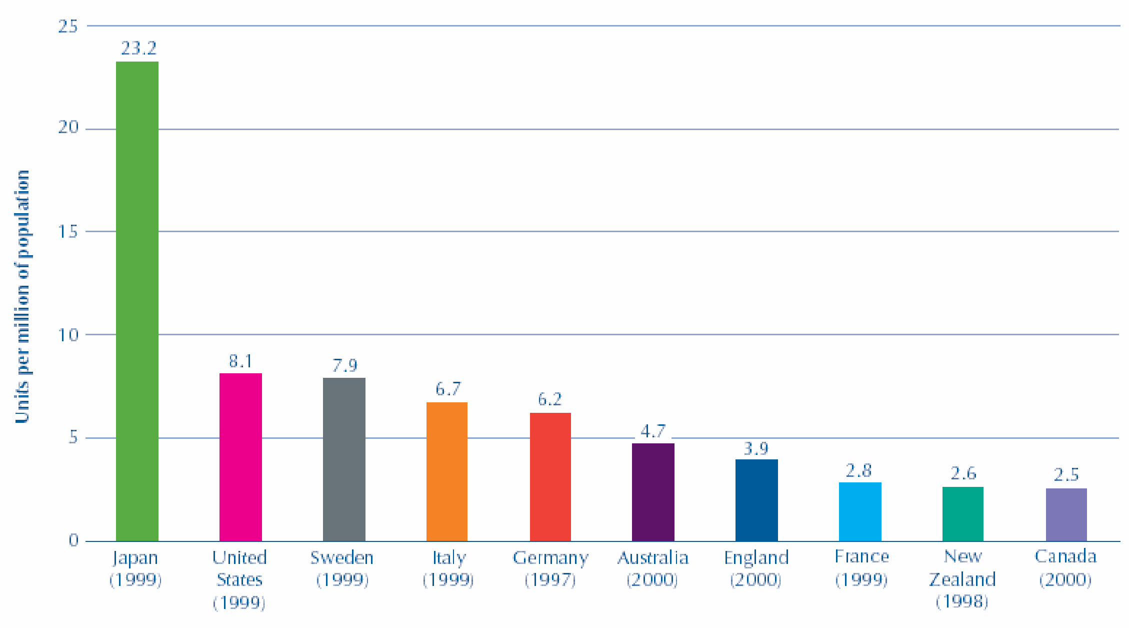
Figure 4.6 Number of acute hospital beds per 1000 of population



Source: National Audit Office (2003a, Figure 13)

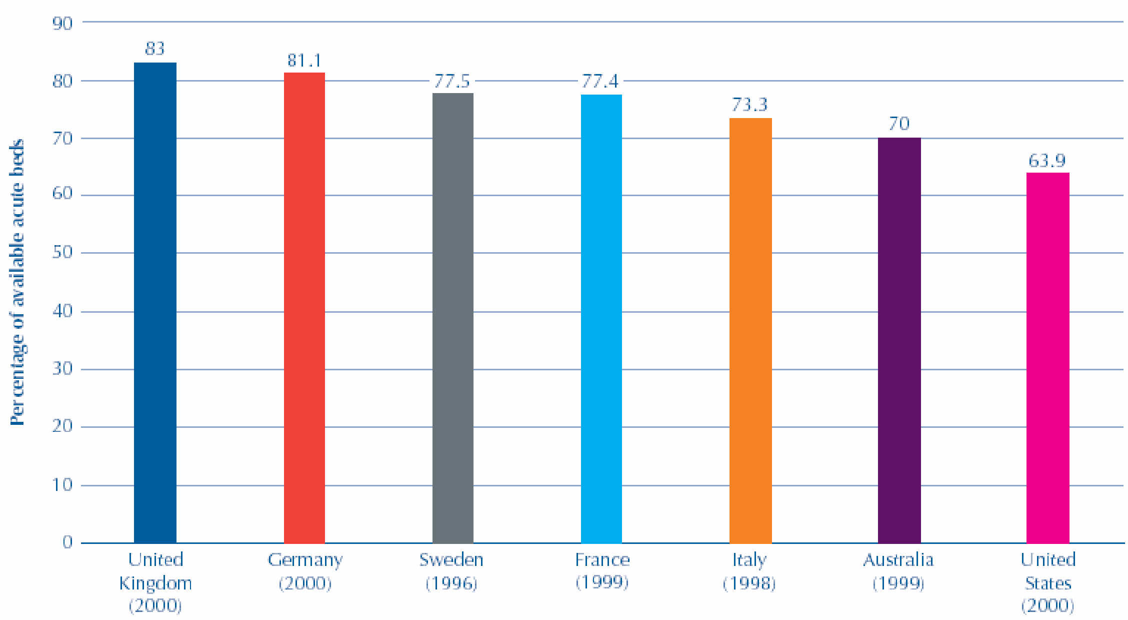
38 OECD (2003) figures for the number of acute care hospital beds and the number of MRI units in the UK in 2000 are 3.9 per 1000 of population and 4.6 per million of population respectively.

Figure 4.7 Number of Magnetic Resonance units per million of population



Source: National Audit Office (2003a, Figure 15)

Figure 4.8 Bed occupancy for acute beds



Source: National Audit Office (2003a, Figure 14)

4.3.4 Pharmaceutical industry

Pharmaceutical products either belong to the category of generic drugs (medicines marketed without a brand name) or branded drugs. The government in the UK requires doctors to prescribe only from an approved lists of drugs, mostly generic products, which, being out of patent, are cheaper (but arguably less effective). Drugs on the so-called "blacklist" are prohibited from being prescribed by GPs on the NHS, whereas products on the "grey list" may be prescribed under stringent criteria.[39]

A different set of pricing rules applies to generic and brand name drugs under current UK legislation. Prices for generic drugs are regulated under the Maximum Price Scheme (MPS), whereas brand name medicines fall under the Pharmaceutical Price Regulation Scheme (PPRS). Both schemes have been established to curb pharmaceutical prices (and profits) so that pharmaceuticals are available to the NHS at an affordable price, whilst recognising that prices should be sufficiently high to enable the pharmaceutical industry to develop and market new and improved medicines.

Price regulation of brand-name products: the PPRS

The PPRS is a voluntary agreement between the DoH and the branded pharmaceutical industry, represented by the Association of the British Pharmaceutical Industry (ABPI), to limit branded medicine prices and profits on sales to the NHS.[40] A series of such agreements have been in place since 1957, each lasting 5 years approximately, and have evolved over time resulting in the last agreement made under Section 33 of the Health Act 1999. Negotiations on a new scheme between all parties involved started at the end of the year 2003. The scheme does not cover generic drugs or branded products available without prescription, i.e. over the counter medicines, except those prescribed

39 Kullman (2001, Section 3.1.1)

40 Information on the PPRS is based on ABPI (2003), DoH (2003e, 2003f).

on the NHS by a doctor. Whereas the PPRS allows companies freedom of pricing for all major new products within the constraint of their PPRS profit target, the DoH's consent is required for further price increases. The UK-wide PPRS scheme applies to some 10,000 products and covers approximately 80% of the value of medicines (of approximately £6.5 billion) and 47% of dispensed prescription items used in the NHS in primary and secondary care, the remainder being taken up by generic drugs. Since the first of October 1999, scheme members have been required to reduce prices of those medicines covered by the PPRS by 4.5%, which delivered annual savings to the NHS of about £200 to £250 million.

As the PPRS limits companies' ability to raise the prices of brand name drugs, it is not surprising that the market for brand-name products has experienced few price changes. Although the industry has not been found to be highly concentrated and the prices set by new entrants in the post-patent period are lower, the incumbent usually does not reduce its list price in reaction to new entry while it is able to retain most of its market share. The latter result is counterintuitive and suggests the presence of a first-mover advantage. On top of that, prescribers base their decision on medicines needed by the patient primarily on the basis of clinical need, while neither the prescriber nor the patient pay for the cost of the drug. This may have contributed to the absence of a clear link between the price and volume of brand-name pharmaceuticals under the PPRS. The latter rose by 7.8% (mostly represents a rise in prescriptions for heart disease, high blood pressure and mental illness), which is less than the 12.1% increase in NHS-spending in 2001/02. The overall proportion of expenditures on medicines remains around 12% of total NHS cost, as in previous years. International comparisons of branded pharmaceutical products, although influenced by factors such as the mix of medicines included, exchange rate volatility and international differences in price control policies, suggest that UK drug prices are significantly lower than those in the USA but higher than those in other European countries. The latter is primarily caused by the appreciation of the pound sterling.

Price regulation of generic products: the MPS

Up to mid-2000 the NHS relied on competition in the market for generic medicines to secure stable supply of generic drugs at affordable prices. In 1999 the generics market experienced significant price increases of many generic products which were accompanied by shortages in supply. Overall, prices increased by approximately 35%, which is estimated to have cost the NHS in England £200 million.

Spiralling costs of generic pharmaceuticals sparked a wide-ranging investigation into alleged price-fixing and restrictive supply of drugs. The Serious Fraud Office is investigating six companies suspected of defrauding the NHS for up to £400 million over prices charged for penicillin-based antibiotics and the blood thinning drug Warfarin, used to counter strokes and heart attacks over a period of four years (1996 to 2000). In 2002 a £28 million legal action was brought against 6 companies over Warfarin. In December 2003, the NHS launched a lawsuit of £30 million against seven pharmaceutical companies over alleged price fixing of a range of common, penicillin-based antibiotics. The NHS further continues investigations into suspected anti-competitive behaviour over more than 30 other drugs, with an estimated cost to the NHS of £170 million, which are expected to lead to further legal actions.[41]

[41] See also “Drug firms face charges over £400m NHS ‘fraud’” (The Sunday Times, 9 November 2003), “NHS investigates £210m drugs sales”, “NHS sues over drug makers ‘rip-off’” (The Times,

In response to the turbulence in the generics market, the government put in place a statutory Maximum Price Scheme in August 2000.[42] This scheme prohibits the sale of certain unbranded generic medicines to community pharmacies and dispensing doctors for NHS use at more than the maximum price. It does not apply to over-the-counter medicines or the sale of generic medicines to hospitals, for which different rules apply.[43] Generally speaking, the MPS applies to some 500 unbranded generics with the highest net ingredient cost (NIC). The maximum prices are primarily based on historic reimbursement prices.

Since the scheme was implemented, reimbursement prices for generics (prices paid by the NHS) have returned to their pre-increase levels and the supply of generics to community pharmacies and dispensing doctors has stabilised. With a view to preserving secure and stable supply conditions and prices in the long-term the government has started negotiations on an alternative proposal in 2001, which it intends to implement in April 2004 in place of the MPS.[44]

Contribution to the economy

The pharmaceutical industry is not only important for the health sector as an intermediate input (see health care finance and expenditures), but also a major

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22 December 2003), "NHS sues drug companies over price-fixing claims" (Tash Shifrin and agencies, Guardian Unlimited, 22 December 2003), "NHS seeks £30m from drug firms in price fixing claim" (James Meikle, Guardian Unlimited, 23 December 2003).

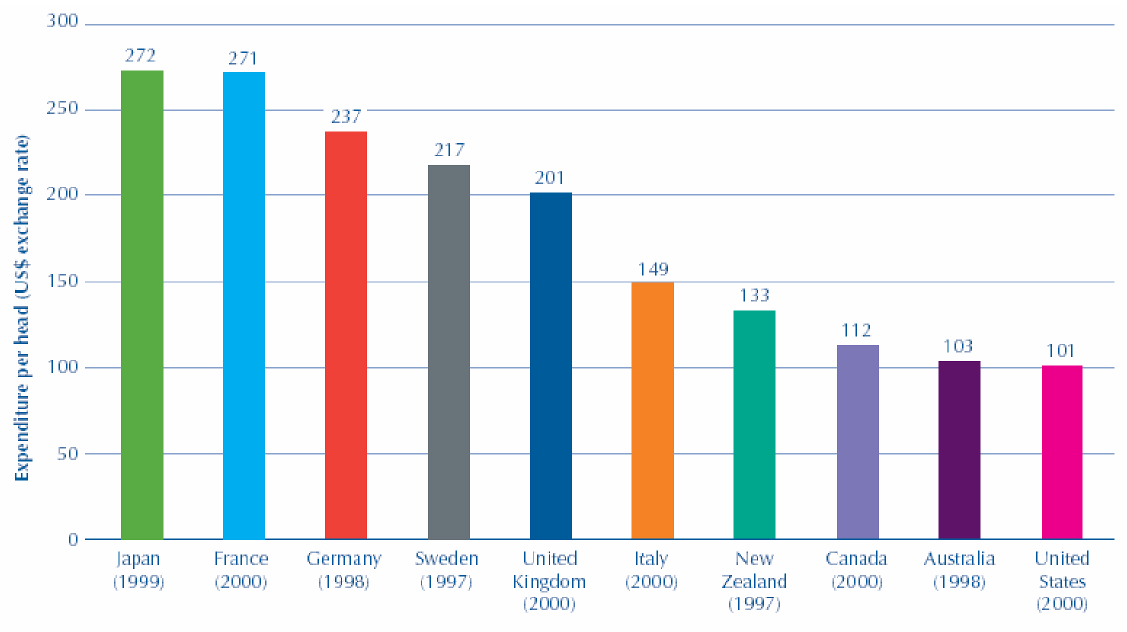
42 The scheme is laid down in the Health Service Medicines (Control of Prices of Specified Generic Medicines) Regulations 2000 (DoH, 2000b). Kullman (2001) provides an overview of pharmaceutical (pricing) policies in the UK.

43 See Kullman (2001, p18-22).

44 In short, the proposal as it stands (DoH, 2003g) allows for more price discretion where there are many manufacturers, whereas in case of a less competitive market consent of the DoH is required. The price of new generics may be set freely provided it is set below the price of the branded version.

contributor to the UK economy in terms of employment (it employs approximately 70,000 people directly, with an estimated 250,000 in related activities), research and development (it accounts for around 24% of UK's total manufacturing industry expenditure on R&D, a value of over £3.2 billion in 2002, which is higher than any other country in Europe) and exports (value of pharmaceutical exports is approximately £10.3 billion, generating a trade surplus of £2.8 billion).[45]

Figure 4.9 Public funding for drugs and other medical non-durables prescribed for outpatients (per capita US$)



Source: National Audit Office (2003a, Figure 16)

Figure 4.9 shows public expenditures on pharmaceuticals and other non-durables prescribed to hospital outpatients for a selection of countries. Cross-country differences follow not only from definitional and/or time differences but also from disparities in the regulation of the pharmaceutical market. With $201 pharmaceutical expenditure per head the UK is the middle-ranking country. Compared to other European countries, only

45 Data are for 2002 (DoH, 2003e, Section 5).

Denmark, the Netherlands and Ireland have lower per capita pharmaceutical expenditures.[46]

4.3.5 Health care finance and expenditures

Financial provision for the NHS is set by the government over a five-year planning period, and the responsible department (the DoH) must bid for a share of the overall budget (approximately 16% in 2003-04) in competition with other government departments such as the Ministry of Defence and the Education department. The NHS administration itself works to a rolling three-year planning horizon, and may seek marginal adjustments to state finance on an annual basis. The Treasury uses the Barnett formula to allocate health care resources over the UK constituencies, yielding a distribution which has historically favoured Scotland, Northern Ireland and Wales over England.[47] Whilst one may argue that this reflects needs because health outcomes compared to England are poorer, an equally valid observation is that the current pattern of health expenditures may actually be legitimising inefficiency in provision.[48] The budget is further broken down between regions, based on needs and outcomes.[49]

In the 2002 Budget, the government announced an annual average increase in NHS expenditures of 7.3% in real terms between 2002-03 and 2007-08, equivalent to a total increase of 42% in real terms over this period.[50]

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46 Association of the British Pharmaceutical Industry (2003, p5).

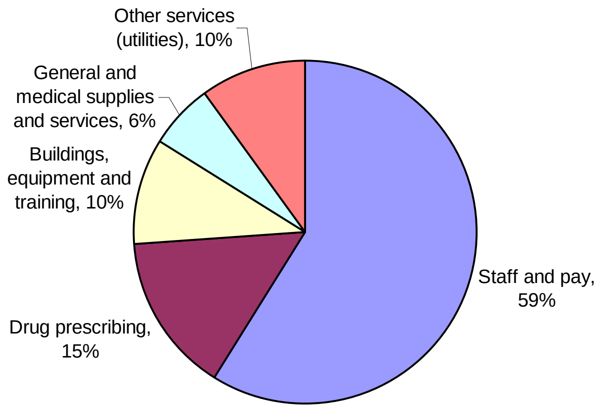
47 Treasury Committee (1997).

48 Dixon et al. (1999). Poor health outcomes could for example reflect less efficient technology.

49 In the spirit of the RAWP weighted-capitation formula (discussed in Section 4.2.3), although it has become relatively more sophisticated over the years.

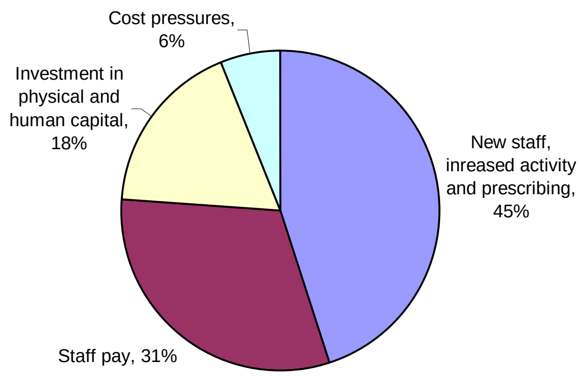
50 DoH (2004b).

Figure 4.10 NHS expenditure in 2003-04 by destination (total £63.7 billion)



Source: DoH (2004b)

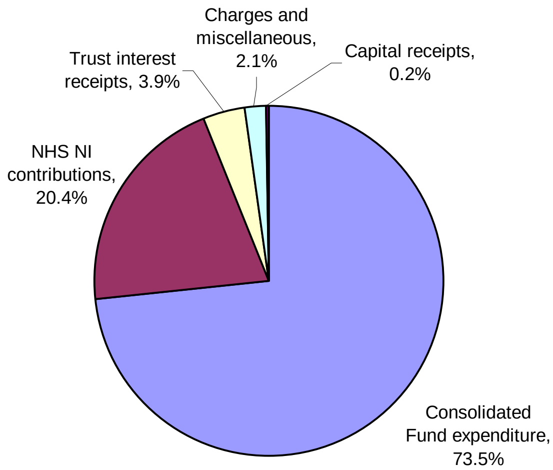
Figure 4.11 NHS expenditure increase in 2003-04 by destination (total £5.9 billion)



Source: DoH (2004b)

For 2003-2004 NHS net expenditure will increase by £5.9 billion to a level of £63.7 billion, which – as shown in Figure 4.10 - will be allocated to staff costs (59%), drugs (15%), investment in buildings, equipment and training (10%), other services (10%, predominantly utilities) and general medical supplies and services (6%), including medical equipment, bandages, catering and cleaning. The additional resources are mostly to be spent on attracting new staff, increased prescribing, the provision of more goods and services and staff pay aimed at retaining existing staff and attracting new employees (see Figure 4.11).[51]

Figure 4.12 NHS sources of finance, 2003-04



Source: DoH (2003d)

The main sources of finance of the NHS budget are displayed in Figure 4.12. The majority of NHS spending is met from the Consolidated Fund - general taxation - and the NHS element of National Insurance contributions, 93.3% in total; the remaining 6.7% comes from user charges and receipts, including land sales and proceeds from income generation schemes. While payments towards National Insurance are separated from general taxation for accounting purposes, National Insurance contributions do not influence eligibility for NHS care and are thus tantamount to an income tax. User charges generate 2% of NHS resources and operate in the area of NHS pay beds and,

51 A further breakdown of expenditure by, for example, type of condition, region, type of care and age/client group is provided in the Departmental Reports (DoH, 2003d and 2004b).

more importantly, in the area of family health services, where they are levied on pharmaceutical, dental and ophthalmic services. Prescription charges for pharmaceutical products are £6.40 per item in England[52], but exempt large sections of the population, including children, elderly, people on low income, chronic ill and for specific uses (e.g. contraception). Approximately 85% of prescriptions are charge exempt. A similar practice occurs in dentistry, where co-payments of 80% of the cost of treatment up to a ceiling of £378 are not levied on certain priority groups, and ophthalmic services, where eye tests are provided for free to priority groups and government support is available to meet the cost of spectacles.[53]

According to the latest estimates of the Office for National Statistics (ONS)[54], private health care accounted for a further £13.7 billion in 2002, which brings total health care expenditures in the UK up to £80.6 billion in 2002, 7.7% of GDP, of which 83% is public and 17% is private. Private health care expenditures comprise out of pocket payments for treatments and over the counter medicines (approximately 12%) and private medical insurance (approximately 5%).

UK spending on health care is typically below the OECD and the EU average. In 2001, total health care expenditure accounted for 7.6% of GDP in the UK, compared to an

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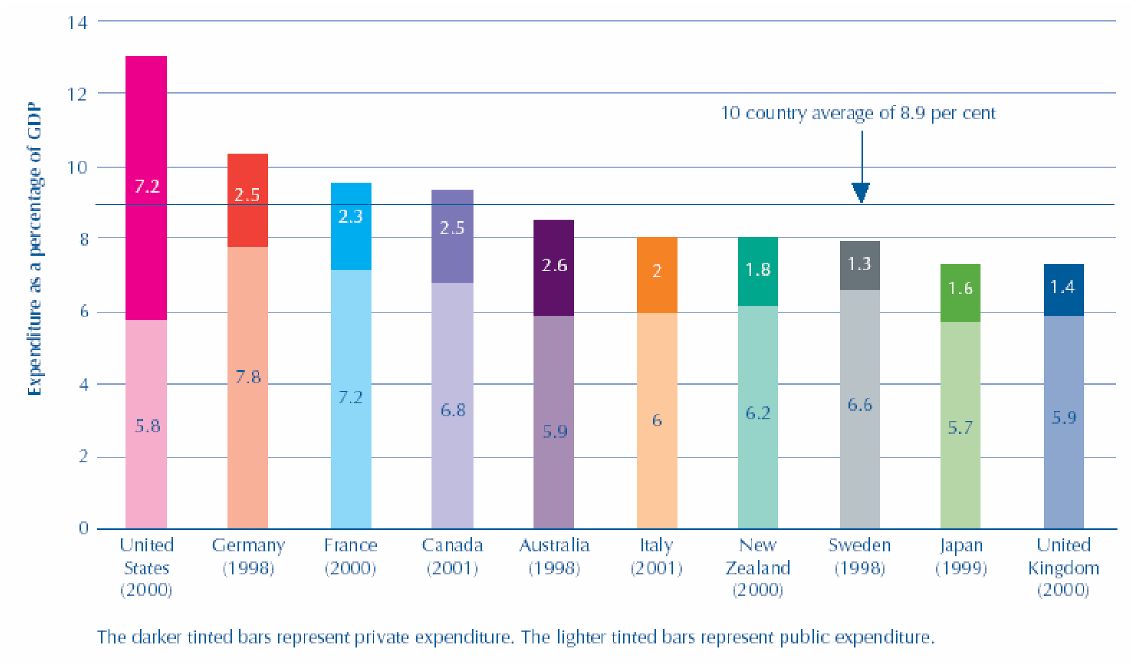
52 Data are valid from the 1st of April 2004 (see also HC12 form "NHS prescription Charges from the 1 April 2004" available at http://www.dh.gov.uk/assetRoot/04/07/37/06/04073706.pdf [13 July 2004]).

53 For more information on user charges in the NHS see European Observatory on Health Care Systems (1999, 2002). With respect to dentistry, from the late 1990s many people have been unable to find an NHS dentist in there area - just 44% of adults and 60% of children are registered with an NHS practice, and have turned to private health care, bearing the full cost of treatment (around 75% of people) or choosing or paying towards a private insurance plan (approximately 25%). This is the consequence of disputes with the government over pay in recent years, which have led NHS dentists to reduce the amount of NHS services or to withdraw from the NHS altogether.

54 Available at: http://www.statistics.gov.uk/ [13 July 2004].

OECD average of 8.4% and an EU average of 8.3%. The share of expenditure accounted for by the public sector is relatively high. In 2001 the share of public expenditure in the UK was 82%, compared to 72% and 73% on average for the OECD and the EU respectively.[55] The relatively low level of health spending has prompted the government to commit itself to the aforementioned increases in health spending, which would lift total spending on health care to 9.4% of GDP in 2008. Figures 4.13 to 4.15 illustrate. Comparisons may be misleading, however, due to definitional and/or time differences, and more importantly due to differences in health system performance, the subject of the next section.[56]

Figure 4.13 Health expenditure as a % of GDP in recent years

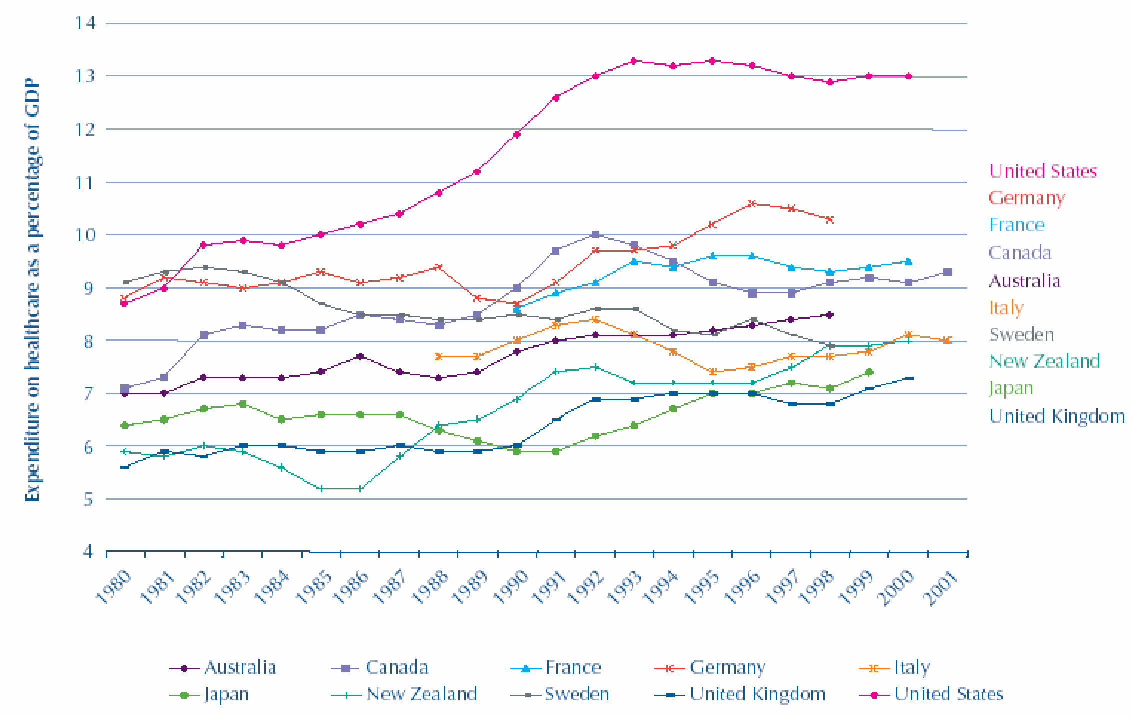


Source: National Audit Office (2003a, Figure 2)

55 Data are from OECD (2003).

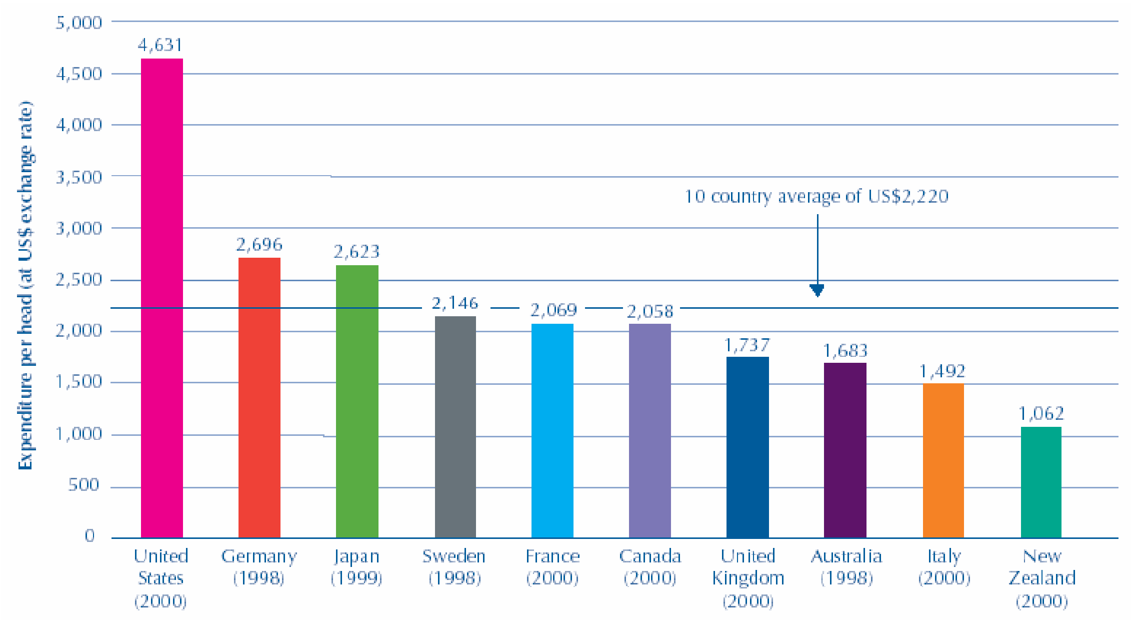
56 For example, the UK's health system may be more cost-effective than other countries, thereby delivering more value for money despite low levels of health spending.

Figure 4.14 Health expenditure as a % of GDP, 1980-2001



Source: National Audit Office (2003a, Figure 3)

Figure 4.15 Per capita health expenditure (US$)



National Audit Office (2003a, Figure 4)

4.3.6 Health care performance

This section assesses the performance of health care provision in the UK, where possible relative to other countries, using indicators of health outcomes, efficiency, equity and quality.

Health status

In general, the health of the population is not only dependent on the health sector (and health policy), but also varies with factors such as lifestyle (smoking, drinking) and diet, income, income distribution, housing and education. Moreover, a range of health measures exist which may yield different country rankings.[57]

Commonly used health measures are life expectancy at birth and potential years of life lost, as displayed in Figure 4.16 and 4.17.[58] In terms of the former the UK ranks relatively low, but with smallest gender differences, whereas in terms of the latter the UK performs significantly better.

Improvements in life expectancy are partially caused by declines in infant mortality[59], shown in Figure 4.18. Countries with relatively high infant mortality rates in 1980 have decreased their rates relatively faster, resulting in a smaller spread in 2000.

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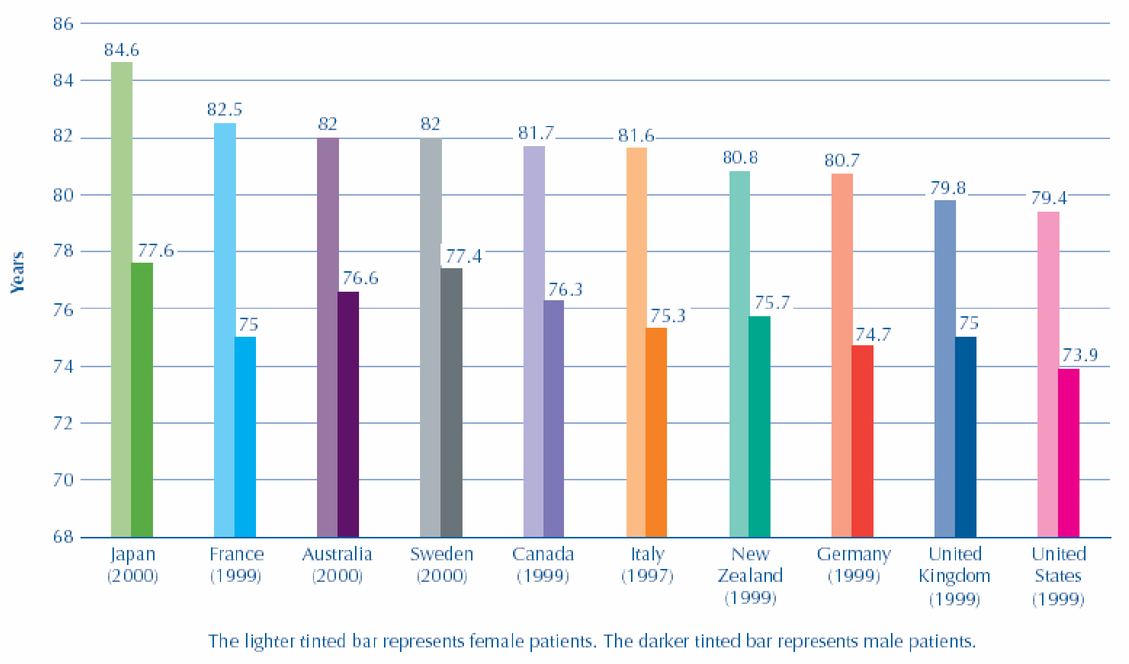
57 See for example the World Health Organization (WHO, 2000, p27-31 and WHO, 2002).

58 Calculated on the assumption that age-specific mortality and disability rates remain the same over time. The latter is based on an expected life span at birth of around 80 and 75 years for women and men respectively.

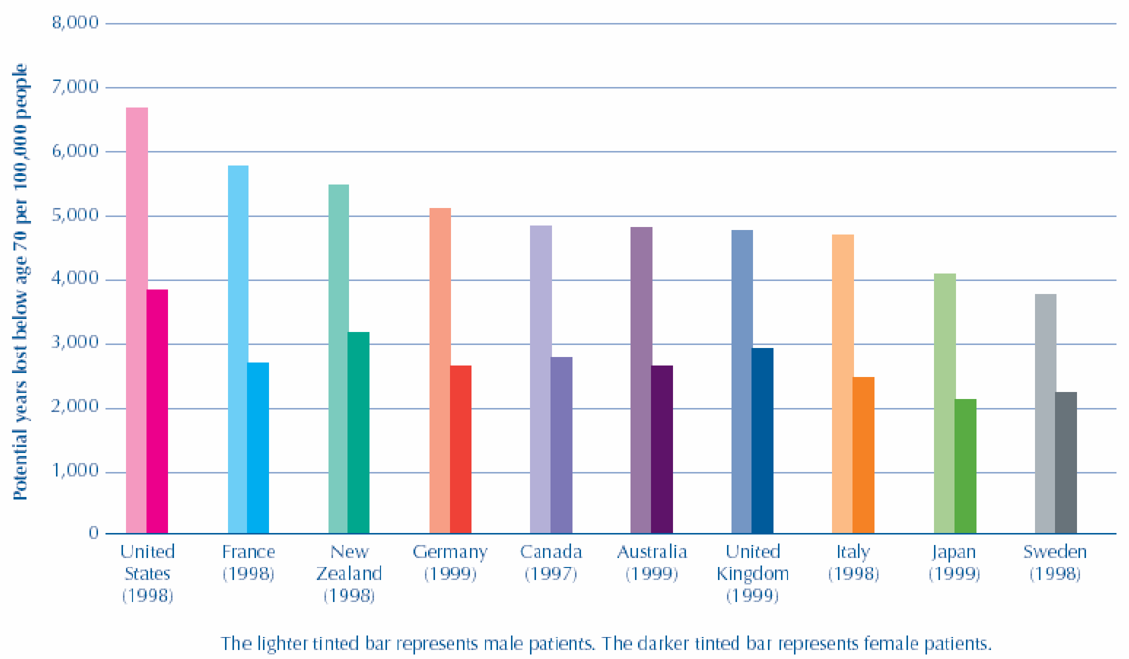
59 Defined as the number of deaths of babies under age 1 per 1000 live births in a given year.

Figure 4.16 Life expectancy at birth



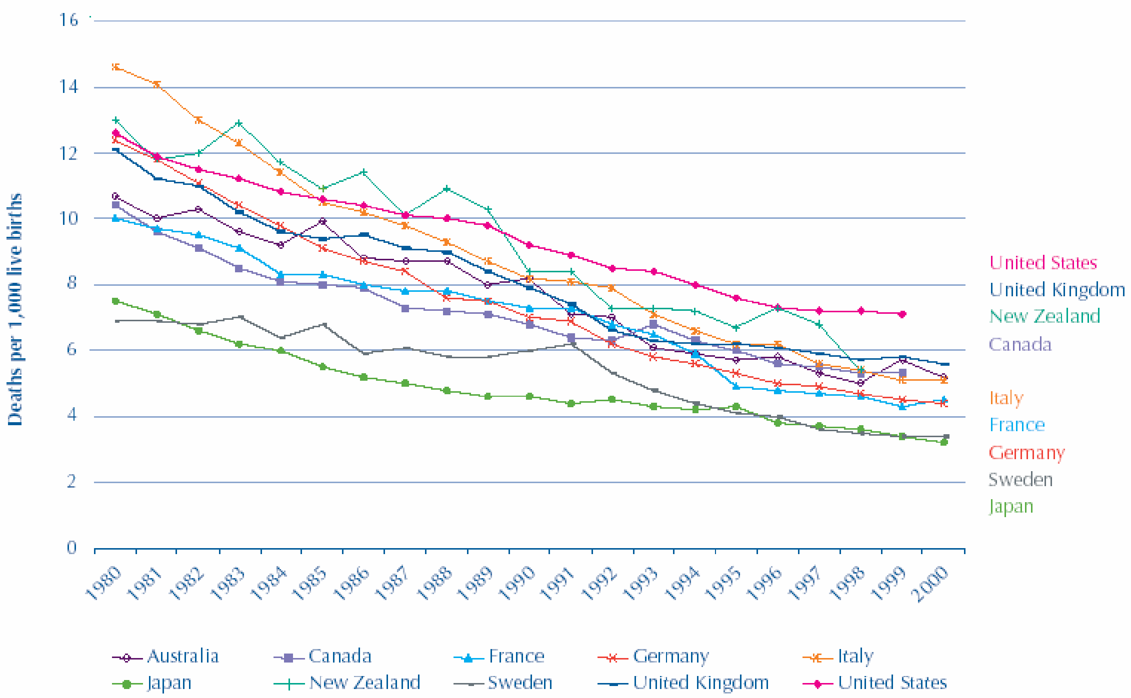
Source: National Audit Office (2003a, Figure 20)

Figure 4.17 Potential years of life lost



Source: National Audit Office (2003a, Figure 21)

Figure 4.18 Infant mortality for 1980-2000



Source: National Audit Office (2003a, Figure 23)

The most common causes of death from illness in developed countries are cancer (malignant neoplasms) and cardio-vascular (circulatory) diseases (Figure 4.19). The UK has the highest mortality rate of all countries and ranks highest in the group of respiratory diseases. In the UK age-standardised death rates from cancer have historically been high compared to other countries (with 184.7 deaths from cancer per 100000 in the UK, only New Zealand ranks higher), although displaying a downward trend, and cancer-survival rates have been relatively low. This has motivated the government to target its health budget to improve the quality of medical intervention in the area of cancer. The same is true for cardio-vascular diseases. The data in Figure 4.19 mask differences between (and within) countries by disease type.[60]

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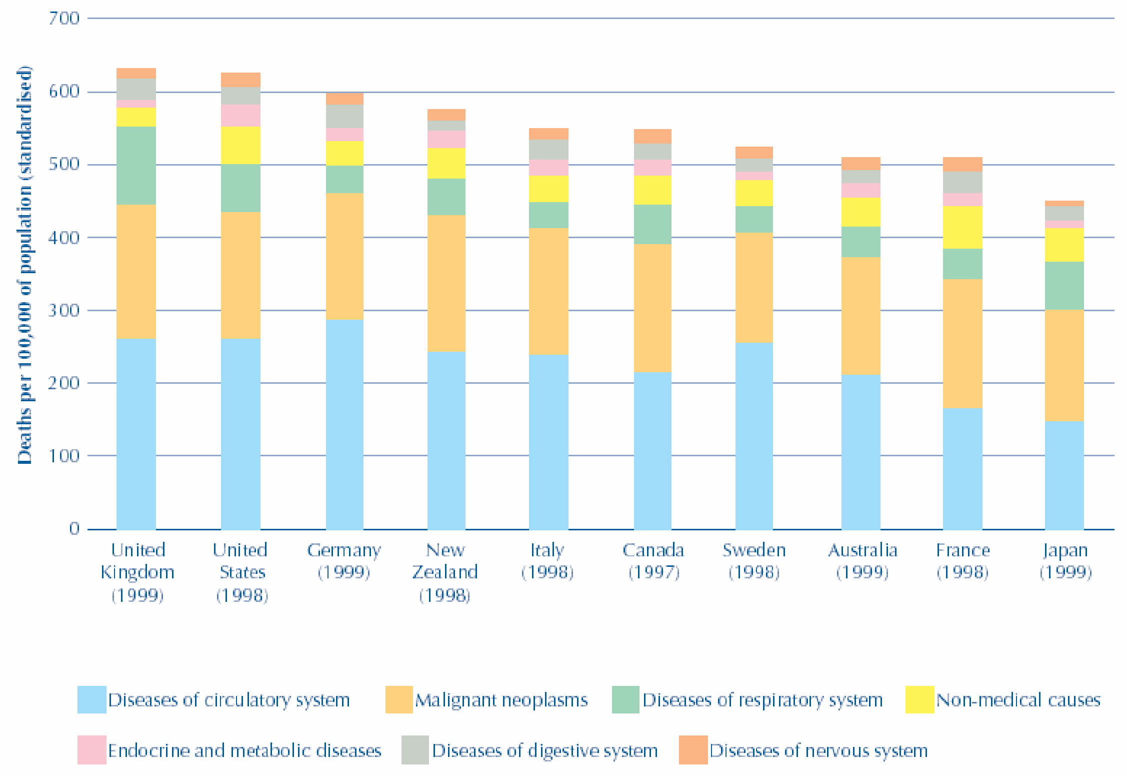
60 For more detailed information across countries see the OECD (http://www.oecd.org/) and the WHO (http://www.who.int/). National data are available from http://www.statistics.gov.uk/health [13 July

Figure 4.19 Age-standardised death rates by cause of death



Source: National Audit Office (2003a, Figure 24)

<u>Efficiency</u>

Efficiency in the context of the NHS usually refers to the ratio of outputs to inputs given the quality and specifications of products, i.e. productivity, an approach followed in this section. Thus if outputs rise for a given bundle of inputs, or the same outputs are produced with less inputs, there has been a gain in efficiency.

Given the complexity of health care systems, efficiency is difficult to measure. One frequently used indicator is the average length of stay in hospital. Assuming that the appropriate amount, type and quality of treatment are provided, a lower length of stay

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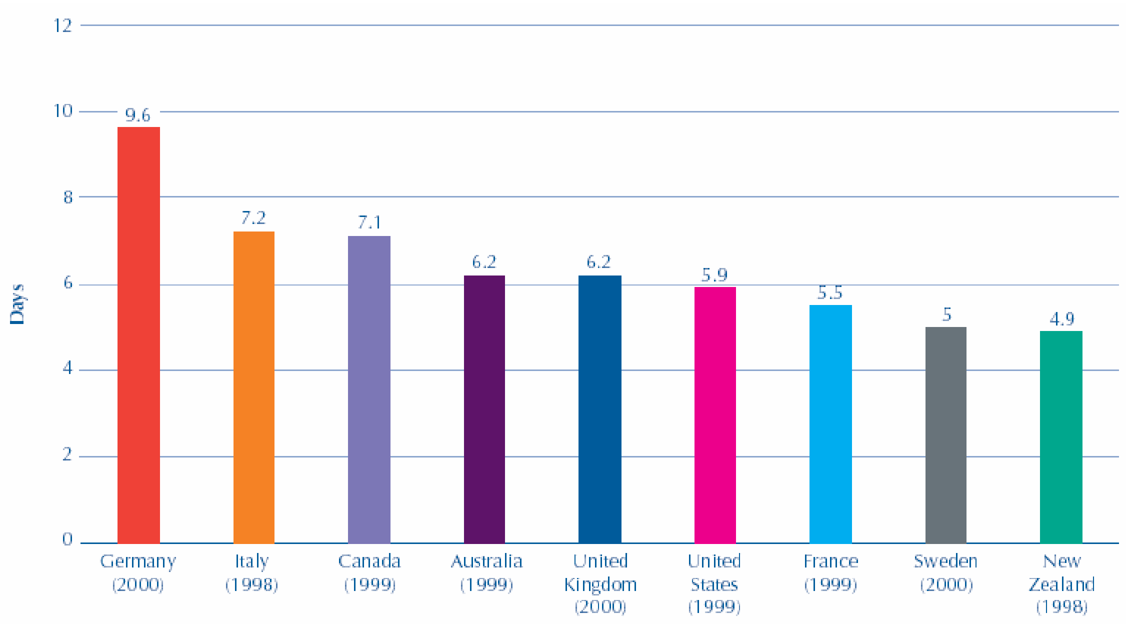
2004]. Morbidity data and data on the use of health services by various socio-economic characteristics in the UK have also been discussed in Chapter 5, Section 5.3.2.

indicates a more efficient use of acute beds (National Audit Office, 2003a, p21). The UK is the middle-ranking country with 6.2 days (Figure 4.20).[61]

Figure 4.20 Average length of stay - acute care



Source: National Audit Office (2003a, Figure 36)

Within the UK, there is a large body of anecdotal evidence that there are inefficiencies in health care provision.[62] Evans et al. (2001) compare the overall efficiency of health systems in 191 countries, as part of a broader attempt by the WHO to analyse the performance of health systems worldwide.[63] Overall performance is based upon the level of attainment of five components: fairness in funding, level of and inequalities in responsiveness (including waiting times), and the level of and inequalities in health attainment. A comparison of the overall indicator of attainment (or the score with

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61 Cross-country comparisons show that the UK makes better use of resources in terms of, for example, beds and staff (Section 4.3.2 and 4.3.3).

62 Evidence is available from the Audit Commission at http://www.audit-commission.gov.uk [13 July 2004]. An example is the Audit Commission (2003a) report on inefficiencies in the use of operating theatres.

63 WHO (2000).

respect to a specific component) with what might have been achieved with the resources available in the country yields an indicator of (overall) performance, i.e. the efficiency with which the goal(s) are achieved. The WHO calculates efficiency in terms of attaining health and the overall indicator of attainment based on all five aforementioned objectives (Table 4.1).

Table 4.1 Efficiency (performance) score and 80% uncertainty interval, 50 highest ranking countries, 1993-1997.

PERFORMANCE ON HEALTH LEVEL (DALE)					OVERALL PERFORMANCE				
Rank	Uncertainty interval	Member State	Index	Uncertainty interval	Rank	Uncertainty interval	Member State	Index	Uncertainty interval
1	1 – 5	Oman	0.992	0.975 – 1.000	1	1 – 5	France	0.994	0.982 – 1.000
2	1 – 4	Malta	0.989	0.968 – 1.000	2	1 – 5	Italy	0.991	0.978 – 1.000
3	2 – 7	Italy	0.976	0.957 – 0.994	3	1 – 6	San Marino	0.988	0.973 – 1.000
4	2 – 7	France	0.974	0.953 – 0.994	4	2 – 7	Andorra	0.982	0.966 – 0.997
5	2 – 7	San Marino	0.971	0.949 – 0.988	5	3 – 7	Malta	0.978	0.965 – 0.993
6	3 – 8	Spain	0.968	0.948 – 0.989	6	2 – 11	Singapore	0.973	0.947 – 0.998
7	4 – 9	Andorra	0.964	0.942 – 0.980	7	4 – 8	Spain	0.972	0.959 – 0.985
8	3 – 12	Jamaica	0.956	0.928 – 0.986	8	4 – 14	Oman	0.961	0.938 – 0.985
9	7 – 11	Japan	0.945	0.926 – 0.963	9	7 – 12	Austria	0.959	0.946 – 0.972
10	8 – 15	Saudi Arabia	0.936	0.915 – 0.959	10	8 – 11	Japan	0.957	0.948 – 0.965
11	9 – 13	Greece	0.936	0.920 – 0.951	11	8 – 12	Norway	0.955	0.947 – 0.964
12	9 – 16	Monaco	0.930	0.908 – 0.948	12	10 – 15	Portugal	0.945	0.931 – 0.958
13	10 – 15	Portugal	0.929	0.911 – 0.945	13	10 – 16	Monaco	0.943	0.929 – 0.957
14	10 – 15	Singapore	0.929	0.909 – 0.942	14	13 – 19	Greece	0.933	0.921 – 0.945
15	13 – 17	Austria	0.914	0.896 – 0.931	15	12 – 20	Iceland	0.932	0.917 – 0.948
16	13 – 23	United Arab Emirates	0.907	0.883 – 0.932	16	14 – 21	Luxembourg	0.928	0.914 – 0.942
17	14 – 22	Morocco	0.906	0.886 – 0.925	17	14 – 21	Netherlands	0.928	0.914 – 0.942
18	16 – 23	Norway	0.897	0.878 – 0.914	18	16 – 21	United Kingdom	0.925	0.913 – 0.937
19	17 – 24	Netherlands	0.893	0.875 – 0.911	19	14 – 22	Ireland	0.924	0.909 – 0.939
20	15 – 31	Solomon Islands	0.892	0.863 – 0.920	20	17 – 24	Switzerland	0.916	0.903 – 0.930
21	18 – 26	Sweden	0.890	0.870 – 0.907	21	18 – 24	Belgium	0.915	0.903 – 0.926
22	19 – 28	Cyprus	0.885	0.865 – 0.898	22	14 – 29	Colombia	0.910	0.881 – 0.939
23	19 – 30	Chile	0.884	0.864 – 0.903	23	20 – 26	Sweden	0.908	0.893 – 0.921
24	21 – 28	United Kingdom	0.883	0.866 – 0.900	24	16 – 30	Cyprus	0.906	0.879 – 0.932
25	18 – 32	Costa Rica	0.882	0.859 – 0.898	25	22 – 27	Germany	0.902	0.890 – 0.914
26	21 – 31	Switzerland	0.879	0.860 – 0.891	26	22 – 32	Saudi Arabia	0.894	0.872 – 0.916
27	21 – 31	Iceland	0.879	0.861 – 0.897	27	23 – 33	United Arab Emirates	0.886	0.861 – 0.911
28	23 – 30	Belgium	0.878	0.860 – 0.894	28	26 – 32	Israel	0.884	0.870 – 0.897
29	23 – 33	Venezuela, Bolivarian Republic of	0.873	0.853 – 0.891	29	18 – 39	Morocco	0.882	0.834 – 0.925
30	23 – 37	Bahrain	0.867	0.843 – 0.890	30	27 – 32	Canada	0.881	0.868 – 0.894
31	28 – 35	Luxembourg	0.864	0.847 – 0.881	31	27 – 33	Finland	0.881	0.866 – 0.895
32	29 – 38	Ireland	0.859	0.840 – 0.870	32	28 – 34	Australia	0.876	0.861 – 0.891
33	27 – 40	Turkey	0.858	0.835 – 0.878	33	22 – 43	Chile	0.870	0.816 – 0.918
34	25 – 48	Belize	0.853	0.821 – 0.884	34	32 – 36	Denmark	0.862	0.848 – 0.874
35	33 – 40	Canada	0.849	0.832 – 0.864	35	31 – 41	Dominica	0.854	0.824 – 0.883
36	32 – 42	Cuba	0.849	0.830 – 0.866	36	33 – 40	Costa Rica	0.849	0.825 – 0.871
37	30 – 49	El Salvador	0.846	0.817 – 0.873	37	35 – 44	United States of America	0.838	0.817 – 0.859
38	28 – 52	Saint Vincent and the Grenadines	0.845	0.812 – 0.876	38	34 – 46	Slovenia	0.838	0.813 – 0.859
39	35 – 43	Australia	0.844	0.826 – 0.861	39	36 – 44	Cuba	0.834	0.816 – 0.852
40	36 – 44	Israel	0.841	0.825 – 0.858	40	36 – 48	Brunei Darussalam	0.829	0.808 – 0.849
41	39 – 47	Germany	0.836	0.819 – 0.852	41	38 – 45	New Zealand	0.827	0.815 – 0.840
42	33 – 54	Dominican Republic	0.834	0.806 – 0.863	42	37 – 48	Bahrain	0.824	0.804 – 0.845
43	37 – 53	Egypt	0.829	0.811 – 0.849	43	39 – 53	Croatia	0.812	0.782 – 0.837
44	41 – 50	Finland	0.829	0.812 – 0.844	44	41 – 51	Qatar	0.812	0.793 – 0.831
45	38 – 55	Algeria	0.829	0.808 – 0.850	45	41 – 52	Kuwait	0.810	0.790 – 0.830
46	41 – 55	Tunisia	0.824	0.803 – 0.844	46	41 – 53	Barbados	0.808	0.779 – 0.834
47	38 – 58	Yugoslavia	0.824	0.798 – 0.848	47	36 – 59	Thailand	0.807	0.759 – 0.852
48	40 – 61	Honduras	0.820	0.793 – 0.844	48	43 – 54	Czech Republic	0.805	0.781 – 0.825
49	37 – 63	Grenada	0.819	0.789 – 0.850	49	42 – 55	Malaysia	0.802	0.772 – 0.830
50	42 – 59	Uruguay	0.819	0.794 – 0.842	50	45 – 59	Poland	0.793	0.762 – 0.819

Source: WHO (2000, Annex Table 10)

In terms of efficiency in improving health, the UK is ranked 24th, ahead of, for example the US (72nd), Australia (39th) and New Zealand (80th), but behind Italy (3rd), France (4th) and Spain (6th), whereas in terms of overall health performance the UK ranked 18th with France first on the list. The results need to be interpreted carefully though due to problems of definition ('what is a health system?'), measurement of performance (indicators used and weights applied to obtain the overall performance indicator), scope of health care (there are many other factors influencing health), within country variations (between regions and/or the various components of a health system) and data availability and comparability across countries.[64] With respect to the UK's relatively poor efficiency rating, the government responded that the WHO data were from 1993 to 1997 and so did not reflect recent policy initiatives.

The latest confidential estimates which have been leaked to the press are nevertheless discouraging, showing that since 1997 public sector productivity in health and education has dropped by 15% to 20% (compared to previous estimates of 3%), where productivity - the production per worker - is a key indicator of efficiency. Whereas the health service had received a 20% increase in resources, treatments only went up by 2% after allowing for inflation.[65] In support of these findings, Le Grand (2002) finds that efficiency gains that were realised since the introduction of the internal market in 1991 seemed to fall at an ever increasing rate from 1997/98 onwards. Similarly, Pritchard (2002) reports an increase in NHS activity of only 15.3% against an increase in resources of 25.3% for the period 1995-2000. Again, the government's reaction is to

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[64] McKee (2001), Mulligan et al. (2000).

[65] The Times and The Sunday Times, various articles, 25 April 2004.

query the accuracy of the productivity figures, despite the fact that the latest findings have been endorsed by the OECD and the European Central Bank, and that the ONS' method of measuring public sector productivity is regarded as a 'best practice' model for the rest of the world.

The NHS is working with the ONS and the Atkinson Review to develop a new measure of productivity.[66] It is argued that the current measure is flawed in that it (1) regards investments in future capacity (such as new hospitals and training places for new doctors) as a decline in productivity, (2) ignores spending that may have led to better outcomes but does not add to output as measured for the national accounts, (3) does not necessarily monitor all outputs produced by the health service (most notably primary care services) and (4) fails to recognise improvements in quality (e.g. shorter waiting times, more effective drugs, higher observed survival rates after treatment). In many instances, quality improvements are counted as a productivity decrease (e.g. preventive campaigns which reduce the number of visits to a family doctor or hospital stays).

Equity

Successive UK governments have had a strong commitment to equity (fairness) in finance and delivery of health care. As part of a wider study of expenditure on health care in the UK, Propper (2001) investigates to what extent this commitment has been realised and has translated into a more equitable distribution of outcomes.

The system of funding of health care resources in the UK is relatively equitable compared to other countries, principally because the NHS is financed largely from

[66] Tuke (2004). Articles describing the progress made in the measurement of government output and productivity are regularly published in *Economic Trends*. See for example Pritchard (2001, 2002, 2003).

general taxes, which are broadly progressive. With respect to the allocation of health care resources, Propper finds that disparities at regional, district and possibly ward level have fallen and follow the measures of need used in RAWP type allocation formulae. Empirical studies on equity in the distribution of health care across individuals reviewed by Propper generally show slight departures from the 'equal treatment for equal need' principle of the NHS, also known as 'horizontal equity'[67], in that the allocation of health care since the 1980s is found to be mildly pro-poor, also relative to other countries – though this seems to be unrelated to the progressivity in finance. Despite a more equal distribution of health care resources across regions, geographical inequities in health outcomes have not been reduced since the 1970s and may well have worsened. The same observation is made for health inequalities across individuals (also documented in Chapter 5, Section 5.3.2). The presence of such (rising) inequities suggests that resource equalisation at the regional level cannot impose equal spending patterns at the individual level and that health outcomes depend on more than health spending alone (Propper, 2001, p163).[68]

A review by Dixon et al. (2003) focuses exclusively on the question of horizontal equity in the NHS, using evidence from macro- and micro-studies. Whereas early macro studies on the use of NHS services in general show that utilisation by higher income groups was higher than that by lower income groups when adjusted for needs, more

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67 Using this definition of equity, an equitable service is one that offers equality of access to health care to individuals in equal need, irrespective of other factors, such as socio-economic status, except in so far as this affects need. Observed inequities in utilisation of health care are usually taken as proxy for inequalities in access, whereas need is usually measured by indicators of health status: the worse the latter, the greater is the need for treatment (See also Dixon et al. 2003, Section 2). Vertical equity is the principle that people who are unequal should be treated differently (examples are health care financing based on ability to pay –as in the UK, and differential access based on differences in need).

68 Audit Commission (2002) also contains some evidence of inequities in the distribution of health care resources, health care delivery and health outcomes.

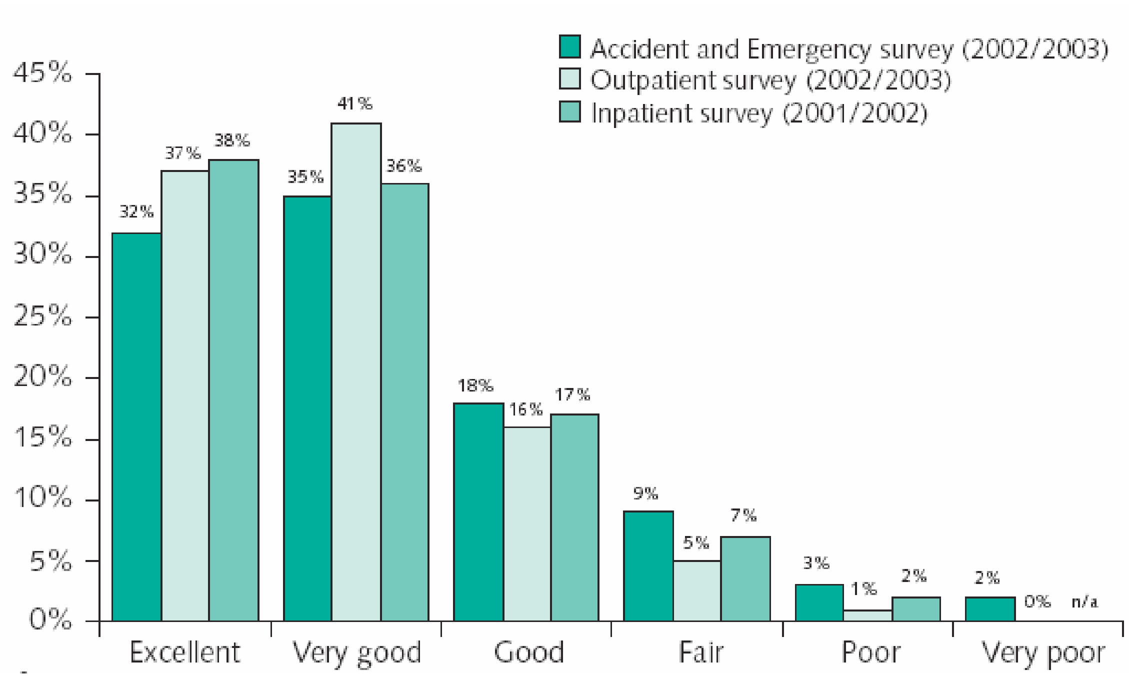
recent macro-studies suggest that the NHS currently is pro-poor (in line with Propper, 2001). In contrast, a recent macro study, using more disaggregated data, and the vast majority of micro-studies on the use of specific NHS services, suggest that inequities in access persist. These conflicting outcomes result from differences in methodology and data used. Specifically, the macro-studies finding broad equity in utilisation rely on self-reported morbidity as the indicator of need and on aggregate measures of utilisation which conceal differences in benefits from utilisation across socio-economic groups. This not only casts doubt on the validity of the findings of these studies relative to the micro-studies and macro-studies using more sophisticated indicators of need and utilisation, but also lends support to the observation made by the latter studies that the NHS is indeed inequitable. Potential barriers to access, which are behind these inequities and which the government should attempt to address, are found to be mostly related to transport difficulties, employment and personal commitments, the ability to use one's 'voice' to demand better and more extensive services, health beliefs and health seeking behaviour, all of which tend to disadvantage the poor in terms of first access to NHS care and follow up treatments.

Quality: waiting for health care

The quality of health care has many facets, such as accessibility of health care (waiting time), coordination of different types of care, environment in which care is provided (cleanliness, safety, comfort, food) and facilities used, the provision of information and education of staff, patient involvement and choice, the extent to which the physical and emotional needs of patients are met (including time spent with a patient) and the respect and dignity with which patients are treated (friendliness of staff).

One method of assessing the quality of care is to look at the patients' satisfaction with the health care system. The Chief Executive's Report to the NHS of May 2004 provides evidence that the majority of patients are satisfied with inpatient, outpatient and accident and emergency (A&E) care (Figure 4.21), though there is further scope for improvement, given the variations in quality across the UK.

Figure 4.21 How do inpatient, outpatient and A&E patients rate care?



Source: DoH (2004c, Graph H)

Evidence of variations in quality and progress made in improving performance is provided by the various institutions that monitor the quality of health care provision, including the Commission for Health Improvement, the Audit Commission, the King's Fund and National Audit Office. The Audit Commission (2002) report on the performance of the NHS in England covers patient's experience of hospital food, the cleanliness of hospitals, standards of GP surgeries and waiting for care. The King's Fund (2004) reviews progress made in key areas of major concern, including shorter waiting times for cancer and heart care, improved accident and emergency departments and cleaner hospitals. A study by the Commission for Health Improvement (2004) shows that up to 16% of the overall variation in patient experience observed in surveys of NHS care in England is explained by patient characteristics, such as age, level of education, gender, ethnic background, and so on. The remainder may be attributed to differences in the quality of health care provision across the country.

Patient satisfaction surveys reveal that waiting times for care are a major cause for concern. While waiting, patients may experience considerable pain and discomfort (and uncertainty), which impacts upon their (working) life, and in some cases the patient's condition may worsen.[69] The Commonwealth Fund (2001), for example, finds that the most common reason cited for not having adequate access to health care in the UK is the presence of long waiting times (46% of respondents). More detailed evidence on waiting lists in the UK (and other countries) is provided in the remainder of this section.

In the UK the GP looks after the health of the local population. If a GP cannot deal with a health problem herself she may refer patients to a hospital to see a consultant for a specialist opinion (outpatient appointment). After seeing the specialist, the patient may be deemed to require further treatment in hospital which either (a) necessitates the use of a hospital bed during the day (day patient appointment) or (b) requires overnight stay (inpatient appointment). At each stage of the referral process, and for emergency admissions to A&E departments, there is typically a wait (see Figures 4.22 to 4.25).

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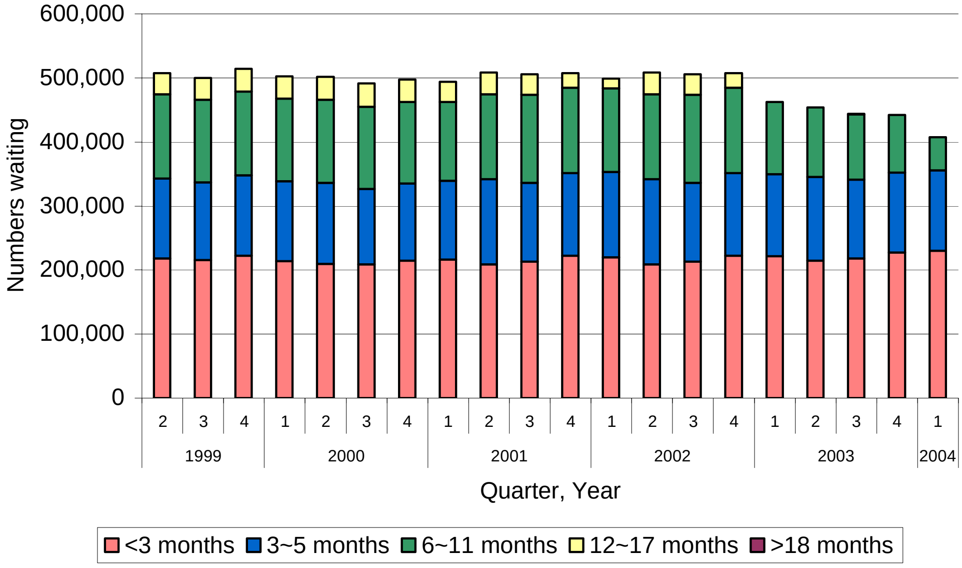
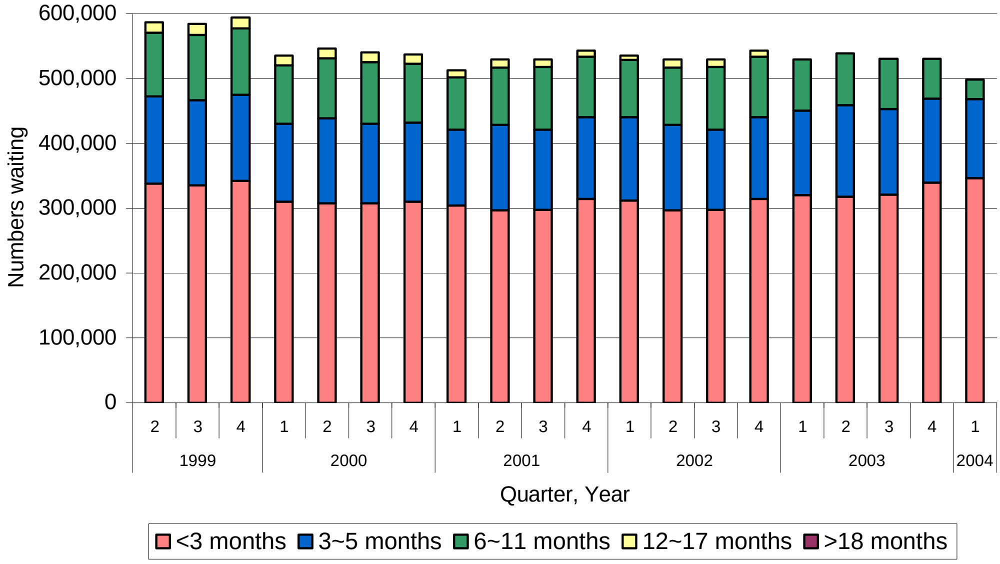
69 Although the general public fear these adverse effects, a cross-country review of patients waiting for a couple of months for several types of elective procedures by Hurst and Siciliani (2003) shows that there is surprisingly little evidence of a deterioration in health whilst waiting. Moreover, among those waiting, patients are found to be tolerant of short to medium waits.

Figure 4.22 Patients awaiting admission by length of wait, all specialities, overnight cases, 1999-2004, England



Source: Hospital Inpatient Waiting List Statistics, Provider Based, England[70]

Figure 4.23 Patients awaiting admission by length of wait, all specialities, day cases, 1999-2004, England



Source: Hospital Inpatient Waiting List Statistics, Provider Based, England

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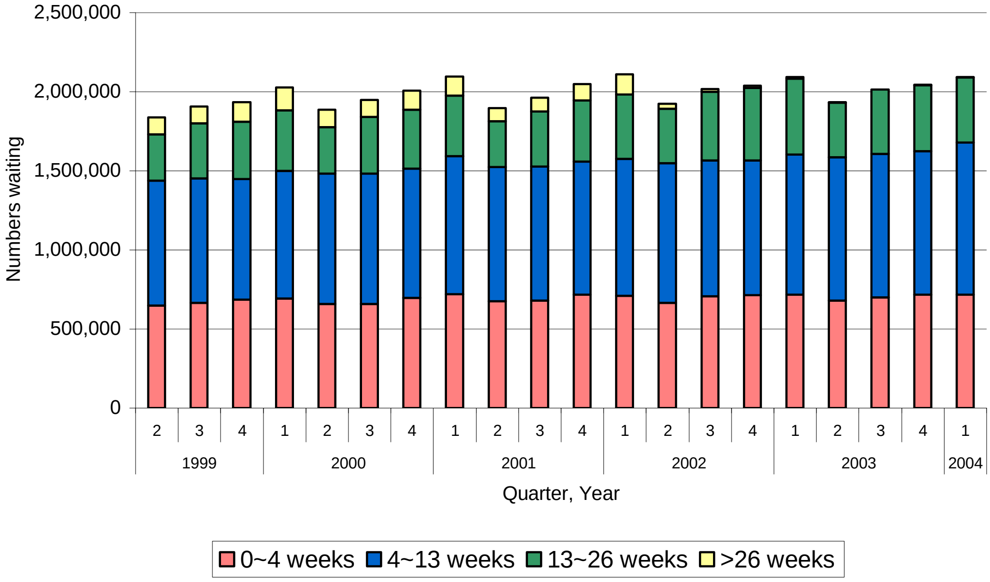
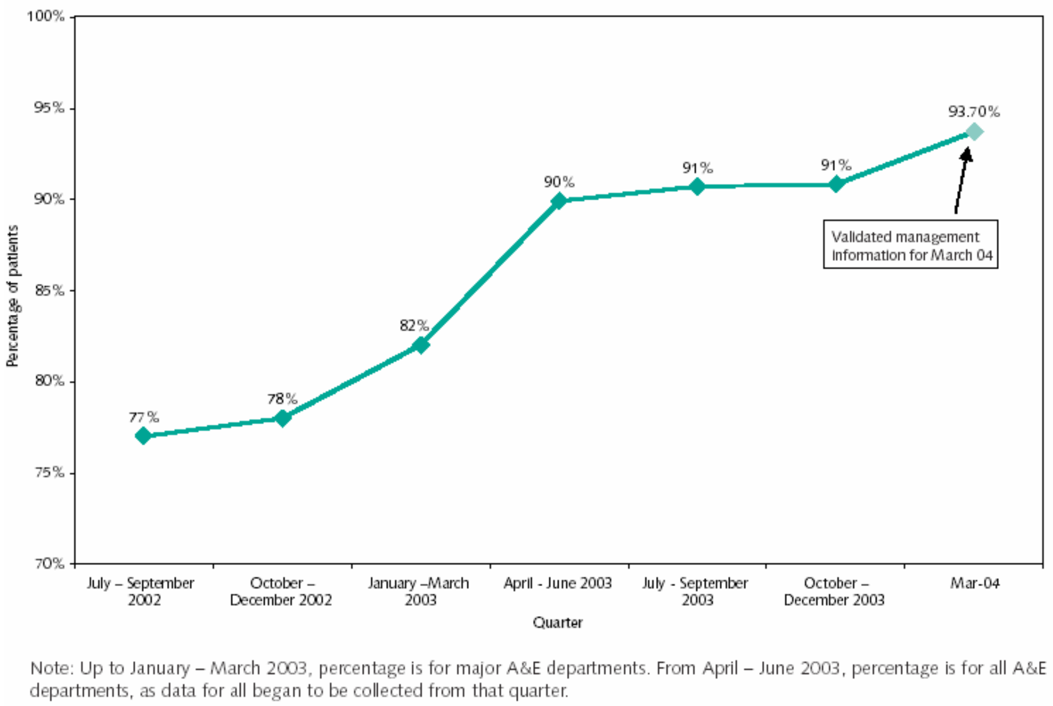
[70] Data for Figures 4.21 to 4.23 are from: http://www.performance.doh.gov.uk/waitingtimes/ [13 July 2004].

Figure 4.24 Waiting times for first outpatient attendance following a written GP referral by length of wait, all specialities, 1999-2004, England



Source: Hospital Waiting Times for 1st Outpatient Appointments, Provider Based: England[71]

Figure 4.25 A&E attenders spending 4 hours or less in A&E, 2002-2004, England



Source: DoH (2004c, Graph D)

[71] Outpatient data only cover first referrals by the GP, approximately 25% of all outpatient activity.

Inpatient and day patient waiting lists in England have fallen since the second quarter of 1999, whereas outpatient waiting lists have risen.[72] Since the early 1980s, day patient waiting lists have risen relative to inpatient waiting lists (the former exceeding the latter from around 1997), which marks a trend towards increasing the utilisation of the beds stock and so lowering unit costs of treatment. Although the large waiting lists attract adverse attention by the media and the public, it is not the number of patients waiting that matters, but how long these patients have to wait. For each type of admission the longest waits - for inpatient and day patient waits exceeding five months and for outpatients waits exceeding twenty six weeks - have fallen, but often at the expense of the shorter waits (as shown by the last four quarters of all graphs). A&E waiting times have also improved: 94% are now seen and treated within four hours, compared to 77% in the 3rd quarter of 2002.

These patterns reflect efforts by the government to drastically reduce (long) waiting times. The NHS Plan 2000 targets for reducing waiting times for aforementioned admission types declared that: by the end of 2005 the maximum waiting time for an outpatient (inpatient) appointment should be reduced to three months (six months), and the average waiting time for an outpatient (inpatient) should fall to five weeks (seven weeks). With respect to A&E, by the end of 2005 no one should be waiting more than four hours from arrival to admission, transfer, or discharge and average waiting times

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72 Data refer to England only. Especially in Wales and Northern Ireland waiting times are relatively long and have risen since 2000. Waiting lists are dominated by routine operations in a few specialities: orthopaedics, ear, nose and throat conditions and ophthalmology accounted for 50% of the total waiting list and 33% of admissions in March 2003 (Jacobs et al., 2003, p6).

should fall to 75 minutes.[73] Measurement difficulties aside, associated interim targets, apart those for A&E, have so far roughly been met.[74]

While reducing waiting lists is in principle a good thing, the cost-effectiveness is unclear as the money could have been spent on other areas of the NHS. It remains to be seen whether efforts to reduce waiting lists and times can be sustained in the long term due to positive feedback effects from reductions in waiting times to demand (via increased referrals and admissions) and the long-run rising trend in demand which reflects technological progress and an ageing population. Target setting with respect to waiting times also entails adverse incentives. Evidence suggests that the targets are met at the expense of longer waits for patients who should have clinical priority (for example, first outpatient appointment targets are met at expense of follow-up treatments with detrimental health consequences) and that inappropriate adjustments to waiting lists are made to meet the targets.[75] A further complication is that waiting lists exist for a variety of reasons, some of which suggest that the optimal waiting time for treatment is positive: short queues may be cost-effective as a short period of delay allows some conditions (such as tonsillitis) to improve, adverse health effects - if any - are small and they help in reducing unused hospital capacity.[76]

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73 DoH (2000a).

74 See for example DoH (2004c). Waiting list data are typically inaccurate due to the recording of people who should no longer be on the list, inappropriate adjustments by Trusts to meet targets and inaccuracies in short and long waits, respectively due to missing the census date and being counted in several censuses. The Audit Commission (2003b) discusses ways in which waiting time statistics can be improved. See also Hurst and Siciliani (2003, Section 2.5).

75 See for example the websites of the National Audit Office and the Audit Commission. See also King’s Fund (2004, p19-20, p22).

76 Hurst and Siciliani (2003, Section 2.7). A succinct overview of the interpretation of and reasons for waiting lists is given by Jacobs et al. (2003).

An OECD study on waiting times shows that waiting lists typically exist in countries with public health insurance (with limited or no cost sharing) and constraints in surgical capacity, such as in the UK.[77] As the NHS is free at the point of consumption, patients will continue to consume until the marginal benefit of consumption is zero. This leads to potentially infinite demand in excess of supply, i.e. waiting lists. In the absence of a price mechanism to realign demand with supply (which is considered to be unfair), waiting lists serve as a method of rationing demand. Patients essentially 'pay' a time price for health care by having to wait for treatment ('rationing by delay').[78]

The study finds a negative association between capacity, measured by number of beds or practicing physicians, and waiting times. The same is true for the level of health spending. Increases in health spending and capacity may significantly reduce waiting times. Evidence also shows that changing the remuneration system for specialists - from salary to fee-for-service - and for hospitals - from fixed budgets to activity-based funding - may enhance productivity.[79]

Further potential to improve productivity and capacity/resource levels is also evident from UK data. Reviews by the Audit Commission on availability and utilisation of operation theatres, beds and staff show that capacity may be used more efficiently by reducing length of patient stays, increasing operations carried out in day surgery and more intensive use of operating theatres. For some specialties capacity increases are

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77 Hurst and Siciliani (2003).

78 The NHS also 'rations by denial' in blocking, or at least delaying, the adoption of new technologies. The fear is that, if a new, superior, technology is approved, there will be a significant increase in demand, whereas if it is not available then patients 'will not miss what they do not have'.

79 Siciliani and Hurst (2003).

required.[80] Variations in waiting times (between Trusts, and even between consultants in the same Trusts/hospitals, for the same specialties) suggest the presence of both insufficient funding and inefficiencies in current working practices.[81]

4.4 THE FUTURE NHS IN THE PRESENCE OF RATIONING

The previous sections identified a large number of problems in health care provision of the UK (and other countries), of which a few lend themselves to modelling in a CGE framework. All of these, and those that can be handled in a CGE setting, have as a common feature that they impinge upon the issue of rationing, either alleviating the rationing constraint or straining it.

4.4.1 Balance sheet

The balance sheet so far for health care provision in the UK is mixed. On the one hand - and in contrast to many other countries - the UK has managed to keep a tight lid on expenditure by funding health care primarily from, mildly progressive, general taxation, whilst providing universal and comprehensive health care coverage to its population and reaching overall satisfactory health outcomes. The UK health system thus appears to be highly cost-effective in achieving reasonable outcomes at substantially lower costs, which explains the reluctance of this and previous governments to change the system of funding.

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80 See for example the Audit Commission (2003a, 2003b). The latter includes evidence on the use of operating theatres. Underlying data are available from the Acute Hospital Portfolio section of the Audit Commission website (http://www.audit-commission.gov.uk [13 July 2004]).

81 Jacobs et al. (2003). Waiting times for a range of non-emergency treatments at local NHS hospitals by type of appointment and by individual consultant are available from the NHS website: http://www.nhs.uk [13 July 2004].

But although the NHS delivers good value for money, many argue - using cross-country comparisons - that the public control of total expenditures has led to insufficient spending on the NHS, which has caused problems in terms of, for example, poor health outcomes in terms of specific diseases (such as cancer), inequities in access and health outcomes, and poor quality of services, including long waiting times for treatment. Inadequate services may however also reflect poor, i.e. inefficient or unproductive, use of existing resources. Evidence on this is mixed (depending on the data used), though on balance it suggests that productivity in the NHS remains unsatisfactory, and has even declined, despite unprecedented increases in expenditures over the last few years. Improvements in productivity in certain areas of the NHS seem feasible.

4.4.2 Future prospects

What of the future prospects for the UK health care system? Rationing had always been present in the past and is unlikely to disappear in the future. On the contrary, the gap between finite resources and potentially infinite demands seems to be rising - as in the past - due to a combination of increases in demands for health care (in terms of quantity, quality and outcomes) from rising incomes, partly fuelled by advances in technology and by an ageing population. Although devoting more resources to health care would alleviate the rationing constraint, it is unlikely to satisfy all demands as ‘the more we have the more we want’: rationing is inevitable and difficult decisions regarding the allocation of health care, ‘who gets what type of health care and when’, will have to be made in future.

Apart from demand pressures there are cost pressures from public sector workers demanding wages in line with private sector wages - necessary to retain staff and to attract new staff - and rising prices of pharmaceutical inputs. The rising cost of provision of health care implies fewer services can be delivered for the same value of expenditures, which thereby worsens the rationing constraint.

Finally, rationing reduces the ability of health systems to cope with unanticipated disease outbreaks.[82] This has been illustrated by, for example, influenza outbreaks throughout this century. The most infamous pandemic was the "Spanish Flu" of 1918-1919, which killed around 20 to 40 million people worldwide. Other influenza pandemics occurred in 1957 (the "Asian Influenza") and 1968 (the "Hong Kong influenza").

Influenza is a highly contagious viral infection which, in developed countries, occurs primarily in winter. Whereas earlier pandemics led to deaths also among healthy, young, people, influenza nowadays primarily affects 'high-risk' groups such as the elderly, children and the chronically ill. Nevertheless, influenza affects people in all age groups (an estimated 10% to 15% of the UK population each year[83]). It is an uncomfortable and self-limiting illness of which the main symptoms, fever, chills, painful muscles, head- and backache and cough, can last up to a week or two. Costs to society in terms of health care, working days lost and productivity declines are significant: "*Epidemiological models project that in industrialized countries alone, the*

82 Anticipated conditions related to life style, for example in terms of smoking (lung cancer) and - recently acknowledged as *the* future health problem of developed countries - diet (obesity and related chronic diseases such as diabetes and asthma) are just as likely to put a heavy claim on future health resources, but the government at least has more time in designing and implementing appropriate policies, thereby reducing the availability of resources for other, unanticipated, health problems.

83 DoH website on Immunisation Policy: 'Summary of flu immunisation policy' available at http://www.dh.gov.uk/PolicyAndGuidance/HealthAndSocialCareTopics/Flu/fs/en [13 July 2004].

next pandemic is likely to result in 57-132 million outpatient visits and 1-2.3 million hospitalisations, and 280000-650000 deaths over less than 2 years." [84]

Most common health measures in response to influenza are vaccinations and - complementary - antiviral drugs to prevent and treat influenza. Following WHO recommendations, the UK government has since 2000 run a highly successful flu immunisation programme, supported by advertising campaigns, to encourage high risk groups to get a free flu jab, and so to reduce the impact of the winter as a 'special event' on primary care services and hospital admissions. This has led to an increase in flu injection uptake of 65% in 2000/01 to 71% in 2003/04 of those aged 65 and over (DoH, 2004c, p29).

The frequent genetic changes of influenza viruses, which are more likely to happen in an increasingly globalised world (e.g. via increased air travel) and which require reformulation of influenza vaccines, are a major cause of concern. The most recent outbreaks, of 1997 and 2003 in Hong Kong, were caused by a new subtype of influenza which is transmitted from birds to humans. New vaccines must be designed each year to match those current strains that are most likely to cause the next epidemic.

4.4.3 Policies aimed at alleviating rationing

What can governments do to alleviate the rationing constraint? Hurst and Siciliani (2003) discuss policies carried out by twelve OECD countries to reduce waiting times for elective (non-urgent) surgery. If the volume of surgery is considered insufficient, supply-side policies - which include raising capacity (in terms of staff and bed numbers,

[84] Data are from the WHO website on influenza: 'Pandemic preparedness', available at http://www.who.int/csr/disease/influenza/pandemic/en/ [13 July 2004].

the use of private sector capacity and sending patients abroad), raising productivity (via funding extra activity, increasing the share of day case treatments, activity-related payments for doctors and hospitals and improving the management of waiting lists) and encouraging patient choice - can reduce waiting times. If the volume of surgery is considered to be sufficient (or the most that is affordable), demand side policies - which include prioritisation of patients according to need and encouraging private health insurance and care - may reduce waiting times in the public sector. Supply side policies have different implications in terms of cost and health outcomes compared to demand side policies: the former enhance health but are relatively costly, whereas the latter are unlikely to improve health, but are relatively cheap to implement. Policies affecting both demand and supply are those acting directly on waiting times, such as maximum waiting time guarantees and financial and non-financial incentives to reduce waiting lists.

The authors argue that in the NHS the volume of surgery is likely to fall short of the ‘optimal’ rate of surgery (where marginal benefits equal marginal costs) because the government exercises direct control over the health care budget, and so has the power to ‘squeeze capacity in the interest of saving public expenditure’, and due to the absence of activity-related remuneration. Supply side policies are thus warranted.

Docteur and Oxley’s (2003) overview of the health care reform experience of OECD member countries covers cost containment initiatives. These generally focused on controlling prices and volumes of health-care and inputs into health care (wage controls and pharmaceutical price regulation, encouraging prescribing of generic drugs and limiting medical school places), caps on health care spending and increased cost-sharing with the private sector (in the form of user charges). Limiting wages and restricting medical personnel has, in their opinion, been taken too far in many countries, including the UK, and has led to shortages of health care personnel. As a consequence, increases in the health care budget in the short term may lead to higher wages for health care personnel (from the perspective of the government unwanted), instead of desired increases in the services provided.

4.4.4 CGE modelling exercises

Having discussed the balance sheet of UK health care so far, and future prospects and policies, this section selects the issues which will or could be examined using the CGE model.

Policies to alleviate rationing

From an economic viewpoint there are two (supply side) policy measures to alleviate the rationing constraint within the current system of funding, i.e. allocate more resources so that capacity in terms of number of beds, operating theatres and other forms of capital and staff numbers can be expanded and more pharmaceutical inputs can be purchased, or to increase the productivity of these available inputs.[85] Both of these increase the amount of health care in terms of number and/or quality of treatments provided.

The economy-wide impact of an increase in government expenditures on health care will be examined using two alternative factor market closures - perfectly mobile factors of production and health care-specific skilled labour and capital. The latter scenario,

[85] Demand side policies such as to increase private health care provision are not so straightforward as private health care is only separated from public health care in final consumption and no separate private health care sector exists (Chapter 6, Section 6.2).

more suited to the short run, takes into account the fact that some labour and capital is respectively highly trained or highly specialised and therefore specific to health care and immobile.

The repercussions of an increase in productivity of health care will be modelled via technological progress in three fashions: (1) an improvement in the cost-effectiveness of pharmaceuticals which, given government expenditures on health care and a more expensive (but more effective) pharmaceutical product, will treat and cure more people; (2) factor-neutral (i.e. Hicks-neutral) technological change and (3) factor-biased technological change. The first technology change can be interpreted as mimicking the increasing importance of primary health care in health service provision, observed over the last decade, which has reduced the number of people going to hospitals.[86] The second and third method of technological change respectively simulate improvements in the efficiency of *all* factors employed in health care and the efficiency of skilled labour employed in health care.

Cost pressures

In parallel with (generally successful) efforts to restrict medical salaries, maintain current working practices, and so on, the government has sought to limit the ever-increasing cost of pharmaceuticals. Nevertheless, prices of pharmaceuticals are not within direct government control. Therefore, an increase in the price of drugs poses problems for the government. Again, two scenarios are implemented which reflect two extreme responses to the pharmaceutical price rise. One is to maintain the official budget expenditure, implying a reduction in expenditure on other treatment costs

86 This can be extended to the increased importance of day case treatment relative to inpatient care.

(numbers treated, time spent in hospital). The alternative is to expand the budget at the cost of offsetting cuts elsewhere.

Alleviating the labour market constraint

Finally, the CGE model is applied to the issue of importing labour from abroad to work in the UK health care sector, applying different assumptions regarding remittances that are sent home. This will lower the wage of health care-specific skilled labour (if it is allowed to fall) and, given government expenditures on health care, increase health care output and so the numbers of people treated and cured.

Disease outbreak

Another potential application of the model is to analyse the impact of a major disease outbreak, such as influenza. Since this requires some adjustments to the model of Chapter 6, this simulation is not as yet included in the modelling exercises.[87]

[87] Other potential applications are the issue of an ageing population and the health tourism phenomenon. The modelling of the former is more appropriate in a dynamic CGE model (such as an overlapping generation model). The latter issue, although it is recognised to be a problem for some localities in the UK, does not play a major role at the national level. Health tourism is estimated to cost in between £50-£200 million a year, which represents approximately 0.07%-0.3% of NHS expenditure (BBC News Online, 14 May 2004, “Are health tourists draining the NHS?”).

CHAPTER 5

A SOCIAL ACCOUNTING MATRIX (SAM) FOR THE UK WITH DETAILED HEALTH CARE DATA

5.1 INTRODUCTION

This chapter describes the augmented UK 2000 Social Accounting Matrix (SAM) to which the Static Computable General Equilibrium (SCGE) model in Chapter 6 is calibrated. A SAM represents the benchmark equilibrium data set in matrix format and thereby provides a comprehensive and consistent picture of the interrelationships in the economy at a point in time.[1] Since the model is applied to the United Kingdom, features that are unique to the UK, and especially its health care system - as discussed in Chapter 4, are emphasised. The SAM is predominantly compiled from the United Kingdom Input-Output Supply and Use Tables (SUT) for the year 2000,[2] supplemented with data from the General Household Survey for the year 2000-2001 (GHS).[3] The structure of production, output, demand and trade are taken from the former data source, which provides a commodity-by-industry use matrix for 123 commodities and industries. A commodity-by-industry make matrix is derived from data on industry and commodity output in 2000 and the most recent published make matrix for the UK, for 1990.[4] The

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1 See Reinert and Roland-Holst (1997) for a discussion of social accounting matrices.

2 Office for National Statistics (ONS, 2002).

3 ONS (2001a). The raw data and supporting material are available online via the United Kingdom Data Archive (UKDA). The ONS and UKDA bear no responsibility for the analysis or interpretation of the data as laid out in this chapter.

4 ONS (1995).

latter data source provides detailed information on a range of topics, including health, the use of health care, earnings and benefits for people living in private households in Great Britain and, for the purpose of this analysis, is also employed in the disaggregation of labour and household data from the SUT. The purpose-built GHS database, available in electronic form from the author upon request, is described in more detail in the appendix to Chapter 5. The UK National Accounts Blue Book is used to ensure that household aggregates are correct.[5]

Section 5.2 proceeds with a discussion of the method of aggregating the GHS and SUT data. Section 5.3 provides a descriptive analysis of the UK economy, its health care system and its households by presenting the data in tables. The last section concludes.

5.2 CLASSIFICATIONS

5.2.1 Sectors

The sector/commodity structure of the SCGE model is an aggregation of the 123 industry/product classification of the SUT (Table 5.1). Sectors that supply a significant part of output to health care as intermediate inputs, the pharmaceutical sector (2) and the sector producing medical instruments (3), are explicitly modelled, as is health care itself (sector 10). The construction sector (6) is distinguished as an important supplier of capital equipment to health care in the form of buildings. The financial sector (8) - including private pensions and private health insurance - and the public sector (9) - including compulsory social security, such as national insurance contributions and public pensions - capture the financial side of the UK health care system.

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[5] ONS (2001b).

Table 5.1 Sectoral aggregation in the SCGE model

#	SECTOR/COMMODITY	DESCRIPTION	CORRESPONDENCE 123 INDUSTRY LEVEL
1	Primary	Agriculture, mining and quarrying	1,..,7
2	Pharmaceuticals	Pharmaceuticals, medicinal chemicals and botanical products	43
3	Medical instruments	Medical, precision and optical instruments, watches and clocks	76
4	Other manufacturing	Manufacturing, excluding pharmaceuticals and medical instruments	8,..,84, excluding 43, 76
5	Energy	Electricity, gas and water supply	85, 86, 87
6	Construction	Construction	88
7	Distribution and transport	Wholesale and retail trade, transport and communication	89,..,99
8	Finance	Financial intermediation	100,..,114
9	Public administration and defence	Public administration and defence, compulsory social security	115
10	Health care	Human health and veterinary activities	117
11	Other services	Education, social work activities and other services	116, 118,..,123

Source: SUT

5.2.2 Factors

The model distinguishes two production factors, capital (mainly land, buildings and equipment) and labour. The latter is subdivided into skilled labour and unskilled labour to address the differences in health outcomes across, and input use of, labour types (Table 5.2). The GHS categorises labour according to the 1990 Standard Occupational Classification (SOC).[6] A skilled-unskilled division is obtained using Winchester's (2002) cluster analysis. Winchester measures skills by observing National Vocational Qualification (NVQ) scores, which evaluate a wide range of educational qualifications, and wages to capture skills acquired informally.[7] Skilled labour employed by health care typically includes medical practitioners, dental practitioners, nurses, technicians and managers. Unskilled labour includes hospital ward assistants and ambulance staff.

6 Office of Population Censuses and Surveys, Employment Department Group (OPCS, EDG, 1990).

7 Winchester distinguishes four skill types: highly skilled, skilled, semi-skilled and unskilled. In this study the first three are grouped into the skilled labour category.

Table 5.2 Classification of labour types in the SCGE model

SOC code	Occupation	SOC Code	Occupation
	Skilled	63	Travel attendants & related occupations
10	General managers in government & large companies	70	Buyers, brokers & related agents
11	Production managers in manufacturing	71	Sales representatives
12	Specialist managers	87	Road transport operatives
13	Financial institution & office managers	88	Other transport & machinery operatives
14	Managers in transport & storing		**Unskilled**
15	Protective service officers	16	Managers in farming, forestry & fishing
17	Managers & proprietors in service industries	44	Stores & despatch clerks, storekeepers
19	Managers & administrators nec	46	Receptionists, telephonists and related occupations
20	Natural scientists	50	Construction trades
21	Engineers & technologists	55	Textiles, garments and related trades
22	Health professionals	56	Printing and related trades
23	Teaching professionals	58	Food preparation trades
24	Legal professionals	59	Other craft and related occupations
25	Business & financial professionals	62	Catering occupations
26	Architects, town planners & surveyors	64	Health and related occupations
27	Librarians & related professionals	65	Childcare and related occupations
29	Professional occupations nec	66	Hairdressers, beauticians and related occupations
30	Scientific technicians	67	Domestic staff and related occupations
31	Draughtspersons, quantity & other surveyors	69	Personal and protective service occupations nec
32	Computer analysts/programmers	72	Sales assistants and checkout operators
33	Ship & aircraft officers, air traffic controllers	73	Mobile, market and door-to-door salespersons
34	Health associate professionals	79	Sales occupations nec
35	Legal associate professionals	80	Food, drink and tobacco process operatives
36	Business & financial associate professionals	81	Textiles and tannery process operatives
37	Social welfare associate professionals	82	Chemicals, paper, plastics and related operatives
38	Literary, artistic & sports professionals	83	Metal making and treating process operatives
39	Associate professional & technical occupations	84	Metal working process operatives
40	Administrative/clerical officers & assistants	85	Assemblers/line workers
41	Numerical clerks & cashiers	86	Other routine process operatives
42	Filing & records clerks	89	Plant and machine operatives nec
43	Clerks (not otherwise specified)	90	Other occupations in agriculture, forestry and fishing
45	Secretaries, personal assistants etc	91	Other occupations in mining and manufacturing
49	Clerical & secretarial occupations nec	92	Other occupations in construction
51	Metal machining & instrument making trades	93	Other occupations in transport
52	Electrical/electronic trades	94	Other occupations communications
53	Metal forming, welding & related trades	95	Other occupations in sales and services
54	Vehicle trades	99	Other occupations nec
57	Woodworking trades		
61	Security & protective service occupations		

Source: adapted from Winchester (2002)

5.2.3 Households

Households in the GHS are aggregated into five types by exploiting the various socio-economic characteristics of household members. The result is a comprehensive classification based on the age and the economic (i.e. working) status of household members that reflects differences in health claims and primary sources of income between households (Table 5.3).

Table 5.3 Classification of households in the SCGE model

		Household member			
		Pensioners (men: 65+, women: 60+)	Children (age: under 16)	Working age (men: 16-64, women: 16-59)	
				Not Working	Working
Household type	Pensioner households	X[1]			
	Non-working households with children		X	X	
	Non-working households without children			X	
	Working households with children		X	X	X
	Working households without children			X	X

Source: GHS.[1]An 'X' indicates that the specific type of household member features in the household.

Economic status, i.e. the separation of households with no working members[8] from households with one or more working members[9], is crucial in various respects. Firstly, to account for the health selection effect, i.e. the observation that entry to and exit from

[8] Definition of not-working: Under 16, those on government scheme with employer, those on government scheme at college, unemployed (ILO definition), other unemployed, permanently unable to work (longstanding illness), retired, keeping house, students, other economic inactive. This includes a very small percentage (0.02%) of individuals whose economic status was not known (either did not know answer or refused to answer).

[9] Definition of working: people aged 16 or over who did at least one hour of paid work in week prior to interview or if they have a job that they are temporarily away from (includes unpaid family work). Note that this definition cannot separate part-time from full-time work.

the labour market is health-related.[10] Secondly, it separates individuals who contribute to the economy in the form of supplying labour from those who do not and thus are net receivers of health care.[11] Moreover, the working status indirectly encompasses the notion that health, however measured, is positively related to income.[12] Furthermore, in the UK income determines consumption, especially of non-health care goods; most health care is publicly provided via the National Health Service (NHS).

The second criterion used to classify households, the age of household members, is of interest as children, those of working age and pensioners have different health needs and, again, to distinguish the net receivers of health care (children and pensioners) from those that are contributing to the country's GDP in terms of supplying labour and so finance health care (working age people).[13]

For the purpose of reducing the number of households, all pensioners living with others in a household have been transferred to the first household type of pensioners.[14] This class thus contains true pensioner households and the members of all other household

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[10] Dahl (1993) and Stronks et al. (1997).

[11] Note that those who have bought (and continue to buy) health care from the private sector also effectively contribute to the NHS in that they do not make (as many) demands on its services. The same is true for capital owners who do contribute towards the financing of health care but not in terms of the supply of labour.

[12] See for example Crémieux et al. (1999), Ettner (1996) and Pritchett and Summers (1996).

[13] The definition of pensioners does not exclude working pensioners and similarly, some of those of working age are not working because of early retirement. Based on the grossed up data, there are very small percentages of early retired and working pensioners, 2.6% of working age are early retired and only 7.4% of the pensioners are working (full-time or part-time), so that the argument still holds.

[14] In total approximately 1.8 million, generally non-working, pensioners have been transferred, forming 1.6 million new households. A pensioner or pensioners living with non-pensioners form a new pensioner household; one pensioner forms a single person household, two pensioners form a two-person household, etc. The transfer slightly lowers the average number of persons and thus average household income for all household types. Nevertheless, per capita income for some households, childless working and non-working households, rises. The effect is largest for the latter: on average

types who are of pensionable age. Presenting the pensioner type as a separate, independent household unit is justifiable on the grounds that this group has very different health needs compared to other age groups and is mostly economically inactive in that they do not supply labour services; and thus its major source of income is formed by income from capital and/or state and/or occupational pensions.[15] Information on children is deducible from a comparison of households with and without children.[16]

5.3 DATA

This section presents the GHS and SUT data, and data from other sources, which are employed in the compilation of the UK 2000 SAM using the aggregations defined in the previous section. Additional background information not directly used in the SAM is provided for illustrative purposes.[17] The data are grouped according to themes, each discussed in a separate section: population data, general health and use of health services, household income by source and household expenditure by destination.

5.3.1 Population data

The classification of households defines the various types of individuals in the model. We distil from the GHS the number of households in Great Britain by type and then for each type the average number of pensioners, children and people of working age. People who are working are either skilled or unskilled, in line with the classification of

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the number of persons in this household falls by 16%, leading to a 15% fall in average household income, though per capita income rises slightly by 1.5%.

15 After the transfer, household incomes have been recalculated from individual level data using the GHS procedure. Possible sharing arrangements (in terms of income and costs) within households with pensioners could work both ways and are therefore assumed to cancel out in aggregate. For example, pensioners may provide child care to the household and, conversely, working children may support retired parents.

16 It is empirically incorrect to put children in a separate household as they are not economically independent; they rely upon parents and/or carers and do not earn much (if any) income of their own.

17 Explicit mention is made when data are employed in the compilation of the SAM.

factors. Skill type information does not exist for some, notably non-working, adults.[18] A complete representation of the skill distribution is obtained by assigning skills to this category using the skill proportions of the sample for which skill information is present.[19] In the category of people who are not working, people who are permanently unable to work are further distinguished as an indicator of the number of long-term ill.[20] Table 5.4 displays the composition of the various households in Great Britain (GB).

Of the 26 million households, most are non-working households without children (38%) or pensioner households (28%). Nevertheless, the majority of the population lives in ‘working, with children’ or ‘working, without children’ households (37% and 34% of the population respectively). The age groups of children and pensioners each comprise approximately 20% of the population. Whereas, non-working households on average consist of 1 adult and working households have 2 (mostly working) adults, both types on average have the same number of children (2). The decision not to work made by the single parent is likely to be correlated with the presence of children. This is in contrast to the childless, non-working household, which has the highest concentration of permanently unable to work (i.e. long-term ill), the majority of which is unskilled. The working population in Britain (48% of the total population) is mostly skilled (64%).

18 Generally, GHS information is missing if: people did not know the answer/refused to answer, were not eligible to answer, or were routed passed the question by the flow of the questionnaire.

19 Unless stated otherwise, this is done for all missing data where information should be present.

20 This group is permanently receiving care and essentially consumes a fixed part of resources.

Table 5.4 Composition of households in GB, 2000-01

Household type		Pensioners		Non-working, children		Non-working, no children		Working, children		Working, no children		All households	
Number of households (millions)		7528464		1122272		2307148		5495448		9983597		26436930	
Average number of persons		1.34		3.28		1.32		3.84		1.92		2.16	
Age groups	Children	0	0%	1.91	58%	0	0%	1.73	45%	0	0%	0.44	20%
	Pensioners	1.34	100%	0	0%	0	0%	0	0%	0	0%	0.38	18%
	Working age	0	0%	1.37	42%	1.32	100%	2.11	55%	1.92	100%	1.34	62%
Economic status and skill type	Skilled workers	0.06	4.5%	0	0%	0	0%	1.09	28.4%	1.10	57.0%	0.66	30.5%
	Unskilled workers	0.04	3.0%	0	0%	0	0%	0.66	17.2%	0.58	30.3%	0.37	17.1%
	Permanently unable to work - skilled	0.01	0.7%	0.06	1.7%	0.20	14.9%	0.01	0.3%	0.02	1.0%	0.03	1.5%
	Permanently unable to work - unskilled	0.02	1.4%	0.13	3.9%	0.25	18.9%	0.02	0.5%	0.03	1.4%	0.05	2.1%
	Other unemployed/inactive - skilled (excl. children)	0.63	46.9%	0.36	11.0%	0.45	34.0%	0.14	3.6%	0.10	5.1%	0.30	13.8%
	Other unemployed/inactive - unskilled (excl. children)	0.58	43.6%	0.82	25.1%	0.43	32.2%	0.19	5.0%	0.10	5.2%	0.32	14.6%

Note on age groups, economic status and skill type: figures represent average number of persons per household and % of average number of persons respectively.

Source: GHS

Table 5.5 Households' use of health care resources in GB, 2000-01

Number of:	Household type	Pensioners	Non-working, children	Non-working, no children	Working, children	Working, no children	All households
NHS GP consultations	Total / year	63522886	22163262	19319875	77442218	70966545	253414786
	Share	25%	9%	8%	31%	28%	100%
	Average	8.4	19.7	8.4	14.1	7.1	9.6
Private GP consultations	Total / year	445763	0	247753	1026646	917879	2638042
	Share	17%	0%	9%	39%	35%	100%
	Average	0.1	0	0.1	0.2	0.1	0.1
GP consultations	Total / year	63968649	22163262	19567628	78468865	71884424	256052828
	Share	25%	9%	8%	31%	28%	100%
	Average	8.5	19.7	8.5	14.3	7.2	9.7
Inpatient visits	Total / year	1966836	412986	604094	1325127	1336920	5645964
	Share	35%	7%	11%	23%	24%	100%
	Average	0.3	0.4	0.3	0.2	0.1	0.2
Days in hospital as daypatient	Total / year	3191723	638184	1941033	2507532	2532792	10811265
	Share	30%	6%	18%	23%	23%	100%
	Average	0.4	0.6	0.8	0.5	0.3	0.4
Outpatient visits	Total / year	18851819	4169963	7021378	17735973	20999353	68778485
	Share	27%	6%	10%	26%	31%	100%
	Average	2.5	3.7	3.0	3.2	2.1	2.6

Notes: excludes persons for whom information is not available because they: are routed past the question by the flow of questionnaire; did not know the answer or refused to answer; or were not eligible to answer. Inpatient and day patient visits exclude maternity stays.

Source: GHS

5.3.2 General health and use of health services

Table 5.5 shows the claims that households in Great Britain make on the health system in terms of primary care and secondary care, using GHS data on the number of publicly and privately financed consultations with a general practitioner (GP), the number of in- and outpatient visits to a hospital, and the number of days in hospital as a day patient.[21] Working households with children account for the majority (31%) of GP consultations. Close second and third are childless working households and pensioners, with shares of 28% and 25% of all GP consultations respectively. This partly reflects the relative size of the households and household groups in the GHS (see Table 5.4). For example, a household with one or more children visits a GP approximately twice as often in a year compared to a childless household (whether working or not working). Next to having children, working status matters most: a non-working household with or without children, though being smaller in size, consults the GP more times in a year than a working household. In terms of GP consultations, households rely heavily on the public sector, which accounts for 99% of all consultations in a year. Pensioners and working households in particular use private sector GPs.

Secondary care use matches that of primary care. Secondary care is mostly used by working households and pensioner households, though childless non-working households also account for a relatively high share of day patient visits made in 2000-01 (18%). At the household level, not participating in the labour market while having children generally increases the number of times secondary care is used by a household.

[21] Tertiary care, i.e. informal care for others, forms a relatively small part of the health care system and is therefore not included.

Due to its relatively small size, a pensioner household on average makes a relatively low number of claims on the health system. Nevertheless, pensioner households account for a relatively large share of total primary and secondary care usage owing to the relatively large size of this household category (28% of households in Great Britain are of the pensioner type) and - more importantly - as a consequence of the relatively high cost of treatment for people of old age.[22]

The household data indicate that the use of primary and secondary care in Great Britain varies with the socio-economic characteristics of households in the SCGE model, such as economic status (participation in the labour market by household members) and age composition. Figures 5.1 to 5.5 further explore these relationships by examining a selection of general population health measures, organised in terms of three socio-economic characteristics of the population: labour market participation (distinguishes working, permanently unable to work and other unemployed / inactive), age (identifies pensioners, working age individuals and children) and skill type (skilled versus unskilled).[23] The reported population health measures rely upon respondents' own assessments and may thus reflect increased expectations which people have about their health as well as changes in the actual prevalence of sickness.[24]

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[22] See for example Emmerson et al. (2000, p 46). Table 5.5 accounts for treatment cost in terms of the number of times health care services are used, but does not show how costly they are.

[23] Individuals for whom information is not available (routed past the question by the flow of the questionnaire; did not know, refused or were not eligible to answer) are excluded from the data. The 'all' category reports data on individuals for whom information on the respective socio-economic characteristic *and* health measure is available. As the size of this category varies by socio-economic characteristic, health outcomes may vary slightly across the 'all' categories.

[24] Evidence shows that there is a high level of agreement between incidence based on self-reporting and on medical examinations, and between self-reporting and doctor diagnosis of specific conditions (ONS, 2001a, p77).

Not surprisingly, the percentage of the population reporting good general health falls with age and rises with skills and participation in the labour market (Figure 5.1), averaging 64% across all ages.

Figure 5.1 Self-perception of general health in GB, GHS 2000-01

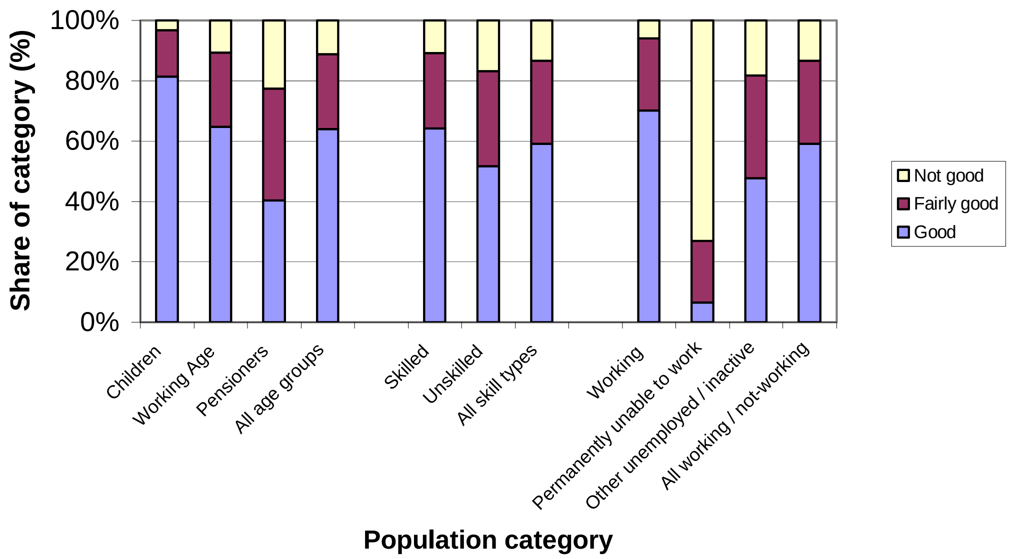


Figure 5.2 Prevalence of self-reported longstanding illness in GB, GHS 2000-01

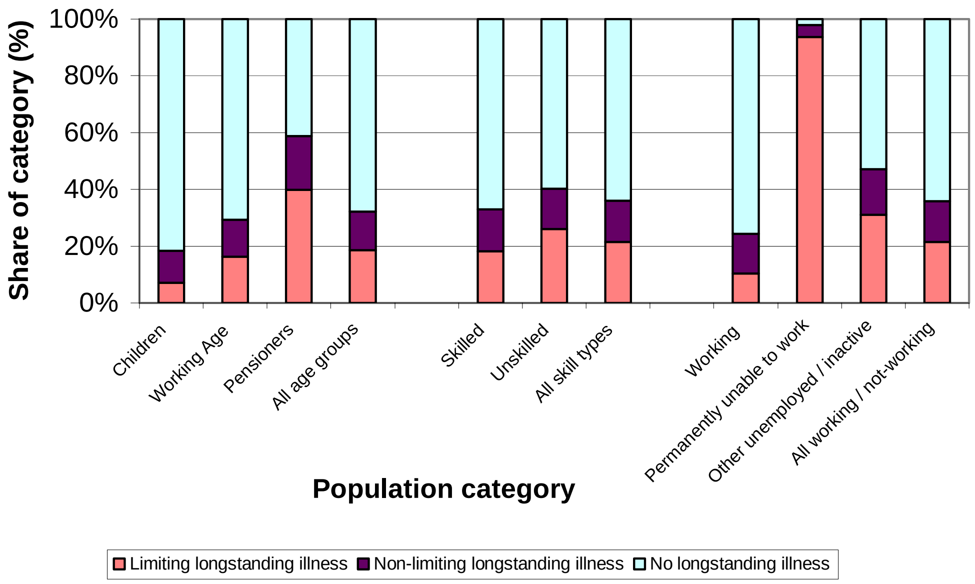
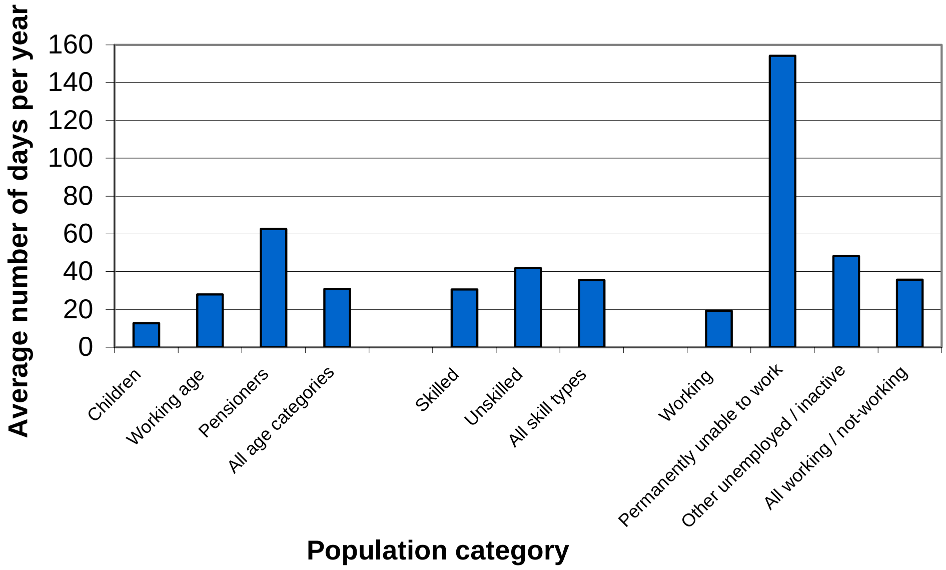


Figure 5.3 Days of restricted activity in GB, GHS 2000-01



Likewise, prevalence of (non-) limiting longstanding illnesses[25] (Figure 5.2) - averaging 19% (14%) for limiting (non-limiting) illnesses, increases by age and falls with skills and labour market participation. The majority (98%) of persons permanently unable to work suffer from one or more longstanding illnesses, of which 94% is considered to be limiting. It is this group that also reports the highest number of days of restricted activity (Figure 5.3). The latter measure - averaging 31 days per year across all age groups (28 for those of working age, 19 for those working and 35 across all skill types) - yet again increases by age and decreases in skills and labour market participation.

Details of reported longstanding illnesses are coded using the 9th revision of the International Classification of Diseases (ICD)[26], and are aggregated into groups

[25] The underlying GHS question is: 'Do you have any longstanding illness, disability or infirmity? By longstanding, I mean anything that has troubled you over a period of time or that is likely to affect you over a period of time?'. Those answering positively are asked if this limits their usual activities (about the house, at work, or in free time) in any way. If answered affirmatively, the number of days of 'restricted activity' is recorded (Figure 5.3).

[26] Published by the World Health Organization (WHO, 1977).

approximating to the ICD chapter headings (Table 5.6). Figures 5.4 and 5.5 show the illnesses that respectively are most and least prevalent across the population.[27]

Figure 5.4 Longstanding illness prevalence: 7 major ICD groups, GHS 2000-01

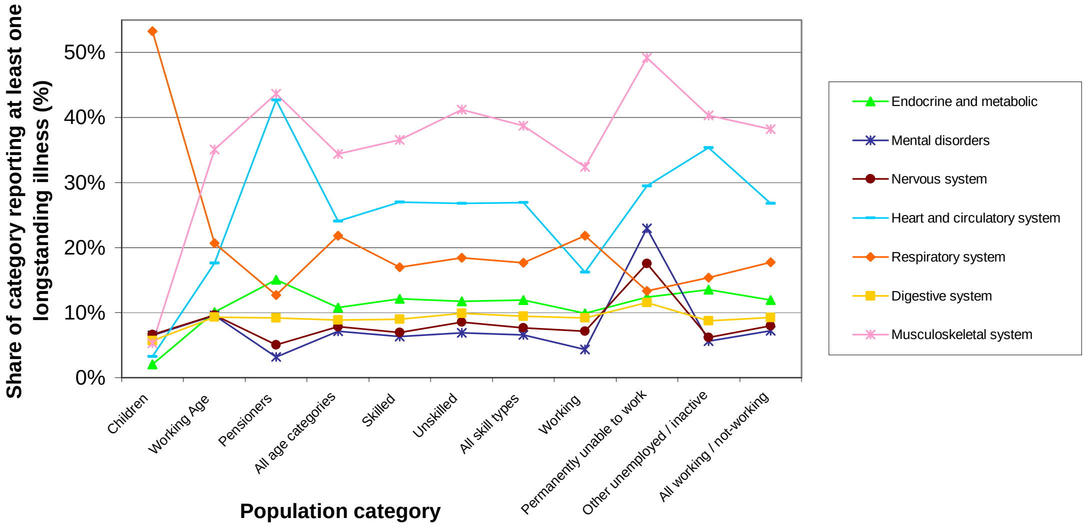
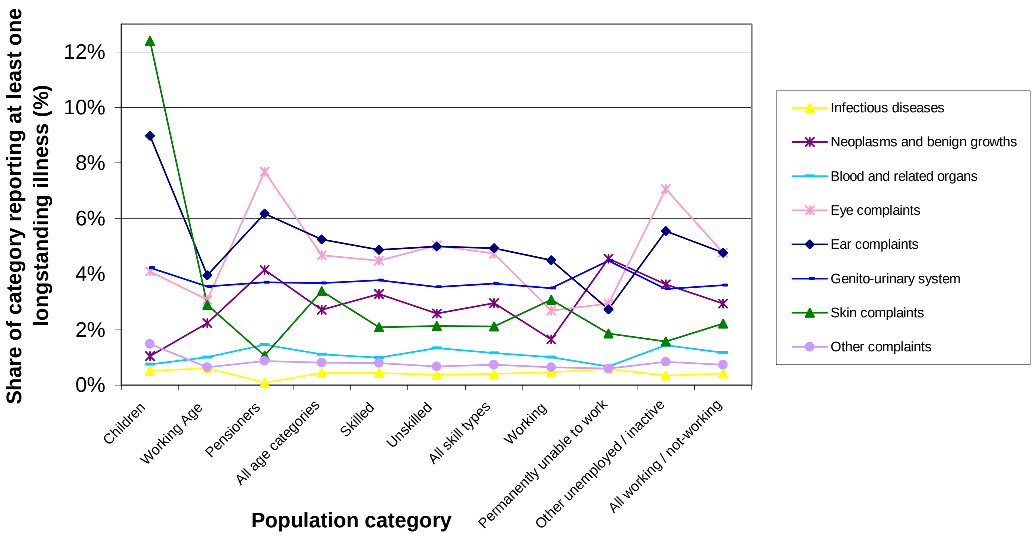


Figure 5.5 Longstanding illness prevalence: 8 minor ICD groups, GHS 2000-01



27 Note that respondents may indicate more than one complaint, with a maximum of six coded, so that percentages do not add up to 100%.

The most common condition reported by respondents suffering from at least one longstanding illness were musculoskeletal problems (34%), especially for adults, heart and circulatory problems (24%), especially for pensioners, and respiratory problems (22%), especially for children. Whereas for all conditions skill type variations are minor[28], the type of longstanding illness reported varies considerably by age and labour market participation of the population.

With respect to age differences, the share of people with one or more longstanding illnesses being ill from musculoskeletal problems, heart and circulatory problems, endocrine and metabolic conditions, neoplasms and benign growths and illnesses of blood and related organs rises with age, whereas respiratory problems and skin problems become less important with age. Compared to other age categories, working age individuals with longstanding illnesses have a higher prevalence of mental disorders and problems of the nervous system, but a lower prevalence of ear and eye complaints.

Concerning labour market participation variations, the working population reporting at least one longstanding illness, compared to those not participating in the labour market, are less likely to be affected by musculoskeletal, heart and circulatory problems but show higher rates of respiratory problems. The permanently unable to work with one or more longstanding illnesses display prevalence rates for mental disorders, problems of the nervous system and musculoskeletal problems well above rates for other unemployed or inactive (rates for mental disorders and nervous system problems are respectively four and three times higher compared to the latter).

[28] With the notable exception of the reported prevalence of musculoskeletal complaints, which falls as skills rise.

Table 5.6 Classification of diseases in the GHS

Condition group		ICD code	Condition
1	Infectious diseases	37	Infectious and parasitic disease
2	Neoplasms and benign growths	1	Cancer (neoplasm) including lumps, masses, tumours and growths and benign (non-malignant) lumps and cysts
3	Endocrine and metabolic	2	Diabetes
		3	Other endocrine / metabolic
4	Blood and related organs	38	Disorders of blood and blood forming organs
5	Mental disorders	4	Mental illness / anxiety / depression / nerves(nes) (include neuroses)
		5	Learning difficulties
6	Nervous system	6	Epilepsy / fits / convulsions
		7	Migraine / headaches
		8	Other problems of nervous system
7	Eye complaints	9	Cataract / poor eye sight / blindness
		10	Other eye complaints
8	Ear complaints	11	Poor hearing / deafness
		12	Tinnitus / noises in the ear
		13	Meniere’s disease / ear complaints causing balance problems
		14	Other ear complaints
9	Heart and circulatory system	15	Stroke / cerebral haemorrhage / cerebral thrombosis
		16	Heart attack / angina
		17	Hypertension / high blood pressure / blood pressure (nes)
		18	Other heart problems
		19	Piles / haemorrhoids
		20	Varicose veins / phlebitis (lower extremities)
		21	Other blood vessels / embolic
10	Respiratory system	22	Bronchitis / emphysema
		23	Asthma
		24	Hay fever
		25	Other respiratory complaints
11	Digestive system	26	Stomach ulcer / ulcer (nes) / abdominal hernia / rupture
		27	Other digestive complaints (stomach, liver, pancreas, bile ducts, small intestine - duodenum, jejunum and ileum)
		28	Complaints of bowel / colon (large intestine, caecum, bowel, colon, rectum
		29	Complaints of teeth / mouth / tongue
12	Genito-urinary system	30	Kidney complaints
		31	Urinary tract infection
		32	Other bladder problems / incontinence
		33	Reproductive system disorders
13	Skin complaints	39	Skin complaints
14	Musculoskeletal system	34	Arthritis / rheumatism / fibrositis
		35	Back problems / slipped disc / spine / neck
		36	Other problems of bones / joints / muscles
15	Other complaints	40	Other complaints (incl. insomnia, sleepwalking, fainting, adhesions, hair falling out, alopecia, travel sickness, nose bleeds, no smell, no speech, dumb)
		41	Unclassifiable (no other codable complaint; including old age / weak with old age, general infirmity and conditions nes)

Source: GHS

5.3.3 Household income by source

Individuals, and thus the households in which they are grouped, receive income from mainly two sources: factor income (labour income and capital income) and income from government transfers. With respect to the former, the SUT provides information on each factor's share in sectoral value added, i.e. income generated by capital and labour, by sector of employment. The GHS is used to disaggregate these types of income further over household types and, where relevant, to skill types. Specifically, labour income by sector of employment is apportioned to skilled and unskilled labour using the GHS distribution of yearly gross earnings by sector over skill types (Table 5.7).[29]

Table 5.7 Gross labour income by skill type and sector of employment, UK 2000

	Sector	Skilled		Unskilled		Sector total	
		million £	(% of sector total)	million £	(% of sector total)	million £	(%)
1	**Primary**	2480	40%	3683	60%	6163	1%
2	**Pharmaceuticals**	2893	89%	369	11%	3262	1%
3	**Medical instruments**	2992	76%	930	24%	3922	1%
4	**Other manufacturing**	75625	73%	27674	27%	103299	20%
5	**Energy**	4641	93%	346	7%	4987	1%
6	**Construction**	14835	68%	7133	32%	21968	4%
7	**Distribution and transport**	92124	73%	33669	27%	125793	24%
8	**Finance**	101066	96%	4152	4%	105218	20%
9	**Public administration and defence**	31999	93%	2347	7%	34346	7%
10	**Health care**	26346	84%	5031	16%	31377	6%
11	**Other services**	67130	79%	17425	21%	84555	16%
	Total	422130	80%	102760	20%	524890	100%

Source: adapted from GHS, SUT

Table 5.7 shows that the primary sector is least skill-intensive in its use of labour (generating only 40% of gross labour income) whereas, at the other end of the spectrum, finance is relatively most skill-intensive (generating 97% of gross labour income in that

[29] Income data for both main and second jobs - which respondents hold in addition to a main full-time or part-time job - are included in the calculations.

sector). Health care lies in between these two extremes, but with 84% of gross labour income earned by skilled labour, is still relatively skill-intensive. Health care, however, generates only 6% of gross labour income in the UK, compared to 24% for distribution and transport, and 20% for both finance and other manufacturing.

Gross labour income by skill type is subsequently distributed over households using GHS data on yearly gross earnings organised by skill and household type. Similarly, gross capital income from the SUT is allocated to households according to the distribution of income from other sources,[30] regular payments[31] and other regular payments[32] in the GHS (Table 5.8).

Table 5.8 Gross factor income by household type, UK 2000

Household type	Capital		Skilled		Unskilled		Total household	
	million £	(% of household total)	million £	(% of household total)	million £	(% of household total)	million £	(%)
Pensioners	139526	95%	5664	4%	1787	1%	146977	18%
Non-working, children	3049	100%	0	0%	0	0%	3049	0%
Non-working, no children	28659	100%	0	0%	0	0%	28659	3%
Working, children	68264	27%	151043	59%	36064	14%	255370	31%
Working, no children	55971	14%	265423	69%	64909	17%	386303	47%
Total factor income	295469	36%	422130	51%	102760	13%	820359	100%

Source: adapted from GHS, SUT

Factor income is mostly received by working households (78% of total gross factor income), the remainder accrues to pensioner households (18%) and childless non-working households (3%). The latter household groups rely heavily on capital as source of *factor* income, whereas working households' factor income mainly takes the form of payments to skilled labour (in the range of 59% to 69% of factor income).

30 Including occupational pensions from former employer/spouse's former employer, redundancy payments, private pensions and training schemes like YT allowance.

31 Including rent from property or subletting, educational grants, regular payments from friends and family outside the household and maintenance-, alimony-, or separation allowance.

Total disposable household income (Table 5.9) is the result of adjusting the gross earnings data for income or employment taxes and adding income from government transfers. The total value of income taxes is obtained from the National Accounts Blue Book and allocated to factors of production by postulating a *net* capital employment tax of 20% and an employment tax for skilled labour of 1.5 times that of unskilled labour, yielding *net* labour employment taxes of 22% and 14% respectively. In *gross* terms - the definition of input taxes employed in the SCGE model in Chapter 6 - this implies employment taxes of 25%, 28% and 17% for capital, skilled and unskilled labour respectively.[33] Income from state benefits, also from the National Accounts Blue Book, is disaggregated using the distribution of income from state benefits in the GHS.[34] Disposable household income from the SUT is approximately 1.4% lower than the resulting total of factor income plus government transfers by household type, so that the latter source of income is reduced by 1.4% of each household type's disposable income.

Table 5.9 Disposable income by type of household, 2000

Household type	Disposable factor income		Government transfers		Total	
	million £	(% of total)	million £	(% of total)	million £	(%)
Pensioners	117586	66%	59702	34%	177287	23%
Non-working, children	2439	17%	11685	83%	14125	2%
Non-working, no children	22927	65%	12103	35%	35030	5%
Working, children	203764	88%	26767	12%	230531	30%
Working, no children	308193	99%	3953	1%	312146	41%
All households	654910	85%	114209	15%	769119	100%

Source: adapted from GHS, SUT

32 Such as income from interest, shares and bonds.

33 An employment tax defined as a *net* tax implies that owners of factors of production receive $(1 - taxrate) \cdot market\ price$, whereas an employment tax defined as a *gross* tax implies that the owners of factors of production receive the $market\ price$, which excludes the tax.

34 These comprise child benefits, state pensions, disability living allowance, attendance allowance, job seekers allowance, incapacity benefits, statutory sick pay, working family tax credit and housing/council tax benefits.

Table 5.9 shows that pensioners and non-working households rely relatively heavily on income from government transfers as a source of disposable income compared to working households. Non-working households with children, for example, receive 83% of their disposable income in state benefits, whereas for childless non-working households and pensioners this share is significantly lower, 35%.

5.3.4 Household expenditure by destination

Households allocate income over consumption and savings. Assuming that only working households save, total nominal savings are distributed over these households in proportion to their income. This yields a savings rate of 30% of disposable household income, equivalent to a national savings rate of 21%. Consumption expenditures by type of household are the resultant of subtracting household savings from disposable income (from Table 5.9). Private health care expenditures are allocated to households using the share of each household in the number of total private GP consultations (from Table 5.5). Accordingly, working households with and without children and pensioners account for most of private health care expenditures (35%, 39% and 17% respectively).[35] A disaggregation by type of commodity other than private health care is obtained by applying common household consumption shares. The results, displayed in Table 5.10, reveal that the bulk of household expenditure on goods is concentrated in other manufacturing, finance, distribution and transport and other services (45%, 21%, 14% and 12% of private consumption expenditures respectively).

[35] These data agree with Emmerson et al. (2000), King and Mossialos (2002) and Propper (2000), which suggest that private health insurance coverage or the use of private health facilities is positively related to factors such as income, employment, age (up to 55), and not having children.

Table 5.10 Household expenditures by type of household, 2000

Household expenditures (million £)	Pensioners	Non-working, children	Non-working, no children	Working, children	Working, no children	Total	Consumption shares
1 Primary	2995	241	583	2679	3654	10151	2%
2 Pharmaceuticals	927	74	181	830	1132	3144	1%
3 Medical instruments	859	69	167	769	1048	2913	0%
4 Other manufacturing	80992	6506	15766	72464	98820	274547	45%
5 Energy	4643	373	904	4154	5665	15740	3%
6 Construction	1307	105	254	1169	1594	4430	1%
7 Distribution and transport	25286	2031	4922	22624	30852	85715	14%
8 Finance	36831	2958	7170	32953	44938	124850	21%
9 Public administration and defence	343	28	67	307	419	1163	0%
10 Health care	1438		799	3312	2961	8509	1%
11 Other services	21665	1740	4217	19383	26433	73439	12%
Total consumption expenditures	177287	14125	35030	160644	217516	604602	100%
Total savings				69887	94630	164517	
Savings rate (% of disposable income)				30%	30%	21%	
Disposable income	177287	14125	35030	230531	312146	769119	

Source: adapted from GHS, SUT

5.4 CONCLUSIONS

This chapter has discussed the compilation of a Social Accounting Matrix (SAM) which is suitable for use in a Computable General Equilibrium (CGE) model applied to the UK with a detailed health care component. The sector/commodity classification distinguishes the main input suppliers to health care, pharmaceuticals, medical instruments and construction as the supplier of capital, health care itself, and financial and public sectors to account for health care financing. Labour is grouped into two types, skilled and unskilled labour, to capture differences in health outcomes and input use, whereas households are allocated to five types based on the age and labour market participation of its members. The SAM is constructed mainly from the Supply and Use Tables (SUT) for 2000, using the aggregations of households, sectors/commodities, and factors. These data are subsequently enriched with data from the 2000-01 General Household Survey (GHS), which are directly employed in determining: the distribution of labour income across skill types; the disaggregation of factor income and income from state benefits over households; and the allocation over households of private health care expenditures. The GHS provides valuable insight into the differences in health care use across households, using information on the numbers and the composition of households and a selection of general population health measures which vary by age, labour market participation and skill type. The purpose-built GHS database (see also the appendix to Chapter 5), is available in electronic form upon request.

The income data reveal that the health care sector is relatively skill-intensive but small in terms of gross labour income. Working and pensioner households with working members receive most of factor income. For pensioner households and non-working households this type of income comes mainly in the form of payments to capital, whereas working households rely primarily on skilled labour. Especially for non-working households with children, income from state benefits is an important source of disposable income. Part of disposable income is saved by working households, the remainder being allocated to the consumption of goods, especially other manufacturing, finance, distribution and transport and services. Private health care expenditures form only 1% of total household consumption expenditures, again suggesting a relatively small (private) health sector.

The population data show that the majority of the 26 million households is of the childless non-working type or pensioner type, although working households, which are bigger in average household size, have the highest population numbers (71% of the population in total). Pensioners and children approximate 20% of the population each. Of the population that is working, the majority is skilled (approximately 2/3), whereas the bulk of those permanently unable to work and, to a lesser extent, other unemployed or inactive are unskilled. The average childless non-working household has the highest propensity of the former group of non-workers.

From data on health care use, it is apparent that working households and pensioners account for most of the General Practitioner (GP) consultations. This is partly explained by household numbers and average household size and partly by household characteristics: the number of GP consultations is positively associated with having children and negatively associated with labour market participation. The use of secondary care across households demonstrates a similar picture. Pensioner- and working households are the main users of private sector GPs, though most GP consultations are provided by the National Health Service (NHS). Pensioners typically need more and more costly care, though the cost of health services used cannot be discerned from the GHS database.

Self-reported data on population health provide background information on the use of health care by households. In spite of the smallness of the health sector, these data show that a significant proportion of the population suffers from ill health. Only 64% of the population is positive about their health status, whereas 19% (14%) indicates having one or more limiting (non-limiting) longstanding illnesses. The latter report an average of 31 restricted activity days per year, which amounts to a share of 8.5%. Typically, the share of the population reporting good general health falls with age and rises with skills and labour market participation. Likewise, the prevalence of (non-) limiting longstanding illnesses and the number of restricted activity days increases with age and falls with skills and labour market participation. The most common complaints are musculoskeletal problems, heart and circulatory problems and respiratory problems. The type of reported condition varies considerably by age and labour market participation, though not so much by skill type.

CHAPTER 6

A STATIC CGE (SCGE) MODEL FOR THE UK WITH HEALTH CARE PROVISION

6.1 INTRODUCTION

This chapter reports on simulations carried out with a Static Computable General Equilibrium (SCGE) model for the UK, which includes health care provision effects. The SCGE model takes the theoretical framework of Chapter 2 as its starting point, but deviates from that where it is deemed insufficient to depict reality, in particular concerning key features of the UK health system, discussed in Chapter 4. The SCGE model is calibrated to the UK 2000 Social Accounting Matrix (SAM) with special detail in terms of health care provision and use (developed in Chapter 5), and programmed in MPSGE (Mathematical Programming System for General Equilibrium analysis), which is a subsystem of the GAMS (General Algebraic Modeling System) software. The model files are included in the appendix to Chapter 6 and available in electronic form from the author upon request. The simulations cover current issues, specifically the economy-wide effects of a rise in public health expenditures, a pharmaceutical price rise, the immigration of health care-specific skilled labour and technological progress, which is factor-neutral, skill-biased, or embodied in pharmaceuticals, respectively.[1] The experiments are carried out using alternative model specifications, mainly regarding factor markets and the government budget. A short outline of the model is given below.

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[1] A preliminary version of this chapter was presented at the International Conference on Policy Modeling in Istanbul, 2003, organised by the EcoMod Network and the Third Annual GEP Postgraduate Conference, 2004, organised by the GEP (Rutten et al., 2003, 2004).

The SCGE model has in most respects a standard structure, the novelty coming from the explicit modelling of the health sector, comprising public and private health care, and its interaction with the rest of the economy through its differential impact across skilled and unskilled labour, and across households, characterised by the age and working status of its members. The effects on welfare of higher health provision are two-fold: it directly increases the 'well-being' of the population and indirectly improves welfare by increasing the size of the *effective* (i.e. 'able to work') endowments of skilled and unskilled labour for use in non-health activities. All other sectors are perfectly competitive, the production technologies are Constant Returns To Scale (CRTS), household preferences are homothetic and factors are homogenous. Domestic sectors are multi-product industries. Cross-border trade is treated using the assumption that the UK is a small open economy facing exogenous world prices for imports and exports. In addition, the Armington assumption is imposed on both production and consumption: goods produced are destined for either the domestic market or for the export market, while consumers differentiate between domestic and imported varieties of the 'same' good. The government uses its revenue from a variety of taxes to purchase a fixed expenditure of goods and to accommodate the trade surplus. The remainder of its budget is spent on income transfers to households which adjust so as to maintain the government account balance. Consumers allocate the latter income and earnings from the supply of capital, skilled and unskilled labour to savings and consumption. With the exchange rate as numéraire and the trade balance fixed in terms of foreign exchange, investments are savings-driven so that the model closure adopts a neoclassical approach.

The remainder of this chapter is structured as follows. Sections 6.2 and 6.3 describe the SCGE classifications and the equations of the model respectively. Section 6.4 discusses the assumptions underlying the calibration process. Model simulations and results are presented in section 6.5 and compared in section 6.6. The sensitivity of results to key parameter values is addressed in section 6.7. The final section concludes.

6.2 CLASSIFICATIONS

The classifications of primary production factors, households and sectors, summarised in Table 6.1, are drawn from the UK 2000 SAM.

Table 6.1 The SCGE model classifications

FACTORS OF PRODUCTION (f)	HOUSEHOLDS (h)
Skill. Skilled labour	Hse1. Pensioners
Unsk. Unskilled labour	Hse2. Non-working, children
Cap. Capital	Hse3. Non-working, no children
	Hse4. Working, children
	Hse5. Working, no children
SECTORS (i) / COMMODITIES (j)	
1. Primary	7. Distribution and transport
2. Pharmaceuticals	8. Finance
3. Medical instruments	9. Public administration and defence
4. Other manufacturing	10. Health care
5. Energy	11. Other services
6. Construction	

Note: labour types, households and sectors are classified using the techniques outlined in Chapter 5.

Skilled labour, unskilled labour and capital are distinguished as production factors. The owners of factors of production, households, are grouped into five types reflecting differences in age and working status composition. The SAM distinguishes eleven sectors (commodities), including health care and its principal sources of inputs, the pharmaceutical sector and the sector producing medical instruments. In terms of *final* demand for commodities a division between the National Health Service (NHS) and private health care (PHC) is created. This rests upon the assumption that both the NHS and PHC purchase health care from the health sector, but that while the NHS sells its health care to the government, PHC sells to households.

6.3 MODEL EQUATIONS

6.3.1 Effective endowments and waiting lists

The effective supply of factor endowments f by households h is specified in equations (6.1) and (6.2).

$$F_{E_{hf}} = \bar{F}_{hf} - WL_{hf} \tag{6.1}$$

$$WL_{hf} = \eta_f \bar{F}_{hf} \tag{6.2}$$

where $0 < \eta_f < 1$ for labour types $f \in l$, $l = \{Skill, Unsk\}$; otherwise (for capital) $\eta_f = 0$. $F_{E_{hf}}$ denotes the effective supply by household h of factor f, $\bar{F}_{hf}$ is the total potential factor endowments of f owned by household h, of which WL_{hf} identifies the part that is not working, i.e. the waiting list. The waiting list, which records ill persons who have not yet been successfully treated and are thereby unable to work, is defined to be positive only for labour ($f \in l$), and is modelled as a fraction of the total given labour endowments in the economy of household h.[2] Capital is always fully effective and fully employed.[3]

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[2] While, for simplicity of exposition, waiting lists and effective labour endowments are defined in terms of numbers of workers, a definition involving scaling in terms of worker-hours is equally valid.

[3] This does of course ignore the loss in effective capital when, for instance, machines break down. However, the cost of repairing a machine is internal to the firm, and is assumed to be assimilated into the cost of capital services, whereas the repair (treatment) of ill workers is a cost to the state or to the worker's insurers.

The fraction of people on the waiting list, the non-participation rate, is assumed to be identical across all households and is defined as a constant elasticity function of a health composite:

$$\eta_{f\in l} = \eta_{0\,f} HC_f^{-\varepsilon_f} \tag{6.3}$$

where $\eta_{f\in l}$ denotes the non-participation rate for l, $\eta_{0\,f\in l} > 0$ is a scale parameter which is calibrated so that $\eta_{f\in l} < 1$,[4] $HC_{f\in l}$ is a health composite, and $\varepsilon_{f\in l} > 0$ is an elasticity parameter.

The health care composite for labour type l is a measure of the 'healthiness', i.e. health status, of this labour type and is modelled as a function of its public and private health care consumption using a Cobb Douglas (CD) formulation:

$$HC_{f\in l} = G_{"10"}^{\upsilon_f} \left(\sum_h C_{"10"h}\right)^{(1-\upsilon_f)} \tag{6.4}$$

where $0 \le \upsilon_l \le 1$ denotes the share of public health care in the health status of labour type l. $G_{"10"}$ denotes health care (commodity "10" in Table 6.1) provided via the NHS, and $\sum_h C_{"10"h}$ represents the level of private health care provisioning, PHC. The former is given by government consumption, G_j, of health care and the latter by the sum of household consumptions, C_{jh}, of private health care.

4 Note that $\lim_{HC_f \to \infty} \left(\eta_f\right) = 0$, but that the upper constraint for η_f is not automatically satisfied.

The scale parameter $\eta_{0\,f \in l}$ measures the non-participation rate for $\varepsilon_{f \in l} = 0$. Health care is then completely ineffective (i.e. does not cure people) and therefore does not affect waiting lists. Alternatively, for a given *level* of health care, a reduction in the scale parameter $\eta_{0\,f \in l}$ implies a lower non-participation rate, hence a lower waiting list and a higher effective labour supply. Accordingly, $\eta_{0\,f \in l}$ measures the effectiveness of a given level of health care in treating and/or curing people.

The elasticity parameter $\varepsilon_{f \in l} = -\left(\partial WL_{hf} / \partial HC_f\right) \cdot \left(HC_f / WL_f\right) > 0$ represents the proportionate change in the size of labour type l's waiting list for household h following a change in the health composite, i.e. the waiting list elasticity. For a given *change*, the higher the value of the elasticity parameter, the greater the reduction in the waiting list and the increase in effective labour. $\varepsilon_{f \in l}$ thus measures the effectiveness of a change in health provisioning in treating and/or curing people.

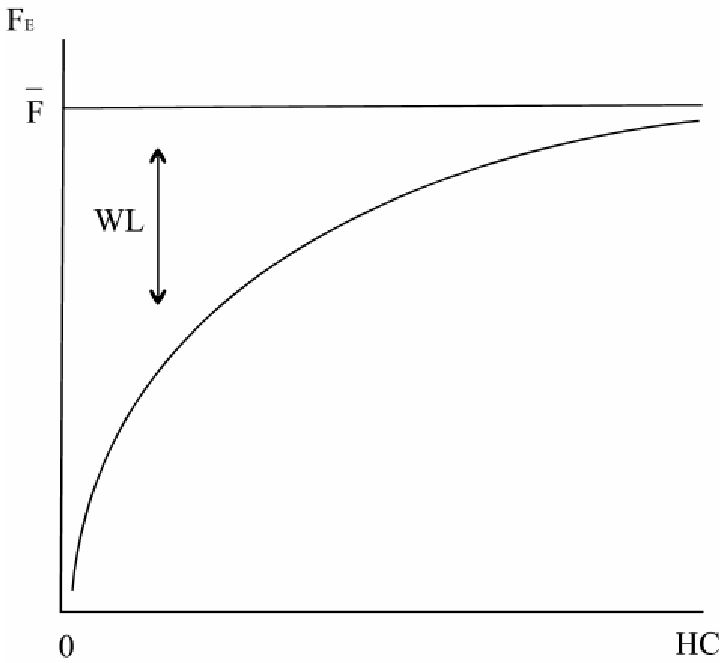
For each labour and household type, the waiting list and the effective labour supply as functions of the health composite follow from equations (6.2) and (6.3): $\left(\partial WL_{hf} / \partial HC_f\right)_{f \in l} = -\varepsilon_f \eta_{0f} HC_f^{-(\varepsilon_f + 1)} \overline{L}_f = -\varepsilon_f \, WL_{hf} / HC_f < 0$ and

$\left(\partial^2 WL_{hf} / \partial HC_f^2\right)_{f \in l} = \varepsilon_f \left(\varepsilon_f + 1\right) \eta_{0f} HC_f^{-(\varepsilon_f + 2)} \overline{L}_f = \varepsilon_f \left(\varepsilon_f + 1\right) WL_{hf} / \left(HC_f\right)^2 > 0$;

hence waiting lists are decreasing in the health composite at a decreasing rate. Equivalently, $\left(\partial F_{E_{hf}} / \partial HC_f\right)_{f \in l} = -\partial WL_{hf} / \partial HC_f > 0$ and

$\left(\partial^2 F_{E_{hf}} / \partial HC_f^2\right)_{f \in l} = -\partial^2 WL_{hf} / \partial HC_f^2 < 0$, implying that the effective labour supply is increasing in the health composite, but at a decreasing rate. Figure 6.1 illustrates.

Figure 6.1 Waiting lists and effective endowments



6.3.2 Production by sector and commodity

The structure of production in each of the sectors is shown in Figure 6.2. Production of sector i, X_i, is a Leontief (constant coefficient) function of value added, V_i - itself a CD function of factor demand for factor f, $F_{D_{fi}}$ - and intermediate inputs from sectors j, N_{ji}. Sector i's production is a CD composite of the commodities j it produces, Q_{ji}. The resulting first order conditions are given by (6.5) to (6.8):[5]

$$V_i = A_{X_i} X_i \qquad (6.5)$$

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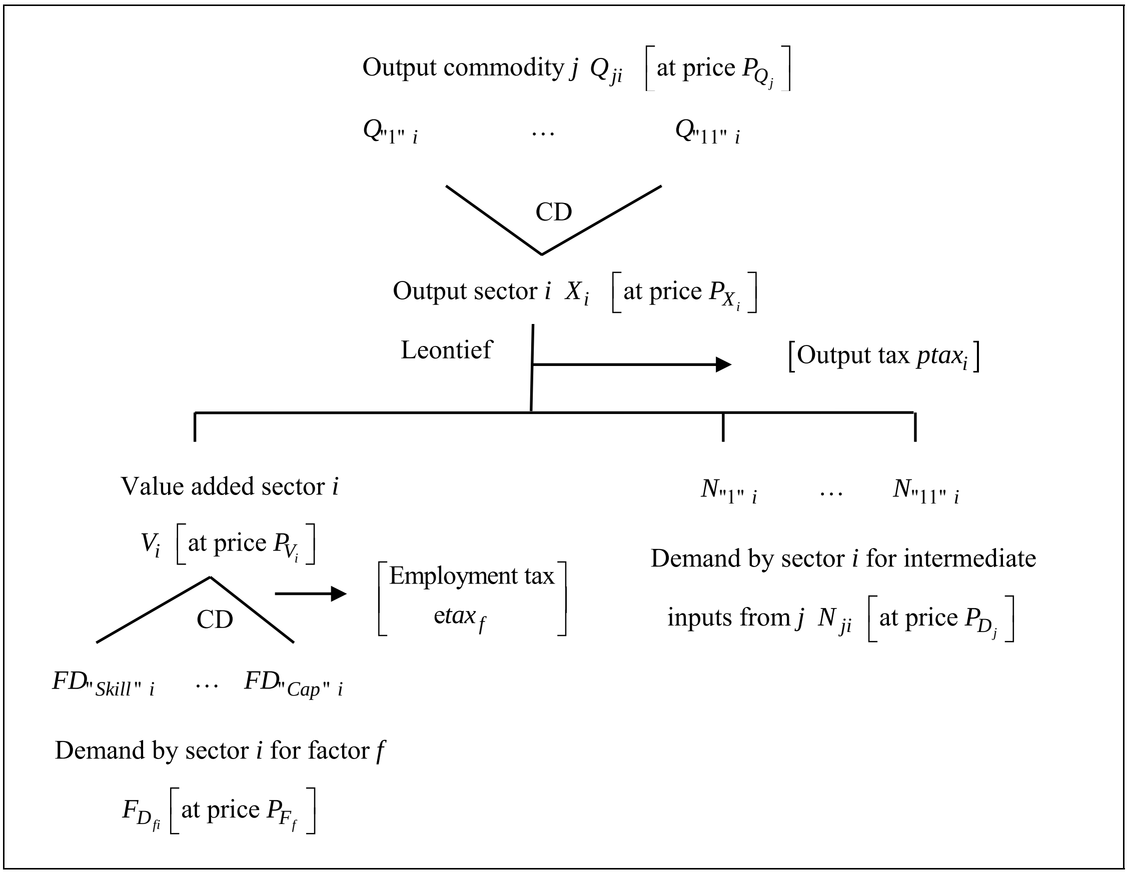
[5] The underlying CD equations for sectoral production and value added are $X_i = A_{Q_i} \prod_j Q_{ji}^{\alpha_{Q_{ji}}}$ and $V_i = A_{Vi} \prod_f F_{D_{fi}}^{\alpha_{V_{fi}}}$ respectively. The Leontief production function is represented by: $X_i = \min\left[V_i / A_{X_i}, N_{ji} / A_{ji} \right]$.

Figure 6.2 The nested production function



$$N_{ji} = A_{ji} X_i \tag{6.6}$$

$$F_{D_{fi}} = \alpha_{V_{fi}} V_i \, P_{V_i} \big/ P_{F_f} \tag{6.7}$$

$$Q_{ji} = \alpha_{Q_{ji}} X_i \, P_{X_i} \big/ P_{Q_j} \tag{6.8}$$

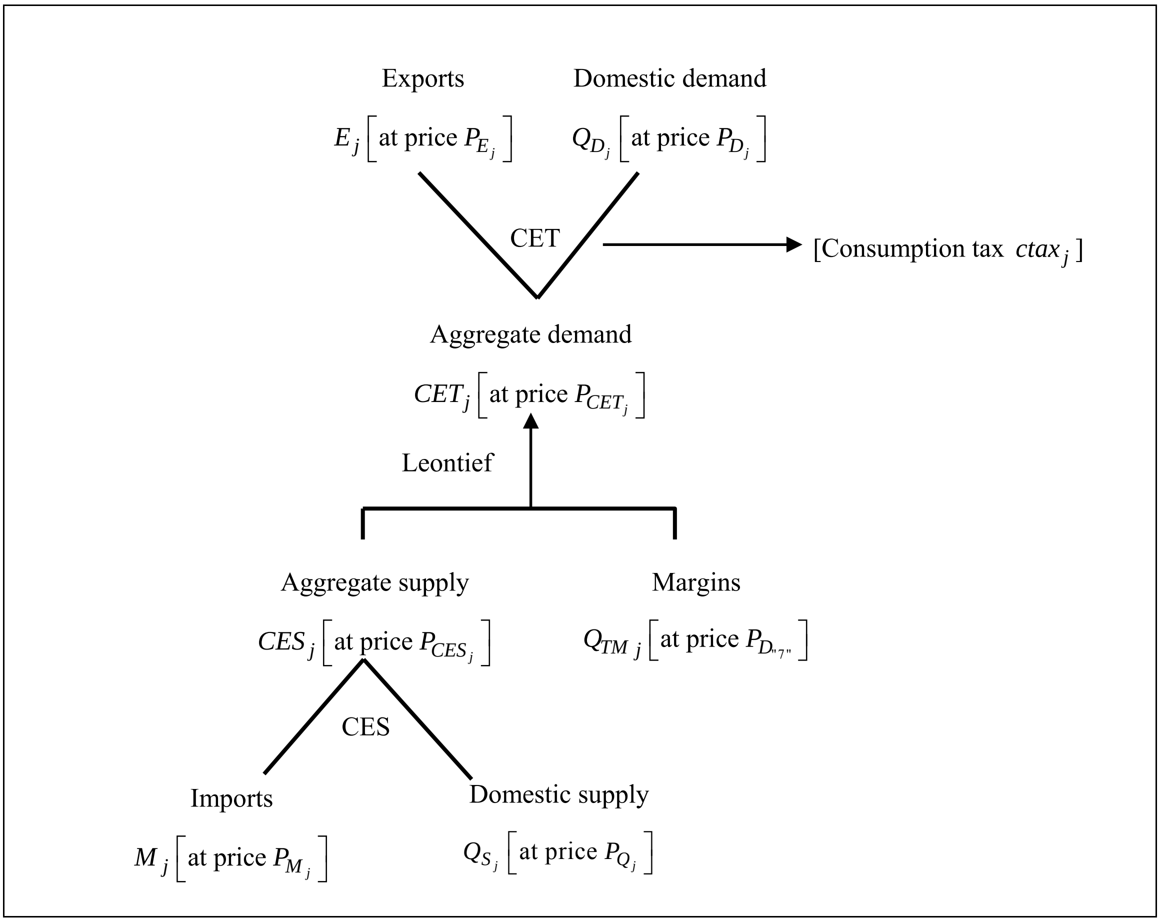
where $0 \le \alpha_{V_{fi}} \le 1$, $0 \le \alpha_{Q_{ji}} \le 1$, $\sum_f \alpha_{V_{fi}} = 1$ and $\sum_j \alpha_{Q_{ji}} = 1$. A, A_X, A_V and A_Q are the scale parameters for the Leontief and CD functions respectively, α_V and α_Q are the share parameters of the CD functions for value added and commodity supply, and

P_X, P_V, P_F and P_Q respectively denote the (domestic) sectoral producer price, value added price, the factor price and the individual commodity producer price.

6.3.3 Domestic supply, exports and imports

Domestic and foreign supplies of commodities in terms of exports and imports are summarised in Figure 6.3.

Figure 6.3 Market supply and demand



Domestic supply of commodity j is equal to the sum of the output of commodity j produced by each sector i:

$$Q_{S_j} = \sum_i Q_{ji} \tag{6.9}$$

Aggregate market supply and demand for commodity j embody the *Armington assumption* (Armington, 1969), whereby goods are differentiated according to country of origin and destination (so-called 'double Armington').

The commodities produced are allocated between domestic demand, Q_{D_j}, and foreign demand (i.e. exports), E_j, according to a constant elasticity of transformation (CET) function and consumers differentiate between total imports, M_j, and domestic supply, Q_{S_j}, of commodity j via a constant elasticity of substitution (CES) function:

$$CET_j = A_{T_j}\left[\alpha_{T_j} E_j^{\rho_{T_j}} + \left(1-\alpha_{T_j}\right) Q_{D_j}^{\rho_{T_j}}\right]^{\frac{1}{\rho_{T_j}}} \tag{6.10}$$

$$CES_j = A_{S_j}\left[\alpha_{S_j} M_j^{-\rho_{S_j}} + \left(1-\alpha_{S_j}\right) Q_{S_j}^{-\rho_{S_j}}\right]^{-\frac{1}{\rho_{S_j}}} \tag{6.11}$$

where CET and CES denote the CET and CES composites respectively; A_T, A_S are the scale parameters; α_T, α_S the share parameters; and ρ_T, ρ_S are the transformation and substitution parameters of the CET and CES function respectively.

The first order conditions for equations (6.10) and (6.11) yield:

$$E_j = Q_{D_j}\left(\frac{1-\alpha_{T_j}}{\alpha_{T_j}} \frac{P_{E_j}}{P_{D_j}}\right)^{\sigma_{T_j}} \tag{6.12}$$

$$M_j = Q_{S_j} \left(\frac{\alpha_{S_j}}{1-\alpha_{S_j}} \frac{P_{Q_j}}{P_{M_j}} \right)^{\sigma_{S_j}} \tag{6.13}$$

where P_D, P_E and P_M denote the domestic consumer price (as opposed to the domestic producer price, P_Q), the export price and the import price for commodities respectively. The elasticities of transformation and substitution are defined as $\sigma_{T_j} = 1/\left(\rho_{T_j} - 1\right) > 0$ and $\sigma_{S_j} = 1/\left(\rho_{S_j} + 1\right) > 0$ respectively, so that $\rho_{T_j} > 1$ and $\rho_{S_j} > -1$.

Aggregate domestic market demand for commodity j, Q_{D_j}, equals the sum of intermediate input demands by sectors i, $\sum_i N_{ji}$, private consumption demands by households h, $\sum_h C_{jh}$, government consumption demand, G_j and investment demand, INV_j:

$$Q_{D_j} = \sum_i N_{ji} + \sum_h C_{jh} + G_j + INV_j \tag{6.14}$$

In order to account for transport costs incurred when delivering goods for domestic or export demand, aggregate supply for commodity j, CES_j is combined with transport and trade margins for commodity j, Q_{TM_j} in a Leontief function, $CET_j = \min\left[CES_j / A_{C_j}, Q_{TM_j} / A_{TM_j} \right]$ so that from the first order conditions:

$$CES_j = A_{C_j} CET_j \tag{6.15}$$

$$Q_{TM_j} = A_{TM_j} CET_j \tag{6.16}$$

where A_C, A_{TM} are the parameters of the Leontief production function.[6] Equation (6.15) represents the product market clearing condition, adjusted for transport and trade margins.

6.3.4 Prices

The structure of production, market supply and demand generates a system of price equations. Equations (6.17) and (6.18) are the equivalent of the unit price equations for sector i, adjusted for *ad valorem* taxes. Output taxes ($ptax_i, ctax_j$) are defined as a net tax so that producers receive $(1-taxrate)\cdot market\ price$ and the market price is a gross price, whereas factor input taxes ($etax_f$) are defined as a gross tax so that producers purchase factor inputs at $(1+taxrate)\cdot market\ price$ and the market price is a net price.

$$P_{X_i}\left(1-ptax_i\right) = A_{X_i} P_{V_i} + \sum_j A_{ji} P_{D_j} \tag{6.17}$$

$$P_{V_i} V_i = \sum_f F_{D_{fi}} P_{F_f}\left(1+etax_f\right) \tag{6.18}$$

The total value of output by sector by definition equals the aggregate value of the output of commodities j produced by this sector, yielding:

$$P_{X_i} X_i = \sum_j Q_{ji} P_{Q_j} \tag{6.19}$$

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6 This construction states that aggregate market supply of commodities, combined with fixed transport and trade margins, equals aggregate market demand for commodities. It is 'unusual' in that it accommodates 'entrepôt' trade, i.e. the re-exporting (re-importing) of imported (exported) goods.

Moreover, the total values of commodity supply and demand in the market, i.e. the values of the CES and CET composites, by definition equal the sum of the values of the domestic and foreign components:

$$P_{CES_j} CES_j = P_{M_j} M_j + P_{Q_j} Q_{S_j} \tag{6.20}$$

$$P_{CET_j} CET_j = P_{E_j} E_j + P_{D_j} \left(1 - ctax_j\right) Q_{D_j} \tag{6.21}$$

where the price paid by domestic consumers, P_{D_j}, includes a consumption tax, $ctax_j$.

Equations (6.22) and (6.23) link domestic prices for imports and exports to world prices ($P_{M_j}^W$ and $P_{E_j}^W$ respectively) by multiplication by the exchange rate, ER. $P_{M_j}^W$ and $P_{E_j}^W$ are fixed so as to model the UK as a small country having no influence on world prices.

$$P_{M_j} = P_{M_j}^W ER \tag{6.22}$$

$$P_{E_j} = P_{E_j}^W ER \tag{6.23}$$

Equation (6.24) describes the price relation between composite aggregate demand, CET, and each of its components, CES and Q_{TM}:

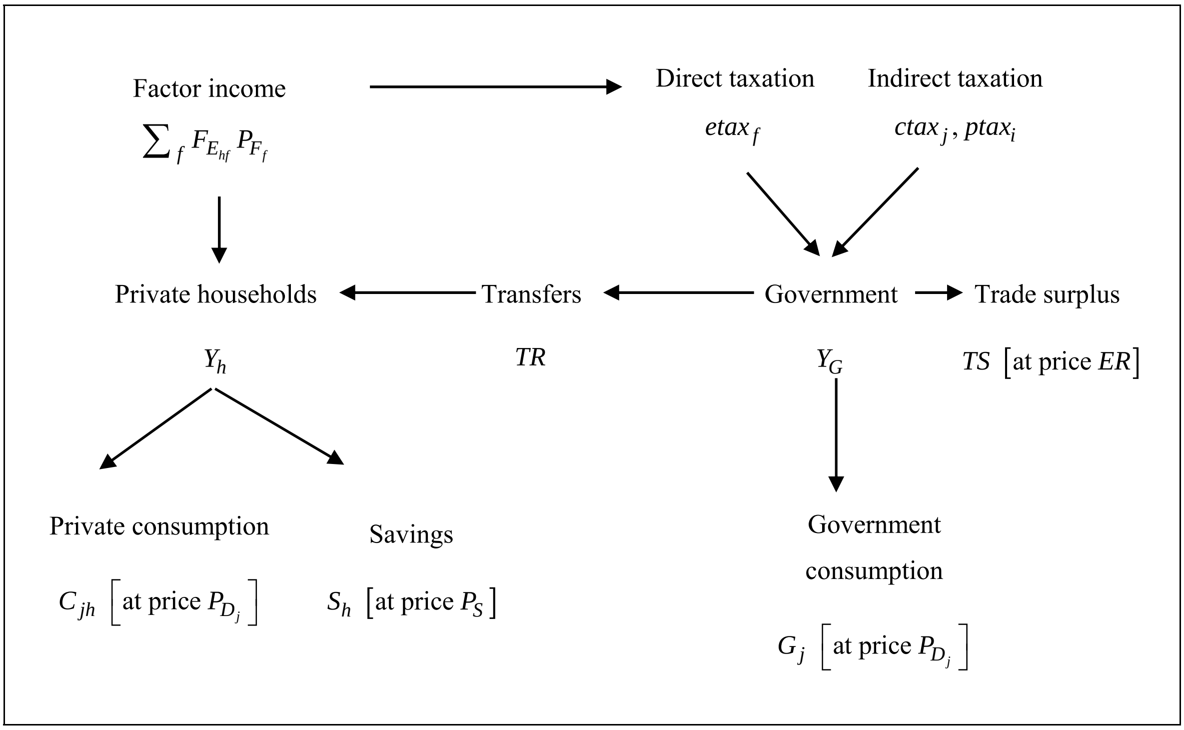
$$P_{CET_j} = A_{C_j} P_{CES_j} + A_{TM_j} P_{D_{"7"}} \tag{6.24}$$

where $P_{D_{"7"}}$ denotes the cost of distributing commodity j (transport and trade margins) as given by the domestic consumer price of distribution and transport (commodity “7” in Table 6.1).

6.3.5 Household income, savings and expenditure

The income generated in the production of commodities is allocated to the representative agents in the model, five households and the government, who spend it on consumption, savings and transfers. Figure 6.4 summarises the flow of income and expenditures in the economy.

Figure 6.4 Flow of income, savings and expenditures



Households receive income from two sources, the employment of factors of production (capital, skilled and unskilled labour) and transfers from the government, T_h, as shown in equation (6.25):

$$Y_h = \sum_f F_{E_{hf}} P_{F_f} + T_h \tag{6.25}$$

Transfers to household h are modelled as a constant share, α_{TRh}, of total government transfers, TR, yielding:

$$T_h = \alpha_{TRh} TR \tag{6.26}$$

where $0 \leq \alpha_{TRh} \leq 1$, $\sum_h \alpha_{TR_h} = 1$.

Household income, Y_h, is subsequently spent on the consumption of goods and savings. Consumption of good j and real savings by household h, C_{jh} and S_h respectively, follow from the optimisation of a CD utility function, $U_h = \prod_j C_{jh}{}^{\beta_{jh}} S_h{}^{\beta_{Sh}}$, subject to the household budget constraint, $Y_h = \sum_j C_{jh} P_{D_j} + S_h P_S$, yielding:

$$C_{jh} = \beta_{jh} Y_h \big/ P_{D_j} \tag{6.27}$$

$$S_h = \beta_{Sh} Y_h / P_S \tag{6.28}$$

where $0 \leq \beta_{jh} \leq 1$, $0 \leq \beta_{Sh} \leq 1$, $\beta_{Sh} + \sum_j \beta_{jh} = 1$ and P_S denotes the price of savings (see equation (6.36)).

Summation of real savings by household yields total real savings, S_T:

$$S_T = \sum_h S_h \tag{6.29}$$

6.3.6 Government income and expenditure

Government receives income, Y_G, from direct taxation of factors of production (via the employment taxes) and indirect taxation of sectoral and commodity outputs (via the production and consumption taxes):

$$Y_G = \sum_i ptax_i P_{X_i} X_i + \sum_f etax_f P_{F_f} F_{E_f} + \sum_j ctax_j P_{D_j} Q_{D_j} \qquad (6.30)$$

The government allocates its income to expenditures on good *j*, $GEXP_j$, household transfers, TR, and purchases a fixed amount of foreign exchange at rate ER in order to accommodate the trade surplus, TS :

$$Y_G = TR + \sum_j GEXP_j + ER \cdot TS \qquad (6.31)$$

Government expenditures on good j are fixed relative to the numéraire at benchmark expenditure levels, $GEXP_j^0$, and defined as (real) government consumption of commodity j, G_j, multiplied by its domestic consumption price, P_{D_j} :

$$GEXP_j = ER \cdot GEXP_j^0 = P_{D_j} G_j \qquad (6.32)$$

The trade surplus is simply the difference in value between exports and imports measured in foreign currency:

$$TS = \sum_j \left(P_{E_j}^W E_j - P_{M_j}^W M_j \right) \qquad (6.33)$$

6.3.7 Investments

Total investments in the economy, i.e. total real savings S_T, are a Leontief function of investment demand for commodity *j*, INV_j, $S_T = \min\left[INV_j / A_{I_j} \right]$, which gives the first order condition:

$$INV_j = A_{I_j} S_T \tag{6.34}$$

6.3.8 Factor market clearing

Equilibrium in factor markets is represented by:

$$F_{E_f} = \sum_i F_{D\,fi} \tag{6.35}$$

Finally, equilibrium in the capital goods market requires the value of total savings to equal the value of total investments:

$$P_S S_T = \sum_j P_{D_j} INV_j \tag{6.36}$$

6.3.9 Welfare

The model includes two measures of changes in household and overall welfare. Firstly, changes in household welfare are calculated from private household utility using the equivalent variation. The equivalent variation reveals the income to which a particular change that has taken place between equilibria is equivalent.[7] For linear homogeneous preferences, the equivalent variation can be written as:

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[7] Shoven and Whalley (1992, p125).

$$EV_h = \frac{U_h^1 - U_h^0}{U_h^0} Y_h^0 \qquad (6.37)$$

where superscript 0 and 1 respectively refer to the equilibria before and after a particular shock occurs.

The change in overall welfare using this measure of household welfare is computed as:

$$EV = \sum_h EV_h \qquad (6.38)$$

A second measure of the change in household welfare is reported, EV_{T_h}, which includes the direct change in well-being related to changes in government consumption of goods, including health care provision via the NHS, assuming that each household receives a share $\alpha_{G_{jh}}$ (where $0 \le \alpha_{G_{jh}} \le 1, \sum_h \alpha_{G_{jh}} = 1$):

$$EV_{T_h} = EV_h + \sum_j \alpha_{G_{jh}} \cdot \left(\frac{G_j^1 - G_j^0}{G_j^0} \right) \cdot GEXP_j^0 \qquad (6.39)$$[8]

The associated measure of overall welfare changes computes the sum of household equivalent variations plus the sum of changes in the real government consumption of goods (i.e. public good provisioning, including health services):

$$EV_T = \sum_h EV_{T_h} \qquad (6.40)$$

8 Note that private health care is already included in the utility function and thus in welfare. The current and, for the purpose of this analysis, more appropriate welfare specification postulates that an increase in the public provision of health care (and other goods) constitutes a direct welfare gain. The

6.3.10 Closure

The term closure refers to the choice of endogenous and exogenous variables in a general equilibrium model. This determines which variables can and cannot adjust, so that the manner in which a new equilibrium is achieved and the equilibrium outcome are sensitive to the choice of closure.[9] In this model TS, $GEXP_j^0$, $\bar{F}_{hf}$, $P_{M_j}^W$, $P_{E_j}^W$, $ptax_i$, $ctax_j$, and $etax_f$ are chosen as exogenous variables. Furthermore, since in general equilibrium models absolute prices cannot be determined, the price of foreign exchange, ER, acts as the numéraire.[10]

The closure of the savings-investment balance, the macro-closure, adopts a neoclassical approach by postulating that total savings determine total investments. Foreign savings, TS, are fixed in foreign currency thereby avoiding 'free lunches' taken from or given to the rest of the world after a shock is applied to the model.[11] With respect to the government account, government expenditures on goods are fixed in foreign exchange at benchmark levels, $GEXP^0$, whereas transfers to households, TR, adjust to equate government income with expenditures on commodities and the trade surplus. Since households save and consume fixed proportions of their income, changes in private and hence total savings originate from adjustments in household income.[12] Alternative

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resulting overall welfare measure, displayed in equation (6.40), is equivalent to a social welfare function with equal weights, i.e. a common utilitarian social welfare function (Johansson 1991, p32).

9 See Reinert and Roland-Holst (1997, p115) for a short overview of closure issues.

10 MPSGE automatically deletes the corresponding equation so that Walras' Law is implemented.

11 The term 'free lunch' is used by De Melo and Tarr (1992, p42) to describe a sudden in- or outflow of foreign capital following a policy shock, which complicates the evaluation of the welfare effects of a domestic policy change.

12 Note that positive (negative) foreign savings in the form of a negative (positive) trade surplus are sold (bought) by the government, which does not save; private (household) savings are thus the only source of savings in the economy.

model specifications, especially those affecting the government account and factor markets, are experimented with when performing simulations.

6.4 CALIBRATION

In order to operationalise the model, values need to be specified for the parameters of the model equations. In CGE modelling this process is known as 'calibration'. It involves choosing parameter values (given exogenously specified behavioural elasticities) such that the model will replicate the benchmark data set, represented by the UK 2000 SAM, as an equilibrium solution.[13] The 'Harberger convention' is used throughout, so that prices that are unaffected by taxes are equal to one in the benchmark and quantities can be derived from the SAM.

6.4.1 Taxes

Where taxes are in place, prices may diverge from unity. Specifically, the price producers pay for factor inputs, $P_{F_f}\left(1+etax_f\right)$, the net price they receive for the production of goods, $P_{X_i}\left(1-ptax_i\right)$, and the net price domestic consumers pay for goods, $P_{D_j}\left(1-ctax_j\right)$, diverge from 1. Employment taxes are derived from the National Accounts Blue Book (Office for National Statistics, 2001b), yielding average values for $etax_f$ of 25%, 28% and 17% for capital, skilled and unskilled labour respectively. Production and consumption taxes, $ptax_i$ and $ctax_j$ respectively, are displayed in Table 6.2.

13 Shoven and Whalley (1984) and Reinert and Roland-Holst (1997) provide an excellent account of the calibration process.

Table 6.2 Production and consumption taxes in the SCGE model

Tax (%)	Sector i / commodity j										
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
$ptax_i$	0	0.4	0.7	0.6	2.6	0.5	2	0.7	0.5	0	1.1
$ctax_j$	-3.6	6.8	8.1	10.7	2.1	7.2	2.4	3.4	0	-0.2	4.5

6.4.2 Substitution and transformation elasticities

Values of behavioural elasticities are usually estimated outside the model or taken from other studies. The advantage of the MPSGE software is that it automatically performs the calibration of functional forms, given that all elasticity parameters are specified.[14] Leontief and CD functions are defined by a substitution elasticity of 0 and 1 respectively. The CES and CET functional forms respectively have substitution and transformation elasticities equal to σ_{S_j} and σ_{T_j}, which are set to 2 in this model.[15]

6.4.3 Household rates and shares

Household savings rates, s_h, and shares in government transfers, α_{TRh}, are obtained from the UK 2000 data set, which was described in Chapter 5.[16] The latter shares are computed from Table 5.9, whereas the former follow from Table 5.10, assuming that only working households save. Welfare changes related to changes in public good provisioning are allocated to households in proportions $\alpha_{G_{jh}}$, which for health care correspond to each household's share of the total number of NHS GP consultations

[14] A description of the MPSGE programming language and a variety of examples is available online from: http://www.gams.com/solvers/mpsge [13 July 2004].

[15] The majority of goods produced in the UK is traded with similar high-income countries and are of the same high quality so that substitution and transformation elasticities are reasonably high. At the multi-commodity level, elasticities in GTAP version 5 (http://www.gtap.org [13 July 2004]) are around 2 to 2.5.

[16] MPSGE calibrates these by including real savings (with a price of savings) in the CD utility function and by introducing an artificial commodity 'transfers', exogenously fixed for each household (and thus in total), but with an endogenous (uniform) price. Both procedures ensure constant shares.

(from Table 5.5) and for other goods (public administration and defence, and other services) correspond to each household's share in the total population (computed from Table 5.4). The resulting parameter estimates are displayed in Table 6.3.

Table 6.3 Rates and shares by type of household

Parameter (%)	s_h	α_{TRh}	$\alpha_{G_{jh}}$		
Household type			Public administration and defence	Health care	Other services
Pensioners		52.3	17.6	25.1	17.6
Non-working, children		10.2	6.4	8.7	6.4
Non-working, no children		10.6	5.4	7.6	5.4
Working, children	30.3	23.4	37	30.6	37
Working, no children	30.3	3.5	33.6	28	33.6

6.4.4 Waiting list parameters

The contribution of public health care to the health status of skilled and unskilled labour, as measured by υ, is obtained from Emmerson et al. (2000, Table 5.1). Using Family Resource Survey data for the period 1994/1995 to 1997/1998, they calculate the percentage of adults with private medical insurance by social class. By applying population weights corresponding to each social class from the GHS, the proportions of skilled and unskilled labour having private medical insurance are estimated at 16.6% and 4% respectively, yielding a residual of 83.4% and 96% of skilled and unskilled labour for whom health care is financed via the NHS. The latter serve as proxies for υ.

The scale parameter η_0 is calibrated to the benchmark non-participation rate. Its value is based on the Barmby et al. (2002, 2003) measure of sickness absence, calculated as the ratio of the number of hours absent due to sickness to the number of hours contracted to work. Using Labour Force Survey (LFS) data, Barmby et al. find a fairly stable long-run average for the (yearly) sickness absence rate in the UK of around 3.20%. These and other studies[17] find that sickness absence varies by socio-economic characteristics. Typically, the higher the wage and the higher the level of responsibility involved in the job, the lower the absence from work. Illness-related absence from work is approximately 1.5 times higher for manual than that for non-manual workers. Assuming that the non-participation rate in the base year for unskilled workers is 1.5 times that of skilled workers and postulating an overall benchmark non-participation rate of 3.20% yields $\eta_0 = 2.89\%$ for skilled and $\eta_0 = 4.34\%$ for unskilled workers.

In the absence of a reliable empirical estimate, the waiting list elasticity parameter, ε, is set to 2 for both labour types, so that a 10% increase in health status leads to a 20% decrease in waiting lists. Given the remaining parameter estimates in Table 6.4, this implies that the elasticities of effective (labour) endowments with respect to the health composite in the benchmark are 0.06 and 0.09 approximately for skilled and unskilled labour respectively.[18] These numbers are consistent with health care elasticity estimates of in between 0.03 and 1 based on US data (Folland et al. 2001, p108-109). The elasticity of effective labour supply with respect to the health composite is higher for unskilled labour due to the fact that a relatively higher proportion of the unskilled suffer illness, so that health expenditure's 'leverage' is greater for this labour type. Alternative values of the waiting list elasticities are considered in Section 6.6. Table 6.4 displays all waiting list parameters.

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[17] See for example the Confederation of British Industry (2001) and Barham and Leonard (2002) for an overview.

[18] These elasticities measure the proportionate change in the size of effective (labour) endowments of skilled and unskilled labour following a change in the health composite, and are calculated

Table 6.4 Waiting list parameters

Parameter	Skilled labour	Unskilled labour
υ	83.4%	96%
η_0	2.89%	4.34%
ε	2	2

6.5 SIMULATIONS AND RESULTS

In order to illustrate the functioning of the SCGE model and potential areas of application five shocks are simulated under alternative model specifications. Results are compared with the benchmark equilibrium values for 2000. Tables and figures containing changes in key variables are presented at the end of the section.

The first shock (Experiment 1) examines the impact of a 10% rise in government expenditures on health care (£5.384 billion approximately), i.e. NHS expenditures, equivalent to the average yearly increase in NHS expenditures from 1999-2000 and planned up to 2007-2008.[19] The expansion of public health care, while drawing resources away from other sectors in the economy, improves both worker income, through increased labour market participation, and welfare, via direct increases in the well-being of the population. Results are reported for two different factor market specifications. Experiment (1a) assumes capital and labour are fully mobile across sectors, in line with the original model specification, whereas Experiment (1b) reports results on the assumption that parts of skilled labour and capital are specific to the health care sector. The latter assumption limits factor movements between the health sector and other sectors and puts upward pressure on specific factors' remunerations.

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as $\left(\partial FE_{hf} / \partial HC_f\right)\left(HC_f / FE_{hf}\right) = \varepsilon_f \, WL_{hf} / FE_{hf} = \varepsilon_f \, \eta_f \Big/ \left(1 - \eta_f\right)$. This corresponds to $\delta\varepsilon$ reported in Chapter 2 (subscripts ignored).

Experiment (2) simulates a 20% increase in the domestic consumer price of pharmaceuticals. This figure corresponds to the increase in the average cost per prescription item dispensed in the community in England from £9.48 to £11.37 over the period 1999-2000 to 2002-2003, reported in the Annual Report of the NHS Chief Executive.[20] Here, the assumptions regarding the closure of the government account are that either the government keeps its (overall) health care budget fixed in value (Experiment 2a) according to the original model specification (see equation (6.32)), or that the government increases expenditures on the NHS, so that total *real* public health expenditures and the number of treatments (of a certain quality and cost) provided by the NHS are maintained to previous, benchmark, levels (Experiment 2b). For a given nominal health care budget as in Experiment (2a), the increase in the cost of pharmaceutical inputs implies lower levels of health care provisioning and that, given the cost-effectiveness of treatments, less people are being treated and cured. This has repercussions for welfare, both directly and through reduced household income (via changes in effective labour supply).

Experiment (3) models government policy aimed at encouraging foreign health care-specific skilled workers, i.e. doctors and nurses, to come and work in the UK in order to mitigate the shortage of highly skilled workers. It is assumed that an equivalent of 10% of domestic endowments of health care-specific skilled labour takes up this offer.[21] The

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19 See the Department of Health (DoH)'s Expenditure Plans for the NHS (DoH 2003a, p3 and p20).

20 DoH (2003b, p9).

21 Currently, an estimated 1 in 12 nurses in England have come from abroad (see for example Buchan, 2003). With respect to the international recruitment of doctors, in 2002, the NHS in England launched an International Fellowship scheme which aimed to offer up to 450 International Fellowships for the coming three years in clinical practice working as a consultant (Press Releases Notice, Wednesday 27-02-2002, reference number 2002/0101, available at http://www.dh.gov.uk [13 July 2004]). Given that the majority (at least of nurses) aims for a long-term career in the NHS and is

government may accommodate the immigration of foreign skilled workers in two fashions. In Experiment (3a) the wage of health care-specific skilled labour is allowed to fall following a rise in the supply of this labour type. Consequently, unit costs of health care provision fall and, given government expenditures on health care, public health care output and its numbers of people treated and cured is expected to rise, with the associated welfare consequences. In Experiment (3b), the government adjusts public health care provision (and expenditures) so as to counteract the fall in health care-specific skilled wages.[22] This induces even larger increases in NHS provision levels. Both experiments are carried out using three alternative assumptions regarding the share of foreign worker income remitted abroad, adopting values of 0, 0.5 and 1 respectively. Remittances have further welfare effects by influencing the trade balance.

The fourth modelling exercise (Experiment 4) investigates the general equilibrium effects of a 10% improvement in the productivity of factors employed in health care, modelled via technical change, as opposed to a 10% improvement in health care resources investigated in Experiment (1). Two alternative forms of technological progress in factors are contrasted with each other (see also Chapter 2, Section 2.5). Experiment (4a) models Factor-Neutral Technical Change (FNTC), which enhances the productivity of all factors of production in health care by 10%, whereas Experiment (4b) simulates Skill-Biased Technical Change (SBTC), which enhances the productivity of skilled labour in health care only by 10%. Given government expenditures on health

expected to stay, and given more planned international recruitment of nurses and doctors, it seems reasonable to look at the effects of an increase in health care-specific skilled labour of 10%.

[22] It is often argued that there is a lack of certain, highly skilled, health care professionals in the NHS due to the relative low pay compared to the private sector. This provides an argument for the government to sustain the wages of health care-specific skilled workers.

care, health care output, levels of health and labour market participation are anticipated to improve, yielding (direct and indirect) welfare gains.

The final modelling exercise, Experiment (5), assesses the general equilibrium effects of technical change in pharmaceuticals. It takes the setup of Experiment (2a) as point of departure by modelling an increase in the domestic consumer price of pharmaceuticals of 20% (observed over the period 1999-2000 to 2002-2003) whilst keeping the government budget spent on health care (and other goods) fixed in value. The higher price of pharmaceuticals is assumed to reflect technical (quality) improvements which make the health service more efficient in its use of pharmaceutical and other inputs, so that it may treat and cure more people, improve labour market participation and the well-being of households. The values for the productivity gains in (i.e. savings in the use of) pharmaceuticals and other inputs in health care are varied in the exercise. Experiment (5a) considers a rise in productivity of pharmaceuticals only, whereas Experiment (5b) considers cumulative effects of introducing productivity gains for other intermediate and factor inputs in health care as well.

6.5.1 Experiment 1a: increasing the NHS budget with mobile factors

Government expenditures are fixed in terms of foreign exchange, so that the immediate effect of an expansion of public health care - implemented by raising $GEXP^0$ by 10% - is, given tax revenues, to reduce transfer payments to households by 4.3%. The additional NHS resources result in an increase in public health care provision by 10% and, via input-output linkages, increase the demand for and domestic production of pharmaceutical products (by 4.9%), and medical, precision and optical instruments (by 1.9%). As a consequence health care, pharmaceuticals and instruments become slightly more expensive, which increases the costs to and hence reduces the size of private health care provision (by 0.3%).

The increase in public health care boosts the health of unskilled labour by 9.6%, which is more than the improvement of 8.2% in the health of skilled labour, as the former is affected primarily by changes in public health care, whereas the latter also responds to changes in private health care provision which contracts. In agreement with this pattern, participation in the labour market (i.e. effective labour supply) increases by 0.43% and 0.76% for skilled and unskilled labour respectively, equivalent to reductions in the waiting lists (across all households) of 14.6% and 16.7%.

The expansion of health and related sectors (and contraction of other sectors), combined with the increase in labour market participation due to improved health, induces changes in factor remunerations: unskilled wages fall by 0.5%, whereas skilled wages and capital rents rise (by 0.02% and 0.18% respectively). Despite the fall in unskilled wages, the increase in labour market participation ensures that all households' income from unskilled labour rises.

The fall in income from state benefits, from which the health care budget increase is financed, leads to reductions in income for working households with children (0.2%), but relatively more so for pensioners (1.3%), non-working households with children (3.6%) and childless non-working households (1.4%). Only childless working households, who own 63% of skilled labour endowments - generating 67% of their household income - and rely least on government transfers (see Table 5.9 Chapter 5), gain slightly (by 0.3%) from higher treatment levels in the NHS.

The same pattern emerges for absolute (and relative) changes in household welfare, measured by EV_h; pensioners suffer a welfare loss of £2.389 billion, and all other households (except for childless working households who gain by £955 million) lose around £500 million on average. Adjusting these figures for changes in levels of public good provisioning (including health care) reduces each household's welfare loss, especially for pensioners and working households who receive a large share of public good provisioning (see Table 6.3). Consequently, only pensioners still experience a significant deterioration in welfare of £1.04 billion. Non-working households with and without children lose by £36 million and £80 million respectively, whereas their working counterparts gain by £1.17 billion and £2.46 billion. Overall welfare (including government consumption of goods) increases by £2.474 billion (a relative gain of 0.26%).

6.5.2 Experiment 1b: increasing the NHS budget with health care-specific factors

Experiment (1a) overlooks the fact that a large part of the labour and capital employed in health sector are, respectively, highly trained or highly specialised and therefore arguably specific to health care and immobile. This scenario provides an alternative specification more suited to the short run by introducing health care-specific skilled labour and capital. The former type consists of mainly doctors and nurses (85% of skilled labour employed in health care)[23] and the latter consists of buildings and land

[23] Calculated as the share of professionally qualified clinical staff relative to the total of professionally qualified clinical staff, managers and senior managers and central functions for 1999-2000 in the NHS in England (DoH, 2004a, Table D1).

(approximately 90% of capital employed in health care)[24], and both earn a health care-specific remuneration.[25]

Key findings are that, unsurprisingly, the presence of health care-specific skilled labour and capital constrains the production expansion of health care and related sectors. A 10% increase in the public health care budget leads to a lesser increase in levels of provisioning, of 4.4%, so that the domestic outputs of pharmaceuticals and medical instruments rise by 1.7% and 0.7% respectively (less than half of the rise in Experiment 1a).

The mounting pressure on health care-specific factors translates into higher remunerations - health care-specific skilled wages and rents rise by 11.7% and 11.9% respectively - which drive up unit costs and prices for public *and* private health care (by 5.4%), so that the public health expenditures increase crowds out private health care by approximately the same percentage.[26]

Within the health sector, some substitution towards (relatively cheaper) mobile factors takes place to relieve the constraint of specific factors. The relative changes in

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[24] Calculated as the share of land, buildings and assets under construction relative to the total net book value of capital including equipment in the NHS for 1996-1997, from DoH (1998, Annex 1).

[25] The process of adjusting the model for health care-specific factors is discussed in more detail in Chapter 2, section 4. When modifying the dataset for this assumption, total endowments of health care-specific capital and skilled labour (90% and 85% of capital and skilled labour employed in health care respectively) are apportioned to individual households according to each household's share of, respectively, mobile capital and skilled labour endowments. Health care-specific factors of production are also assumed to have the same labour market characteristics, i.e. same non-participation rate and health status, as their mobile counterparts.

[26] One could argue that the government exerts more or less direct control on wages of NHS personnel, whereas capital rents are given on the market. If wages of health care-specific skilled labour are kept at pre-shock levels so as to control labour costs of extra health care, provision of NHS care increases by 9%, approximately equal to the rise in public provision when factors are fully mobile. The results of such a scenario are therefore equivalent to those reported in Experiment (1a).

production levels across sectors induce changes in factor remunerations of opposite sign to Experiment (1a); unskilled wages rise by 0.2%, whereas wages of mobile skilled labour and rents on mobile capital fall (by less than 0.1%). Nevertheless, households' income from mobile unskilled *and* skilled labour rises due to the health-induced changes in effective labour supply. The health status of both unskilled labour and skilled labour increases by 4% and 2.8% respectively - much smaller health improvements than in (1a) due to relatively lower levels of health care provisioning - so that labour market participation increases by 0.16% and 0.34%, equivalent to reductions in the waiting lists (across all households) of 5.3% and 7.6% for *all* skilled and unskilled labour respectively.

Government transfers to households fall by slightly (0.3 percentage points) less than before to finance a (smaller) expansion of public health care, so that compared to Experiment (1a) income losses (gains) of households fall (rise). The same is true for absolute and relative changes in household welfare excluding government consumption of goods. However, once the changes in the public provision of goods (including public health care, which expands by much less in the presence of health care-specific factors) is accounted for in household welfare, losses are higher and gains are lower relative to Experiment (1a). Overall welfare (including government consumption) increases by £920 million (a relative gain of 0.1%).

6.5.3 Experiment 2a: a pharmaceutical price rise under an exogenous NHS budget

The price simulation is implemented by adding to the model the following equation, which fixes the domestic consumer price for pharmaceuticals (commodity "2") at a level of 120% relative to the numéraire:

$$P_{D_{"2"}} = 1.2 \cdot ER \qquad (6.41)$$

In order to maintain the number of endogenous variables, the pharmaceutical price rise is postulated to originate from an increase in the exogenous world price of pharmaceutical imports, $P^{W}_{M_{"2"}}$.

The simulation results demonstrate by how much the world import price (and in fact all other endogenous prices) of pharmaceuticals needs to change in order to generate a rise in the domestic consumer price of 20%[27]; the former rises by 42% whereas, for example, the domestic producer price of pharmaceuticals rises by 4%. As pharmaceuticals become more expensive, imports fall by 43% and domestic production of pharmaceuticals grows by 6.5%. Confronted with higher unit costs of intermediate inputs, public and private health care commodity prices increase by 1.8%. Consequently, private health care demand falls by 2.1% and, given the government closure rule, the production of public health care via the NHS decreases by 1.7%.

Lower levels of public and private health care imply a fall in the level of health for skilled and unskilled labour by 1.8% and 1.76% respectively. The change in health status is slightly more pronounced for skilled labour as they consume relatively more of private health care, which contracts relatively more. Effective labour supplies fall by 0.11% and 0.16% for skilled and unskilled workers respectively, leading to a relative rise in waiting lists (across all households) of 3.7% and 3.6% for skilled and unskilled

[27] Note that this is a different simulation from one which investigates a rise in the world price of imports directly, as this will lead to a rise in domestic consumer price of less than 20% as the latter is the Armington composite of domestic and import prices (see nesting Figure 6.3).

labour respectively. The changes in factor supply and demand lead to a fall in all factor rewards (including rental rates of capital) in the range of 0.2% to 0.3%.

Government income from taxes falls by 0.3%. In order to keep its finances balanced the government reduces transfers to households by 0.7%. Given that factor rewards and effective labour endowments fall, income from labour and capital falls as well so that all households experience a deterioration in income (of 0.6% or less). Working households are worse off compared to non-working households by losing labour income on top of the losses in income from capital (which are also relatively high for these households) and state benefits. For working households with children the loss in state benefits also plays a significant role (these households receive 23% of state benefits; see Table 6.3). Pensioners are worse off compared to non-working households by suffering significant reductions in state benefits (of which they receive 52%; see Table 6.3) as well as income from capital, of which they own 47% (from Table 5.8, Chapter 5). Relative to original income, the losses for non-working households and pensioners exceed those of working households since they have a much smaller income to begin with and rely relatively heavily on state benefits (see Table 5.9, Chapter 5).

A similar picture is obtained for changes in household welfare, measured in terms of the EV_h; the welfare loss for pensioner households is relatively high and equal to £554 million. Working households with and without children experience similar welfare losses of £564 million and £638 million respectively. The welfare loss for the remaining non-working households is much less pronounced in absolute terms - losses of £69 million and £120 million for non-working household with and without children respectively - because they do not enter the labour market so that the deterioration in health does not affect their labour supply. The EV_{T_h} as a measure of change in household welfare incorporates the fall in public provision of health care and therefore increases the welfare loss for each household. Overall, welfare thereby falls by £2.64 billion, a deterioration of 0.28%.

6.5.4 Experiment 2b: a pharmaceutical price rise under exogenous NHS provision

In contrast to the previous experiment, here the government increases its health care expenditure in order to maintain real provision levels under the NHS. This scenario is implemented by changing the original government closure. Specifically, the exogenous variable $GEXP_j^0$ is removed for health care (commodity "10"), and equation (6.32) for health care is replaced by:

$$GEXP_{"10"} = P_{D_{"10"}} G_{"10"} \qquad (6.42)$$

where real government consumption of health care, $G_{"10"}$, is exogenous. When implementing the pharmaceutical price rise as in Experiment (2a), public health care remains at pre-shock levels. The results of Experiment (2a) show that the price of health care increases by approximately 1.8% following a 20% pharmaceutical price rise. Hence, in order to maintain original levels of public health care provision the government matches the price increase by the appropriate increase in expenditures on public health care. As this is such a minor change, results differ marginally and a short summary is given below.

Domestic output of pharmaceuticals rises by an additional percentage compared to Experiment (2a) as more intermediate inputs from the pharmaceutical industry are needed to produce the additional public health care. For identical reasons, production of medical, precision and optical instruments expands slightly (instead of contracting as in Experiment 2a). By construction, public health care provision is constant, whereas private health care contracts by 2.13% relative to the base (2.1% in Experiment 2a).

In contrast to previous results, the health of unskilled labour, which depends primarily on levels of NHS provisioning, is maintained approximately at its original level. Thus, unskilled labour participates at a similar rate as before and supplies approximately the same amount of labour. In contrast, skilled labour is worse off in terms of health (health status falls by 0.4%) and labour participation (falls by 0.02%), leading to a rise in the waiting list of 0.7% relative to the base; compared to (Experiment 2a) these changes are however small.

In order to maintain levels of public health care following an increase in the cost of provisioning, the government reduces transfer payments to households by more compared to Experiment (2a), given expenditures on other goods. In contrast, households' income from all factors of production falls by less: rents on capital fall by slightly less, whereas wages for skilled labour are approximately constant and wages for unskilled labour fall by almost twice as much relative to Experiment (2a). As effective unskilled labour supply is maintained close to the pre-shock level, overall income from this factor of production is higher. However, most households are still worse off compared to Experiment (2a), the exception being childless working households who least rely on state benefits and supply over half of skilled labour endowments. Adding changes in public good provisioning mitigates welfare losses: overall welfare falls by £2.14 billion, a deterioration of 0.23% relative to the benchmark; £508 million or 0.05 percentage points less compared to Experiment (2a), by maintaining levels of NHS care.

6.5.5 Experiment 3a: immigration of health care-specific skilled labour under an exogenous NHS budget

In Experiment (1b), the presence of health care-specific skilled labour constrained the expansion of the health sector following a rise in government expenditures. In this section, the government allows foreign health care-specific skilled workers, 10% of domestic endowments of this labour type, to come and work in the UK so as to alleviate this constraint, given the government budget for the NHS. Using the same model specification as Experiment (1b), foreign workers earn the health care-specific skilled wage and possess the same labour market characteristics (i.e. non-participation rate and health status), as their domestic counterparts.

In the presence of remittances further adjustments have to be made to the SCGE model. Foreign workers effectively employed in the health care sector, denoted by FW_E, receive the health care-specific skilled wage, denoted by $P_{FS"skill,"10"}$, so that foreign worker income, Y_F, amounts to:

$$Y_F = P_{FS"skill,"10"} FW_E \qquad (6.43)$$

This income is transferred to households in the form of foreign worker transfers, FWT, or abroad in the form of remittances, denoted in foreign currency by REM:

$$Y_F = ER \cdot REM + FWT \qquad (6.44)$$

The value of remittances in domestic currency is modelled as a share of foreign worker income, α_R, where $0 \leq \alpha_R \leq 1$:

$$ER \cdot REM = \alpha_R \cdot Y_F \qquad (6.45)$$

The value of α_R is varied in the experiment, adopting a value of 0 (no remittances), 0.5 (50% of foreign worker income is remitted) or 1 (all income is remitted abroad) respectively.

The remittances abroad lower the trade surplus, so that the expression for the trade balance, equation (6.33), becomes the balance of payments condition:

$$TS = \sum_j \left(P^W_{E_j} E_j - P^W_{M_j} M_j \right) - REM \qquad (6.46)$$

The remainder of foreign worker income is distributed over domestic households according to each household's share of health care-specific skilled labour endowments, α_{F_h}, where $\sum_h \alpha_{F_h} = 1$, yielding foreign worker transfers to households, T_{F_h}:

$$T_{F_h} = \alpha_{F_h} FWT \qquad (6.47)$$

The income of household h, given by equation (6.25), is adjusted accordingly:

$$Y_h = \sum_f F_{E_{hf}} P_{F_f} + T_h + T_{F_h} \qquad (6.48)$$

In the absence of remittances, a 10% increase in the supply of health care-specific skilled workers, from abroad, reduces health care-specific skilled wages and so the income of domestic workers of this type by approximately 12% so that unit costs of health care output fall and (public and private) health care output rises by 4.9%. This stimulates demand for and (domestic) output of pharmaceuticals and medical instruments by 3% and 1.3% respectively. As both the public and private health sectors expand, the unskilled and the skilled workers benefit equally in terms of health, which improves by 4.9% approximately for both types of labour. Consequently, labour market participation increases by 0.3% and 0.4% for skilled and unskilled labour respectively, equivalent to a waiting list reduction of approximately 9.2% across all households and labour types.

The changes in relative factor supplies and demand induce changes in factor remunerations. Wages of sectorally mobile skilled and unskilled labour fall by 0.06% and 0.35% respectively, due to factor substitution in favour of health care-specific skilled labour (which lowers demand for other production factors). Health care-specific capital rents fall by 3.2% whereas the rents on mobile capital rise by 0.3%.

In the absence of remittances abroad, the income of all household types rises. Households benefit from a rise in income from all non-health care-specific factors, the additional income earned by foreign workers, who essentially form new households of the existing types (36% of new foreign workers belong to working households with children, the remainder belong to mainly childless working households), and from an increase in state benefits by 0.43% stemming from a rise in government tax revenues of 0.17%. Pensioners and non-working households gain by relatively more (0.3% rise in income on average, compared to 0.1% for working households), though in absolute terms it is the pensioner and working household types that gain most.

The same picture obtains from changes in household welfare, measured by EV_h; all households gain, in absolute terms especially pensioners (who experience a gain of £505 million) and working households with and without children (gains of £398 and £301 million respectively), though in relative terms the gain for working (and pensioner) households is much less pronounced compared to non-working households.

Once changes in public good provisioning are accounted for, welfare gains rise by even more, to a total of £4.06 billion (a relative gain of 0.43%).[28]

The general equilibrium effects of foreign workers sending remittances abroad operate via the trade balance. Since the balance of payments is exogenously fixed to benchmark levels, remittances are financed by an increase in exports and/or a reduction in imports compared to a situation where foreign worker income is spent domestically. The effects of remittances on health care production, and thus health, labour market participation and waiting lists are negligible. Nevertheless, household income gains are reduced: if 50% of foreign worker income is remitted only working households experience income losses, whereas if immigrants send all income abroad, all households lose out. This is due to a combination of the direct effect of retaining less income from foreign workers, more pronounced factor price changes (most notably the fall in wages) and lower receipts from government transfers as government tax revenues rise by less or even fall (if all immigrant income is remitted). This is reflected in lower welfare gains (or higher welfare losses) for households, though when public good provisioning is included all households are still better off. Overall welfare (including government consumption of goods) rises by £3.231 billion (0.34% in relative terms) and £2.4 billion (0.35% in relative terms) if 50% and 100% of foreign worker income is remitted respectively.

28 Excluding foreign workers (and so acknowledging that their domestic colleagues actually experience a decline in their earnings) from the welfare measures does not alter these outcomes by much since they only form a small percentage, approximately 0.5%, of the overall domestic work force. The measure of ‘domestic’ overall welfare is found to fall by 0.5% compared to the reported overall welfare measure for all reported immigration experiments. Hence, our conclusions remain valid once foreign workers are excluded from the welfare evaluation.

6.5.6 Experiment 3b: immigration of health care-specific skilled labour at a given wage

This experiment is identical to Experiment (3a) apart from the government closure rule. Here, the government adjusts public health care provision (and expenditures) so as to counteract the fall in health care-specific skilled wages. The latter are now effectively fixed relative to the numéraire, implemented as:

$$P_{FS"skill","10"} / ER = 1 \qquad (6.49)$$

where the exogenous variable $GEXP^0_{"10"}$ is removed and $G_{"10"}$ is endogenised, using equation (6.42) in place of (6.32) for health care (commodity "10").

In the absence of remittances, NHS provision levels have to rise by 10.3% (equivalent to an 11.6% increase in expenditures), compared to 4.9% in Experiment (3a), so as to guarantee the foreign (and domestic) workers the original health care-specific skilled wage. This induces higher increases in the demand for and domestic production of pharmaceutical products (by 5.2%), and medical instruments (by 2.2%) and since unit costs of health care provision rise by 1.2% (compared to a reduction of approximately 4.9% before), the private sector now contracts by 1.2%.

Given that the public sector expands and the private sector contracts unskilled workers benefit relatively more in terms of health compared to skilled workers; health gains for the unskilled equal 9.9%, compared to health gains of 8.3% for the skilled, but both exceed those in Experiment (3a). Consequently, labour market participation increases by 0.4% and 0.8% for skilled and unskilled labour, equivalent to reductions in the waiting lists of 15% and 17%, respectively. Factor reward changes are notably different as well. Apart from the unchanged health care-specific skilled wage, rents on health care-specific capital rise by 10.5% compared to a fall of 3.2% in Experiment (3a). Factor rewards for mobile capital (labour types) rise (fall) as before so that households experience a rise in income from *all* factors of production.

While government income from taxes increases by 0.5%, the additional government expenditures on health care are financed from a reduction in household transfers (which fall by 4.2%). As a result of the latter, the incomes of pensioners and non-working households fall in the range of 1% to 3.5% approximately. Working households, benefiting from the income generated by foreign workers and associated factor price changes, gain by relatively more (0.4% versus 0.1% in Experiment 3a).

The income changes are reflected in welfare changes. Whereas welfare gains (including public good provisioning) are approximately £1 billion higher compared to Experiment (3a), amounting to £5.124 (0.54% in relative terms), disparities across households have grown. Excluding changes in public good provisioning, non-working households with and without children lose by £485 million and £407 million respectively, which combined is still less than the welfare loss suffered by pensioners of £1.94 billion (though in relative terms the income loss for pensioners compared to non-working households is less). In contrast, working households with and without children benefit by £261 million and £2.075 billion respectively. Remittances operate as in Experiment (3a) and are therefore not discussed here.

6.5.7 Experiment 4a: factor-neutral technical change (FNTC)

The productivity of all factors of production (capital, skilled and unskilled labour) in health care is increased by 10%. This form of technological progress is implemented by reducing the constant term of the Leontief production function for health care, $A_{X"10"}$, in equation (6.5) by $1/11 \approx 9.1\%$. Hence, for the same volume of health care outputs, $X_{"10"}$, 9.1% less factor inputs are used, captured by the value-added aggregate $V_{"10"}$, or holding the volume of factor inputs constant, $\left[100/\left(100-9.1\right)\right]\cdot 100-100=10\%$ more health care outputs are generated.

Given government expenditures on health care, the direct effect of the rise in factor productivity is to enhance production of health care by 5.9% on average (6.3% for private health care and 5.9% for NHS care), reduce health care demands for factor inputs by 3.6%, 3.5% and 4.1% for skilled labour, unskilled labour and capital respectively, and reduce unit costs of health care production by 5.6%. Via input-output linkages this induces increased supply of, especially, pharmaceuticals (3.8%) and medical instruments (1.7%).

Health improvements for skilled and unskilled labour are approximately identical, 6% for skilled labour and 5.9% for unskilled labour, due to a corresponding rise in both public and private health care provision. Hence, participation in the labour market rises by 0.3% and 0.5% and waiting lists fall by 11% and 10.9% for skilled and unskilled labour respectively.

Changes in effective supplies and demands for factors generate changes in factor remunerations. Both skilled and unskilled workers receive lower wages, by 0.1% and 0.3% for skilled and unskilled labour respectively, whereas capital owners are better off by 0.4%. Despite reductions in wages, household income from all factors rises due to increased effective labour supplies.

The adjustments to factor income, combined with a rise in income from state benefits of 0.9% (originating from a rise in government tax income of 0.3%), yield income gains across all households, especially for pensioners and working households, though the relative gains (in the range of 0.2% to 0.8%) are higher for pensioners and non-working households as they have a smaller income in the first place (and rely relatively heavily on state benefits).

An examination of welfare variables yields similar results. In absolute terms, and excluding changes in public good provisioning, pensioners gain by £1 billion. For non-working households with and without children these gains are £112 million and £236 million respectively. Welfare of working households with and without children also improves significantly, by £871 and £806 million. Including changes in the government's consumption of goods improves welfare, especially of pensioners and working households who receive a relative large share (see Table 6.3), by even more, resulting in a total welfare gain of £6.3 billion (a relative gain of 0.67%).

6.5.8 Experiment 4b: skill-biased technical change (SBTC)

In contrast to Experiment (4a), here technological progress in the health sector enhances only the productivity of skilled labour by 10% (this amounts to savings in skilled labour inputs of $1/11 \approx 9.1\%$ given health care outputs).

An improvement in the productivity of only one factor enhances health care production by 3.9% on average (4.1% and 3.9% for private and public health care respectively), unsurprisingly less than with the 10% FNTC improvement. Given government expenditures on health care, the health sector demands 5.4% less skilled labour, but 3.6% and 3.4% *more* unskilled labour and capital respectively and produces at a 3.7%

lower unit cost, approximately two percentage points less than in Experiment (4a). Domestic outputs of the main input suppliers of health care rise by 2.6% and 1.1% for pharmaceuticals and medical instruments respectively.

Since fewer health improvements are realised (3.9% gain in health compared to 5.9% in Experiment 4a), effective supplies of skilled and unskilled labour rise only by 0.2% and 0.3% and waiting lists fall by 7.4% and 7.3% respectively for skilled and unskilled labour. The fall in demand for skilled labour in health care, combined with the rise in its effective supply, results in lower skilled wages (a fall of 0.3%), whereas unskilled wages and capital rents rise by 0.1% and 0.4% respectively. Consequently, income from skilled labour falls and income from other factors of production rises. These factor market adjustments, combined with lower rises in government tax revenue and state benefits (0.1% and 0.4% lower respectively) yield less generous household income gains (which for SBTC lie in the range of 0.1% to 0.5%), although the previously observed patterns still hold.

In absolute terms, and excluding government consumption, households are better off by £837 million for pensioners, £72 and £190 million for non-working households with and without children and £493 and £328 for their working equivalents. These figures are low compared to FNTC, an outcome exacerbated once changes in public good provisioning are included in welfare. Overall welfare then improves by £4.1 billion (a relative gain of 0.4%) for SBTC, compared to £6.3 billion observed for FNTC.

6.5.9 Experiment 5a: technical change in pharmaceuticals - increasing the price and productivity of pharmaceuticals in health care

This simulation acknowledges that the 20% price increase in pharmaceuticals observed over the last three years may well be a sign of improvements in the effectiveness of pharmaceuticals, which yield savings in the health care sector. Starting off with the setup of Experiment (2a), technical change in pharmaceuticals is assumed to generate a rise in the productivity of pharmaceuticals in the health care sector of β%. The constant term $A_{"2","10"}$ in equation (6.6) accordingly falls by $\left[1-100/(100+\beta)\right]\cdot 100\%$. β ≈ 20% is the minimum productivity rise required for the health care sector to expand[29], whereas β ≈ 30% is the lower boundary for a positive overall welfare impact (including public good provisioning; excluding the latter requires β ≈ 60%). Results are reported for 20% ≤ β ≤ 100%.

For β ≥ 20% the productivity improvements counteract the negative health and welfare effects of higher intermediate input costs observed in Experiment (2a). The savings in the use of more expensive pharmaceuticals yield a fall in the unit costs of health care, an equivalent expansion of public health care production (given government expenditures on health care), and lower health care demands for pharmaceutical inputs, with a value close to $\left[1-100/(100+\beta)\right]\cdot 100\%$, since the health sector expands little (by less than 5%). The increase in public health care provision partially crowds out private health care, which expands by approximately 0.2% less compared to public health care (or even contracts for the lower boundary of β = 20%). The rise in the domestic consumer price of pharmaceuticals, driven by a 42% rise in the world price of imports and a 4% rise in the domestic producer price (see also Experiment 2a), induces a fall in final demands of all categories (domestic and export demands), whereas intermediate demand declines due to the more efficient use of pharmaceuticals in the health care

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[29] This is also the condition for adoption of the technique (i.e. *progress*) that per unit of output of health care, production costs should fall, $PD^1_{"2"}\cdot A^1_{"2","10"}=1.2\cdot PD^0_{"2"}\cdot A^1_{"2","10"}\leq PD^0_{"2"}\cdot A^0_{"2","10"}$, where superscripts 0, 1 indicate the situation before and after the technical change respectively.

sector. In response, domestic commodity supply and sectoral production of the pharmaceutical industry adjust downwards. Similarly, the foreign supply of pharmaceuticals from imports drops due to the rise in world import prices.

The expansion of the health care sector, albeit small, brings about a rise in the health of the unskilled and skilled population (of less than 5%), and only slightly more so for the former as they primarily consume public health care (the difference never exceeds 0.03% and approaches zero as β rises). Consequently, effective labour supplies increase and waiting lists fall, by less than 0.4% and 9% respectively. Factor demand changes follow the adjustments in sectoral production and, combined with the rise in labour market participation, induce reductions in all factor remunerations of less than 0.4%. In addition, government transfers to household fall by 0.6% or less due to lower receipts from taxes on products and factors so that, combined with income losses from all factors of production, all households experience a decline in income (but of less than 0.5%). The fall in incomes becomes even less pronounced as higher productivity gains of pharmaceuticals in health care are realised.

In absolute terms pensioners, and to a lesser extent working households with children, suffer especially from losses in state benefits, the former also being relatively hard hit by the fall in rental income on capital, whereas working households lose a significant amount of labour income. Consequently, pensioners and working households suffer the largest declines in incomes compared to non-working households, whereas in relative terms pensioners and non-working households are relatively hard hit compared to working households as their income, consisting largely of state benefits, is much smaller.

The same pattern emerges for absolute and relative welfare changes. Excluding changes in public good provisioning, pensioners and non-working households with and without children experience welfare losses of at most £387 million, £55 million and £77 million respectively, whereas working households with and without children lose £283 million and £275 million at most. Adding benefits from public good provisioning to these figures turns the losses into gains for most households for $\beta \geq 32\%$, with the exception of pensioner households who benefit only for $\beta \geq 41\%$. Overall welfare gains (including public good provisioning) depend positively on β and lie in the range of -£714 million (-0.075%) to £3.22 billion (0.34%) for the specified range for β.

6.5.10 Experiment 5b: technical change in pharmaceuticals - increasing the pharmaceutical price and productivity of all inputs in health care

The issue investigated in this experiment is that of the improvement in the cost-effectiveness of pharmaceuticals modelled in Experiment (5a) leading to a more efficient use of other inputs in the health service as well. Let γ indicate the productivity rise (in %) in all intermediate and factor inputs other than pharmaceuticals in health care. Naturally, adding a γ% rise in productivity of non-pharmaceutical inputs to a given β% rise in the productivity of pharmaceuticals used in health care yields higher welfare gains. Driving this result is that the savings in other inputs yield a greater fall in unit cost of health care and, given the health care budget, a greater expansion of public health care. Consequently, health care demands for pharmaceuticals fall by less and the contraction of the pharmaceutical sector observed in Experiment (5a), and the fall in pharmaceutical exports and imports, is less pronounced. Private health care expands relatively (0.02 percentage points) more than public health care since the additional productivity gains yield income gains, as opposed to losses in Experiment (5a), across all households, who subsequently buy more of health care and other goods.

The greater expansion of public and private health care yields higher health gains compared to Experiment (5a). For example, adding a $\gamma = 5\%$ rise in productivity of non-pharmaceutical inputs to a given β% rise in the productivity of pharmaceuticals yields an additional health gain of approximately eight percentage points for both skilled and unskilled labour, with the former benefiting relatively more as they consume more private health care (again the difference disappears for larger β). The improved health impacts upon effective labour supplies, which expand by an additional 0.5 percentage points, and induces a fall in waiting lists of an extra 14 percentage points.

The larger increase in effective labour supplies, despite inducing bigger reductions in wages and a rise in rents on capital, yields income gains for all factors of production so that, combined with a rise in income from state benefits, all households' income rises: in relative terms especially for pensioners and non-working households, since they have a much smaller income compared to working households (consisting for a large part of state benefits); in absolute terms mainly for pensioners and working households, who gain from increased earnings in the factor market (labour *and* capital) and, for pensioners and to a lesser extent working households with children, from the rise in state benefits. Similar conclusions follow from absolute and relative welfare changes. The rise in public good provisioning yields significant overall welfare gains, for example for $\gamma = 5\%$, and $20\% \leq \beta \leq 100\%$, overall welfare gains (including public goods) lie in the range of £7.45 billion (0.79%) to £11.6 billion (1.23%).

To put these welfare gains into perspective, if the technical change embodied in a more expensive pharmaceutical product is such that the productivity of non-pharmaceutical inputs in health care rises by $\gamma = 1\%$, then an increase in the productivity of pharmaceuticals in health care of β ≈ 9% or more is sufficient to guarantee overall welfare gains (including gains from public good provisioning; excluding the latter β ≈ 28% is required). In contrast, productivity improvements in non-pharmaceutical health care inputs of γ = 2% do not require any productivity gains in pharmaceutical inputs for overall welfare effects to be positive (excluding public good provisioning β ≈ 7% is required, and γ = 3% does not require any productivity gains in pharmaceutical inputs). In conclusion, small productivity gains (i.e. savings) in all health care inputs are sufficient for technical progress in pharmaceuticals to enhance overall welfare.

6.6 A COMPARISON OF THE POLICIES/SHOCKS

Tables 6.5, 6.6 and Figure 6.5 to 6.9 summarise the key results of the experiments.[30]

The last column of Table 6.5 shows that encouraging an inflow of foreign skilled workers of 10% (Experiment 3) generally leads to higher welfare gains than an increase in the health care budget of 10% (Experiment 1), and certainly so if one compares the experiments with the same model specification (i.e. Experiment 3 and 1b). In addition, welfare gains of a 10% FNTC (Experiment 4a) or a 10% SBTC (Experiment 4b) outweigh those realised when increasing the health care budget by the same percentage (Experiment 1a), or when increasing the inflow of health care-specific skilled labour by 10% using immigrant labour (Experiment 3), but where the government maintains health care-specific skilled wages (Experiment 3b), only if more than half of foreign worker income is remitted.

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[30] Figures 6.5 to 6.7 report values for Experiment 3 in the absence of remittances as the effect on health related variables is negligible. The results of Experiment 5a and b are not included as values for the productivity gains are highly experimental.

Table 6.5 Welfare changes in Equivalent Variations including changes in public good provisioning[31]

Scenario		EV_T	HSE1	HSE2	HSE3	HSE4	HSE5	Overall
EXP1A		Millions £	-1040	-36	-80	1169	2460	2474
		%	-0.49	-0.13	-0.17	0.40	0.67	0.26
EXP1B		Millions £	-1460	-248	-270	657	2244	920
		%	-0.69	-0.93	-0.59	0.22	0.61	0.10
EXP2A		Millions £	-747	-135	-178	-763	-821	-2640
		%	-0.35	-0.50	-0.39	-0.26	-0.22	-0.28
EXP2B		Millions £	-909	-140	-188	-537	-363	-2140
		%	-0.43	-0.52	-0.41	-0.18	-0.10	-0.23
EXP3A (Remittances in % of foreign worker income)	0%	Millions £	1175	284	330	1219	1052	4060
		%	0.55	1.06	0.72	0.42	0.29	0.43
	50%	Millions £	1070	271	313	951	625	3231
		%	0.50	1.01	0.68	0.32	0.17	0.34
	100%	Millions £	965	258	297	683	198	2400
		%	0.45	0.96	0.65	0.23	0.05	0.25
EXP3B (Remittances in % of foreign worker income)	0%	Millions £	-533	3	19	1984	3651	5124
		%	-0.25	0.01	0.04	0.68	0.99	0.54
	50%	Millions £	-656	-13	-0.4	1678	3166	4174
		%	-0.31	-0.05	0.00	0.57	0.86	0.44
	100%	Millions £	-778	-29	-20	1371	2679	3223
		%	-0.37	-0.11	-0.04	0.47	0.73	0.34
EXP4A		Millions £	1835	394	482	1870	1720	6300
		%	0.86	1.47	1.05	0.64	0.47	0.67
EXP4B		Millions £	1382	261	355	1175	952	4126
		%	0.65	0.98	0.77	0.40	0.26	0.44

As expected, the picture that emerges from the welfare effects of the simulations is a lot less optimistic if changes in public good provisioning are excluded from the welfare measures (Table 6.6). In Experiment (1), (2b), (3) and (4) welfare gains fall and losses rise since the expansion of the public health care sector does not constitute a welfare gain (in Experiment (2a) welfare losses are reduced since the contraction of the public health care sector does not constitute a welfare loss). Additionally, a 10% increase in public health care expenditures under fully mobile factors of production (Experiment 1a) yields higher welfare losses compared to a rise in the domestic consumer price of

[31] The EV_{T_h} (change in household welfare) and EV_T (change in overall welfare) both include changes in public good provisioning and are reported in absolute terms (£ million) and relative to original income, i.e. as a % of original expenditures on goods (including government consumption) and savings. Household equivalent variations may not add up to overall welfare changes due to small measurement errors.

pharmaceuticals (Experiment 2). This somewhat counterintuitive result is explained by the reduction in other expenditures (in this model, state benefits) needed to finance the increase in the health care budget. Furthermore, only technical progress of 10% in health care (Experiment 4) and the immigration of foreign health care-specific skilled workers of 10% of domestic endowments, with wages adjusting accordingly and 50% or less of income remitted abroad, are welfare enhancing.

Table 6.6 Welfare changes in Equivalent Variations excluding changes in public good provisioning[32]

Scenario		EV	HSE1	HSE2	HSE3	HSE4	HSE5	Overall
EXP1A		Millions £	-2390	-504	-489	-476	955	-2900
		%	-1.35	-3.57	-1.39	-0.21	0.31	-0.38
EXP1B		Millions £	-2060	-457	-452	-80	1570	-1480
		%	-1.16	-3.23	-1.29	-0.03	0.50	-0.19
EXP2A		Millions £	-554	-69	-120	-564	-638	-1940
		%	-0.31	-0.49	-0.34	-0.24	-0.20	-0.25
EXP2B		Millions £	-952	-155	-201	-626	-444	-2380
		%	-0.54	-1.10	-0.57	-0.27	-0.14	-0.31
EXP3A (Remittances in % of foreign worker income)	0%	Millions £	505	52	127	398	301	1384
		%	0.28	0.37	0.36	0.17	0.10	0.18
	50%	Millions £	371	29	102	77	-174	404
		%	0.21	0.20	0.29	0.03	-0.06	0.05
	100%	Millions £	238	5	76	-246	-651	-577
		%	0.13	0.03	0.22	-0.11	-0.21	-0.08
EXP3B (Remittances in % of foreign worker income)	0%	Millions £	-1940	-485	-407	261	2075	-496
		%	-1.09	-3.43	-1.16	0.11	0.66	-0.06
	50%	Millions £	-2100	-512	-436	-106	1533	-1620
		%	-1.18	-3.63	-1.25	-0.05	0.49	-0.21
	100%	Millions £	-2250	-540	-466	-475	991	-2740
		%	-1.27	-3.82	-1.33	-0.21	0.32	-0.36
EXP4A		Millions £	1023	112	236	871	806	3048
		%	0.58	0.79	0.67	0.38	0.26	0.40
EXP4B		Millions £	837	72	190	493	328	1921
		%	0.47	0.51	0.54	0.21	0.11	0.25

The observed patterns from Table 6.5 nevertheless carry over to the welfare measures excluding changes in public good provisioning: Experiment (3) still outperforms Experiment (1) (apart from Experiment (3b), which, if approximately 50% or more of

[32] In absolute terms and relative to original income, i.e. expenditures on goods (excluding public goods) and savings. Household EVs may not add up to the total due to small measurement errors.

foreign worker income is remitted, yields higher welfare losses compared to Experiment 1b), and Experiment (4) yields the greatest welfare gains.

Nevertheless, as is obvious from Figures 6.5, 6.6 and 6.7, if the government maintains health care-specific skilled wages (Experiment 3b), attracting foreign workers performs better in terms of health status, participation in the labour market and reducing the waiting list compared to technological change in the health sector (Experiment 4) and increasing the health care budget (Experiment 1). If the government allows health care-specific skilled wages to adjust (Experiment 3a), such a policy still yields greater health and labour market participation gains compared to an increase in health expenditures using the same model specification (i.e. Experiment 1b), but it does only better than skill-biased, not factor-neutral, technical change in the health care sector.

The latter policy of a 10% increase in the health budget yields relatively low health and welfare gains if specificity of skilled labour and high-tech capital in health care (Experiment 1b) is taken into account, if one acknowledges the welfare effects from changes in public good provisioning (see Table 6.5). Pharmaceutical price rises (Experiment 2) also lower welfare. Otherwise, using Table 6.6, any measure which curbs the expansion of the health care sector and associated costs, e.g. the presence of health care-specific factors (Experiment 1b relative to 1a) or not maintaining NHS provision levels when pharmaceutical prices rise (Experiment 2a relative to 2b), reduces welfare losses.

Figure 6.5 Change in health status

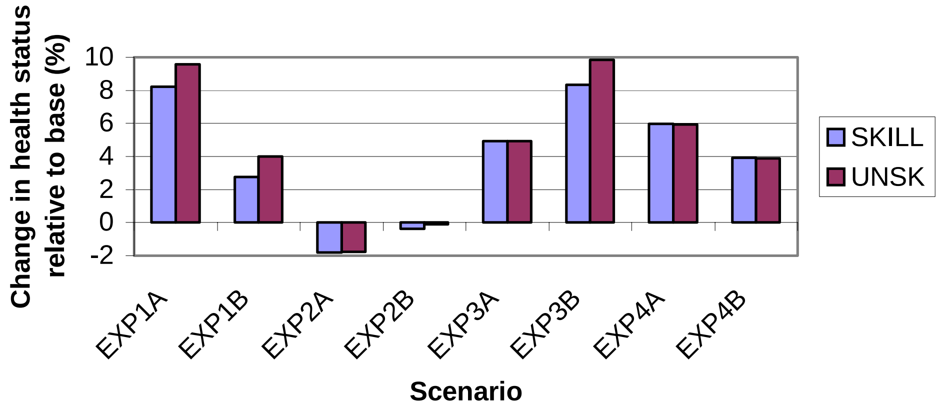


Figure 6.6 Non-participation rate of labour

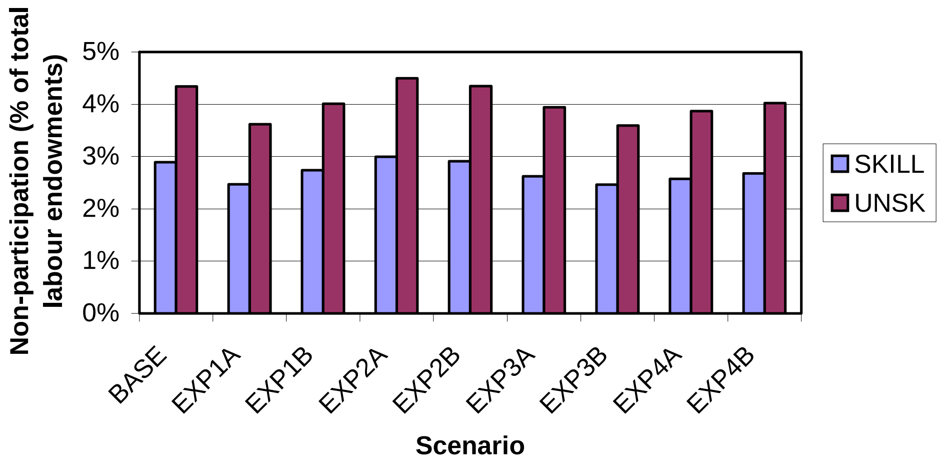
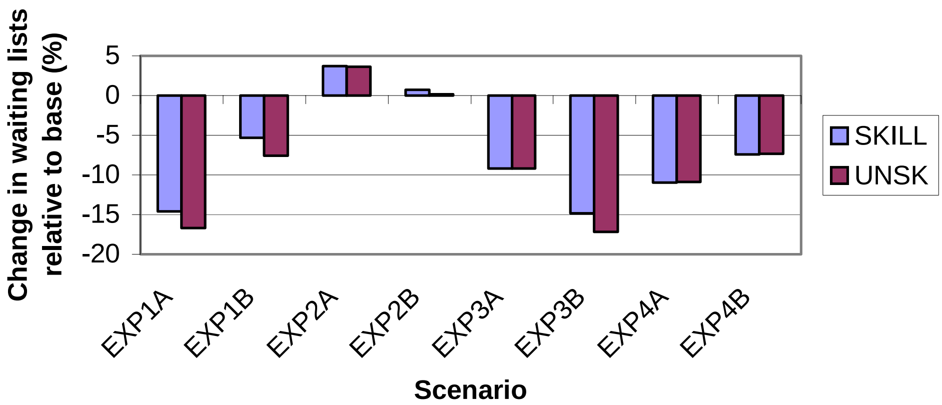


Figure 6.7 Change in waiting list



The negative welfare effects of a 20% rise in the domestic consumer price of pharmaceuticals may become welfare gains if it is assumed that the more expensive pharmaceutical product embodies a technical (quality) improvement, which makes the health care sector more efficient in terms of the use of pharmaceuticals and other inputs (Experiment 5). It was found that small productivity gains across a wide range of health care inputs are sufficient to enhance overall welfare.

Figure 6.8 Changes in household welfare (incl. public goods)

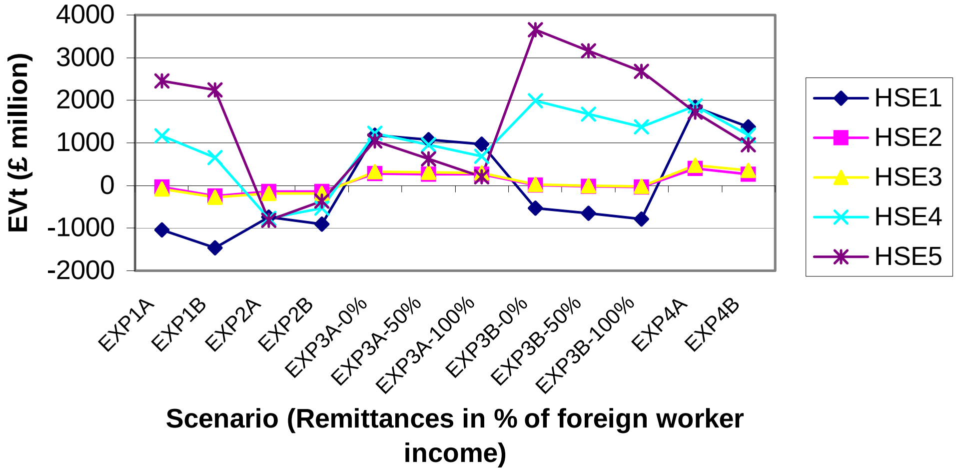
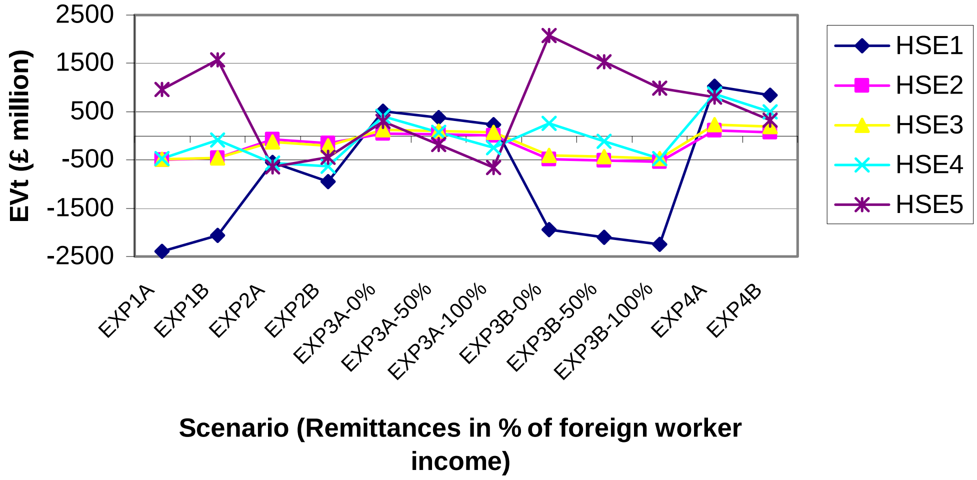


Figure 6.9 Changes in household welfare (excl. public goods)



Furthermore, according to Table 6.5 and Figure 6.8 household interests do not always align. Technical change (Experiment 4) benefits and thus will be supported by all households. The same is true for foreign health care-specific skilled workers coming to work in the UK at an endogenous wage (Experiment 3a), although in this case domestic health care-specific skilled workers lose out. Conversely, pharmaceutical price rises (Experiment 2) make all households worse off and thus will be unpopular with all households. With respect to the remaining policies, household interests differ strongly. Government policy aimed at encouraging highly skilled foreign doctors and nurses to come and work in the UK at the current wage will benefit working households, whilst non-working households, and especially pensioner households, generally lose. A similar argument holds with respect to an expansion of the government budget on health care, which will have to be at the cost of other government expenditures (here transfers to households, on which pensioners and non-working households rely relatively heavily as a source of income). Excluding direct improvements in well-being from public good provisioning generally, apart from Experiment (2a), lowers the values of the equivalent variations so that fewer households gain and those that were already losing, lose by more (Table 6.6 and Figure 6.9).

Whereas it is useful to rank the experiments based purely on the outcomes, from the perspective of policy making, a proper evaluation of policies necessitates a comparison of the outcomes *relative to* the costs of implementation. The policies which improve the productivity of health care inputs via technical change that is factor-neutral or skill-biased are essentially ‘free lunches’ in the sense that these policies come at no additional cost to the government[33], so that - based on solely the two overall welfare measures - these experiments are found to outperform the policy of increasing the health care budget.[34] Whether this conclusion still holds if costs faced by the government are taken into account remains an empirical question and no estimates are available as yet to comment on this. Further insights into the policy of technical change in health care may be obtained by translating the effects in terms of the rise in the government budget on health care required to obtain the same overall welfare gain (including public good provisioning). It can be shown that an increase in government expenditures on health care of 37.9% yields the same overall welfare gain as when implementing a 10% factor-neutral technical change (Experiment 4a), whereas an increase of 19.1% results in an identical rise in overall welfare as a 10% skill-biased technical change (Experiment 4b).

With respect to the policies of importing health care-specific skilled labour and technical change which improves the cost-effectiveness of pharmaceuticals in health care, some additional costs could have been involved, respectively, in terms of wage payments and a more expensive pharmaceutical product. However, in Experiment (3a) and (5) the government budget was held fixed. Hence, the conclusion, that a policy of encouraging foreign skilled workers equal to 10% of domestic endowments to come and work in the UK health sector, whilst allowing their wage to adjust, outperforms the policy of a 10% increase in the health care budget (especially using the same model specification), remains valid once additional costs to the government are accounted

[33] These technological improvements may be funded by, say, charitable institutions, or may have been made in other countries yet be freely available.

[34] Technical change in factors is imposed exogenously and not modelled as an endogenous process.

for.[35] Only in Experiment (3b) do government expenditures on health care rise so as to sustain health care-specific skilled wages. Specifically, when foreign worker income is remitted, government health expenditures have to rise by 11.64% to sustain their wage. Such an increase in expenditures per se can be shown to yield a rise in welfare including changes in welfare from public good provisioning of respectively £2.808 billion (£1.038 billion) in the presence of mobile (health care-specific) factors, i.e. using the model specification of Experiment (1a) (1b). These gains are lower than those following from the immigration policy such that, again, the conclusion must be that immigration of foreign skilled workers at the current wage, even when the costs to the government of such a policy are acknowledged, yields higher overall welfare gains.[36]

6.7 SENSITIVITY ANALYSES

In Chapter 1 it was noted that one of the main weaknesses of CGE modelling is the sensitivity of results to assumptions made, for example with regards to the behaviour of agents, the functioning of markets and the choice of key parameter values. Whereas Experiments (1) to (5) have tested the results for sensitivity with respect to especially the first two types of assumption, this section reports on the sensitivity of the results to alternate parameter specifications. In Chapter 2 it was shown that the effects of changes in health care provision on non-health care outputs crucially depend upon the magnitude of the elasticity of effective labour supply with respect to health care, i.e. the waiting list elasticity and the dependency ratio. Whereas the latter has been empirically estimated in

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[35] Such conclusions with respect to Experiment (5) cannot be made due to the uncertainty regarding the productivity gains in health care relative to the price increase of pharmaceuticals.

[36] Using the indicator of changes in private welfare, an 11.64% rise in the government budget on health care results in welfare losses of £3.448 and £1.741 billion respectively using the model specification of Experiment (1a) and (1b). Hence, only if more than 50% of foreign worker income is remitted, an increase in the health care budget of 11.64% will yield lower welfare losses, using the same model specification.

Section 6.4.4, the waiting list elasticity parameter has been assigned a value of 2. Given that no reliable estimate exists, the sensitivity analyses focus mainly on that waiting list elasticity (ε).[37] The remainder of this section investigates the sensitivity of the results to the elasticities of transformation and substitution.

6.7.1 Waiting list elasticity

Firstly, values for this parameter are varied while adhering to the assumption of equal elasticities across labour types. Secondly, this section considers unilateral changes in the waiting elasticity for skilled labour, whilst keeping the waiting list elasticity for unskilled labour at the benchmark level of 2. The former procedure tests the sensitivity of model results to the effectiveness of a change in health care provisioning in treating and/or curing people across all labour types, whereas the latter procedure shows how model outcomes are altered by allowing for skill-biased health effects - implying that a given increase in health care provisioning treats and/or cures more skilled workers relative to unskilled workers.[38] As altering the level of the waiting list elasticity impinges upon the effectiveness of a change in health care provisioning, the sensitivity analysis is carried out for Experiment (1a), which simulates an increase in public health care expenditures. The observed patterns carry over to the other experiments.

The results of Experiment (1a) are relatively robust to skill-biased and skill-neutral changes in the waiting list elasticity - differences are generally within the margin of 1-2 percentage points - though the sign of effects and magnitudes for health (care) and labour market related variables (including changes in welfare) is affected. When

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[37] Subscripts are omitted for simplicity. The waiting list elasticity is referred to in absolute value.

[38] In other words, health care expenditures are either targeted more towards skilled workers *or* skilled workers respond better to treatment.

simulating a 10% increase in levels of NHS care (Experiment 1a), the following patterns can be observed from uniform increases in the waiting list elasticities:

The higher the waiting list elasticity, the more the non-participation rate and the size of the waiting lists are reduced for a 10% increase in public health care expenditures. Eventually, the more pronounced expansion in effective labour endowments ensures that the production of all goods rises. This includes both public *and* private health care provisioning, which in turn magnifies the positive health effects. Skilled and unskilled labourers are relatively less scarce in supply, so that wages for both labour types fall whereas rents on capital rise. As more people return to the labour force and so more is produced in the economy for a given increase in NHS expenditures, the government sees its tax revenue rise so that it needs to reduce transfer payments to households by less in order to finance the increase in the health care budget. Consequently, more and more households gain; at first only working households, but for higher levels of the waiting list elasticity also pensioners and non-working households. Overall welfare (including government consumption of goods) rises for relatively low values of the waiting list elasticities (the boundary value is 0.375) and increases by more for higher values. The overall welfare measure which ignores direct improvements in well-being from public good provisioning requires much higher waiting list elasticity values for welfare effects to become positive (the boundary value is 4.285).

Skill-biased increases in the waiting list elasticities reveal much the same tendencies, except when it comes to labour market variables; a given 10% increase in public health care expenditures reduces the non-participation rate and the size of the waiting list for skilled labour by more, the higher the waiting list elasticity for skilled labour. Given that the waiting list elasticity for unskilled labour remains at the benchmark level of 2, the changes in the non-participation rate and the waiting list for this type of labour in Experiment (1a) are not affected by the increase in the waiting list elasticity. For higher levels of the waiting list elasticity of skilled labour relative to unskilled labour, only skilled labour becomes relatively less scarce in supply, so that wages for skilled labour fall, whereas rents on capital and unskilled wages rise. Comparison of the sensitivity of overall welfare changes in Experiment (1a) to uniform and skill-biased changes in the waiting list elasticity reveals that welfare gains are lower if the waiting list elasticity for unskilled labour lags behind that of skilled labour, i.e. if the change in NHS treatment levels treats and/or cures relatively more skilled workers.

The effect of changing the waiting list elasticity is illustrated in Figure 6.10 for a selection of variables. Results are reported for uniform or skill-biased changes in the waiting list elasticities, where the relevant elasticities parameters are set to values of 0, 1... 10 (in scenario sc0, sc1... sc10, respectively).[39] A waiting list elasticity of zero illustrates the direct impact of additional health expenditures on the economy (and welfare), and suppresses the indirect effects of improving (household) income through increased labour market participation. This may be interpreted as the *short run* economic impact of expanding health care, as opposed to the *long run*, in which consequent health improvements materialise. For completeness, the impact of uniform changes in the waiting list elasticities for the remaining experiments are reported as well in Tables 6.7 and 6.8, using indicators of overall welfare changes which respectively include and exclude public goods.

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[39] For skill-biased changes, the waiting list elasticity for unskilled labour remains at a level of 2, whereas the skilled waiting list elasticity adopts aforementioned values.

Figure 6.10 Sensitivity of results in Experiment (1a) to the waiting list elasticity

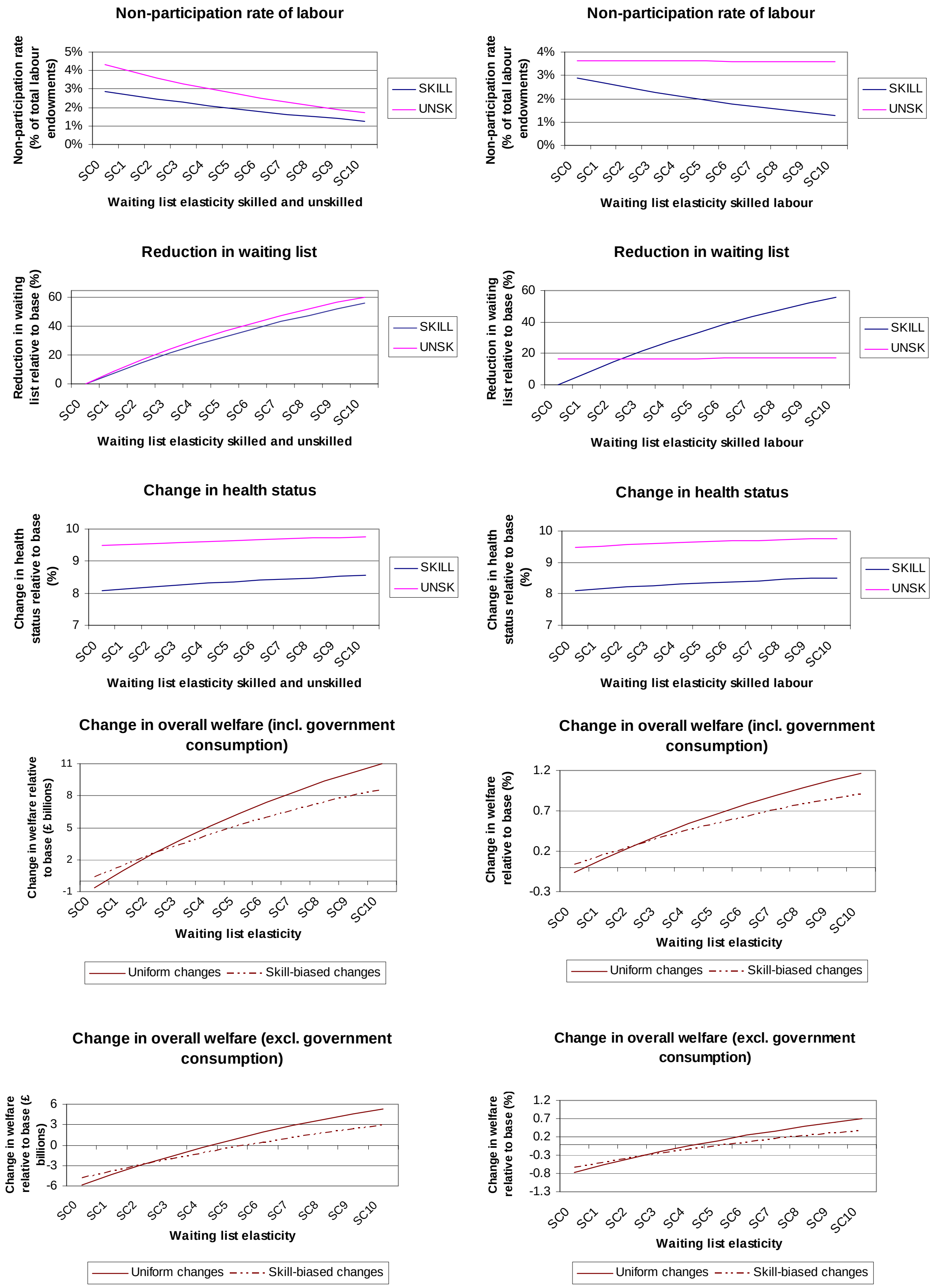


Table 6.7 Relative change in overall welfare (incl. public goods)

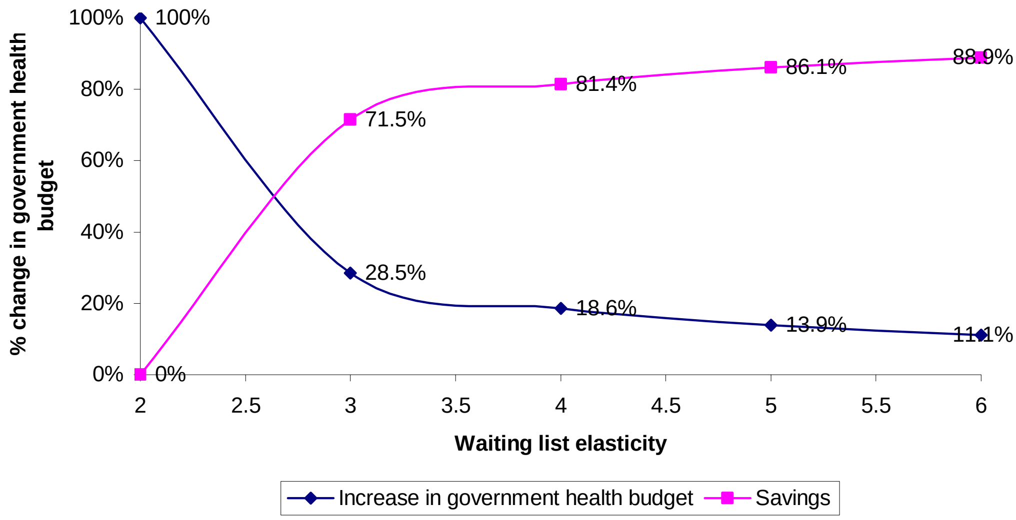
Experiment	Scenario: ε										
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1a	-0.065	0.104	0.261	0.407	0.542	0.667	0.783	0.889	0.988	1.078	1.161
1b	-0.030	0.034	0.097	0.161	0.224	0.288	0.351	0.414	0.476	0.537	0.598
2a	-0.200	-0.239	-0.279	-0.321	-0.363	-0.408	-0.453	-0.501	-0.550	-0.602	-0.655
2b	-0.213	-0.220	-0.226	-0.232	-0.238	-0.244	-0.251	-0.257	-0.264	-0.271	-0.277
3a -0%	0.232	0.331	0.429	0.525	0.619	0.710	0.799	0.885	0.969	1.048	1.125
3a - 50%	0.143	0.243	0.341	0.438	0.532	0.624	0.713	0.800	0.883	0.963	1.040
3a - 100%	0.054	0.155	0.253	0.350	0.445	0.538	0.627	0.714	0.798	0.878	0.955
3b -0%	0.211	0.379	0.541	0.696	0.843	0.981	1.109	1.228	1.338	1.438	1.529
3b - 50%	0.110	0.279	0.441	0.596	0.743	0.881	1.009	1.128	1.237	1.337	1.428
3b - 100%	0.009	0.178	0.340	0.496	0.643	0.780	0.909	1.028	1.137	1.237	1.328
4a	0.430	0.550	0.665	0.775	0.879	0.978	1.072	1.161	1.246	1.325	1.401
4b	0.277	0.358	0.436	0.512	0.586	0.657	0.727	0.794	0.859	0.922	0.983

Table 6.8 Relative change in overall welfare (excl. public goods)

Experiment	Scenario: ε										
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
1a	-0.765	-0.564	-0.377	-0.204	-0.044	0.105	0.242	0.369	0.485	0.592	0.691
1b	-0.339	-0.266	-0.193	-0.120	-0.046	0.027	0.100	0.172	0.243	0.314	0.383
2a	-0.159	-0.205	-0.253	-0.302	-0.353	-0.405	-0.460	-0.516	-0.575	-0.635	-0.699
2b	-0.295	-0.302	-0.309	-0.317	-0.324	-0.331	-0.339	-0.347	-0.354	-0.362	-0.370
3a -0%	-0.046	0.068	0.180	0.290	0.398	0.503	0.605	0.704	0.799	0.891	0.979
3a - 50%	-0.175	-0.060	0.053	0.163	0.271	0.377	0.480	0.579	0.674	0.766	0.855
3a - 100%	-0.303	-0.188	-0.075	0.036	0.145	0.251	0.354	0.454	0.550	0.642	0.730
3b -0%	-0.427	-0.243	-0.064	0.106	0.267	0.418	0.559	0.689	0.809	0.919	1.019
3b - 50%	-0.574	-0.389	-0.210	-0.040	0.121	0.272	0.413	0.544	0.663	0.773	0.872
3b - 100%	-0.720	-0.535	-0.356	-0.186	-0.025	0.127	0.267	0.398	0.517	0.627	0.726
4a	0.117	0.260	0.396	0.526	0.650	0.768	0.879	0.985	1.085	1.180	1.269
4b	0.061	0.157	0.250	0.340	0.428	0.513	0.596	0.676	0.753	0.828	0.900

The shaded areas indicate values for the waiting list elasticity in between which a sign change occurs. As the results show, for the welfare indicator which acknowledges the direct improvements in well-being from better health (Table 6.7) such changes occur only for Experiment (1), but at a relatively low level (less than 1). The welfare indicator which does not incorporate direct gains in well-being is less robust and changes sign in Experiments (1) *and* (3). For the former the change occurs at a relatively high level of the elasticity (between 4 and 5), whereas for the latter experiment the sign change occurs at a low level (less than 1), but gradually moves up if more remittances are sent home (and if the health-care specific skilled wage is maintained at pre-shock levels).

Figure 6.11 Combinations of the waiting list elasticity and the rise in the government health budget yielding identical overall welfare gains (incl. public goods) - using the model specification of Experiment (1a)



The importance of making the additional health care expenditures count, i.e. ensuring 'value for money', is shown in Figure 6.11 by plotting the increase in the government health budget required to achieve the same overall welfare gains (including gains from public good provisioning) as a 100% rise in this budget assuming a waiting list elasticity of 2, when the waiting list elasticity for skilled and unskilled labour (in absolute value) rises incrementally by 50 percentage points, using the model specification of Experiment (1a). It shows the potential savings in the government health budget when the additional expenditures are more effectively treating and/or curing people. For example, an increase in the waiting list elasticity for skilled and unskilled labour from 2 to 3 requires a rise in public health expenditures of only 28.5% compared to 100% before, yielding savings in public health expenditures of 71.5%.

6.7.2 Elasticities of substitution and transformation

This section assesses the sensitivity of the results to the elasticities of substitution (σ_S) and transformation (σ_T) in the CES and CET functions respectively, as well as the elasticity of substitution in the value-added composite, referred to in this section as σ_V.[40] The former two elasticities were assigned values of 2 in the SCGE model, whereas the latter, which uses the CD functional form, has been assigned a value of 1. The alternative values that are considered are 50% and 200% of the original values.[41] These changes are introduced separately for the respective elasticities and the impact upon key welfare indicators is shown in Table 6.9 and 6.10, reporting changes in overall welfare including public goods and excluding public goods respectively.[42]

Table 6.9 Relative change in overall welfare (incl. public goods)

% change in overall welfare (incl. public goods)	Scenario:						
	Base elasticities	$0.5\sigma_V$	$2\sigma_V$	$0.5\sigma_S$	$2\sigma_S$	$0.5\sigma_T$	$2\sigma_T$
Experiment 1a	0.261	0.263	0.261	0.261	0.262	0.261	0.262
Experiment 1b	0.097	0.060	0.143	0.097	0.098	0.097	0.098
Experiment 2a	-0.279	-0.280	-0.279	-0.278	-0.283	-0.279	-0.279
Experiment 2b	-0.226	-0.226	-0.226	-0.231	-0.221	-0.224	-0.226
Experiment 3a -0%	0.429	0.454	0.394	0.429	0.428	0.429	0.429
Experiment 3a - 50%	0.341	0.371	0.303	0.341	0.341	0.341	0.341
Experiment 3a - 100%	0.253	0.287	0.212	0.253	0.253	0.254	0.253
Experiment 3b -0%	0.541	0.535	0.544	0.541	0.542	0.541	0.542
Experiment 3b - 50%	0.441	0.434	0.445	0.440	0.442	0.441	0.441
Experiment 3b - 100%	0.340	0.333	0.345	0.339	0.342	0.340	0.341
Experiment 4a	0.665	0.667	0.664	0.665	0.666	0.665	0.666
Experiment 4b	0.436	0.437	0.435	0.436	0.436	0.435	0.436

40 Subscripts are omitted for simplicity.

41 This is conform common practice. Devarajan et al. (1997, p166 and further) note that with respect to the elasticity of substitution and transformation, for developed countries, its value is likely to lie above 1. Trade is usually with similar high-income countries and goods are of the same high quality and so highly substitutable. See also footnote 15.

42 Experiment 5 is not shown in the table, though unreported simulations confirm that welfare changes from changing the respective elasticities are negligible for any combination of gamma and beta.

Table 6.10 Relative change in overall welfare (excl. public goods)

% change in overall welfare (excl. public goods)	**Scenario:**						
	Base elasticities	$0.5\sigma_V$	$2\sigma_V$	$0.5\sigma_S$	$2\sigma_S$	$0.5\sigma_T$	$2\sigma_T$
Experiment 1a	-0.377	-0.378	-0.377	-0.377	-0.378	-0.376	-0.378
Experiment 1b	-0.193	-0.154	-0.242	-0.192	-0.194	-0.192	-0.194
Experiment 2a	-0.253	-0.252	-0.253	-0.303	-0.192	-0.240	-0.259
Experiment 2b	-0.309	-0.308	-0.310	-0.354	-0.256	-0.298	-0.314
Experiment 3a - 0%	0.180	0.135	0.226	0.179	0.181	0.180	0.180
Experiment 3a - 50%	0.053	0.014	0.093	0.046	0.060	0.046	0.059
Experiment 3a - 100%	-0.075	-0.107	-0.040	-0.087	-0.062	-0.088	-0.062
Experiment 3b -0%	-0.064	-0.089	-0.052	-0.064	-0.065	-0.063	-0.066
Experiment 3b - 50%	-0.210	-0.234	-0.200	-0.216	-0.204	-0.217	-0.204
Experiment 3b - 100%	-0.356	-0.379	-0.347	-0.369	-0.343	-0.371	-0.342
Experiment 4a	0.396	0.386	0.402	0.396	0.397	0.397	0.396
Experiment 4b	0.250	0.231	0.260	0.250	0.250	0.250	0.250

The results of the analyses indicate that, generally, the direction of effects is unaffected or not much affected by the changes in elasticity values, though magnitudes differ. Generally speaking, greater quantity changes are observed as elasticities are increased and smaller price changes, which conforms to expectations. This, naturally, impacts upon the magnitude of macroeconomic variables. Some peculiarities are commented on.

Changing the CD function for value-added into a CES function, with the elasticity of substitution between factors (σ_V) equal to 0.5 and 2 respectively, impacts particularly upon factor markets (i.e. factor prices and sectoral employment). A higher elasticity implies that factors are more easily substitutable so that factor price changes are dampened. In Experiment (1b), for example, the constraint imposed by the presence of specific factors becomes less stringent as the elasticity of substitution between factors is increased so that higher welfare gains are reported in Table 6.9, whereas in Table 6.10 higher welfare losses are reported since a greater expansion of the health care sector does not constitute a direct improvement in well-being (indeed, via the reduction in government transfers, they imply a welfare loss). Simulations using Experiments (1), (3) and (4) reveal that factor price changes may change sign so that households' earnings from factors of production may change from positive (negative) to negative (positive) as well. This holds especially for capital since each household's capital endowment is fixed. The impact upon overall household income is nevertheless negligible in the sense that no sign changes occur there.

Alternative values for the elasticity of substitution in the Armington composite (σ_S) principally affect domestic supply of goods (and sectoral production), imports and hence (as the trade balance is fixed) exports and all related prices. Simulations of Experiments (2) and (5) reveal that changes in some of these variables may change in sign when varying the elasticity. This has repercussions for factor markets as well. It appears that in Experiment (2), for a greater substitution elasticity (of around 4) the domestic production of pharmaceuticals expands (and imports contract) to such an extent that factor reward changes generally change from negative to positive. Combined with lower reductions in state benefits eventually, i.e. for sufficiently high elasticity values, all households' incomes rise. Due to the contraction of the health care sector welfare losses are still reported. In Experiment (5), the previously reported productivity improvements in health care which were sufficient for an expansion of the health care sector or an increase in overall welfare variables are no longer sufficient for higher values of the elasticity of substitution. Consequently, the lower boundary values for productivity improvements to yield overall welfare gains must go up.

Variations in the elasticity of transformation in the CET composite (σ_T) affect the same variables. For example, using Experiment (2), it can be shown that for a greater elasticity of transformation (of around 4), domestic production of pharmaceuticals falls.

This however does not yield any major changes in terms of remaining model variables, including health, household income and welfare variables.

6.8 CONCLUSIONS

This chapter has presented results from a Static Computable General Equilibrium (SCGE) model applied to the UK, which incorporates interactions between public and private health care, outputs of non-health goods and national welfare in a small open economy. The effects on welfare of higher provision may come through direct gains affecting the well-being of households, distinguished by the age and working status of its members, and indirectly through increases in the effective (i.e. ‘able to work’) endowments of skilled and unskilled labour for use in non-health activities. The endogenous labour supply, i.e. working time, effect of changes in the quantity of health care provided are modelled, whilst recognising the resource claims this requires in terms of capital and, more importantly, labour inputs. Endogeneity of effective labour endowments is achieved by using an artificial ‘waiting list’ variable, which records the working time lost due to ill health by skill type. The size of the waiting list is indirectly, via a health status measure, determined by the levels of National Health Service (NHS) and private health care provisioning.

The model is calibrated in MPSGE (Mathematical Programming System for General Equilibrium analysis) to the purpose-built UK dataset for the year 2000 and subsequently employed in a variety of simulations covering current health care issues in the UK. The model files are documented in the appendix to Chapter 6 and available in electronic form from the author upon request.

The simulation results reveal that a 10% increase in government expenditures on the NHS (£5.384 billion), while drawing away resources from other non-health related sectors and its private counterpart, leads to an overall welfare gain of £2.474 billion (a relative gain of 0.26%) through increased worker (and capital) incomes and direct increases in the well-being of the population. The overall welfare gain is reduced to £920 million (a relative gain of 0.1%) if health care-specific skilled labour and capital in the short run are accounted for and shows the importance of tackling rigidities in the health sector.

A 20% rise in the domestic consumer price of pharmaceuticals, one of the main intermediate inputs into health care, has adverse overall welfare effects of £2.64 billion (0.28% in relative terms) through falling household incomes and direct decreases in the well-being of the population. These welfare losses are mitigated by $500 million if the government allows the health care budget to grow by 1.8% so as to cover additional costs of health care provision and maintain previous treatment levels under the NHS.

The immigration of health care-specific skilled workers equal to 10% of domestic health care-specific skilled endowments alleviates the shortage of highly skilled workers in UK health care. As the latter labour type’s wages fall, the same government health budget allows for more people to be treated and cured. Consequently, overall welfare rises by £4.06 billion (a relative gain of 0.43%), which can be shown to derive from a rise in income for all non-health care-specific factors, the additional foreign worker income, which remains in the economy in the absence of remittances, an increase in state benefits and direct improvements in population well-being. The effect of remitting foreign worker income abroad is to reduce the welfare gains; ultimately, if all income is remitted, to a level £2.4 billion (a relative gain of 0.25%). If the government invites these foreign skilled doctors and nurses to the UK at a wage equal to the pre-immigration level, public health expenditures have to rise by 11.6% inducing even larger increases in NHS provision levels (and lower private provision levels) compared to a situation where the wage would not be kept at the original level. As a result, overall welfare gains are higher and amount to £5.124 billion (0.54% in relative terms). As before, these gains fall in the presence of remittances, ultimately to £3.223 billion (a relative gain of 0.34%) if all foreign worker income is remitted.

Technical change in all factors employed in health care (Factor-Neutral Technical Change, FNTC), modelled as a 10% rise in the productivity of these factors, results in a reduction in the unit costs of health care provision of 5.6% and, given the health care budget, an equivalent rise in the production of health care. The consequent gains in income from state benefits, income from factors of production, and direct improvements in population well-being yield overall welfare gains of £6.3 billion (0.67% in relative terms). If the technical change in health care is confined to skilled labour (Skill-Biased Technical Change, SBTC), the health care provision increase and reduction in unit costs are approximately two percentage points smaller compared to FNTC, giving rise to lower overall welfare gains of £4.1 billion (a relative gain of 0.4%).

The final simulation models technical change embodied in pharmaceuticals which gives rise to a 20% increase in the domestic consumer price and a more effective pharmaceutical product in the health sector. The simulations reveal that a 20% rise in the productivity of pharmaceuticals in health care only is sufficient for the health sector to expand, whereas a 30% productivity rise is sufficient to ensure overall welfare gains.

In that situation the direct improvements in well-being counteract the private welfare losses from falling factor incomes and state benefits. If the technical change embodied in pharmaceuticals also ensures a more efficient use of non-pharmaceutical inputs into health care, overall welfare gains are shown to rise. This result is driven by a greater expansion of public health care, a bigger increase in effective labour endowments, yielding a rise in income from all factors of production, a rise in income from state benefits and greater direct improvements in well-being. A rise in the productivity of non-pharmaceutical inputs into health care of 2% is sufficient to guarantee overall welfare gains.

Distributional effects of the counterfactual simulations are unequal across sectors, factors and households. Firstly, with respect to sectoral effects, changes in public health care provision seem to particularly impact upon its private counterpart and health-related sectors, i.e. the pharmaceutical industry and the sector producing medical, precision and optical instruments. Specifically, an expansion of the public health care sector may crowd out private health care provision, for example when public health expenditures rise, and via input-output linkages increase the price of pharmaceuticals and medical instruments. On the other hand, if an intermediate input such as pharmaceuticals becomes more expensive this yields a contraction in both public and private health care (unless of course the government maintains levels of public provisioning). In sum, input-output linkages seem decisive in explaining variations in production across sectors.[43]

[43] The role of relative factor-intensities in sectoral effects will be assessed in Chapter 7, where an attempt is made to draw parallels with the results of Chapter 2.

Secondly, with respect to the impact on skilled and unskilled workers, unskilled workers are at least as well off, and frequently better off, in terms of improvements in health status and labour market participation relative to skilled workers. The former type of workers largely benefits from public health care, whereas some of the latter consume private health care which, as shown, often becomes more costly and less available. Another contributing factor is that the health expenditure's leverage is assumed greater for unskilled labour relative to skilled labour. Depending on changes in relative factor demands and (effective) supply of labour endowments, factor remunerations rise or fall. If effective labour endowments rise and wages fall, a rise in labour income is often observed (the exception being SBTC where skilled labour income falls, a rise in the price and productivity of pharmaceuticals in health care where income from skilled and unskilled labour falls, and the immigration of health care-specific skilled labour under endogenous wages where the wage income of the domestic endowments of this type falls, and, in the presence of remittances, unskilled labour income falls). Hence, the endowment-enhancing effect of an expansion in health care provision often, though not generally, outweighs the negative wage effect.

Thirdly, with respect to the impact of health-related policies or shocks on households, a distinction can be made between households with and without working members. Working households benefit indirectly from health improvements through increased participation in the labour market and directly from improvements in well-being from changes in public good provisioning (of which pensioners and working households receive a relatively large share). Non-working households and the majority of pensioners only profit from the latter. Furthermore, while pensioners and working households with children receive a relatively large proportion of state benefits, relative to household income pensioners and non-working households rely most heavily on this source of income. Hence, if the expansion of the health sector, as follows for example from a rise in the government budget on health care or the immigration of foreign health care-specific skilled workers at the current wage, is financed from a reduction in state benefits, these households are generally found to lose out as opposed to working households who gain. If the health sector contracts, as when the pharmaceutical price rises, this works to their advantage, because in this case these households do not suffer from losses in labour income due to lower treatment levels. Nevertheless, since the income from state benefits falls, relative to their original income or welfare these households are still worse off. If the income from this source rises, as in the case of immigration of foreign skilled labour at an endogenous wage, and technical change in factors employed in health care, pensioners and non-working households are, in relative (though not absolute) terms, better off than working households.

A ceteris paribus comparison of the policies/shocks in terms of their impacts upon overall welfare, whilst accounting for cost differences and, where possible, using the same model specification, reveals that encouraging a 10% inflow of foreign health care-specific skilled workers to come and work in the UK health sector yields higher welfare gains compared to a 10% rise in the health care budget. FNTC and SBTC of 10%, whose implementation is costless, also outweigh the welfare gains of the latter policy and perform better compared to the immigration policy, but if the wage is kept at the original level, a 10% SBTC will only do better if more than half of foreign worker income is remitted. The policies of FNTC and SBTC were demonstrated to be equivalent to a rise in the NHS budget of 38% and 19% respectively, showing the potential savings of such technical improvements. In terms of health status and labour market participation, the immigration of health care-specific skilled workers at the current wage does better than the FNTC and SBTC and increasing the health care budget by 10%. Immigration at an endogenous wage outperforms both the increase in the health care budget and SBTC, but not FNTC.

A ceteris paribus comparison of the policies/shocks in terms of their impact upon household welfare reveals that the policies of SBTC, FNTC and immigration of health care-specific skilled workers at a flexible wage benefits and thus will be supported by all households (though in case of the latter not by domestic health care-specific skilled workers who earn less), whereas a rise in the price of pharmaceuticals will make all households worse off and thus will be uniformly unpopular. Technical change in pharmaceuticals, yielding a more expensive *but* more effective product, will be welcomed by all households if productivity gains in pharmaceuticals and other inputs in health care are high enough. Immigration of aforementioned workers at the current wage and an increase in government expenditures benefits working households and generally harms non-working households and pensioners so that the former will support and the latter will object to such policies.

A sensitivity analysis of the elasticity of the waiting list with respect to health status, for which reliable estimates do not exist, suggests that, in the presence of increasingly strong skill-neutral health effects, an expansion of NHS care following from a 10% increase in the health care budget, although representing an immediate cost to society, may lead to substantial welfare gains in the long-run through increases in effective labour supply and production, and by enhancing the tax earning ability of the government which benefits both working households (in terms of wage income) and non-working households (in terms of income from state benefits). Overall welfare is shown to rise for relatively low values of the waiting list elasticity (between 0 and 1). A rise in the waiting list elasticity has been shown to significantly reduce the health budget increase required to attain a certain overall welfare gain and demonstrates the importance of ensuring 'value for money' by some technical or administrative improvement in health care. Skill-biased increases in the waiting list elasticity are also considered so as to test the assumption of skilled workers being treated more effectively. Welfare gains rise but are found to be lower relative to those from skill-neutral increases in the waiting list elasticity. The remaining experiments are relatively robust to changes in the waiting list elasticity in the sense that with respect to overall welfare only magnitudes vary but no sign changes occur. The same conclusion follows from a sensitivity analysis for the elasticities of substitution and transformation: although sign changes do occur for some variables, the impact of changing the respective elasticities upon overall welfare is negligible.

CHAPTER 7

CONCLUSIONS

This chapter presents the main conclusions of this thesis. Before summarising the main results, in an attempt to answer the research questions posed in the introductory chapter, deriving policy implications, and outlining limitations and recommendations for future research, the chapter commences with a comparison of the results of the theoretical model (Chapter 2) and the empirical model (Chapter 6) used to study the economic impact of health care provision.

7.1 A SYNTHESIS BETWEEN THEORY AND APPLICATION?

Two of the major contributions of this thesis are Chapter 2, which presented the theoretical model casting light on some of the resource allocation issues related to the provision of health care, and the applied SCGE model of Chapter 6, which in essence accomplishes the same objective but, given its applied nature, allows for a more accurate and detailed modelling of the UK economy, its health care system, health and welfare effects. A logical avenue of research is therefore to compare the outcomes of these two components, insofar as the model specifications allow, and investigate whether or not the predictions that were made in the theoretical model are validated by the applied model. Although in theory three 'simulations' may be compared (being an increase in the government budget under the assumption of respectively, mobile and specific factors; the immigration of health care-specific skilled labour; and technical change in factors of production), the comparisons are initially limited to the first of these, for which the pair-wise comparison of Chapter 2 and Chapter 6 is the least demanding in terms of parameter restrictions. If no analogy of outcomes between Chapter 2 and Chapter 6 with respect to this simulation holds, one may reasonably argue that the same is true for the remaining experiments carried out with both models.

The Heckscher-Ohlin (HO) model predictions of the effects of an increase in public health expenditures have been outlined in Table 2.3. For given relative factor-intensities in health care and the two tradables sectors and a given size of the waiting list elasticity times the dependency ratio, i.e. the elasticity of effective labour supply with respect to health care, this table presents the rankings of relative output changes. The variant of the theoretical model that is closest to the SCGE model is given by Case 2, as explained below.

Firstly, using Table 5.7, the ratio of payments to skilled and unskilled labour by sector and in total gives the following ranking in decreasing order of skill-intensity for sectors and overall labour endowments (with mobile factors of production): 24.34 (sector 8), 13.63 (sector 9), 13.41 (sector 5), 7.83 (sector 2), 5.24 (sector 10, i.e. the health sector), 4.11 (overall endowment ratio), 3.85 (sector 11), 3.22 (sector 3), 2.74 (sector 7), 2.73 (sector 4), 2.08 (sector 6) and 0.67 (sector 1). Hence, the health sector is relatively skill-intensive (ranked in fifth position), its intensity in skills exceeding that of the overall endowment ratio, which itself exceeds the intensity of some six sectors. Given that the health sector is not the only sector with a skill-intensity exceeding that of the overall endowment ratio, Cases 4 to 7 are ruled out.

Furthermore, from Section 6.4.4 the elasticity of effective labour endowments with respect to health care (in Chapter 6 the health status variable) is close to zero, equalling 0.06 for skilled labour and 0.09 for unskilled labour, which rules out Cases 1 and 3.

Using Case 2, the theoretical model predictions are that ‘on average’ the relatively skill-intensive sectors (sectors 2, 5, 8 and 9) contract and the relatively unskilled-intensive sectors (sectors 1, 3, 4, 6, 7 and 11) and the health sector expand.[1] In the SCGE model the health care sector is skill-intensive in that its skilled-unskilled ratio is greater than the endowment ratio, so that an expansion of health care will reduce the skilled-unskilled endowment ratio for the rest of the economy. However, the skill-intensity for health is only just above the endowment ratio, so we would expect the ‘correlation’ to be low. Does the SCGE model behave accordingly? The changes in the production of sectors (variable X in the model) are reported in the second column of Table 7.1.

Table 7.1 Relative changes in sectoral production in the SCGE model (%)

Sector	**Experiment 1a**	**Experiment 1b**
8. Finance	-0.125	-0.011
9. Public administration and defence	-0.023	0.033
5. Energy	-0.191	-0.104
2. Pharmaceuticals	5.233	1.819
10. Health care	8.245	2.876
1. Primary	-0.310	-0.122
3. Medical instruments	2.086	0.793
4. Other manufacturing	-0.211	-0.091
6. Construction	0.052	0.258
7. Distribution and transport	-0.123	-0.070
11. Other services	-0.142	-0.096

Note: the shaded rows represent the outcomes of the relatively skill-intensive sectors.

Sectors 5, 8 and 9 do contract, albeit mildly, but the pharmaceuticals sector expands. This suggests that, following a rise in the health care budget and the consequent expansion of the health sector, the increased demand for intermediate inputs from this sector outweighs the reduced availability of skilled labour relative to unskilled labour.

[1] When there are many sectors in a Heckscher-Ohlin model, the Rybczynski Theorem becomes a ‘correlation’. As Falvey (1994) states, “There is a tendency for an increase in those outputs using intensively those factors whose endowments have risen and a decline for others.” Further uncertainty about outcomes in induced by the existence of intermediate inputs.

Also, most of the unskilled-intensive sectors contract, apart from construction and the medical instruments sector. The latter's expansion is much more pronounced and, as before, may be due to the intermediate demand effect from the health sector, rather than the increased availability of unskilled relative to skilled labour. The predictions of the theoretical HO model of an increase in public health expenditures thus do not generally seem to carry over to the applied SCGE model.

The Specific-Factors (SF) model predictions of an increase in public health expenditures have been outlined in Table 2.5. The parameters that need specification to determine which row of the table is appropriate are: the substitution elasticity, the waiting list elasticity times the dependency ratio (i.e. the elasticity of effective labour supply with respect to health care) and the health sector's use of unskilled labour relative to the tradables sectors.

As before, the elasticity of effective labour endowments with respect to health care is close to zero, 0.09 for unskilled labour and 0.06 for health care-specific and non-health care-specific skilled labour types. Furthermore, Chapter 6 (Section 6.3.2) postulates a Cobb-Douglas functional form for sectoral value-added, giving a substitution elasticity between factors in health care of 1. The health sector's use of unskilled labour relative to the remaining (tradables) sectors may be derived from Table 5.7 as 5031/(102760-5031) $\approx$ 0.05. The closest match between Chapter 2 and Chapter 6 is thus provided by the upper row of Table 2.5, which predicts that the health sector and tradables sectors' output rises but that the skilled-intensive sectors expand by relatively more than the unskilled-intensive sectors.

Does the SCGE model behave in this fashion? The changes in sectoral production are reported in the third column of Table 7.1. Only two of the four skilled-intensive sectors increase production (pharmaceuticals, public administration and defence), whereas four of the six unskilled-intensive sectors (primary, other manufacturing, distribution and transport, other services) lower as opposed to increase production. It is impossible to pinpoint the precise causes of the differences in results, but among the many potential candidates related to the production side are the presence of intermediate inputs (the pharmaceuticals and medical instruments sectors report the biggest output changes) and the specificity of two types of factors in health care (skilled labour *and* capital) rather than one. Consequently, the conclusion that follows is that the predictions of the theoretical SF model of an increase in public health expenditures do not generally agree with the applied SCGE model.

A comparison between the theoretical model of Chapter 2 and the applied model of Chapter 6 in terms of welfare effects, rather than sectoral output effects, is less straightforward. The variable in Chapter 2 closest to an indicator of welfare change is the proportionate change in per capita income of the population, in this framework also equivalent to the proportionate change in total income or GDP and the total value of output at world prices (equation 2.41). According to this measure of welfare, an improvement in the health of both skilled and unskilled labour generates an increase in per capita income of the population, even if the health improvements are equal across labour types, but the increase in per capita income will be higher, the more the health of the skilled is improved relative to the unskilled. Does this outcome hold in the SCGE model?

As noted before, the SCGE model is parameterised with an elasticity of health care (health status) with respect to effective labour endowments of 0.06 and 0.09 for skilled and unskilled labour respectively, suggesting that the unskilled benefit relatively more from an increase in health care output. Using equation (2.41), an expansion of the health sector is predicted to yield a rise in the per capita income of the population (and total income). An analysis of changes in household income from skilled and unskilled labour following an increase in government health expenditures (Experiment 1a) shows that this is indeed the case: household income from skilled and unskilled labour (and capital) rises by 0.45 and 0.29 (and 0.18) percent respectively so that per capita labour (or, including capital, factor) income of the unchanged total population, including the ill and therefore unable to work, must rise as well. As observed in Chapter 6, the income gains become losses once the fall in income from state benefits (by 4.3%) is taken into account so that the indicator of overall private welfare declines by 0.38%. Nevertheless, overall welfare rises again (by 0.26%) when the direct improvements in well-being from an increase in the public provision of health care (and other goods) is taken into account. The simple framework of Chapter 2 is not able to capture the latter two effects and the changes in income from capital. Hence, the conclusion with respect to the income/welfare predictions of Chapter 2 is that they seem to be substantiated by the applied SCGE model if limited to changes in labour income only. Once changes in income from state benefits, capital and benefits from public good provisioning are taken into account, the analogy between the theoretical and applied model breaks down.

In sum, the attempt to draw parallels between the outcomes of the theoretical model of Chapter 2 and the applied model of Chapter 6 seems to have failed. Although the outcomes of Chapter 2 provide some guidance to the effects operating in the background of Chapter 6, the added complexities - for example in terms of dimensionality (more sectors, factors and households), the presence of intermediate inputs, health care-specific factors, differences in health effects across labour types, a tax-charging government providing transfer income to households and public goods yielding direct welfare gains, ensure that the predictions we may expect from the theory do not generally hold in reality. This is the strongest argument for the use of an applied model in addition to a theoretical model.

7.2 A SUMMARY OF THE MAIN FINDINGS

The interactions between health care, health and the remainder of the economy are multiple and complex. While the interdependencies between health care, health and the rest of the economy are now widely acknowledged, economic models which are used to assess these fail to incorporate the main channels through which interactions take place. This thesis seeks to determine the macro-economic impacts of changes in health care provision using a general equilibrium model of the UK economy, whilst recognising the simultaneous effects of consequent changes in health upon effective labour supplies and the resource claims made by the health care sector. The resource allocation issues have been explored in theory, by developing an extension of the standard Rybczynski (R) theorem from a low-dimension Heckscher-Ohlin (HO) framework, and empirically, by developing a Computable General Equilibrium (CGE) model with an extended health care component, calibrated to a purpose-built dataset for the UK. These components constitute the three major contributions of this thesis.

Chapter 2 examined the resource allocation effects of an expanding health sector in their simplest form, using a low-dimension HO model of a small open economy. It was shown that an identical improvement in the health of skilled and unskilled workers does not affect the per capita income of the working population, whereas the per capita income of the total population rises. Furthermore, if the health improvement is relatively higher for skilled (unskilled) labour, per capita income of the working population will rise (fall), whereas per capita income of the total population always rises. Setting aside other considerations such as well-being and equity, both indicators thus favour a, morally questionable, government policy of health care provision biased towards skilled workers.

The analysis henceforth proceeded with the modelling of effective endowment changes via a non-traded, government provided health sector while accounting for all those not (yet) succesfully treated and so unable to work by means of an artificial waiting list sector. The change in effective labour endowments following a change in health care provision was shown to depend positively on three multiplicative factors - the dependency ratio (the ratio of ill to non-ill, i.e. non-working to working population), the absolute value of the waiting list elasticity (measuring the proportionate reduction in the waiting list in response to a one percent rise in health care output) and the proportionate change in the output of health care - where the first two combined represent the elasticity of effective labour supply with respect to health care. In the derivation of Rybczynski-style predictions of an increase in health expenditures on non-health outputs, the magnitudes of the dependency ratio and the waiting list elasticity were, in the absence of reliable estimates, assumed identical for both skilled and unskilled labour by employing the homogeneity assumption. This assumption postulates that skilled and unskilled labour are equal (homogeneous) in terms of illness, health and effectiveness of treatments so that an increase in health care provision, allocated in proportion to illness, results in balanced growth in the effective endowments of skilled and unskilled labour.

The impact of an increase in health expenditures on non-health outputs was shown to consist of a factor-bias and a scale effect. The former measures the impact of the health care sector on effective endowments remaining for tradables in terms of the resource claims it makes, whereas the latter measures the effect of improved health on effective labour supplies. Assuming that health care is the most skill-intensive sector, the factor-bias effect is negative for the skill-intensive tradable and positive for the other good, since an expansion of the health sector reduces the skilled-unskilled effective labour endowment ratio available for the tradable good sectors. The scale effect is always positive for the skill-intensive good, but may be negative for the unskilled-intensive good depending on the ordering of the skill-intensity of the middle ranking sector relative to the overall effective endowment ratio.

The analysis establishes that the rankings based on factor-bias effects alone are preserved when scale effects are added, provided that the elasticity of effective labour supply with respect to health care, i.e. the waiting list elasticity and dependency ratio combined, is small enough (and less than one). Gradually increasing the elasticity leads to a rise in the production of both the unskilled-intensive *and* skill-intensive goods provided it is less than one, whereas for improvements in the elasticity beyond one the output rise for the skill-intensive good exceeds that of the unskilled-intensive good, which could in one particular situation even show a decline. It was argued that, despite the uncertainty about the magnitude of the elasticity of effective labour supply with respect to health care for skilled relative to unskilled labour, for developed countries and hence the UK, the elasticity is likely to lie well below the value of one. Consequently, an exogenous increase in health expenditures is expected to benefit the unskilled-intensive sector and harm (or possibly slightly benefit) the skilled-intensive sector.

The introduction of health care-specific skilled labour in the 'Specific-Factors' (SF) model was demonstrated to alter these results by reversing the factor-bias effects of an increase in health expenditures. Specifically, an expansion of the health sector reduces the supply of unskilled labour remaining for tradables, so that, on the basis of the R theorem, the output of the unskilled-intensive good falls and the output of the other good rises. Restricting the elasticity of effective labour supply with respect to health care to a likely value of below one and assuming some substitution between factor inputs in health care, the incorporation of scale effects allows the reproduction of the factor-bias effects, although the output of the unskilled-intensive good may now rise if health care is relatively less reliant on the use of unskilled labour.

The remainder of Chapter 2 was concerned with implementing policies or shocks aimed at alleviating the rationing constraint in health care and to contrast them with the policy of increasing the health care budget. The first is the immigration of foreign health care-specific skilled labour in the SF model. In the absence of remittances abroad, the wage of this labour type and unit cost of health care is shown to fall, which - given the fixed health budget - results in an increase in health care provision. For limited factor substitution in health care in favour of skilled labour, factor-bias effects are found to be positive for the skill-intensive good and negative for the other good, since overall employment of unskilled labour in health care rises and so the relative supply of unskilled labour available for tradables falls, and vice versa. Adding scale effects and restricting the elasticity of effective endowments with respect to health care to a value below one preserves the factor-bias effects, although the contracting sector may now expand if health care is relatively less reliant on unskilled labour.

The second shock applied to the HO and SF models is technical change in health care, which can be factor-neutral or skill-biased by respectively increasing the productivity of all labour types or increasing the productivity of skilled labour only. If technical change is neutral across factors, factor-bias effects are absent so that the relatively skill-intensive tradable sector expands, whereas the unskilled-intensive tradable sector may or may not contract depending on the ordering of the skill-intensity of the middle ranking sector relative to the overall effective endowment ratio. In the SF model the scale effects result in balanced growth in tradables outputs since, due to the homogeneity assumption and an elasticity of effective endowments with respect to health care of less than one, tradables-specific skilled labour and unskilled labour grow in the same proportion. If technical change is skill-biased, the health sector saves on the employment of skilled labour so that factor-bias effects reappear and benefit (harm) the skilled- (unskilled-) intensive good. The inclusion of scale effects is shown to intensify the factor-bias effect in the skill-intensive sector and, depending on the relative rankings of skill-intensities, either reinforces or mitigates the factor-bias effect in the other sector, whilst magnifying the gap between the outputs of the two tradables sectors. Skill-biased technical change in the SF model yields similar factor-bias effects, since health care expands and needs more unskilled labour, thereby making skilled labour relatively more abundant. When allowing for scale effects and assuming the elasticity of effective endowments with respect to health care lies below one), factor-bias effects are maintained, though if health care is relatively less reliant on unskilled labour the formerly contracting unskilled-intensive sector may now expand.

Chapter 3 investigated to what extent the simultaneous impacts of health care on effective labour endowments and the health sector's demand for production factors have been incorporated in applied economic models by surveying CGE studies. The few CGE studies on health care and health that exist are arranged in three groups according to their research theme, being Basic Needs models, Externality models and HIV/AIDS models. The literature review clearly reveals a gap in the sense that most of these models do not endogenously assess the impact of changes in health care provision on the size and composition of the population, the labour force and its impact on production, income and welfare over time in a (developed country) CGE setting. The remaining chapters address this caveat by developing a CGE model for the UK with an extended health care component.

As background to the UK CGE model and simulations, **Chapter 4** provided an overview of the UK health care system and policy, dominated by state provision via the National Health Service (NHS). It was observed that, in funding health care from general taxation, the UK government has kept a tight lid on health care expenditures, whilst securing access to the majority of the population and reaching overall satisfactory health outcomes. However, evidence suggests that excessive public control has led to systematic underfunding of and inefficiencies in health care provision, leading to pressures in terms of poor health outcomes for some diseases (such as cancer), poor quality of services, including long waiting lists and waiting times for certain treatments, and inequities in access and health outcomes. These problems typically revolve around the issue of rationing, i.e. the conflict between potentially unlimited demands and limited financial means, and in this respect the UK does not differ from any other country. In future rationing is likely to get worse in the face of increased demand pressures from rising incomes, partly fuelled by an ageing population and advances in medical technology, and cost pressures from rising wages and pharmaceutical prices.

The analysis proceeded with identifying several policy options which address the issue of rationing. The UK government could, and has in recent years been observed to, allocate more resources to health care which buy more health care inputs, or instead may aim to increase the productivity (efficiency) of the available health care inputs via an improvement in technology. Three types of technical change were identified for modelling purposes, being factor-neutral technical change, skill-biased technical change or one that that is embodied in a more cost-effective pharmaceutical product. A policy measure that directly targets the constraint of the limited availability of highly skilled doctors is to encourage foreign skilled workers to work in the UK health sector.

Chapter 5 presented the dataset, the Social Accounting Matrix (SAM), to which the UK CGE model is calibrated. It has been constructed by augmenting the UK Input-Output Supply and Use Tables for 2000 using household data from the General Household Survey 2000-01. The latter purpose-built GHS database is a valuable source of information for a range of socio-economic characteristics of private households living in Great Britain, most notably health and health care use data.

The economic data revealed that the health sector is relatively skill-intensive but small in terms of gross labour income and private health care expenditures. The data on health care use demonstrated that working households and pensioners account for most of the General Practitioner (GP) consultations. This is partly explained by household numbers and average household size and partly by household characteristics: the number of GP consultations is positively associated with having children and negatively associated with labour market participation. The use of secondary care across households demonstrated a similar picture. In addition, pensioner- and working households are the main users of private GPs, though most GP consultations are provided by the NHS.

Self-reported data on population health provided background information on the use of health care by households. In spite of the smallness of the health sector, these data show that a significant proportion of the population suffers from ill health which varies by socio-economic characteristic. Typically, the share of the population reporting good general health falls with age and rises with skills and labour market participation. Likewise, the prevalence of (non-)limiting longstanding illnesses and the number of restricted activity days increases with age and falls with skills and labour market participation. The most common complaints are musculoskeletal problems, heart and circulatory problems and respiratory problems. The type of condition was shown to vary considerably by age and labour market participation, though not so much by skill type.

Chapter 6 outlined the Static CGE (SCGE) model for the UK employed in MPSGE with health care provision effects and presented simulation results which cover current issues in (developed country) health care systems and that of the UK in particular. The SCGE model has in most respects a standard structure, the novelty coming from the explicit modelling of the health sector and its interaction with the rest of the economy through its differential impact across labour and household types. The model differentiates between eleven sectors (among which are health care and its main intermediate input suppliers), three factors (capital, skilled and unskilled labour), the government and five types of households (characterised by age and working status of its members), and separates public from private health care in consumption. The effects on welfare of higher provision are modelled through direct gains affecting the well-being of households and indirect gains via increases in the effective (i.e. able to work) endowments of skilled and unskilled labour for use in non-health activities. Endogeneity of effective labour endowments is achieved by using an artificial waiting list variable, which records the working time lost due to ill health by skill type. The size of the waiting list is indirectly, via a health status measure, determined by the levels of NHS and private health care provisioning.

The simulation results indicated that a 10% increase in government expenditures on the NHS, while drawing away resources from other non-health related sectors and its private counterpart, leads to an overall welfare gain, through increased worker (and capital) incomes and direct increases in population well-being, which is reduced if health care-specific skilled labour and capital in the short run are accounted for.

A 20% rise in the domestic consumer price of pharmaceuticals, one of the main intermediate inputs into health care, was shown to impact negatively on overall welfare through falling household incomes and direct decreases in the well-being of the population, which are mitigated if the government allows the health care budget to grow so as to maintain previous treatment levels under the NHS.

The (permanent) immigration of health care-specific skilled workers equal to 10% of domestic endowments of this labour type alleviates the shortage of highly skilled workers in UK health care. As the latter labour type's wages fall, the same government health budget allows for more people to be treated and cured. Overall welfare improves due to a rise in income for all non-health care-specific factors, the additional foreign worker income, an increase in state benefits and direct improvements in population well-being. Furthermore, adjusting the government health budget upwards so as to give these foreign (and domestic) skilled workers a wage equal to the pre-immigration level, was revealed to induce even larger increases in NHS provision levels (though lower private provision levels) so that overall welfare gains are higher. The effect of remitting foreign worker income abroad is to reduce the welfare gains.

Finally, technical change in all factors employed in health care, modelled as a 10% rise in the productivity of these factors, gives rise to a reduction in the unit costs of health care provision and, given the health care budget, a rise in the production of health care. The consequent gains in income from state benefits, income from factors of production, and direct improvements in population well-being were shown to yield overall welfare gains. If the technical change in health care is confined to skilled labour only, the health care provision increase and reduction in unit costs are smaller, hence giving rise to lower overall welfare gains. Technical change embodied in a 20% more costly but more effective pharmaceutical product in health care may also yield overall welfare gains. The simulations suggested that a 20% rise in the productivity of pharmaceuticals in health care only is sufficient for the health sector to expand, whereas a 30% productivity rise is sufficient to ensure overall welfare gains. A productivity rise of 2% in non-pharmaceutical inputs into health care is sufficient to guarantee overall welfare gains.

The impacts of the policies/shocks were observed to differ widely across sectors, factors and households. Firstly, in terms of sectoral effects, changes in public health care provision seem to particularly impact upon its private counterpart, often crowding out private sector provision, and intermediate input sectors, i.e. the pharmaceutical industry and the sector producing medical, precision and optical instruments. Input-output linkages appear decisive in explaining the major production changes across sectors, a finding corroborated by the comparison between the outcomes of the theoretical and the applied model carried out in **Section 7.1**. The main outcome of this attempted synthesis was that although the results of the theoretical model provide some guidance to the effects operating in the background of the SCGE model, the added complexities ensure that the predictions one may expect from the theory do not generally hold in reality. This provided the strongest argument for the use of an applied model in addition to a theoretical model in this thesis.

Secondly, concerning the impact across skilled and unskilled workers, unskilled workers seem at least as well off, and are frequently better off, in terms of improvements in health status, reductions in the waiting list and labour market participation relative to skilled workers. Contributing factors are that some of the skilled consume public *and* private health care which often becomes more costly and less available, and that the health expenditure's leverage is assumed greater for unskilled relative to skilled labour. Depending on changes in relative factor demands and (effective) supply of labour endowments, factor remunerations change. If effective labour endowments rise and wages fall, a rise in labour income is often, though not always, observed. Hence, the endowment-enhancing effect of an expansion in health care provision often, though not generally, outweighs the negative wage effect.

Thirdly, the impact across households was found to be distinctively different for households with and without working members. Working households benefit indirectly from health improvements through increased labour market participation and directly from improvements in well-being from changes in public good provisioning, whereas non-working households and the majority of pensioners only profit from the latter.

Furthermore, pensioners and non-working households rely most heavily on state benefits as a source of income. Hence, if the expansion of the health sector, as follows from a rise in the government budget on health care or the immigration of health care-specific skilled workers at the current wage, is financed from a reduction in state benefits, these households are generally found to lose out as opposed to working households who gain. If the health sector contracts, as when the pharmaceutical price rises, this works to their advantage, because in this case these households do not suffer from losses in labour income due to lower treatment levels. Nevertheless, since the income from state benefits falls, relative to their original income or welfare these households are still worse off than working households. If the income from this source rises, as in the case of immigration of foreign skilled labour at an endogenous wage, and technical change in factors used in health care, pensioners and non-working households are, in relative (though not absolute) terms, better off than working households.

Sensitivity analyses for the elasticities of substitution and transformation show that the results of the counterfactual simulations are relatively robust: although sign changes do occur for some variables, the impact of changing the respective elasticities upon overall welfare is negligible. The same cannot be said for the waiting list elasticities for skilled and unskilled labour, for which no reliable estimates exist. In the presence of increasingly strong skill-neutral health effects, an expansion of NHS care following from a 10% increase in the health care budget, although representing an immediate cost to society, was shown to yield substantial welfare gains in the long-run through increases in effective labour supply and production, and by enhancing the tax earning ability of the government which benefits both working households (in terms of wage income) and non-working households (in terms of income from state benefits). Overall welfare rises for relatively low values of the waiting list elasticity (between zero and one). Skill-biased increases in the waiting list elasticity, which test the assumption of skilled workers being treated more effectively, yield lower welfare gains. The remaining experiments are relatively robust to changes in this elasticity in the sense that with respect to overall welfare only magnitudes vary but no sign changes occur.

7.3 POLICY IMPLICATIONS

A ceteris paribus comparison of the specified policies/shocks in terms of their impacts upon overall welfare, whilst accounting for cost differences and, where possible, using the same model specification, suggests that the policy of immigration of health care-specific skilled workers in the UK health sector targeted towards alleviating the scarcity of highly skilled workers performs better than an identical rise in the health care budget which is spent on all health care inputs. The factor-neutral and skill-biased technical change shocks, whose implementation is costless, also outperform the latter policy and the immigration policy, but if the wage is kept at the original level, the skill-biased technical improvement only does better if more than half of foreign worker income is remitted.

If health care-specific skilled labour and capital in the short run are accounted for, the welfare gains from a rise in the government expenditures on health care are markedly lower. For the specified 10% rise in the health budget, approximately two thirds of the health sector's production expansion is 'lost' to higher wages and rents, thereby reducing overall welfare gains by 62%. The observation that the extra funds which have been allocated to the NHS are being absorbed by higher wage payments rather than resulting in an increase in levels of production, i.e. treatments of patients, has worried both current and recent governments, and shows the importance of tackling rigidities in the health sector. As indicated by the simulations, a relatively quick way of doing this is via the recruitment of highly skilled foreign doctors and nurses, who do not need to be educated and, as evidence suggests, are likely to remain in the UK since the majority is aiming for a long-term career in the NHS. This is not to say that it is also a desirable policy since, from the perspective of the UK, domestic workers of this type earn less income if their wages are not sustained and thus may require some form of compensation, and, from the perspective of the country of origin, many come from developing countries which need their own educated staff (this form of brain-drain would be more appropriately analysed in a multi-country model). In the long-term, and in order to avoid relying purely on highly skilled health care personnel from abroad, increasing the number of medical school places is likely to reduce the scarcity of highly qualified health care workers and so improve overall welfare levels. Such a policy is itself a resource allocation issue as education increases the skill level of individuals, but also uses up resources which could have been employed elsewhere. This has not been investigated in this thesis and presents an interesting avenue of future research.

A second health care cost-enhancing and welfare-reducing factor that has been identified in this thesis is the rising price of pharmaceutical products. A specified 20% increase in the (average) domestic purchase price of pharmaceuticals, identical to the increase in average cost of prescription items dispensed in England over the period 1999/00 to 2002/03, was shown to reduce overall welfare by 0.28% or £2.64 billion. Efforts to maintain public provision levels would reduce these losses by 0.05 percentage points or £500 million only, indicating the importance of government policy to control pharmaceutical prices. If the latter proves difficult to implement, the specified rise was found to stem mainly from a rise in the world import price by 42%, the negative welfare effects of rising pharmaceutical prices may be mitigated by purchasing a more effective pharmaceutical product, which yield savings in the health sector. The simulations revealed that a technical improvement which increases the productivity of pharmaceuticals in health care by 30% is sufficient to guarantee overall welfare gains, whereas if the improved pharmaceutical product yields savings in the use of other inputs, a productivity rise of 2% proved adequate. Hence, fairly small productivity gains of less than 2% across all inputs in health care are sufficient for technical progress in pharmaceuticals to be welfare enhancing.

The policies of a 10% factor-neutral and skill-biased technical change generally resulted in the highest overall welfare gains and were demonstrated to be equivalent to a rise in the NHS budget of 38% and 19% respectively, showing the potential cost savings of such technological improvements. Both the factor-neutral and skill-biased technical changes were modelled as entailing no extra costs. In this context one may think of improved medical procedures which have been developed abroad yet are freely available, or have been funded by charitable institutions as often is the case. Another policy measure that one may classify within this category, and makes skilled labour more productive, is the UK government's determination to reduce administrative overhead, i.e. bureaucracy, in health care, so that doctors and nurses have more time to devote to the provision of medical services, and more resources can be devoted to frontline staff (a recent example is the Health Secretary John Reid's announced intention to streamline the NHS 'arm's length' bodies). At the same time the Department of Health argues that the proportion of managers employed in the NHS, which amounts to three percent, is small relative to other private and public organisations (see also Section 4.3.2) and that good management is needed to implement reforms in the NHS. This reminds us of the conflict between the centre (administrators) and the periphery (health care providers) which has been present since the creation of the NHS in 1948 (Klein, 2001, p37-40) and suggests that there is some ‘optimum’ proportion of managers employed in the NHS at which overall costs of provision (including management) are minimised. Where exactly this optimum lies is a matter of opinion, though evidence on inefficiencies in the NHS makes many commentators believe that at present levels of managerial control are too high.

A ceteris paribus comparison of the policies/shocks in terms of their impact upon household welfare indicates that the policies of skill-biased and factor-neutral technical change and the immigration of health care-specific skilled workers at a flexible wage benefits and thus will be supported by all households (though in case of the latter not by domestic health care-specific skilled workers who earn less and so may require some compensation), whereas the rise in the price of pharmaceuticals will make all households worse off and thus will be uniformly unpopular. As previously indicated, the rising pharmaceutical price may be accepted by the majority of the population if it is reflected in a more effective pharmaceutical product. Immigration of health care-specific skilled workers at the current wage and an increase in government expenditures benefits working households and generally harms non-working households and pensioners so that the former will support and the latter will object such policies. This outcome points out that, in order to mitigate the adverse welfare consequences for these households, some sort of redistribution from the working to the non-working and pensioner households is warranted.

Finally the uncertainty surrounding the waiting list elasticities for skilled and unskilled labour demonstrates the importance of ensuring that additional care resources are effective in reducing waiting lists and increasing effective labour supplies, or using the catch phrase of the current labour government, ensuring ‘value for money’. In support of this observation, a rise in the absolute value of the waiting list elasticity was shown to significantly reduce the health budget increase required to attain a certain overall welfare gain. This may be achieved via the aforementioned technical and administrative improvements in health care.

7.4 LIMITATIONS AND DIRECTIONS FOR FUTURE RESEARCH

In this thesis health care and its effects on other product and factor markets, households and overall welfare have been summarised at a rather aggregate level by a few parameters, variables and simple functional forms. Consequently, the limitations of this research and the improvements which address these primarily concern providing more detail in terms of the modelling of the economic impact of health care provision. This not only enhances the richness of the model in terms of its outcomes and the predictions that it conveys, but also opens up new areas of application.

The first set of limitations, which was observed in the introduction, relate to **the modelling of health and health effects**. In this thesis health is explicitly measured in terms of the size of effective, i.e. able to work, labour endowments and changes in health are assumed to have a parallel effect on effective labour endowments. In the SCGE model a health status measure was introduced as a function of public and private health care which impacts upon effective labour supplies, and direct improvements in well-being from an increase in the public provision of health care (and other goods) were added to household and overall utility functions.

Modelling health effects in this fashion precludes the modelling of improved health on the non-working populations, i.e. children and pensioners. Although the SCGE model accounts for these population groups, it does not model longer-term population processes (births, deaths, transitions from ‘young’ to ‘working’ and from ‘working’ to ‘retired’), nor does it model the decomposition of those moving from ‘young’ to ‘working’ into ‘skilled’ and ‘unskilled’. An obvious way forward is to change from a comparative static model to a dynamic model so that people can be tracked through their life cycle and births and deaths may be accounted for. As a first step, a recursive dynamic CGE model, which essentially links a series of single-period equilibria via the updating of the capital stock, may be considered, but more appropriate is an intertemporal dynamic model, which allows the modelling of behavioural changes over time (forward looking behaviour) and, ultimately, the overlapping generations (OLG) model, which also accounts for intergenerational processes.[2]

OLG models are typically applied to social security issues, such the economic impact of ageing (i.e. the sustainability of pension schemes). An interesting area for future research is to link the issue of ageing with health care. Ageing may be modelled as the result of improved health and health care provision and, conversely, a larger population, in which the share of the elderly rises, increases the demands made on health care and other sectors, which could otherwise have been devoted to the working population and are paid for by the latter in the form of state pensions.

In addition, the modelling of health effects at present ignores the impact upon the choice between labour and leisure time, does not distinguish part-time from full-time work, and

[2] A prototype recursive dynamic model has been developed but not as yet applied to real world data.

takes no notice of time as opposed to money spent on health improvements. Some of those ill and not working (i.e. individuals on the waiting list), may not have been working anyway, and if cured may opt for a part-time rather than a full-time job. One should ideally try to incorporate these effects, as well as model the transition of individuals from falling 'ill' to getting 'well' in more detail. The latter includes considerations of how the benefits from household consumption of health care are distributed to individual household members, what factors cause individuals to become ill in the first place (such as age, income, skills, lifestyle, environment, and so on), and what factors contribute to them partially or fully recovering (which is likely to include health care consumption, age and possibly also income or skill-related variables).

Finally, the indicators of changes in household and overall welfare in the SCGE model, which measure the direct benefits from a rise in the public provision of health care and other goods, in addition to changes in private utility, are rather rudimentary in the sense that: (1) they attach equal weights to private utility and public provision[3], and more importantly (2) the direct improvement in well-being from a rise in public good provisioning is considered equal to the cost of providing these additional goods.

Improved estimates for the direct gains in well-being may be elicited from the literature on happiness (see for example Clark and Oswald, 2002). Using the compensation principle, this literature typically attaches a very high welfare gain to an improvement in health so that some sort of scaling would be required to bring it in line with the

[3] Though at the household level the latter was distributed over households according to each household's share of NHS GP consultations for health care and population shares for other goods.

monetary values in the model.[4] The method of evaluating direct improvements in well-being employed in the SCGE model may thus be considered as giving rather conservative, lower boundary, estimates.

In sum, the measurement of health and benefits of improved health is and is likely to remain a highly contentious issue and this thesis has taken a crude, though simple and pragmatic approach to these matters.

The second set of shortcomings relate to **the level of disaggregation in health care and related sectors and markets**. Firstly, a health care good/sector as such does not really exist. There are many different types of diseases which require different types of health care (treatments), which in turn demand different combinations of health care inputs, with different costs and different health effects. Currently, the types of care that are distinguished in the SCGE model are rationed public health care and (unrationed) private care, each with a different clientele. In future one may want to expand this classification for example in terms of primary and secondary (medical and surgical; inpatient versus outpatient and day patient) health care, possibly with a referral system, each of which differs in terms of health care inputs and costs and the impact upon the ill and effective labour supplies. This, as well as the inclusion of a variety of treatments for the same condition, may provide an indication of the cost-effectiveness of types of health care or treatments and the allocative efficiency of current health care spending.

4 Clark and Oswald (2002) for example find that a decline in health from ‘excellent’ to ‘fair’ is equivalent to a loss of approximately £500,000 a year, 21 times the average yearly household income in the sample used.

Other useful distinctions are to separate preventive from curative care and palliative care, to separate public from private care in production as well as in consumption, to separate maternity care, and to distinguish the chronically ill (who mainly consume palliative care) from other ill. Whereas preventive care ceteris paribus reduces the number of people falling ill, curative care impacts upon the number of people recovering from illness. Palliative care has no such effects other than softening the negative side-effects of illness. A public-private division in production seems appropriate since the private sector is arguably more efficient in production and more effective in treating and/or curing people, resulting in lower waiting lists.

Secondly, further detail in terms of the health care workforce does justice to the wide variety of health care staff working in UK health care. An additional skill level, of semi-skilled, would for example make a distinction possible between say unskilled ancillary staff, semi-skilled nurses and skilled doctors and managers. The skilled may be further categorised into a medical category of doctors and an administrative class of managers (similarly, capital may be divided between high-tech equipment, and buildings and land). This thesis has incorporated the latter to some extent by introducing health care-specific skilled labour (and capital), where the remaining skilled labourers (capital) may be interpreted as managers (land and buildings).

An interesting avenue of research is to investigate the effects of differential elasticities of substitution between these types of health care workers and types of capital. For example, nurses are more and more given additional responsibilities so as to reduce the workload of doctors and ultimately waiting lists, which could be modelled by an increase in the substitution elasticity between these two types of health care workers.

Also, some highly skilled doctors are depending upon high-tech equipment to carry out their duties, suggesting a very low elasticity of substitution. How these adjustments will impact upon the health sector is unclear, though generally higher (lower) elasticities of substitution soften (increase) price changes and increase (soften) volume changes.

Finally, **data constraints** have limited the way in which the health improvements conditioned on the health sector have been modelled (for example no reliable data were available on the costs of provision of different types of care, the consumption by household and/or individual of these types of care and their effectiveness). Each of the suggestions for future research put forward in this section will be more demanding in terms of data and thus worsen these constraints so that improving the availability of data on health care provisioning and its effects on the rest of the economy will be crucial for any progress made in this area of research.

The most obvious weakness of the SCGE model in terms of data is the lack of reliable estimates of the waiting list elasticity. Whereas for some conditions waiting lists and/or times have been falling, for others they have been rising and it is unclear how waiting lists in general respond to health care expenditures (note that distinguishing between types of care or treatments may solve this problem). Nevertheless, by varying the magnitude of the waiting list elasticities for skilled and unskilled labour in the sensitivity analysis, the importance of making health care more effective was shown.

Other directions for future research include the modelling of productivity effects of improved health, modelling the health sector in more detail and the health insurance market (in line with the Health Sector and Health Insurance models discussed in Section 3.1), varying the country of application and modelling the outbreak of a disease to see how the health care system and the economy cope. Applying the analysis to a developing country is likely to produce different outcomes due to, for example, differences in workforce composition (likely to be unskilled abundant), differences in the relative importance of sectors (likely to be biased towards agro-based sectors) and differences in health effects across different population groups (in general the marginal effect of a rise in health care provision is likely to be greater as the ‘flat of the curve’ has not yet been reached). Finally, with respect to the modelling of a specific type of disease, for a developed country one may think of modelling influenza, which is a recurring phenomenon in winter, and has claimed many lives, whereas for a developing country one may think of modelling the AIDS epidemic and the effect of different types of treatments (as in Dixon et al., 2004).

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FREQUENTLY USED WEBSITES / ONLINE DATA SOURCES

Association of the British Pharmaceutical Industry (ABPI)	http://www.abpi.org.uk
Audit Commission	http://www.audit-commission.gov.uk
BBC News	http://news.bbc.co.uk
Commission for Health Improvement (CHI)	http://www.chi.gov.uk
Commission on Macroeconomics and Health (CMH)	http://www.cmhealth.org
Confederation of British Industry (CBI)	http://www.cbi.org.uk
Department of Health (DoH)	http://www.dh.gov.uk
EcoMod (Global Economic Modeling Network)	http://www.ecomod.net
Economist	http://www.economist.com
European Observatory on Health Care Systems	http://www.euro.who.int/observatory
Global Trade Analysis Project (GTAP)	http://www.gtap.agecon.purdue.edu
Guardian Unlimited	http://www.guardian.co.uk
Institute for Fiscal Studies (IFS)	http://www.ifs.org.uk
King’s Fund	http://www.kingsfund.org.uk
London School of Economics (LSE)	http://www.lse.ac.uk
MPSGE (Mathematical Programming	

System for General Equilibrium analysis)	http://www.gams.com/solvers/mpsge
National Audit Office (NAO)	http://www.nao.org.uk
National Health Service (NHS)	http://www.nhs.uk
National Institute for Clinical Excellence (NICE)	http://www.nice.org.uk
Organisation for Economic Cooperation and Development (OECD)	http://www.oecd.org
Office of Health Economics (OHE)	http://www.ohe.org
Office for National Statistics (ONS)	http://www.statistics.gov.uk
Rivett (1988) updates	http://www.nhshistory.net
Times and Sunday Times	http://www.timesonline.co.uk
UK Data Archive (UKDA)	http://www.data-archive.ac.uk
World Health Organization (WHO)	http://www.who.int

The GHS database and SCGE model files can be obtained from either Martine Rutten (mmrutten@hotmail.com) or Geoffrey Reed (geoffrey.reed@nottingham.ac.uk).

APPENDICES

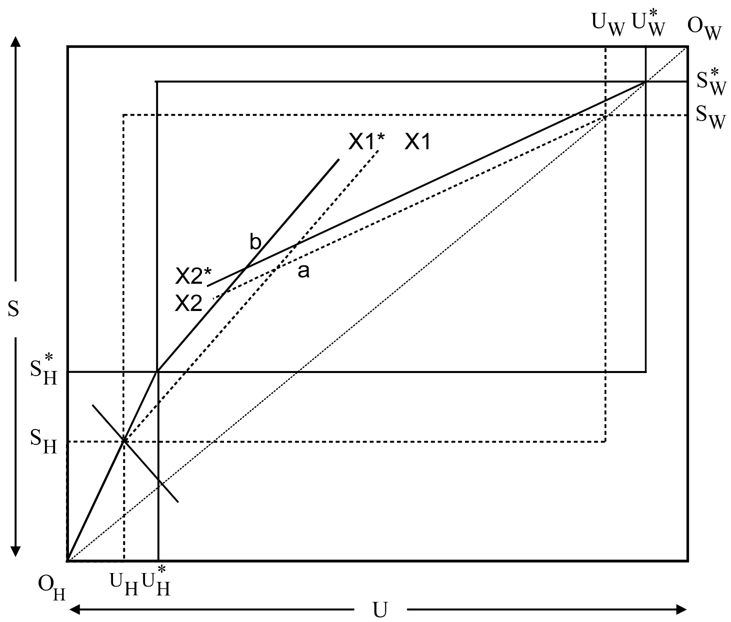
APPENDIX TO CHAPTER 2

A1. FACTOR-BIAS & SCALE EFFECTS HO MODEL: CASES 2-7

Case 2: $s_H > s_1 > s_E > s_2$ and $0 < \delta\varepsilon < 1 - \frac{|\lambda|}{(\lambda_{U2} - \lambda_{S2})} = \frac{\lambda_{U2}\lambda_{SH} - \lambda_{S2}\lambda_{UH}}{\lambda_{U2} - \lambda_{S2}}$

The first part of the condition is the same as for Case 1 so that we know that sector 2's output will rise, whereas sector 1's output will rise or fall depending on whether the scale effect outweighs the factor-bias effect. Since $\delta\varepsilon < 1$ still holds, from equation (2.80) $\hat{T} > \hat{X}_2$. But using equation (2.76), $\delta\varepsilon < 1 - \frac{|\lambda|}{(\lambda_{U2} - \lambda_{S2})}$ implies $\hat{X}_1 < 0$, i.e. the factor-bias effect dominates.

Figure A.1 Factor-bias and scale effects in the HO model - Case 2



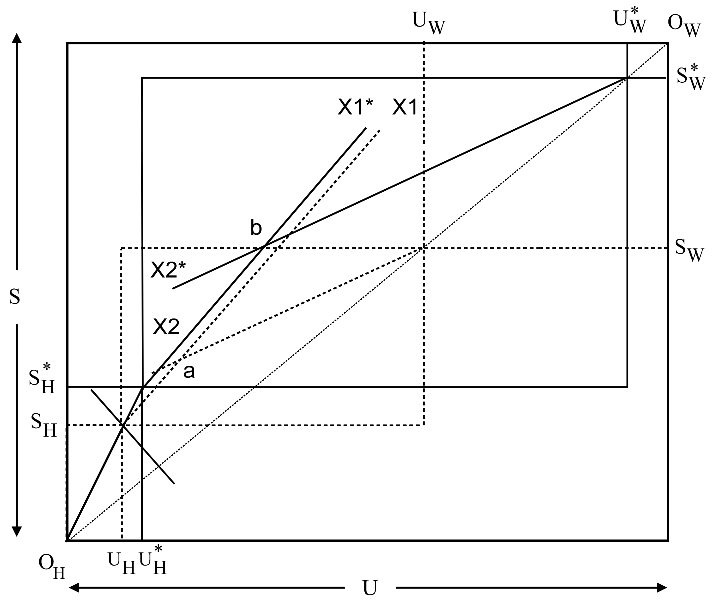
Hence $s_H > s_1 > s_E > s_2$ and $0 < \delta\varepsilon < 1 - \frac{|\lambda|}{(\lambda_{U2} - \lambda_{S2})} = \frac{\lambda_{U2}\lambda_{SH} - \lambda_{S2}\lambda_{UH}}{\lambda_{U2} - \lambda_{S2}}$ results in $\hat{T} > \hat{X}_2 > 0 > \hat{X}_1$. Figure A.1 illustrates this situation.

Case 3: $s_H > s_1 > s_E > s_2$ and $\delta\varepsilon > 1$

Given that $\lambda_{S1} - \lambda_{U1} > 0$ and $\delta\varepsilon > 1$, equation (2.80) yields $\hat{X}_2 > \hat{T}$. Furthermore, $\delta\varepsilon > 1$ implies $\delta\varepsilon > 1 - \frac{|\lambda|}{(\lambda_{U2} - \lambda_{S2})}$ and hence, from equation (2.76), $\hat{X}_1 > 0$. Using equation (2.82), $s_H > s_E$ implies $\lambda_{SH} - \lambda_{UH} > 0$ so that, given $\delta\varepsilon > 1$, $\hat{X}_1 > \hat{X}_2$.

Therefore $s_H > s_1 > s_E > s_2$ and $\delta\varepsilon > 1$ yields $\hat{X}_1 > \hat{X}_2 > \hat{T} > 0$. The scale effect of an expansion in health care on the outputs of sector 1 and 2 is so strong that both sectors 2 *and* 1 experience a rise in output which exceeds the relative change in the health budget. Figure A.2 illustrates this situation.

Figure A.2 Factor-bias and scale effects in the HO model - Case 3



Case 4: $s_H > s_E > s_1 > s_2$ and $\delta\varepsilon > 1 - \frac{|\lambda|}{(\lambda_{S1} - \lambda_{U1})} = \frac{\lambda_{S1}\lambda_{UH} - \lambda_{U1}\lambda_{SH}}{\lambda_{S1} - \lambda_{U1}}$ [1]

Compared to the previous cases, the ordering of the middle-ranking sector 1 relative to the economy-wide endowment ratio has now changed. The health sector is more skill-intensive than sector 2, so $\frac{\lambda_{SH}}{\lambda_{UH}} > \frac{\lambda_{S2}}{\lambda_{U2}}$, or $\lambda_{SH}\lambda_{U2} - \lambda_{S2}\lambda_{UH} > 0$, and hence from equation (2.74) $\hat{X}_1^F < 0$. Since the health sector is also more skill-intensive than sector 1, $\lambda_{SH}\lambda_{U1} - \lambda_{S1}\lambda_{UH} > 0$, and hence from equation (2.75) $\hat{X}_2^F > 0$. Sector 1 now has a skilled-unskilled labour ratio lower than the effective endowment ratio, so that $\lambda_{S1} - \lambda_{U1} < 0$, and from equation (2.73) $\hat{X}_2^S < 0$. Similarly, sector 2 has a skilled-unskilled labour ratio lower than the effective endowment ratio, so that $\lambda_{U2} - \lambda_{S2} > 0$ and from equation (2.72) $\hat{X}_1^S > 0$. Whereas in cases 1, 2 and 3, sector 2's output must rise, in cases 4, 5, 6 and 7 output of either 1 or 2 must expand. Whether output of the other good expands or contracts depends on whether the scale effect outweighs the factor-bias effect.[2] This is again determined by the magnitude of $\delta\varepsilon$.

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[1] The lower boundary for $\delta\varepsilon$ can be derived from either equation (2.71) or equation (2.77) by setting $\hat{X}_2 < 0$. Notice that the value of the lower boundary is positive and greater than 1, given that the health sector is more skill-intensive than sector 1, sector 1's skill-intensity lies below the effective skilled-unskilled labour endowment ratio and $|\lambda| > 0$.

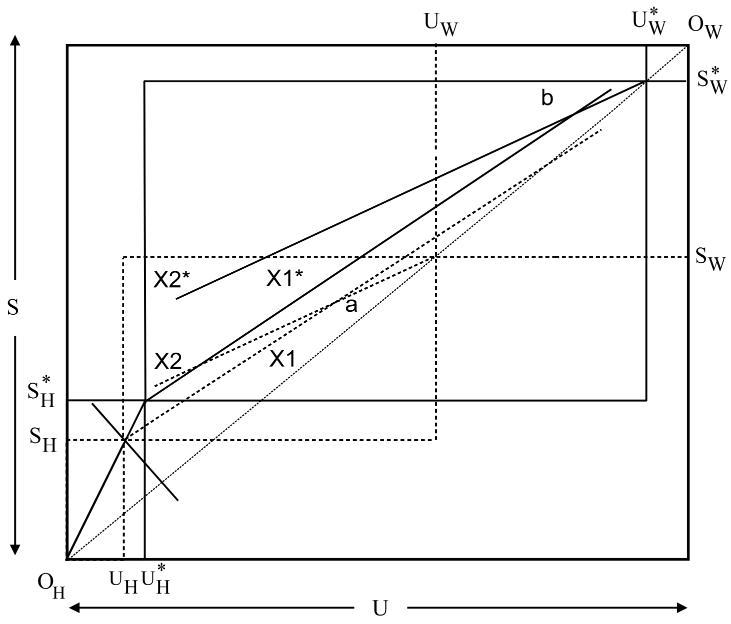
[2] Notice that the factor-bias effect, i.e. the effect of a fall in the skilled-unskilled effective labour ratio on outputs, is always positive for sector 2 and negative for sector 1, whereas the scale effect is always positive for sector 1 but changes sign for sector 2. The negative scale effect for sector 2 is analogous to the R effect where an increase in skilled labour endowments decreases the output of the unskilled labour-intensive good. The borderline case where effective endowments are increased in the same proportion as the factor proportion of sector 1, replicates the R corollary mentioned in footnote 4 of Chapter 2, i.e. increases the output of sector 1 and leaves the output of the sector 2 unchanged.

Using equation (2.77), $\delta\varepsilon > 1 - \frac{|\lambda|}{(\lambda_{S1} - \lambda_{U1})}$ implies $\hat{X}_2 < 0$.[3] Subtracting $\hat{X}_1$ from $\hat{T}$ yields the following expression:

$$\hat{T} - \hat{X}_1 = \hat{T}\left[\frac{(1-\delta\varepsilon)(\lambda_{U2} - \lambda_{S2})}{|\lambda|}\right] \quad \text{(A.1)}$$

Since $s_E > s_2$, $\lambda_{U2} - \lambda_{S2} > 0$ and given $1 - \frac{|\lambda|}{(\lambda_{S1} - \lambda_{U1})} = \frac{\lambda_{S1}\lambda_{UH} - \lambda_{U1}\lambda_{SH}}{\lambda_{S1} - \lambda_{U1}} > 1$, $\delta\varepsilon > 1$, so that $\hat{X}_1 > \hat{T}$.

Figure A.3 Factor-bias and scale effects in the HO model - Case 4



3 The same result is achieved by combining equation (2.71) and $\delta\varepsilon > \frac{\lambda_{S1}\lambda_{UH} - \lambda_{U1}\lambda_{SH}}{\lambda_{S1} - \lambda_{U1}}$.

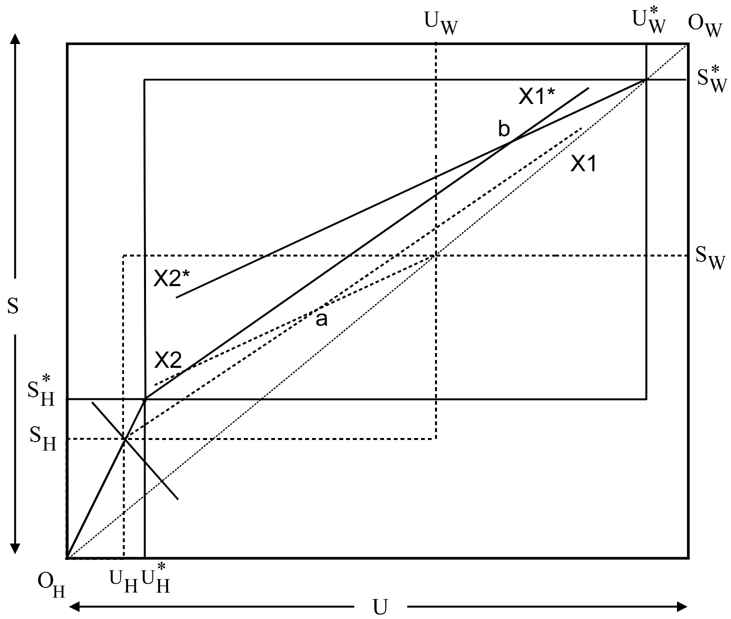
Thus, $s_H > s_E > s_1 > s_2$ and $\delta\varepsilon > 1 - \frac{|\lambda|}{(\lambda_{S1} - \lambda_{U1})} = \frac{\lambda_{S1}\lambda_{UH} - \lambda_{U1}\lambda_{SH}}{\lambda_{S1} - \lambda_{U1}}$ gives $\hat{X}_1 > \hat{T} > 0 > \hat{X}_2$. Figure A.3 illustrates this situation.

Case 5: $s_H > s_E > s_1 > s_2$ and $1 < \delta\varepsilon < 1 - \frac{|\lambda|}{(\lambda_{S1} - \lambda_{U1})} = \frac{\lambda_{S1}\lambda_{UH} - \lambda_{U1}\lambda_{SH}}{\lambda_{S1} - \lambda_{U1}}$

From equation (2.77), $\delta\varepsilon < 1 - \frac{|\lambda|}{(\lambda_{S1} - \lambda_{U1})}$ implies $\hat{X}_2 > 0$. As $\delta\varepsilon > 1$ still holds, and given that $\lambda_{S1} - \lambda_{U1} < 0$, equations (2.80) and (2.83) yield $\hat{X}_1 > \hat{T} > \hat{X}_2$.

Consequently, $s_H > s_E > s_1 > s_2$ and $1 < \delta\varepsilon < 1 - \frac{|\lambda|}{(\lambda_{S1} - \lambda_{U1})} = \frac{\lambda_{S1}\lambda_{UH} - \lambda_{U1}\lambda_{SH}}{\lambda_{S1} - \lambda_{U1}}$ yields $\hat{X}_1 > \hat{T} > \hat{X}_2 > 0$. Figure A.4 illustrates this situation.

Figure A.4 Factor-bias and scale effects in the HO model - Case 5

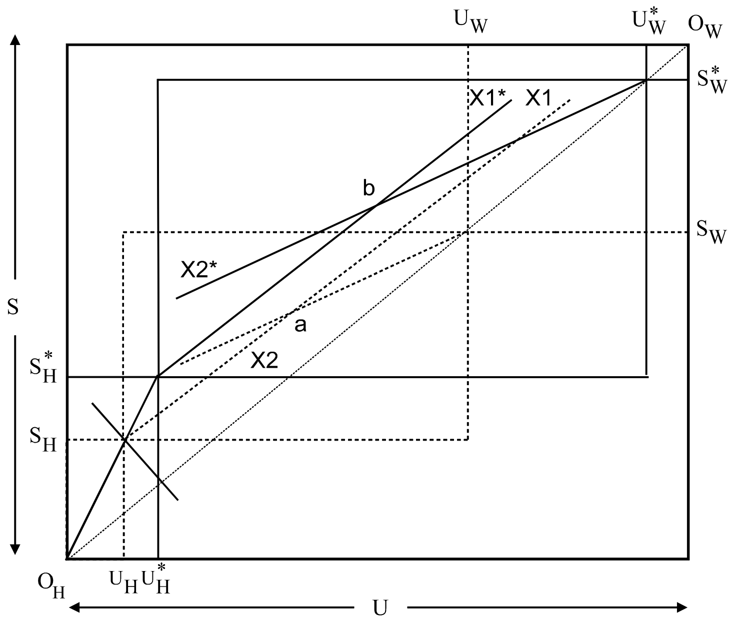


Case 6: $s_H > s_E > s_1 > s_2$ and $1 - \frac{|\lambda|}{(\lambda_{U2} - \lambda_{S2})} = \frac{\lambda_{U2}\lambda_{SH} - \lambda_{S2}\lambda_{UH}}{\lambda_{U2} - \lambda_{S2}} < \delta\varepsilon < 1$

Since $\delta\varepsilon < 1$, $\lambda_{U2} - \lambda_{S2} > 0$ and $\lambda_{S1} - \lambda_{U1} < 0$, equation (2.80) and (2.83) yield $\hat{X}_2 > \hat{T} > \hat{X}_1$. Using equation (2.76), $\delta\varepsilon > 1 - \frac{|\lambda|}{(\lambda_{U2} - \lambda_{S2})}$ implies $\hat{X}_1 > 0$.

Hence, $s_H > s_E > s_1 > s_2$ and $1 - \frac{|\lambda|}{(\lambda_{U2} - \lambda_{S2})} = \frac{\lambda_{U2}\lambda_{SH} - \lambda_{S2}\lambda_{UH}}{\lambda_{U2} - \lambda_{S2}} < \delta\varepsilon < 1$ implies $\hat{X}_2 > \hat{T} > \hat{X}_1 > 0$. Figure A.5 illustrates this situation.

Figure A.5 Factor-bias and scale effects in the HO model - Case 6



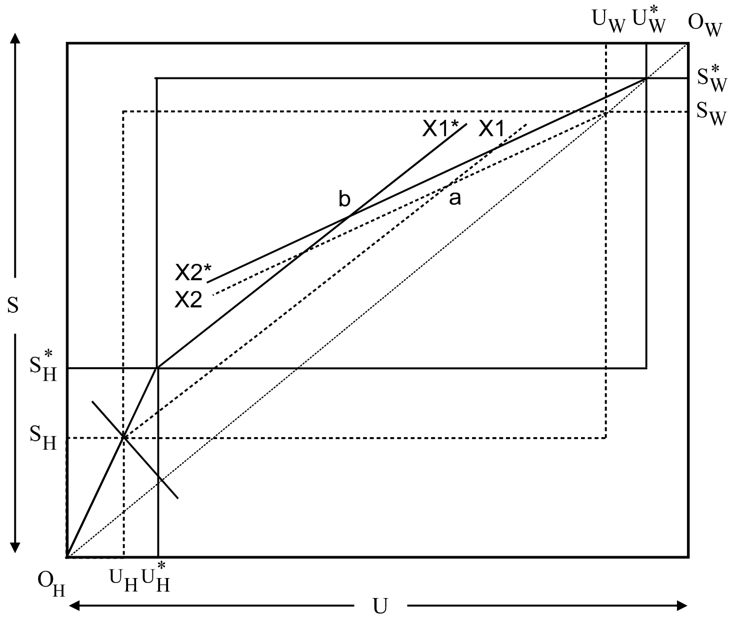
Case 7: $s_H > s_E > s_1 > s_2$ and $0 < \delta\varepsilon < 1 - \frac{|\lambda|}{(\lambda_{U2} - \lambda_{S2})} = \frac{\lambda_{U2}\lambda_{SH} - \lambda_{S2}\lambda_{UH}}{\lambda_{U2} - \lambda_{S2}}$

This is identical to Case 6, but now using equation (2.76) $\delta\varepsilon < 1 - \frac{|\lambda|}{(\lambda_{U2} - \lambda_{S2})}$ yields $\hat{X}_1 < 0$.

Therefore, $s_H > s_E > s_1 > s_2$ and $0 < \delta\varepsilon < 1 - \frac{|\lambda|}{(\lambda_{U2} - \lambda_{S2})} = \frac{\lambda_{U2}\lambda_{SH} - \lambda_{S2}\lambda_{UH}}{\lambda_{U2} - \lambda_{S2}}$ implies

$\hat{X}_2 > \hat{T} > 0 > \hat{X}_1$. Figure A.6 illustrates this situation.

Figure A.6 Factor-bias and scale effects in the HO model - Case 7



A2. DERIVATION OF THE R THEOREM FOR THE SF MODEL

The derivation of the R theorem for the model in which skilled labour is assumed specific to respectively health care and tradables starts with the market clearing equations (2.83), (2.85) and (2.50). Manipulation using the factor demand equations (2.7), (2.8) and (2.45) yields for health care-specific skilled labour and skilled labour remaining for tradables:

$$a_{SH} X_H = S_E^H = S^H - S_W^H \qquad \text{(A.2)}$$

$$a_{S1} X_1 + a_{S2} X_2 = S_E^T = S^T - S_W^T \qquad \text{(A.3)}$$

For unskilled labour, equation (2.50) is rewritten as:

$$U_1 + U_2 = U_E^T = U_E - U_H = U - U_W - U_H \tag{A.4}$$

where U_E^T is unskilled labour employed by the tradables sectors. Manipulation using the factor demand equations (2.9), (2.10) and (2.46) yields:

$$a_{U1} X_1 + a_{U2} X_2 = U - U_W - a_{UH} X_H \tag{A.5}$$

where $a_{li} = a_{li}\left(w_S^T / w_U\right)$ for i = 1, 2, l = S, U and $a_{lH} = a_{lH}\left(w_S^H / w_U\right)$ for l = S, U.

Since total unskilled, health care- and tradables-specific skilled labour, U, S^H and S^T, their respective illness rates, ir_U, ir_S^H and ir_S^T, and initial waiting lists, U_W^0, S_W^{H0} and S_W^{T0}, remain unchanged, total differentiation of equations (A.2), (A.3) and (A.5) is simplified considerably. Firstly for health care-specific skilled labour, the proportionate change in effective endowments is given by:

$$\hat{a}_{SH} + \hat{X}_H = \delta_{S_W^H} \left|\varepsilon_{X_H}^{S_W^H}\right| \hat{X}_H \tag{A.6}$$

where $\left|\varepsilon_{X_H}^{S_W^H}\right| = -\frac{\partial S_W^H}{\partial X_H} \frac{X_H}{S_W^H} = -S_W^{H\,'}\left(X_H; S_W^{H0}, ir_S^H S^H\right) \frac{X_H}{S_W^H} > 0$ denotes the absolute value of the waiting list elasticity for health care-specific skilled labour, and $\delta_{S_W^H} = S_W^H / S_E^H > 0$ the “dependency ratio” for health care-specific skilled labour.

The proportionate change in effective tradables-specific skilled labour equals:

$$\lambda_{S_1^T}\hat{a}_{S1}+\lambda_{S_2^T}\hat{a}_{S2}+\lambda_{S_1^T}\hat{X}_1+\lambda_{S_2^T}\hat{X}_2=\delta_{S_W^T}\left|\varepsilon_{X_H}^{S_W^T}\right|\hat{X}_H \qquad \text{(A.7)}$$

where $\lambda_{S_i^T}=S_i/S_E^T$ denotes the proportion of S_E^T employed in sector *i*, and $\sum_i \lambda_{S_i^T}=1$, for i = 1, 2. $\left|\varepsilon_{X_H}^{S_W^T}\right|=-\frac{\partial S_W^T}{\partial X_H}\frac{X_H}{S_W^T}=-S_W^{T'}\left(X_H;S_W^{T0},ir_S^T S^T\right)\frac{X_H}{S_W^T}>0$ denotes the absolute value of the waiting list elasticity for tradables-specific skilled labour and $\delta_{S_W^T}=S_W^T/S_E^T>0$ is the "dependency ratio" for tradables-specific skilled labour.

The proportionate change in effective endowments of unskilled labour employed in the tradables sectors is given by (A.8):

$$\begin{aligned}&\lambda_{U_1^T}\hat{a}_{U1}+\lambda_{U_2^T}\hat{a}_{U2}+\lambda_{U_1^T}\hat{X}_1+\lambda_{U_2^T}\hat{X}_2\\&=\delta_{UW}\left(1+\phi\right)\left|\varepsilon_{X_H}^{U_W}\right|\hat{X}_H-\phi\left(\hat{a}_{UH}+\hat{X}_H\right)\end{aligned} \qquad \text{(A.8)}$$

where $\lambda_{U_i^T}=U_i/U_E^T$ is the proportion of U_E^T employed in sector i, $\sum_i \lambda_{U_i^T}=1$ for $i=1,2$, $\delta_{UW}=U_W/U_E>0$ is the "dependency ratio" for unskilled labour, and $\left|\varepsilon_{X_H}^{U_W}\right|=-\frac{\partial U_W}{\partial X_H}\frac{X_H}{U_W}=-U_W'\left(X_H;U_W^0,ir_U U\right)\frac{X_H}{U_W}>0$ denotes the absolute value of the elasticity of the waiting list for unskilled labour with respect to health care output.

$\phi = U_H / U_E^T$ is the ratio of unskilled labour employed in health care to total unskilled labour employed in the tradables sectors.[4]

Since $a_{l_i} = a_{l_i}\left(w_S^T / w_U\right)$ for i = 1, 2 and l = S, U, from equations (2.97) and (2.98) factor prices w_S^T and w_U depend on commodity prices p_1 and p_2 only. As commodity prices for sector 1 and 2 are exogenously fixed to world prices by the small country assumption, the aforementioned factor prices remain the same such that $\hat{a}_{l_i} = 0$ for i = 1, 2 and l = *S*, *U*.[5] Equations (A.7) and (A.8) simplify into:

$$\lambda_{S_1^T} \hat{X}_1 + \lambda_{S_2^T} \hat{X}_2 = \delta_{S_W^T} \left| \varepsilon_{X_H}^{S_W^T} \right| \hat{X}_H \qquad \text{(A.9)}$$

$$\lambda_{U_1^T} \hat{X}_1 + \lambda_{U_2^T} \hat{X}_2 = \delta_{UW} \left(1+\phi\right) \left| \varepsilon_{X_H}^{U_W} \right| \hat{X}_H - \phi\left(\hat{a}_{UH} + \hat{X}_H\right) \qquad \text{(A.10)}$$

which can be solved for $\hat{X}_1$ and $\hat{X}_2$ once $\hat{X}_H$ and $\hat{a}_{UH}$ are known.

The solution for $\hat{X}_H$ results from equation (A.6):

$$\hat{X}_H = \hat{a}_{SH} \Big/ \left(\delta_{S_W^H} \left| \varepsilon_{X_H}^{S_W^H} \right| - 1 \right) \qquad \text{(A.11)}$$

4 Note that, using equation (A.4), the term U_W / U_E^T is rewritten as $\delta_{UW}\left(1+\phi\right)$ in equation (A.8).

5 This simplification does not obtain if skilled labour is specific to *all* sectors; the two price equations for sectors 1 and 2 then contain three unknowns instead of two.

In contrast to the input-output coefficients for the tradables sectors, $\hat{a}_{SH}$ and $\hat{a}_{UH}$ are not equal to zero. From equations (2.94) and (2.95), $a_{lH} = a_{lH}\left(w_S^H / w_U\right)$, for *l* = *S*, *U*. With w_U being determined from one of the commodity price equations for tradables and $\hat{w}_U = 0$, w_S^H follows from the unit price equation for health care, equation (2.96), and $\hat{w}_S^H$ is fully explained by the relative change in the price of health care, $\hat{p}_H$. The latter responds to the exogenously given change in the health budget, $\hat{T}$, from expression (2.55).

Total differentiation of (2.96) yields:

$$dp_H = w_S^H da_{SH} + w_U da_{UH} + a_{SH} dw_S^H + a_{UH} dw_U \tag{A.12}$$

From the first order condition for cost minimisation the slope of the unit-production isoquant equals the factor price ratio, $da_{SH} / da_{UH} = -w_U / w_S^H$, or $w_S^H da_{SH} + w_U da_{UH} = 0$, such that, after further manipulation, the following expression results:

$$\hat{p}_H = \theta_{SH} \hat{w}_S^H + \theta_{UH} \hat{w}_U \tag{A.13}$$

where $\theta_{SH} = a_{SH} w_S^H / p_H$ and $\theta_{UH} = a_{UH} w_U / p_H$ are the cost shares of health care-specific skilled and unskilled labour in the output of health care respectively, and $\theta_{SH} + \theta_{UH} = 1$ by definition.

Since $\hat{w}_U = 0$, the relative change in the wage of health care-specific skilled labour equals:

$$\hat{w}_S^H = \hat{p}_H / \theta_{SH} \qquad (A.14)$$

From the health budget restriction (2.55), the exogenously given proportionate change in the health budget equals the sum of the proportionate changes in the health care price and quantity, so that $\hat{p}_H$ equals:

$$\hat{p}_H = \hat{T} - \hat{X}_H \qquad (A.15)$$

The proportionate change in the input output coefficients, $\hat{a}_{SH}$ and $\hat{a}_{UH}$, can be derived using two simple relationships.[6] Firstly, $w_S^H da_{SH} + w_U da_{UH} = 0$ is equivalent to:

$$\theta_{SH}\hat{a}_{SH} + \theta_{UH}\hat{a}_{UH} = 0 \qquad (A.16)$$

And secondly, the relative change in the ratio of input-output coefficients in reaction to a relative change in the factor price ratio is given by the elasticity of substitution between factors. The definition of the elasticity of substitution between health care-specific skilled labour and unskilled labour in health care is:

$$\sigma = \frac{\hat{a}_{UH} - \hat{a}_{SH}}{\hat{w}_S^H - \hat{w}_U} \qquad (A.17)$$

6 The derivation follows Jones (1971).

Substitution of equation (A.16) in equation (A.17) and further manipulation of terms yields:

$$\hat{a}_{SH} = -\sigma\theta_{UH}\hat{w}_S^H \tag{A.18}$$

$$\hat{a}_{UH} = \sigma\theta_{UH}\hat{w}_S^H \tag{A.19}$$

Substituting equations (A.14), (A.15) and (A.18) into equation (A.11) yields:

$$\hat{X}_H = B\hat{T} \tag{A.20}$$

where $B = \sigma\,\theta_{UH} \Big/ \left(\left(1 - \delta_{S_W^H} \left| \varepsilon_{X_H}^{S_W^H} \right| \right) \theta_{SH} + \sigma\theta_{UH} \right)$.

And thus:

$$\hat{p}_H = (1-B)\hat{T} \tag{A.21}$$

$$\hat{w}_S^H = (1-B)\hat{T} \big/ \theta_{SH} \tag{A.22}$$

$$\hat{a}_{SH} = -\sigma\left(\theta_{UH}/\theta_{SH}\right)(1-B)\hat{T} \tag{A.23}$$

$$\hat{a}_{UH} = \sigma\left(\theta_{UH}/\theta_{SH}\right)(1-B)\hat{T} \tag{A.24}$$

The solution outcomes for the proportionate changes in outputs of sector 1 and 2 are:

$$\hat{X}_1 = \frac{B\hat{T}}{|\lambda|}\left[\lambda_{U_2^T}\delta_{S_W^T}\left|\varepsilon_{X_H}^{S_W^T}\right| - \lambda_{S_2^T}\left(\delta_{U_W}\left(1+\phi\right)\left|\varepsilon_{X_H}^{U_W}\right| - \phi\left(2-\delta_{S_W^H}\left|\varepsilon_{X_H}^{S_W^H}\right|\right)\right)\right] \qquad \text{(A.25)}$$

$$\hat{X}_2 = \frac{B\hat{T}}{|\lambda|}\left[\lambda_{S_1^T}\left(\delta_{U_W}\left(1+\phi\right)\left|\varepsilon_{X_H}^{U_W}\right| - \phi\left(2-\delta_{S_W^H}\left|\varepsilon_{X_H}^{S_W^H}\right|\right)\right) - \lambda_{U_1^T}\delta_{S_W^T}\left|\varepsilon_{X_H}^{S_W^T}\right|\right] \qquad \text{(A.26)}$$

where $|\lambda| = \lambda_{S_1^T}\lambda_{U_2^T} - \lambda_{U_1^T}\lambda_{S_2^T} = \lambda_{S_1^T} - \lambda_{U_1^T} = \lambda_{U_2^T} - \lambda_{S_2^T} > 0$ under the assumption that sector 1 is relatively skill-intensive compared to sector 2.

Equations (A.20) to (A.26) summarise the relative output, input, factor price and output price changes following a change in the size of the health budget in the SF model.

To limit the number of possible outcomes of an expansion of the health sector, waiting lists are henceforth postulated as being homogeneous in ill health, and thus in treatment, across labour types. Using the homogeneity assumption $\left|\varepsilon_{X_H}^{S_W^H}\right| = \left|\varepsilon_{X_H}^{S_W^T}\right| = \left|\varepsilon_{X_H}^{U_W}\right| = \varepsilon > 0$ and $\delta_{S_W^H} = \delta_{S_W^T} = \delta_{U_W} = \delta > 0$ so that $B = \sigma\,\theta_{UH} \big/ \left(\left(1-\delta\varepsilon\right)\theta_{SH} + \sigma\theta_{UH}\right)$ and the proportionate changes in outputs, inputs and prices are given by:

$$\hat{X}_1 = \frac{\sigma\theta_{UH}\hat{T}}{\left(\left(1-\delta\varepsilon\right)\theta_{SH} + \sigma\theta_{UH}\right)}\left[\delta\varepsilon + \frac{2\lambda_{S_2^T}\phi\left(1-\delta\varepsilon\right)}{\left(\lambda_{U_2^T} - \lambda_{S_2^T}\right)}\right] \qquad \text{(A.27)}$$

$$\hat{X}_2 = \frac{\sigma\theta_{UH}\hat{T}}{\left(\left(1-\delta\varepsilon\right)\theta_{SH} + \sigma\theta_{UH}\right)}\left[\delta\varepsilon + \frac{2\lambda_{S_1^T}\phi\left(\delta\varepsilon-1\right)}{\left(\lambda_{S_1^T} - \lambda_{U_1^T}\right)}\right] \qquad \text{(A.28)}$$

$$\hat{X}_H = \sigma\theta_{UH}\hat{T} \big/ \left(\left(1-\delta\varepsilon\right)\theta_{SH} + \sigma\theta_{UH}\right) \qquad \text{(A.29)}$$

$$\hat{p}_H = (1-\delta\varepsilon)\theta_{SH}\hat{T} \Big/ \left((1-\delta\varepsilon)\theta_{SH} + \sigma\theta_{UH}\right) \tag{A.30}$$

$$\hat{w}_S^H = (1-\delta\varepsilon)\hat{T} \Big/ \left((1-\delta\varepsilon)\theta_{SH} + \sigma\theta_{UH}\right) \tag{A.31}$$

$$\hat{a}_{SH} = -\sigma\theta_{UH}(1-\delta\varepsilon)\hat{T} \Big/ \left((1-\delta\varepsilon)\theta_{SH} + \sigma\theta_{UH}\right) \tag{A.32}$$

$$\hat{a}_{UH} = \sigma\theta_{UH}(1-\delta\varepsilon)\hat{T} \Big/ \left((1-\delta\varepsilon)\theta_{SH} + \sigma\theta_{UH}\right) \tag{A.33}$$

A3. IMMIGRATION OF HEALTH CARE-SPECIFIC SKILLED LABOUR IN THE SF MODEL

The government allows foreign health care-specific skilled labour to enter the UK, whilst keeping the health care budget at the same level. It is assumed that the income generated by these additional foreign workers remains within the economy.

Taking the differential of the right-hand side of equation (A.2) yields:

$$dS_E^H = dS^H - dS_W^H \tag{A.34}$$

where $dS^H > 0$. After further manipulation of (A.34) the following expression for $\hat{S}_E^H$ results:

$$\hat{S}_E^H = \left(1 + \delta_{S_W^H}\right)\hat{S}^H + \delta_{S_W^H}\left|\varepsilon_{X_H}^{S_W^H}\right|\hat{X}_H \tag{A.35}$$

Consequently, equation (A.6) becomes:

$$\hat{a}_{SH} + \hat{X}_H = \left(1 + \delta_{S_W^H}\right)\hat{S}^H + \delta_{S_W^H}\left|\varepsilon_{X_H}^{S_W^H}\right|\hat{X}_H \tag{A.36}$$

Equation (A.11) changes into:

$$\hat{X}_H = \left(\left(1+\delta_{S_W^H}\right)\hat{S}^H - \hat{a}_{SH}\right) \Big/ \left(1-\delta_{S_W^H}\left|\varepsilon_{X_H}^{S_W^H}\right|\right) \qquad \text{(A.37)}$$

The remainder of the analysis is the same as the derivation of the R theorem for the SF model, with the difference that the health care budget does not change, i.e. $\hat{T}=0$. Substitution of (A.14), (A.15) and (A.18) into (A.37), yields:

$$\hat{X}_H = B\hat{S}^H \qquad \text{(A.38)}$$

where $B = \dfrac{\left(1+\delta_{S_W^H}\right)\theta_{SH}}{\left(1-\delta_{S_W^H}\left|\varepsilon_{X_H}^{S_W^H}\right|\right)\theta_{SH} + \sigma\theta_{UH}}$.

The proportionate changes in the remaining variables are as follows:

$$\hat{p}_H = -B\hat{S}^H \qquad \text{(A.39)}$$

$$\hat{w}_S^H = -B\hat{S}^H \big/ \theta_{SH} \qquad \text{(A.40)}$$

$$\hat{a}_{SH} = \sigma\theta_{UH} B\hat{S}^H \big/ \theta_{SH} \qquad \text{(A.41)}$$

$$\hat{a}_{UH} = -\sigma\theta_{UH} B\hat{S}^H \big/ \theta_{SH} \qquad \text{(A.42)}$$

$$\hat{X}_1 = \frac{B\hat{S}^H}{|\lambda|}\left[\lambda_{U_2^T}\delta_{S_W^T}\left|\varepsilon_{X_H}^{S_W^T}\right| - \lambda_{S_2^T}\left(\delta_{U_W}(1+\phi)\left|\varepsilon_{X_H}^{U_W}\right| - \phi\left(1-\sigma\left(\theta_{UH}/\theta_{SH}\right)\right)\right)\right] \qquad \text{(A.43)}$$

$$\hat{X}_2 = \frac{B\hat{S}^H}{|\lambda|}\left[\lambda_{S_1^T}\left(\delta_{U_W}(1+\phi)\left|\varepsilon_{X_H}^{U_W}\right| - \phi\left(1-\sigma\left(\theta_{UH}/\theta_{SH}\right)\right)\right) - \lambda_{U_1^T}\delta_{S_W^T}\left|\varepsilon_{X_H}^{S_W^T}\right|\right] \quad \text{(A.44)}$$

Using the homogeneity assumption, $B = \frac{(1+\delta)\theta_{SH}}{(1-\delta\varepsilon)\theta_{SH} + \sigma\theta_{UH}}$, and the proportionate changes in outputs, inputs and prices are given by:

$$\hat{X}_1 = \frac{(1+\delta)\theta_{SH}\hat{S}^H}{(1-\delta\varepsilon)\theta_{SH} + \sigma\theta_{UH}}\left[\delta\varepsilon + \frac{\lambda_{S_2^T}\phi\left(1-\delta\varepsilon - \sigma\left(\theta_{UH}/\theta_{SH}\right)\right)}{\left(\lambda_{U_2^T} - \lambda_{S_2^T}\right)}\right] \quad \text{(A.45)}$$

$$\hat{X}_2 = \frac{(1+\delta)\theta_{SH}\hat{S}^H}{(1-\delta\varepsilon)\theta_{SH} + \sigma\theta_{UH}}\left[\delta\varepsilon - \frac{\lambda_{S_1^T}\phi\left(1-\delta\varepsilon - \sigma\left(\theta_{UH}/\theta_{SH}\right)\right)}{\left(\lambda_{S_1^T} - \lambda_{U_1^T}\right)}\right] \quad \text{(A.46)}$$

$$\hat{X}_H = \frac{(1+\delta)\theta_{SH}\hat{S}^H}{(1-\delta\varepsilon)\theta_{SH} + \sigma\theta_{UH}} \quad \text{(A.47)}$$

$$\hat{p}_H = -\frac{(1+\delta)\theta_{SH}\hat{S}^H}{(1-\delta\varepsilon)\theta_{SH} + \sigma\theta_{UH}} \quad \text{(A.48)}$$

$$\hat{w}_S^H = -\frac{(1+\delta)\hat{S}^H}{(1-\delta\varepsilon)\theta_{SH} + \sigma\theta_{UH}} \quad \text{(A.49)}$$

$$\hat{a}_{SH} = \frac{\sigma\theta_{UH}(1+\delta)\hat{S}^H}{(1-\delta\varepsilon)\theta_{SH} + \sigma\theta_{UH}} \quad \text{(A.50)}$$

$$\hat{a}_{UH} = -\frac{\sigma\theta_{UH}(1+\delta)\hat{S}^H}{(1-\delta\varepsilon)\theta_{SH} + \sigma\theta_{UH}} \quad \text{(A.51)}$$

Equation (A.45) to (A.51) summarise the relative input, output and factor price changes following the immigration of health care-specific skilled labour in the SF model, using the homogeneity assumption.

A4. FNTC IN HEALTH CARE USING THE SF MODEL

FNTC in the production of health care implies that $\hat{a}_{SH} = \hat{a}_{UH} = \hat{a} < 0$ (and $\hat{a}_{li} = 0$ for $l = S$, U and $i = 1, 2$). The new technology will be adopted if the unit cost of health care at current factor prices falls. At *unchanged* factor prices, total differentiation of the unit cost equation for health care (2.96) yields:

$$\hat{p}_H = \theta_{SH}\hat{a}_{SH} + \theta_{UH}\hat{a}_{UH} \tag{A.52}$$

where $\theta_{SH} = a_{SH} w_S^H / p_H$ and $\theta_{UH} = a_{UH} w_U / p_H$ are the cost shares of health care-specific skilled and unskilled labour in the output of health care respectively, and $\theta_{SH} + \theta_{UH} = 1$ by definition. Substituting $\hat{a}_{SH} = \hat{a}_{UH} = \hat{a} < 0$ in equation (A.52) gives $\hat{p}_H = \hat{a} < 0$, so that unit cost of health care at *current* factor prices falls and the new technology will be adopted.

Since in the SF model, the wage of health care-specific skilled labour may change, the total (i.e. allowing for factor price changes) proportionate change in the unit cost of health care, using (A.12), is given by:

$$\hat{p}_H = \hat{a} + \theta_{SH}\hat{w}_S^H \tag{A.53}$$

The derivation of the impact of FNTC on outputs proceeds in a similar fashion as Section A2. The proportionate changes in outputs are given by equation (A.9), (A.10) and (A.11), but substituting for $\hat{a}_{SH} = \hat{a}_{UH} = \hat{a} < 0$:

$$\lambda_{S_1^T} \hat{X}_1 + \lambda_{S_2^T} \hat{X}_2 = \delta_{S_W^T} \left| \varepsilon_{X_H}^{S_W^T} \right| \hat{X}_H \tag{A.54}$$

$$\lambda_{U_1^T} \hat{X}_1 + \lambda_{U_2^T} \hat{X}_2 = \delta_{UW} (1+\phi) \left| \varepsilon_{X_H}^{U_W} \right| \hat{X}_H - \phi\left(\hat{a} + \hat{X}_H\right) \tag{A.55}$$

$$\hat{X}_H = \hat{a} \Big/ \left(\delta_{S_W^H} \left| \varepsilon_{X_H}^{S_W^H} \right| - 1 \right) \tag{A.56}$$

where the parameter definitions of Section A2 apply.

Furthermore, given the health care budget, T, the following condition must hold:

$$\hat{X}_H = -\hat{p}_H \tag{A.57}$$

Hence, equation (A.53) to (A.57) represent a system of five equations with five unknowns, $\hat{X}_H$, $\hat{p}_H$, $\hat{w}_S^H$, $\hat{X}_1$ and $\hat{X}_2$, which yields solution values:

$$\hat{X}_H = \hat{a} \Big/ \left(\delta_{S_W^H} \left| \varepsilon_{X_H}^{S_W^H} \right| - 1 \right) \tag{A.58}$$

$$\hat{p}_H = -\hat{a} \Big/ \left(\delta_{S_W^H} \left| \varepsilon_{X_H}^{S_W^H} \right| - 1 \right) \tag{A.59}$$

$$\hat{w}_S^H = -\hat{a}\delta_{S_W^H} \left| \varepsilon_{X_H}^{S_W^H} \right| \Big/ \left[\left(\delta_{S_W^H} \left| \varepsilon_{X_H}^{S_W^H} \right| - 1 \right) \theta_{SH} \right] \tag{A.60}$$

$$\hat{X}_1 = \frac{\hat{a}\left[\lambda_{U_2^T}\delta_{S_W^T}\left|\varepsilon_{X_H}^{S_W^T}\right| - \lambda_{S_2^T}\delta_{UW}\left|\varepsilon_{X_H}^{U_W}\right| - \lambda_{S_2^T}\phi\left(\delta_{UW}\left|\varepsilon_{X_H}^{U_W}\right| - \delta_{S_W^H}\left|\varepsilon_{X_H}^{S_W^H}\right|\right)\right]}{|\lambda|\left(\delta_{S_W^H}\left|\varepsilon_{X_H}^{S_W^H}\right| - 1\right)} \quad \text{(A.61)}$$

$$\hat{X}_2 = \frac{\hat{a}\left[\lambda_{S_1^T}\delta_{UW}\left|\varepsilon_{X_H}^{U_W}\right| - \lambda_{U_1^T}\delta_{S_W^T}\left|\varepsilon_{X_H}^{S_W^T}\right| + \lambda_{S_1^T}\phi\left(\delta_{UW}\left|\varepsilon_{X_H}^{U_W}\right| - \delta_{S_W^H}\left|\varepsilon_{X_H}^{S_W^H}\right|\right)\right]}{|\lambda|\left(\delta_{S_W^H}\left|\varepsilon_{X_H}^{S_W^H}\right| - 1\right)} \quad \text{(A.62)}$$

Using the homogeneity assumption the proportionate changes in outputs, inputs and prices are simplified to:

$$\hat{X}_H = \hat{a}\big/\left(\delta\varepsilon - 1\right) \quad \text{(A.63)}$$

$$\hat{p}_H = -\hat{a}\big/\left(\delta\varepsilon - 1\right) \quad \text{(A.64)}$$

$$\hat{w}_S^H = -\hat{a}\delta\varepsilon\big/\left[\left(\delta\varepsilon - 1\right)\theta_{SH}\right] \quad \text{(A.65)}$$

$$\hat{X}_1 = \frac{\hat{a}\left[\left(\lambda_{U_2^T} - \lambda_{S_2^T}\right)\delta\varepsilon\right]}{|\lambda|\left(\delta\varepsilon - 1\right)} \quad \text{(A.66)}$$

$$\hat{X}_2 = \frac{\hat{a}\left[\left(\lambda_{S_1^T} - \lambda_{U_1^T}\right)\delta\varepsilon\right]}{|\lambda|\left(\delta\varepsilon - 1\right)} \quad \text{(A.67)}$$

Equations (A.63) to (A.67) summarise the relative input, output and factor price changes following factor neutral technical change in health care under the homogeneity assumption and within the SF model.

The rankings of relative output (and price) changes are relatively straightforward. Specifically for $0 \le \delta\varepsilon < 1$ $\hat{X}_H > 0$, $\hat{p}_H < 0$, $\hat{w}_S^H \le 0$ and $\hat{X}_1 = \hat{X}_2 \ge 0$, whereas for $\delta\varepsilon > 1$ $\hat{X}_H < 0$, $\hat{p}_H > 0$, $\hat{w}_S^H > 0$ and $\hat{X}_1 = \hat{X}_2 < 0$. As in the HO model FNTC (Section 2.5.1) only yields scale effects (the proportionate change in health care employment equals $\hat{L}_H = \hat{a}_{lH} + \hat{X}_H = \hat{a} + \hat{a}/(\delta\varepsilon - 1) = \hat{a}\delta\varepsilon/(\delta\varepsilon - 1)$, for $L = S,U$). But in contrast with this model, the changes in outputs of sector 1 and 2 are identical and follow the sign of the change in health sector output, which can also become negative.[7]

A5. SBTC IN HEALTH CARE USING THE SF MODEL

SBTC in the production of health care implies that $\hat{a}_{SH} < 0$, $\hat{a}_{UH} = 0$ and $\hat{a}_{li} = 0$ for l = S, U and i = 1, 2. The new technology will be adopted if the unit cost of health care at current factor prices falls. Using expression (A.52), $\hat{p}_H = \theta_{SH}\hat{a}_{SH} < 0$, so that the new technology will be adopted.

Since in the SF model, the wage of health care-specific skilled labour may change, the total (i.e. allowing for factor price changes) proportionate change in the unit cost of health care, using (A.12), is given by:

$$\hat{p}_H = \theta_{SH}\left(\hat{a}_{SH} + \hat{w}_S^H\right) \qquad \text{(A.68)}$$

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[7] Due to the homogeneity assumption, FNTC in the SF model replicates the R result that changing the endowments of both factors in the same proportion leads to a change in the production of both goods in that proportion. Note that, if $\varepsilon = 0$, the SF and HO model yield the same result: FNTC reduces the unit-requirement of skilled and unskilled labour by $\hat{a}$ so that the unit cost falls and, given the health budget, the output of health care rises by this proportion so that in total the demand for skilled and unskilled labour in health care does not change and, hence, outputs of tradables are unchanged.

Taking the proportionate changes in outputs of the SF model, given in equation (A.9), (A.10) and (A.11), but substituting for $\hat{a}_{SH} < 0$ and $\hat{a}_{UH} = 0$, yields:

$$\lambda_{S_1^T}\hat{X}_1 + \lambda_{S_2^T}\hat{X}_2 = \delta_{S_W^T}\left|\varepsilon_{X_H}^{S_W^T}\right|\hat{X}_H \quad \text{(A.69)}$$

$$\lambda_{U_1^T}\hat{X}_1 + \lambda_{U_2^T}\hat{X}_2 = \delta_{UW}\left(1+\phi\right)\left|\varepsilon_{X_H}^{U_W}\right|\hat{X}_H - \phi\hat{X}_H \quad \text{(A.70)}$$

$$\hat{X}_H = \hat{a}_{SH}\Big/\left(\delta_{S_W^H}\left|\varepsilon_{X_H}^{S_W^H}\right| - 1\right) \quad \text{(A.71)}$$

where the parameter definitions of Section A2 apply.

Furthermore, given the health care budget, T, the following condition must hold:

$$\hat{X}_H = -\hat{p}_H \quad \text{(A.72)}$$

Hence, equation (A.68) to (A.72) represent a system of five equations with five unknowns, $\hat{X}_H$, $\hat{p}_H$, $\hat{w}_S^H$, $\hat{X}_1$ and $\hat{X}_2$, which yields solution values:

$$\hat{X}_H = \hat{a}_{SH}\Big/\left(\delta_{S_W^H}\left|\varepsilon_{X_H}^{S_W^H}\right| - 1\right) \quad \text{(A.73)}$$

$$\hat{p}_H = -\hat{a}_{SH}\Big/\left(\delta_{S_W^H}\left|\varepsilon_{X_H}^{S_W^H}\right| - 1\right) \quad \text{(A.74)}$$

$$\hat{w}_S^H = -\hat{a}_{SH} - \hat{a}_{SH}\Big/\left(\theta_{SH}\left(\delta_{S_W^H}\left|\varepsilon_{X_H}^{S_W^H}\right| - 1\right)\right) \quad \text{(A.75)}$$

$$\hat{X}_1 = \frac{\hat{a}_{SH}}{\left(\delta_{S_W^H}\left|\varepsilon_{X_H}^{S_W^H}\right|-1\right)|\lambda|}\left[\lambda_{U_2^T}\delta_{S_W^T}\left|\varepsilon_{X_H}^{S_W^T}\right|-\lambda_{S_2^T}\left((1+\phi)\delta_{UW}\left|\varepsilon_{X_H}^{U_W}\right|-\phi\right)\right] \text{(A.76)}$$

$$\hat{X}_2 = \frac{\hat{a}_{SH}}{\left(\delta_{S_W^H}\left|\varepsilon_{X_H}^{S_W^H}\right|-1\right)|\lambda|}\left[\lambda_{S_1^T}\left((1+\phi)\delta_{UW}\left|\varepsilon_{X_H}^{U_W}\right|-\phi\right)-\lambda_{U_1^T}\delta_{S_W^T}\left|\varepsilon_{X_H}^{S_W^T}\right|\right] \text{(A.77)}$$

Using the homogeneity assumption the proportionate changes in outputs, inputs and prices simplify to:

$$\hat{X}_H = \hat{a}_{SH}/(\delta\varepsilon-1) \quad \text{(A.78)}$$

$$\hat{p}_H = -\hat{a}_{SH}/(\delta\varepsilon-1) \quad \text{(A.79)}$$

$$\hat{w}_S^H = -\hat{a}_{SH} - \hat{a}_{SH}/\left(\theta_{SH}(\delta\varepsilon-1)\right) \quad \text{(A.80)}$$

$$\hat{X}_1 = \frac{\hat{a}_{SH}}{(\delta\varepsilon-1)|\lambda|}\left[\left(\lambda_{U_2^T}-(1+\phi)\lambda_{S_2^T}\right)\delta\varepsilon+\phi\lambda_{S_2^T}\right] \quad \text{(A.81)}$$

$$\hat{X}_2 = \frac{\hat{a}_{SH}}{(\delta\varepsilon-1)|\lambda|}\left[\left((1+\phi)\lambda_{S_1^T}-\lambda_{U_1^T}\right)\delta\varepsilon-\phi\lambda_{S_1^T}\right] \quad \text{(A.82)}$$

Equation (A.78) to (A.82) summarise the relative input, output and factor price changes following skill-biased technical change in health care under the homogeneity assumption and within the SF model.

In the absence of scale effects ($\varepsilon = 0$), SBTC in the SF model replicates the results of SBTC the HO model: $\hat{X}_1 = \hat{X}_1^F > 0$ and $\hat{X}_2 = \hat{X}_2^F < 0$, so that more (less) of skilled and unskilled labour is employed in sector 1 (2). In health care, production and thus employment of unskilled labour rises by $\hat{X}_H = -\hat{a}_{SH} > 0$ (note that employment of health care-specific skilled labour in health care remains the same since the fixed health care budget constrains the output expansion). Consequently, the innovation benefits the skilled-intensive sector and harms the unskilled-intensive sector by using more unskilled labour, thereby making skilled labour relatively more abundant in the rest of the economy.

If scale effects are present, the rankings can be derived as shown in Table A.1, and are identical to the results obtained from increasing expenditures on health care, apart from the substitution elasticity, which does not play a role anymore (Table 2.5).

Table A.1 Output changes in the SF model following SBTC in health care

Waiting list elasticity and dependency ratio assuming homogeneous health and treatment	The health sector's use of unskilled labour relative to the tradables sectors	Output changes for $-\hat{a}_{SH} > 0$
$0 < \delta\varepsilon < 1$ $\Leftrightarrow \hat{X}_H > 0$	$0 < \phi < \dfrac{\delta\varepsilon\left(\lambda_{S_1^T} - \lambda_{U_1^T}\right)}{\lambda_{S_1^T}(1-\delta\varepsilon)}$	$\hat{X}_1 > \hat{X}_2 > 0$
	$\phi > \dfrac{\delta\varepsilon\left(\lambda_{S_1^T} - \lambda_{U_1^T}\right)}{2\lambda_{S_1^T}(1-\delta\varepsilon)}$	$\hat{X}_1 > 0 > \hat{X}_2$
$\delta\varepsilon > 1$ $\Leftrightarrow \hat{X}_H < 0$	$0 < \phi < \dfrac{\delta\varepsilon\left(\lambda_{U_2^T} - \lambda_{S_2^T}\right)}{2\lambda_{S_2^T}(\delta\varepsilon - 1)}$	$0 > \hat{X}_1 > \hat{X}_2$
	$\phi > \dfrac{\delta\varepsilon\left(\lambda_{U_2^T} - \lambda_{S_2^T}\right)}{2\lambda_{S_2^T}(\delta\varepsilon - 1)}$	$\hat{X}_1 > 0 > \hat{X}_2$

APPENDIX TO CHAPTER 5

This appendix describes the General Household Survey (GHS) database which was used in the disaggregation of household and labour data and served as the main source of data on health and the use of health care of households in the UK. The purpose-built GHS database is available in electronic form from the author upon request.

The database was constructed from the 2000/01 General Household Survey, which provides a wealth of information on people living in private households in Great Britain, including household/family information, demographic detail on household/ family members, earnings, benefits, employment, education, health, the use of health services, housing tenure, durable goods, migration, smoking and drinking patterns.[8] The original data were obtained online from the United Kingdom Data Archive (UKDA) and subsequently imported to Microsoft Access.[9]

The raw data consist of two files, GHS00client1.tab and GHS00hclient1.tab, containing person-level and household-level data respectively.[10] The person-level file stores one record for each responding person, whereas the household-level file stores one record for each responding household. Each household is uniquely identified by a household serial number (HSERIAL) and this index is attached to all individuals belonging to this

8 Associated publication: ONS (2001a).

9 Registered Trademark. Software is copyrighted and available commercially.

10 Two other files were excluded from the database: the informal carers module (ghscare00.tab) and social capital module (scaparchive.tab). The former contains data on tertiary care, informal care for others, which forms a relatively small part of the health care system. The latter documents data on social capital (including civic engagement, neighbourliness and reciprocity, social networks, social support and views about the local area) which is not of direct relevance to the topic of study.

household in the person-level file. In this way each individual, who has also been given a unique identification number (ID) in this thesis, is linked to one household. As the GHS is based on a sample of the population of Great Britain (approximately 19266 people living in 8221 households), a weighting factor (WEIGHT00) is included to adjust for non-response and grossing up to match known population distributions. A weight connected to a household (and so all household members) thus stands for the number of households in Great Britain that it represents.

The GHS database, at this stage of data collection, was very large and slow when extracting specific data. Since it contained data that were irrelevant to the purpose of this study, a large number of variables were deleted, mostly concerning family information, housing tenure, durable goods, migration, smoking and drinking patterns.[11] Subsequently, for the purpose of aggregating the GHS data, households and individuals were classified into household types (Hholdtype1) and skill types (Skilltype1) respectively, and with respect to the latter a further categorisation in terms of sector of employment (Sector1) was made (see Chapter 5, Section 5.2; Chapter 6, Section 6.2).

The classification of households is unique in that it presents pensioners as a separate household type, with different health care needs and income sources compared to the remaining households. In order to obtain this classification, all pensioners were removed from the households to which they belonged and put into separate household units. When transferring pensioners, it was assumed that a pensioner (pensioners) living with non-pensioners is “taken out” and put in a new pensioner household (one pensioner

[11] These data are not ‘lost’: the unique ID and HSERIAL fields for individual- and household-level data ensures that, if deemed necessary, variables can be re-imported using the original data files.

forms a single pensioner household, two pensioners form a two-person household, et cetera). This led to the creation of 564 new households in the sample, representing approximately 1.6 million 'pensioner' households in Great Britain, and lowered the average number of persons in the remaining households. The manipulation of households meant breaking the link between the household- and person-level data files based on HSERIAL. To distinguish the 'new' households from the 'old' households identified by HSERIAL, all households in the household file were given a unique household identification number (HID). The person-level file contains both HSERIAL and HID so that it is obvious which households the pensioners belonged to in the survey as well as of which households they form a part for the purpose of this thesis.

The resulting data are stored in three tables in Microsoft Access, recording household-level data and person-level health care and socio-economic data respectively. The content of the tables is shown below (identical to the 'Design View' in MS Access).

Table: Household_data

Name	Description
HID	Household ID (unique)
HSERIAL	Old household serial number (before transfer pensioners, so not unique anymore)
WEIGHT00	Sample/population based weights 2000
Hholdtype1	Household types: 1= pensioners (including pensioners from other household types), 2=non-working, children, 3=non-working, no children, 4=working, children, 5= working, no children
NPERSONS	Number of persons
NUMCHILD	Number of children (AGE <=15)
NPENSNRS	Number of pensioners (SEX =2, AGE >=60, SEX=1 AGE>=65)
NWORKAGE	Number of working age persons (NPERSONS-NUMCHILD-NUMPENSNRS)
NWORKING	Number of working persons (ECSTILO=1)

Table: Individual_health_care_data

Name	Description
ID	Individual ID (unique)
HID	Household ID (unique)
HSERIAL	Old household serial number (before transfer pensioners, so not unique anymore)
WEIGHT00	Sample/Population based weights 2000
GENHLTH	Health on the whole in the last 12 months (1 good, 2 fairly good, 3 not good)
ILLNESS	Any longstanding illness or disability? (1 yes, 2 no)
LMATNUM	Number of illnesses
ICD1	For first illness, illness type (using International Classification of Diseases 9th revision)
ICD2	For second illness, illness type
ICD3	For third illness, illness type
ICD4	For fourth illness, illness type
ICD5	For fifth illness, illness type
ICD6	For sixth illness, illness type
Condition Group1	Condition group first illness (1=infectious diseases, 2=neoplasms and benign growths, 3=endocrine and metabolic, 4=blood and related organs, 5=mental disorders, 6=nervous system, 7=eye complaints, 8=ear complaints, 9=heart and circulatory system, 10=respiratory system, 11=digestive system, 12=genito-urinary system, 13=skin complaints, 14=musculoskeletal system, 15=other complaints
Condition Group2	Condition group second illness
Condition Group3	Condition group third illness
Condition Group4	Condition group fourth illness
Condition Group5	Condition group fifth illness
Condition Group6	Condition group sixth illness
LIMITACT	If longstanding illness, limits activity? (1=yes, 2=no)
CUTDOWN	Illness/injury in last 2 weeks reduce activity? (1=yes, 2=no)
NDYSCUTD	Number of days cut down last 2 weeks
DOCTALK	Consulted doctor last 2 weeks, excl. hospital? (1=yes, 2=no)
NCHATS	Number of consultations
CONSULN1	Consultation number 1
WHSBHLF1	On whose behalf?
FORPERN1	Person number consulted for
NHS1	Under NHS or private? (1=NHS, 2=private)
GP1	Type of doctor? (1=GP, 2=Specialist, 3=other)
DOCWHER1	Where talk to doctor? (1=by telephone, 2=at your home, 3=in the doctors surgery, 4=at a health centre, 5=elsewhere)
PRESC1	Given prescription? (1=yes, 2=no)
CONSULN2	
WHSBHLF2	
FORPERN2	
NHS2	
GP2	

Individual_health_care_data continued

DOCWHER2
PRESC2
CONSULN3
WHSBHLF3
FORPERN3
NHS3
GP3
DOCWHER3
PRESC3
CONSULN4
WHSBHLF4
FORPERN4
NHS4
GP4
DOCWHER4
PRESC4
CONSULN5
WHSBHLF5
FORPERN5
NHS5
GP5
DOCWHER5
PRESC5
CONSULN6
WHSBHLF6
FORPERN6
NHS6
GP6
DOCWHER6
PRESC6
CONSULN7
WHSBHLF7
FORPERN7
NHS7
GP7
DOCWHER7
PRESC7
CONSULN8
WHSBHLF8
FORPERN8
NHS8

Individual_health_care_data continued

GP8	
DOCWHER8	
PRESC8	
CONSULN9	
WHSBHLF9	
FORPERN9	
NHS9	
GP9	
DOCWHER9	
PRESC9	
OUTPATNT	Hospital outpatient attended - last 3 months? (1=yes, 2=no)
NTIMES1	How many times attended as outpatient in first month?
NTIMES2	How many times attended as outpatient in second month?
NTIMES3	How many times attended as outpatient in third month?
NTIMESOP	Number of outpatient visits in last 3 months
CASUALTY	Whether visit was to casualty department (1=at least one to casualty, 2=no casualty)
NCASVIS	Number of visits to casualty
PRVISTS	Whether outpatient visit under NHS or private (1=NHS, 2=private)
NPRVISTS	Number of private outpatient visits
DAYPATNT	In hospital as day patient in last year? (1=yes, 2=no)
MATDPAT	Any days as day patient for maternity? (1=yes, 2=no)
NUMMATDP	Number of separate days as day patient for having a baby
PRMATDP	Private or NHS maternity care (1=NHS, 2=private)
NPRMATDP	Number of private visits
NHSPDAYS	Number of separate days in hospital as a day patient (excl maternity stays)
PRDPTNT	Whether day patient visit under NHS or private (1=NHS, 2=private)
NPRDPTNT	Number of private day patient visits
INPATNT	In hospital as inpatient in last year? (1=yes, 2=no)
MATINPAT	Whether inpatient for maternity (1=yes, 2=no)
NMTSTAY	Number of stays inpatient maternity
MTNIGHT1	Number of nights stay maternity (visit nr. 1)
MATNHST1	Treated under NHS or private (visit nr. 1) (1=NHS, 2=private)
MTPRVST1	Number of private maternity visits (visit nr. 1)
MTNIGHT2	
MATNHST2	
MTPRVST2	
MTNIGHT3	
MATNHST3	
MTPRVST3	
MTNIGHT4	
MATNHST4	

Individual_health_care_data continued

MTPRVST4	
MTNIGHT5	
MATNHST5	
MTPRVST5	
MTNIGHT6	
MATNHST6	
MTPRVST6	
NSTAYS	Number of separate inpatient stays (excl maternity stays)
NIGHTS1	Number of nights altogether in hospital (first stay)
NHSTREA1	Whether treated NHS or private (first stay) (1=NHS, 2=private)
PRVSTAY1	Treated in NHS or private hospital (first stay) (1=NHS, 2=private)
NIGHTS2	
NHSTREA2	
PRVSTAY2	
NIGHTS3	
NHSTREA3	
PRVSTAY3	
NIGHTS4	
NHSTREA4	
PRVSTAY4	
NIGHTS5	
NHSTREA5	
PRVSTAY5	
NIGHTS6	
NHSTREA6	
PRVSTAY6	
SEENURSE	Respondent saw GP practice nurse? (1=yes, 2=no)
NNURSE	Number of times saw practice nurse
SEECHN1	saw nurse or clinic nr1 (1=practice nurse at GP surgery, 2=health visitor at GP surgery, 3=go to a child health clinic, 4=go to a child welfare clinic, 5=none of these)
SEECHN2	saw nurse or clinic nr2
SEECHN3	saw nurse or clinic nr3
NNHSGP	Number of NHS GP consultations last 2 weeks
NNHSGPY	Number of NHS GP consultations per year
NNHGPEL	Number of NHS GP consultations elsewhere last 2 weeks
NNHGPELY	Number of NHS GP consultations elsewhere per year
NNHGPHO	Number of NHS GP consultations at home last 2 weeks
NNHGPHOY	Number of NHS GP consultations at home per year
NNHGPSH	Number of NHS GP consultations at surgery last two weeks
NNHGPSHY	Number of NHS GP consultations at surgery per year
NNHGPTL	Number of NHS GP consultations by phone last two weeks

Individual_health_care_data continued

NNHGPTLY	Number of NHS GP consultations by phone per year
NOTHDOC	Number of consultations other doctor last two weeks
NOTHDOCY	Number of consultations other doctor per year
NPRIVGP	Number of private GP consultations last 2 weeks
NPRIVGPY	Number of private GP consultations per year
NPRIVSP	Number of private specialist consultations last 2 weeks
NPRIVSPY	Number of private specialist consultations per year
NSTYSY	Number of inpatient stays last year
CNHGPEL	If consulted NHS GP elsewhere last 2 weeks? (1=consultation elsewhere, 2=no consultation elsewhere)
CNHGPHO	If consulted NHS GP at home last 2 weeks? (1=consultation at home, 2=no consultation at home)
CNHGPPS	If consulted NHS GP and got prescription last 2 weeks? (1=got prescription, 2=no prescription/consultation)
CNHGPSH	If consulted NHS GP at surgery last 2 weeks? (1=consultation at surgery, 2=no consultation at surgery)
CNHGPTL	If consulted NHS GP by phone last 2 weeks? (1=consultation by phone, 2=no consultation by phone)
CNHSGP	If consulted NHS GP last 2 weeks? (1=consulted GP, 2=not consulted GP)
CNHSSP	If consulted NHS specialist last 2 weeks? (1=consulted NHS specialist, 2=no consultation NHS specialist)
COTHDOC	If consulted other doctor last 2 weeks? (1=consulted other doctor, 2=no consultation other doctor)
CPRIVGP	If consulted GP privately last 2 weeks? (1=consulted GP privately, 2=no consultation privately)
CPRIVSP	If consulted specialist privately last 2 weeks? (1=consulted specialist privately, 2=no private specialist consultation)
NIGHTS	Total number of nights spent in hospital
NTIMSOP	Number of outpatient visits in three months
NTIMSOPY	Number of outpatient visits per year. calculated
RADYS	Number of days of restricted activity in last two weeks
RADYSPYR	Number of days of restricted activity per year. calculated
LONGILL	Limiting or non-limiting longstanding illness? (1=limiting longstanding illness, 2=non-limiting longstanding illness, 3=no longstanding illness)
LSIRA	Limiting (LMT) longstanding illness (LSI) or restricted activity (RA)? (1=LMT LSI + RA, 2=RA non LMT LSI, 3=LMT LSI only, 4=non LMT LSI only, 5=RA only, 6=no reported illness, 7=anything else)
PNURSE	Practice nurse consulted last 2 weeks? (1=yes, 2=no)
NPNY	Number of practice nurse consultations per year

Table: Individual_socio-economic_data

Name	Description
ID	Individual ID (unique)
HID	Household ID (unique)
HSERIAL	Old household serial number (before transfer pensioners, so not unique anymore)
WEIGHT00	Sample/Population based weights 2000
SEX	Male 1/female 2
AGE	Age of person
AGEGROUP	Children 1, working age 2, pensioners 3
SOC90	Standard occupational classification 1990
Skilltype	1 highly skilled, 2 skilled, 3 semi-skilled, 4 unskilled following Winchester (2002)
Skilltype1	Skill types: Skilltype = 1, 2, 3 gives skill type1= 1 (skilled), skilltype 4 gives skilltype1= 2 (unskilled)
INDSTRY1	1980 Standard Industrial Classification
SIC92	1992 Standard Industrial Classification
INDSTRY123	123 industry/product classification
Sector1	Sector/Commodity structure (1 Primary, 2 Pharmaceuticals, 3 Medical instruments, 4 Other manufacturing, 5 Energy, 6 Construction, 7 Distribution and transport, 8 Finance, 9 Public administration and defence, 10 Health care, 11 Other services
SC	Social class (1 Professional, 2 Managerial and Technical, 3.1=Skilled non-manual, 3.2=Skilled manual, 4 Partly Skilled, 5 Unskilled, 6 armed forces)
WORKHRS	Total work hours
UNPAIDHR	Unpaid hours in last 7 days
UNPAIDHM	Unpaid work at home or away
TOTHRS	Hours usually worked excluding breaks, including overtime
ECSTILO	Economic status ILO (1 Working, 2 Government scheme with employment, 3 Government scheme at college, 4 Unemployed (ILO definition), 5 Other unemployed, 6 Permanently unable to work, 7 Retired, 8 Keeping house, 9 Student, 10 Other economically inactive)
W_NW	Working or not working (derived from ECSTILO = 1) working=1, permanently unable to work=2, other inactive =3
WKSTILO	Working status (1 Full time 2 Part time 3 Working NA hours 4 Government scheme 5 Unemployed (ILO def) 6 Econ inactive)
NVQLEV	NVQ/SVQ
GNVQ	GNVQ/GSVQ
HIQUAL	Highest qualification
EDLEV00	Education level -2000
EDLEV7	Education level -2000 (3 groups)
EDLEV10	Education level -2000 (4 groups)
BENTOT	Annual income from state benefits
GROTHER	Gross annual income from other sources
NTOTHER	Net annual income from other sources
REGLRTOT	Annual income from regular payments
OTHREG	Other regular payments per year

	Individual_socio_economic_data continued
GRMAINJB	Usual gross annual earnings from main job (employee plus bonus, self employed/profits)
NTMAINJB	Usual net annual earnings from main job
GRSECJOB	Gross annual earnings from other jobs
NTSECJOB	Net annual earnings from other jobs
GREARN	Gross earned income (main and other jobs) per year
NTEARN	Net earned income (main and other jobs) per year
GRIND	Usual gross annual income (GREARN+BENTOT+GROTHER+REGLRTOT+OTHREG)
NTIND	Usual net annual income

Some further notes regarding the tables are relevant. Firstly, by nature of the direct link between the household and individual data provided by HID, the household data displayed in the Table Household_data (i.e. Hholdtype1, NPERSONS, NUMCHILD, NPENSNRS, NWORKAGE and NWORKING) can be constructed directly from the Table Individual_socio-economic_data using the appropriate definitions.

Secondly, longstanding illnesses in the Table Individual_health_care_data (ICD1-6) have been recorded using the International Classification of Diseases (ICD) Revision 9 (WHO, 1997) and were aggregated using the ICD chapter headings (Condition Group1-6).

Thirdly, the sector/commodity classification (Sector1) has been derived using the variable INDM92M - available online from the UKDA as Variable 589, Quarterly Labour Force Survey, September-November 2002 - and the 123 industry/product classification of the Supply and Use Tables (ONS, 2002). The former decodes the GHS version of the 1992 Standard Industrial Classification (SIC92), whereas the latter categorises these into 123 industry/products, which in turn were grouped into Sector1.

Fourthly, missing values are generally reported by a '-6', a '-8' or a '-9' value:

- '-6' means that the person was not eligible to answer a particular section;
- '-8' means 'No answer' and was used if the respondent either did not know the answer or refused to answer a particular question;
- '-9' means 'Does not apply' and is used when a household/individual is eligible to answer but is routed past the question by the flow of the questionnaire.

For the income section, missing values are reported by a '-7' (the person refuses to answer the whole income section), a '-8' (see above) or a '-9' (combines '-6' and '-9' from above).

Finally, the income data of the GHS provided values in excess of National Statistics data from the ONS, so that the data had to be scaled down (usually by a factor between 1.5 and 2) in order to match the totals. Consequently only the distribution of income across labour and household types in the GHS was used and the use of its totals was avoided. The GHS does not seem to be a reliable source of income data.[12] For example, closer inspection of gross income (GRIND) yields many strange values, including zero (approximately 950 respondents representing 3 million individuals) or close to zero incomes. The source of these anomalies is not clear. In contrast, all other non-income data extracted from the GHS seem in line with other National Statistics Publications (apart from minor differences associated with the transfer of pensioners to a separate household unit).

[12] Indicative in this respect is that the GHS report only contains one table on income: usual gross weekly household income by family type (Table 3.11, ONS, 2001a).

APPENDIX TO CHAPTER 6

This appendix contains the GAMS model files employed in the calibration of and the simulations carried out with the static CGE model for the UK with health care provision effects. The files are available in electronic form from the author upon request. Explanatory text is included (either by insertion of an '*' at the beginning of a sentence, or using the commands $ontext and $offtext before and after a paragraph).

READDATA.GMS

```
* This file imports data from the Excel data file (HealthSAM.xls) and puts data in
* HealthSAM.dat using libinclude routine gams2prm. This is a routine to write parameters
* or level values in GAMS readable form to an external file (text file HealthSAM.dat)
* and so is a relatively easy way of transfering data to and from a spreadsheet program

* Import data from HealthSAM.xls and put in parameters Use, Make and SAM
Parameters Use(*,*), Make(*,*), SAM(*,*);
$libinclude xlimport Use HealthSAM.xls Use
$libinclude xlimport Make HealthSAM.xls Make
$libinclude xlimport SAM HealthSAM.xls SAM

* declare GAMS readable file
file mydata /'HealthSAM.dat'/;

* make it current (i.e. file to be written to)
put mydata;

* write output to HealthSAM.dat
$libinclude gams2prm Use
$libinclude gams2prm Make
$libinclude gams2prm SAM
```

DATA.GMS

```
* This file defines all sets (sectors or activities, households,
* factors of production), multiplier to check for homogeneity and
* performs calculations on data put in HealthSAM.dat:
*       scaling (all values in MPSGE represent billions)
*       calculation of ad valorem tax rates
*       reformating health expenditures into NHS and PHC

$offlisting


$include healthsam.dat
Sets a  all activities/
```

```
1       Primary
2       Pharmaceuticals
3       Medical instruments
4       Other manufacturing
5       Energy
6       Construction
7       Distribution and transport
8       Finance
9       Public administration and defence
10      Health care
11      Other services
NHS       Dummy sector for National Health Service
PHC       Dummy sector for private health consumption
SKILL     Skilled labour
UNSK      Unskilled labour
CAP       Capital (operating surplus)
TAX       Net taxation on products
HSE1      Pensioners
HSE2      Non-working with children
HSE3      Non-working without children
HSE4      Working with children
HSE5      Working without children
INV       Investment
GOVT      Government
EXPORT  Exports
MARGIN  Margins
IMPORT    Imports
/;
alias(a,b);

set i   sectors and commodities/
1       Primary
2       Pharmaceuticals
3       Medical instruments
4       Other manufacturing
5       Energy
6       Construction
7       Distribution and transport
8        Finance
9        Public administration and defense
10       Health care
11       Other services
NHS   Dummy sector for National Health Service
PHC   Dummy sector for private health consumption
/;
alias (i,j);

set f   factors of production/
skill     Skilled labour
unsk    Unskilled labour
CAP    Capital (operating surplus)
/;
alias (f,d);
set h   households/
HSE1    Pensioners
HSE2    Non-working with children
HSE3    Non-working without children
```

```
HSE4    Working with children
HSE5    Working without children
/;
alias(h,g);

* Reformat health expenditures (NHS and PHC)
*       NHS buys health care from the health sector and sells it to the government
*       PHC buys health care from the health sector and sells it to households

Use("10","NHS")        = Use("10","GOVT");
Use("NHS","GOVT") = Use("10","GOVT");
Use("10","GOVT")     = 0;

Use("10","PHC")   = sum[h, Use("10",h)];
Use("PHC",h)        = Use("10",h);
Use("10",h)           = 0;

Make("NHS","NHS") = Use("NHS","GOVT");
Make("PHC","PHC")  = sum[h, Use("PHC",h)];

Display Use,Make;

* Scaling: (SCALE can be declared previously, otherwise default of 1,000)
$if not declared Scale Scalar Scale /1E3/;
Use(a,b)   = Use(a,b) / Scale;
Make(a,b)=Make(a,b) / Scale;
alias(*,all1,all2);
sam(all1,all2) = sam(all1,all2) / Scale;

* Calculation ad valorem tax rates:
*       output tax (ctax,ptax) are net tax, so producers receive (1-taxrate)* market price
*       input tax (etax) defined as gross tax, so producers pay  (1+taxrate)* market price

Parameters
CTAX    consumption tax
PTAX    production tax
ETAX    employment tax

CTAX0,PTAX0,ETAX0;

PTAX(j)$sum[a, USE(a,j)] = USE("TAX",j) / sum[a, USE(a,j)];
PTAX0(j)= PTAX(j);

ETAX(f)$sum[h, SAM(h,f)] = SAM("tax",f) / sum[h, SAM(h,f)];
ETAX0(f) = ETAX(f);

Parameters
VE        Value of exports
VM       Value of imports
VD        Value of domestic demand including consumption tax
VDN     Value of domestic demand excluding consumption tax;

VE(i)    = Use(i,"EXPORT")         ;
VM(i)   = Make(i,"IMPORT")        ;
VD(i)    = sum[a, Make(i,a)] - VE(i);
VDN(i) = VD(i) - MAKE(i,"TAX")    ;
```

```
CTAX(i)$VD(i) = 1 - VDN(i)/VD(i);
CTAX0(i)      = CTAX(i)        ;

display PTAX,ETAX,CTAX;

Scalar  Mult Check homogeneity of model /1/;
```

MODEL.GMS

```
* This is a simple static CGE model for the UK

* stops echoprinting input file
$offlisting
$include data.gms

* GAMS cannot read MPSGE syntax, so make it a GAMS text section
$ontext

* declare model name
$model:SCGE

* declare quantity variables for production sectors
* (solutions from zero profit conditions)
$sectors:
        X(i)          ! production of sector i
        CET(i)        ! armington aggregate demand (domestic and export)
        ST            ! total (real) savings
        M(i)$VM(i) ! imports of commodity i
        E(i)$VE(i)   ! exports of commodity i

* declare price variables for commodities
* (solutions from market clearing equations)
$commodities:
        PQ(i)         ! producer price commodity i
        PD(i)         ! domestic consumption price commodity i
        PE(i)$VE(i)      ! export price commodity i
        PM(i)$VM(i)    ! import price commodity i
        PF(f)         ! price of factor f
        PS            ! price of savings
        ER            ! exchange rate (price of foreign exchange)
        PYG           ! price of artificial commodity 'real tax income'
        PTR           ! price of artificial commodity 'transfer'

* declare income variables of consumers
* (solutions from income balance equations)
$consumers:
        YG            ! government income
        TR            ! transfers to households
        Y(h)          ! household income

* specify production functions
* note you need benchmark quantities Q (1st order approximation: anchor point),
* prices P(2nd order approx: slope) and s (3rd order approx: curvature)
$prod:X(i)       s:0     t:1     va:1
     O:PQ(j)   Q:Make(j,i)                        A:YG  T:PTAX(i)  P:(1-PTAX0(i))
     I:PF(f)     Q:(Use(f,i)/(1+ETAX0(f)))       A:YG T:ETAX(f)  P:(1+ETAX0(f)) va:
```

```
     I:PD(j)     Q:Use(j,i)

$prod:CET(i)      s:0     t:2   arm:2
     O:PD(i)      Q:VD(i)                        A:YG T:CTAX(i)  P:(VDN(i)/VD(i))
     O:PE(i)      Q:VE(i)
     I:PQ(i)      Q:(sum(j, Make(i,j)))          arm:
     I:PM(i)      Q:VM(i)                        arm:
     I:PD("7")   Q:Make(i,"Margin")

$prod:ST          s:0
     O:PS        Q:(sum(i,Use(i,"inv")))
     I:PD(i)     Q:Use(i,"inv")

$prod:M(i)$VM(i)
     O:PM(i)     Q:VM(i)
     I:ER        Q:VM(i)

$prod:E(i)$VE(i)
     O:ER        Q:VE(i)
     I:PE(i)     Q:VE(i)

* specify demand functions
$demand:YG
     D:PYG       Q:SAM("gov","tax")

$demand:TR        s:1
     E:PYG       Q:(Mult*SAM("gov","tax"))
     E:PD(i)     Q:(-Mult*Use(i,"GOVT"))
     E:ER        Q:(Mult*(SAM("gov","row")-SAM("row","gov")))
     D:PTR       Q:(sum(h,SAM(h,"gov")))

$demand:Y(h)      s:1
     E:PF(f)     Q:(Mult*SAM(h,f))
     E:PTR       Q:(Mult*SAM(h,"gov"))
     D:PD(i)     Q:Use(i,h)
     D:PS        Q:SAM("inv",h)

* report variable levels
$report:
     V:U(h)      W:Y(h)
$offtext

* SCGE model is defined: invokes MPSGE preprocessor to declare model for GAMS
* reads MPSGE code and generates GAMS readable code including generator file
$sysinclude mpsgeset SCGE

* check benchmark replication (marginals are slack variables, should be zero):
SCGE.ITERLIM = 0    ;

* numeraire (fix variable implies equation is omitted)
ER.FX = 1;

* SCGE model is generated: replicates model with values instead of parameter
* names. All functions in the model are calibrated at this point (using Q, P
* and s el info; not T: field!) so do not include GAMS statements between this
* statement and the solve statement. Note that calibration tax levels are
* denoted by a 0, and simulation levels (in T: field) are not. If you want to
```

```
* change starting values of taxes (incorporated in calibration) then change the
* former, whereas if you want to perform a counter-factual simulation then
* change the latter.
$include SCGE.GEN

* check  what model looks like after last statement using the
* execute 'dos command'; statement where ' ' is any valid dos command or
* program name
* execute 'pause';

* SCGE model is solved: using Mixed Complementarity Programming
* (solves quantities, prices and income levels from zero-profit,
* market clearing and income balance equations respectively
solve SCGE using mcp;

* residual after solving model should be close to zero
abort$(SCGE.OBJVAL > 1e-3) "benchmark replication failed", SCGE.OBJVAL;

* numeraire check:
SCGE.ITERLIM = 1000 ;
ER.FX             = 10     ;
$include SCGE.GEN
solve SCGE using mcp;
abort$(abs(ST.l-1) > 1e-5) "numeraire check failed", SCGE.OBJVAL;

* homegeneity check:
ER.FX  = 1         ;
MULT  = 10         ;
$include SCGE.GEN
solve SCGE using mcp;
abort$(abs(PS.l-1) > 1e-5) "homegeneity check failed", SCGE.OBJVAL;
```

MODEL2.GMS

```
* This is the simple static model (model.gms) with additions:
*  (1) health care affects effective labour supply (Thesis Chapter 6)
*  (2) government expenditures on each good (incl. health care) fixed in value
*      (measured in fe terms (ER)) or in real terms (see GCMult(i))
*  (3) pharmaceuticals price which domestic consumers pay (PD) is set by
*      world import price (if target("2")>0). The purpose is to generate an import
*      price that leads to a certain rise (20%) in PD. The price rise is fully
*      compensated in foreign exchange so does not alter government account
*      in which imports are put.

$offlisting
$include data.gms

Parameter
Target(i)       If target(i)>0 commodity i's price is set by world price
GCMult(i)     Government consumption multiplier

* Parameters associated with effective labour supply and waiting lists
Eta0             Non participation rate if health care does not affect WL
Fbar              Fixed endowment of factor f by household h
Upsilon(i,f)   Share parameter health composite
Epsilon(f)     Waiting list elasticity;
```

```
* Price of pharmaceuticals is set on world market
Target(i)      = 0;
Target("2")  = 1;

* government expenditures on each good (incl. health care) fixed in value
GCMult(i)    = 1;

* Waiting list elasticity values
Epsilon(f)   = 2;

* with HC = 1 in benchmark, eta0 is also benchmark non-participation rate
Eta0("skill")   = 0.0289;
Eta0("unsk")  = 0.0434;
Fbar(h,f)         = SAM(h,f) * 1/(1-Eta0(f));

* Share of 'health' determined by public (NHS) care:
Upsilon("NHS","Unsk") = 0.960;
Upsilon("NHS","Skill")  = 0.834;

* Share of 'health' determined by private (PHC) care:
Upsilon("PHC","Unsk")   = 1-Upsilon("NHS","Unsk") ;
Upsilon("PHC","Skill")    = 1-Upsilon("NHS","Skill");

* if there is a parent file that includes this file then solution and solver
* status file not printed
$if not "%system.incparent%"=="" option sysout=off;option solprint=off;

$ontext
$model:SCGE
$sectors:
        X(i)            ! production of sector i
        CET(i)        ! armington aggregate demand (domestic and export)
        ST                                          ! total (real) savings
        M(i)$(VM(i) and Target(i)=0)    ! imports of commodity i
        E(i)$VE(i)                              ! exports of commodity i
$commodities:
        PQ(i)              ! producer price commodity i
        PD(i)              ! domestic consumption price commodity i
        PE(i)$VE(i)     ! export price commodity i
        PM(i)$VM(i)   ! import price commodity i
        PF(f)               ! price of factor f
        PS                   ! price of savings
        ER                   ! exchange rate (price of foreign exchange)
        PYG               ! price of artificial commodity real tax income
        PTR                ! price of artificial commodity transfer
$consumers:
        YG                  ! government income
        TR                   ! transfers to households
        Y(h)                ! household income

* Specify auxiliary variables that are solved in the $constraint block
* The constraints are applied by using the label R: in endowment field
* the auxiliary variable enters as multiplier
$auxiliary:
        QM(i)$(VM(i) and Target(i))   ! Auxiliary var imports
        NET(i)$(VM(i) and Target(i))  ! Auxiliary var foreign exchange
```

```
        GOVCONS(i)$(USE(i,"GOVT"))    ! Real government consumption
        HC(f)                         ! Health composite
        EPR(f)                        ! Effective participation rate

$prod:X(i)      s:0  t:1  va:1
     O:PQ(j)    Q:Make(j,i)                         A:YG T:PTAX(i) P:(1-PTAX0(i))
     I:PF(f)     Q:(Use(f,i)/(1+ETAX0(f)))   A:YG T:ETAX(f) P:(1+ETAX0(f))  va:
     I:PD(j)     Q:Use(j,i)

$prod:CET(i)     s:0  t:2  arm:2
     O:PD(i)     Q:VD(i)                  A:YG T:CTAX(i) P:(VDN(i)/VD(i))
     O:PE(i)     Q:VE(i)
     I:PQ(i)      Q:(sum(j, Make(i,j)))       arm:
     I:PM(i)     Q:VM(i)                      arm:
     I:PD("7")  Q:Make(i,"margin")

$prod:ST         s:0
     O:PS       Q:(sum(i,Use(i,"inv")))
     I:PD(i)    Q:Use(i,"inv")

* Imports modelled as usual if prices not determined on world market
$prod:M(i)$(VM(i) and Target(i)=0)
     O:PM(i)    Q:VM(i)
     I:ER         Q:VM(i)

$prod:E(i)$VE(i)
     O:ER       Q:VE(i)
     I:PE(i)     Q:VE(i)

$demand:YG
     D:PYG      Q:SAM("gov","tax")

$demand:TR                  s:1
     E:PYG                          Q:(Mult*SAM("gov","tax"))
     E:PD(i)$Use(i,"GOVT")  Q:(-Mult*Use(i,"GOVT"))        R:GOVCONS(i)
     D:PTR                          Q:(sum(h,SAM(h,"gov")))
     E:ER                           Q:(Mult*(SAM("gov","row")-SAM("row","gov")))
* Put imports here if price is determined on world market:
* Instead of import sector the government buys imports with foreign exchange
* and sells at price PM. QM: Quantity of imports normalised to 1 replacing M
* for positive target required to meet target price equation.
* NET: value of foreign exchange of these imports. Is fully compensated so does
* not alter government account; ER#(i): undocumented GAMS feature:
* foreign exchange for i if target(i)>0
     E:PM(i)$Target(i)      Q:(Mult*VM(i))                R:QM(i)
     E:ER#(i)$Target(i)     Q:(-Mult*VM(i))               R:NET(i)

$demand:Y(h)               s:1
     E:PF(f)              Q:(Mult*Fbar(h,f))            R:EPR(f)
     D:PD(i)              Q:Use(i,h)
     D:PS                  Q:SAM("inv",h)
     E:PTR                Q:(Mult*SAM(h,"gov"))

$report:
     V:U(h)     W:Y(h)
     V:FD(f,i)   I:PF(f)        prod:X(i)
     V:N(j,i)     I:PD(j)        prod:X(i)
```

```
     V:QS(i)     I:PQ(i)        prod:CET(i)
     V:QTM(i)  I:PD("7")    prod:CET(i)
     V:INV(i)   I:PD(i)        prod:ST
     V:C(i,h)    D:PD(i)      demand:Y(h)
     V:S(h)      D:PS          demand:Y(h)

* Domestic consumer price PD is targeted by world import price
* (PWM = 1 in benchmark)
$constraint:QM(i)$(VM(i) and Target(i))
       PD(i) =E= Target(i) * ER;

* test constrain imports pharmaceuticals (condition is always met)
*       PM(i) =E= ER;

* Government pays correct amount of foreign exchange for imports
$constraint:NET(i)$(VM(i) and Target(i))
       NET(i)=E= QM(i)* PM(i)/ER;

* GCMult(i)=0: govt exp on good i are fixed in real terms
* GCMult(i)>0: govt exp on good i are fixed in value (ER) and equal to:
* PD(i)*Mult*Use(i,"GOVT")*GCMult(i)*ER/PD(i), so (real) government
* consumption of good i equals: Mult*Use(i,"GOVT")*GCMult(i)*ER/PD(i)
* Fixed in terms of another price (here numeraire ER) to prevent choice of /
* change in numeraire to affect outcome. Rewrite constraint:PD(i)*GOVCONS(i)=
* ER* GCMULT(i): lhs is fixed in ER terms, GCMULT(i)>1 simulates rise exp on i
$constraint:GOVCONS(i)$Use(i,"GOVT")
        GOVCONS(i) =E= GCMult(i) * ER/PD(i) + 1$(GCMult(i) = 0);

* Specification of health composite as a function of NHS and PHC
$constraint:HC(f)
        HC(f)      =E= prod[i, (CET(i)/Mult)**Upsilon(i,f)];

* Effective participation rate = 1- non-participation rate
$constraint:EPR(f)
        EPR(f)     =E= 1-Eta0(f)/(HC(f)**Epsilon(f));

$offtext
$sysinclude mpsgeset SCGE

* check benchmark replication:
SCGE.ITERLIM = 0       ;
QM.L(i)      = Target(i);
NET.L(i)     = Target(i);
HC.L(f)      = 1       ;
EPR.L(f)     = 1-Eta0(f);
GOVCONS.L(i) = 1       ;
ER.FX        = 1       ;
$include SCGE.GEN
solve SCGE using mcp;
abort$(SCGE.OBJVAL > 1e-3) "benchmark replication failed", SCGE.OBJVAL;

* store utility to quickly save variable values, changes and % changes
$libinclude store these X CET ST M E PQ PD PE PM PF PS ER YG TR Y QM NET
$libinclude store these GOVCONS HC EPR U FD N QS QTM INV C S

* EV = change utility for each household
$libinclude store calc Utility (h)= u.l(h)*[sum[i,Use(i,h)]+Sam('inv',h)];
```

```
* total EV (sum of each household's EV + govt cons (incl. public health care):
$libinclude store calc Welfare = sum[h,utility(h)] + sum[i, GOVCONS.L(i)*Use(i,"govt")];

Table alphaG(i,h) Share of household h in public good provisioning of i
        HSE1    HSE2  HSE3  HSE4   HSE5
9       0.176   0.064   0.054   0.370   0.336
NHS  0.251   0.087   0.076   0.306   0.280
11     0.176   0.064   0.054   0.370   0.336;

* EV, including welfare changes related to public goods (incl. health care):
$libinclude store calc Utility1 (h) = utility(h) + sum[i, alphaG(i,h)*GOVCONS.L(i)*Use(i,"govt")];

* total EV (sum of household EV's excluding public good provisioning):
$libinclude store calc WelfareEx = sum[h,utility(h)];

* Household income from factors and transfers
$libinclude store calc YHF (h,f) = PF.l(f)*Fbar(h,f)*EPR.l(f);
$libinclude store calc YHTR (h) = PTR.l* SAM(h,"gov");

* Variables waiting list (WL), effective endowments (FE) and
* non-participation rate (eta):
$libinclude store calc FE (h,f)= Fbar(h,f)*EPR.l(f)  ;
$libinclude store calc WL (h,f)= Fbar(h,f)-FE(h,f)   ;
$libinclude store calc eta (f) = 1-EPR.l(f)          ;

* Government expenditures
$libinclude store calc GEXP (i) = GOVCONS.L(i)*Use(i,"govt")*PD.l(i);

* set the model name and base scenario in the store utility:
$libinclude store setmodel SCGE
$libinclude store base
$libinclude store setbase base

* numeraire check:
SCGE.ITERLIM = 1000;
ER.FX        = 1.5;
$include SCGE.GEN
solve SCGE using mcp;
abort$(abs(ST.l-1) > 1e-5) "numeraire check failed", SCGE.OBJVAL;

* homegeneity check:
ER.FX = 1;
MULT  = 2;
$include SCGE.GEN
solve SCGE using mcp;
abort$(abs(PS.l-1) > 1e-5) "homegeneity check failed", SCGE.OBJVAL;
MULT  = 1;

* if there is a parent file that includes this file then do not include following
* simulations and display statement, but go directly to the label end
$if not "%system.incparent%"=="" $goto end

* test increase in pharmaceutical price, govt exp all goods i fixed in value:
* Target("2") = 1.2; This statement followed directly by the $batinclude
* statement gives errors in equations. GAMS just carries on from where it came
* to - the levels (.L) of variables don't get reset, so instead do it stepwise:
```

```
Target("2") = 1.1 ;
$include SCGE.gen
solve SCGE using mcp;

Target("2") = 1.2 ;

* statement invokes solve file
$batinclude solve exp2a
Target("2")   = 1;

* test increase in pharmaceutical price, govt cons health care (NHS) fixed
* for other goods govt expenditures still fixed in value:
GCMult("NHS") = 0;
Target("2") = 1.2;

$batinclude solve exp2b
Target("2")   = 1;
GCMult("NHS") = 1;

* test an increase in health expenditure, govt exp all goods i fixed in value
* pharmaceutical price NOT determined on world market:
Target("2")   = 0;
GCMult("NHS") = 1.1;
$batinclude solve exp1A
GCMult("NHS") = 1;
Target("2")   = 1;

* test constraints imports of pharmaceuticals (compare with NHS):
* while replacing constraint on QM by PM(i) =E= ER
* Target("2")   =1;
* GCMult("NHS") = 1.1;
* $batinclude solve test

* display the variable values, changes and % changes
$libinclude store display changes percent

* Write results to text file (readable in Excel):
* declare file
file myresults /'resultsm2.csv'/;
* make it current (i.e. file to be written to)
put myresults;
* write output to results.csv
$libinclude writecsv  p_PF v_EPR v_ETA p_HC c_Utility1 p_Utility1
*ResultsCh ResultsPer
Parameters p_FEunsk,p_FEsk,p_WLunsk, p_WLsk, p_Welfare, c_Welfare;
p_FEunsk(h,sims) = p_FE(sims,h,"unsk") ;
p_FEsk(h,sims)   = p_FE(sims,h,"skill");
p_WLunsk(h,sims) = p_WL(sims,h,"unsk") ;
p_WLsk(h,sims)   = p_WL(sims,h,"skill");
p_Welfare(sims)  = ResultsPer("Welfare",sims);
c_Welfare(sims)  = ResultsCh("Welfare",sims);

$libinclude writecsv p_FEunsk p_FEsk p_WLunsk p_WLsk p_Welfare c_Welfare

Parameter c_WelfareEx, p_WelfareEx;
p_WelfareEx(sims)  = ResultsPer("WelfareEx",sims);
c_WelfareEx(sims)  = ResultsCh("WelfareEx",sims);
```

```
$libinclude writecsv c_Utility p_Utility c_WelfareEx p_WelfareEx

$label end
```

MODEL3.GMS

```
* This is the same as model2, but with possibility of sector-specific factors

$offlisting
$include data.gms

Parameter
Target(i)     If target(i)>0 comm i's price is set by world price
GCMult(i)  Government consumption multiplier
Eta0           Non participation rate if health care does not affect WL
Fbar           Fixed endowment of factor f by household h
SFbar         Fixed endowment of sector-specific factor by household h
Upsilon(i,f) Share parameter health composite
Epsilon(f)   Waiting list elasticity;

Target(i)      = 0;
Target("2")  = 1;
GCMult(i)   = 1;

Epsilon(f)      = 2;
Eta0("skill")  = 0.0289;
Eta0("unsk") = 0.0434;

Upsilon("NHS","Unsk") = 0.960;
Upsilon("NHS","Skill")  = 0.834;
Upsilon("PHC","Unsk") = 1-Upsilon("NHS","Unsk") ;
Upsilon("PHC","Skill")  = 1-Upsilon("NHS","Skill");

* Introduce sector-specific factor: share of factor f in sector i immobile
Parameter FSHARE(f,i) Share of sector-specific factor in factor use sector;
FSHARE(f,i)           = 0   ;
* doctors and nurses in health care are immobile (85%)
FSHARE("skill","10")   = 0.85;

* 90% of capital (buildings) in health care are immobile
FSHARE("cap","10")     = 0.90;

* Adjust endowments households accordingly
Fbar(h,f)      = SAM(h,f);
SFbar(h,f,i) = (Fbar(h,f)/sum(g,Fbar(g,f)))*FSHARE(f,i)*Use(f,i)/(1+ETAX0(f));
Fbar(h,f)     = Fbar(h,f)-sum(i, SFbar(h,f,i));
Fbar(h,f)     = Fbar(h,f)*1/(1-Eta0(f))       ;
SFbar(h,f,i) = SFbar(h,f,i)*1/(1-Eta0(f))    ;

* Adjust factor use in production accordingly
Parameter Mfactor(f,i) Use of mobile factor by sector
               Sfactor(f,i) Use of sector-specific factor;
Sfactor(f,i)  = Use(f,i)*FSHARE(f,i)/(1+ETAX0(f))    ;
Mfactor(f,i) = Use(f,i)*(1-FSHARE(f,i))/(1+ETAX0(f));

$if not "%system.incparent%"=="" option sysout=off; option solprint=off;
```

```
$ontext
$model:SCGE
$sectors:
        X(i)          ! production of sector i
        CET(i)        ! armington aggregate demand (domestic and export)
        ST            ! total (real) savings
        M(i)$(VM(i) and Target(i)=0)    ! imports of commodity i
        E(i)$VE(i)   ! exports of commodity i
$commodities:
        PQ(i)            ! producer price commodity i
        PD(i)            ! domestic consumption price commodity i
        PE(i)$VE(i)   ! export price commodity i
        PM(i)$VM(i) ! import price commodity i
        PF(f)            ! price of factor f
        PFS(f,i)$fshare(f,i)    ! sector specific factors
        PS                          ! price of savings
        ER              ! exchange rate (price of foreign exchange)
        PYG             ! price of artificial commodity 'real tax income'
        PTR             ! price of artificial commodity transfer
$consumers:
        YG           ! government income
        TR           ! transfers to households
        Y(h)         ! household income
$auxiliary:
        QM(i)$(VM(i) and Target(i))   ! Auxiliary var imports
        NET(i)$(VM(i) and Target(i))  ! Auxiliary var foreign exchange
        GOVCONS(i)$(USE(i,"GOVT"))    ! Real government consumption
        HC(f)                       ! Health composite
        EPR(f)                      ! Effective participation rate

$prod:X(i)      s:0  t:1  va:1
     O:PQ(j)    Q:Make(j,i)     A:YG T:PTAX(i) P:(1-PTAX0(i))
     I:PF(f)    Q:Mfactor(f,i)  A:YG T:ETAX(f) P:(1+ETAX0(f))  va:
     I:PFS(f,i) Q:Sfactor(f,i)   A:YG T:ETAX(f) P:(1+ETAX0(f))  va:
     I:PD(j)    Q:Use(j,i)

$prod:CET(i)     s:0  t:2  arm:2
     O:PD(i)    Q:VD(i)        A:YG  T:CTAX(i) P:(VDN(i)/VD(i))
     O:PE(i)    Q:VE(i)
     I:PQ(i)    Q:(sum(j, Make(i,j))) arm:
     I:PM(i)    Q:VM(i)                 arm:
     I:PD("7")  Q:Make(i,"Margin")

$prod:ST        s:0
     O:PS       Q:(sum(i,Use(i,"inv")))
     I:PD(i)    Q:Use(i,"inv")

$prod:M(i)$(VM(i) and Target(i)=0)
     O:PM(i)    Q:VM(i)
     I:ER        Q:VM(i)

$prod:E(i)$VE(i)
     O:ER       Q:VE(i)
     I:PE(i)    Q:VE(i)

$demand:YG
```

```
    D:PYG     Q:SAM("gov","tax")

$demand:TR            s:1
    E:PYG                         Q:(Mult*SAM("gov","tax"))
    E:PD(i)$Use(i,"GOVT")  Q:(-Mult*Use(i,"GOVT"))     R:GOVCONS(i)
    D:PTR                    Q:(sum(h,SAM(h,"gov")))
    E:ER                     Q:(Mult*(SAM("gov","row")-SAM("row","gov")))
    E:PM(i)$Target(i)     Q:(Mult*VM(i))            R:QM(i)
    E:ER#(i)$Target(i)    Q:(-Mult*VM(i))            R:NET(i)

$demand:Y(h)              s:1
    E:PF(f)               Q:(Mult*Fbar(h,f))        R:EPR(f)
    E:PFS(f,i)            Q:(Mult*SFbar(h,f,i))      R:EPR(f)
    D:PD(i)               Q:Use(i,h)
    D:PS                  Q:SAM("inv",h)
    E:PTR                 Q:(Mult*SAM(h,"gov"))

$report:
    V:U(h)      W:Y(h)
    V:FD(f,i)   I:PF(f)        prod:X(i)
    V:SFD(f,i) I:PFS(f,i)     prod:X(i)
    V:N(j,i)     I:PD(j)        prod:X(i)
    V:QS(i)     I:PQ(i)        prod:CET(i)
    V:QTM(i) I:PD("7")     prod:CET(i)
    V:INV(i)   I:PD(i)        prod:ST
    V:C(i,h)    D:PD(i)       demand:Y(h)
    V:S(h)       D:PS          demand:Y(h)


$constraint:QM(i)$(VM(i) and Target(i))
       PD(i)      =E= Target(i) * ER;
$constraint:NET(i)$(VM(i) and Target(i))
       NET(i)   =E= QM(i)* PM(i)/ER;
$constraint:GOVCONS(i)$Use(i,"GOVT")
       GOVCONS(i) =E= GCMult(i) * ER/PD(i) + 1$(GCMult(i)=0);
$constraint:HC(f)
       HC(f)      =E= prod[i, (CET(i)/Mult)**Upsilon(i,f)];
$constraint:EPR(f)
       EPR(f)    =E= 1-Eta0(f)/(HC(f)**Epsilon(f));
$offtext
$sysinclude mpsgeset SCGE

* check benchmark replication:
SCGE.ITERLIM = 0        ;
QM.L(i)      = Target(i);
NET.L(i)     = Target(i);
HC.L(f)       = 1        ;
EPR.L(f)     = 1-Eta0(f);
GOVCONS.L(i) = 1        ;
ER.FX         = 1        ;
$include SCGE.GEN
solve SCGE using mcp;
abort$(SCGE.OBJVAL > 1e-3) "benchmark replication failed", SCGE.OBJVAL;

$libinclude store these X CET ST M E PQ PD PE PM PF PS ER YG TR Y QM NET
$libinclude store these GOVCONS HC EPR U PFS FD SFD N QS QTM INV C S
```

```
$libinclude store calc utility (h)  = u.l(h)*[sum[i,Use(i,h)]+Sam('inv',h)];
$libinclude store calc welfare     = sum[h,utility(h)] + sum[i, GOVCONS.L(i)*Use(i,"govt")];
$libinclude store calc WelfareEx = sum[h,utility(h)];

Table alphaG(i,h) Share of household h in public good provisioning of i
       HSE1     HSE2  HSE3  HSE4  HSE5
9       0.176    0.064   0.054   0.370   0.336
NHS  0.251    0.087   0.076   0.306   0.280
11      0.176    0.064   0.054   0.370   0.336;

$libinclude store calc Utility1 (h) = utility(h) + sum[i, alphaG(i,h)*GOVCONS.L(i)*Use(i,"govt")];

$libinclude store calc YHF (h,f) = PF.l(f)*Fbar(h,f)*EPR.l(f);
* YHFS (income household from specific factors)
$libinclude store calc YHFS (h,f,i) = PFS.l(f,i)*SFbar(h,f,i)*EPR.l(f);
$libinclude store calc YHTR (h)     = PTR.l* SAM(h,"gov");

$libinclude store calc FE (h,f)  = Fbar(h,f)*EPR.l(f)  ;
$libinclude store calc WL (h,f) = Fbar(h,f)-FE(h,f)   ;
$libinclude store calc eta (f)      = 1-EPR.l(f)          ;

* store SFE (effective endowment specific factor) and SWL (its waiting list)
$libinclude store calc SFE (h,f,i)  = SFbar(h,f,i)*EPR.l(f)  ;
$libinclude store calc SWL (h,f,i) = SFbar(h,f,i)-SFE(h,f,i);

$libinclude store calc GEXP (i) = GOVCONS.L(i)*Use(i,"govt")*PD.l(i);

$libinclude store setmodel SCGE
$libinclude store base
$libinclude store setbase base

* numeraire check:
SCGE.ITERLIM = 1000;
ER.FX                 = 1.5;
$include SCGE.GEN
solve SCGE using mcp;
abort$(abs(ST.l-1) > 1e-5) "numeraire check failed", SCGE.OBJVAL;

* homegeneity check:
ER.FX = 1;
MULT  = 2;
$include SCGE.GEN
solve SCGE using mcp;
abort$(abs(PS.l-1) > 1e-5) "homegeneity check failed", SCGE.OBJVAL;
MULT  = 1;

$if not "%system.incparent%"=="" $goto end

* test an increase in health expenditure, govt exp all goods i fixed in value
* pharmaceutical price NOT determined on world market:
* skilled wage in health care is fixed
* PFS.fx("skill","10")= 1;
Target("2")                = 0;
GCMult("NHS")        = 1.1;
$batinclude solve exp1B
GCMult("NHS")       = 1;
Target("2")               = 1;
```

```
$libinclude store display changes percent

file myresults /'resultsm3.csv'/;
put myresults;

$libinclude writecsv  p_PF v_EPR v_ETA p_HC c_Utility1 p_Utility1

Parameters p_FEunsk,p_FEsk,p_WLunsk, p_WLsk, p_Welfare, c_Welfare;
p_FEunsk(h,sims) = p_FE(sims,h,"unsk") ;
p_FEsk(h,sims)     = p_FE(sims,h,"skill");
p_WLunsk(h,sims) = p_WL(sims,h,"unsk") ;
p_WLsk(h,sims)     = p_WL(sims,h,"skill");
p_Welfare(sims)     = ResultsPer("Welfare",sims);
c_Welfare(sims)     = ResultsCh("Welfare",sims);

$libinclude writecsv p_FEunsk p_FEsk p_WLunsk p_WLsk p_Welfare c_Welfare

Parameter c_WelfareEx, p_WelfareEx;
p_WelfareEx(sims)  = ResultsPer("WelfareEx",sims);
c_WelfareEx(sims)  = ResultsCh("WelfareEx",sims);

$libinclude writecsv c_Utility p_Utility c_WelfareEx p_WelfareEx

$label end
```

IMPORTSKILLEDWORKERSMODEL3.GMS

```
* This is the same as model3, but with import of skilled workers in health care

* Foreign workers (FW) earn the health care specific skilled wage.
* The income (YF) can be sent home in the form of remittances (REM) or kept
* in the economy in the form of foreign worker transfers (FWT) at an artifical
* price (PFWT). These are distributed over households according to each
* household's share (alphaf) of the endowment of hc spec skilled labour (yielding
* YFW). Foreign skilled workers in health care benefit in the same way from health
* improvements as their domestic counterpart (yielding effective endowment FWE
* and waiting list FWL).

* Target variable fixing import p of pharmaceuticals is removed for simplicity

$offlisting
$include data.gms

Parameter
GCMult(i)     Government consumption multiplier
Eta0             Non participation rate if health care does not affect WL
Fbar             Fixed endowment of factor f by household h
SFbar          Fixed endowment of sector-specific factor by household h
Upsilon(i,f)  Share parameter health composite
Epsilon(f)    Waiting list elasticity;

GCMult(i)    = 1;

Epsilon(f)     = 2;
Eta0("skill") = 0.0289;
```

```
Eta0("unsk")= 0.0434;

Upsilon("NHS","Unsk") = 0.960;
Upsilon("NHS","Skill")  = 0.834;
Upsilon("PHC","Unsk") = 1-Upsilon("NHS","Unsk") ;
Upsilon("PHC","Skill")  = 1-Upsilon("NHS","Skill");

Parameter FSHARE(f,i) Share of sector-specific factor in factor use sector;
FSHARE(f,i)           = 0   ;
FSHARE("skill","10")   = 0.85;
FSHARE("cap","10")     = 0.90;

Fbar(h,f)    = SAM(h,f);
SFbar(h,f,i) = (Fbar(h,f)/sum(g,Fbar(g,f)))*FSHARE(f,i)*Use(f,i)/(1+ETAX0(f));
Fbar(h,f)     = Fbar(h,f)-sum(i, SFbar(h,f,i));
Fbar(h,f)     = Fbar(h,f)*1/(1-Eta0(f))       ;
SFbar(h,f,i) = SFbar(h,f,i)*1/(1-Eta0(f))    ;

Parameter Mfactor(f,i) Use of mobile factor by sector
              Sfactor(f,i) Use of sector-specific factor;
Sfactor(f,i)  = Use(f,i)*FSHARE(f,i)/(1+ETAX0(f))    ;
Mfactor(f,i) = Use(f,i)*(1-FSHARE(f,i))/(1+ETAX0(f));

Parameter

alphaf(h)  share of income foreign worker to household h
FW(f,i)     foreign worker of type f employed in sector i
alphar      remittances of income foreign workers to ROW as share;

FW(f,i)              = 0;
alphar               = 0;
alphaf(h)             = 0;

$if not "%system.incparent%"=="" option sysout=off; option solprint=off;

$ontext
$model:SCGE
$sectors:
        X(i)            ! production of sector i
        CET(i)          ! armington aggregate demand (domestic and export)
        ST              ! total (real) savings
        M(i)$VM(i) ! imports of commodity i
        E(i)$VE(i)   ! exports of commodity i
$commodities:
        PQ(i)             ! producer price commodity i
        PD(i)             ! domestic consumption price commodity i
        PE(i)$VE(i)    ! export price commodity i
        PM(i)$VM(i)  ! import price commodity i
        PF(f)             ! price of factor f
        PFS(f,i)$fshare(f,i) ! sector specific factors
        PS                        ! price of savings
        ER                  ! exchange rate (price of foreign exchange)
        PYG                ! price of artificial commodity 'real tax income'
        PTR                ! price of artificial commodity transfer
        PFWT$(SUM(i,SUM(f,FW(f,i))) AND (1-alphar)) ! price of art.comm. for. worker transfer
$consumers:
        YG                        ! government income
```

```
        TR                        ! transfers to households
        Y(h)                      ! household income
        YF$SUM(i,SUM(f,FW(f,i)))      ! income of foreign workers
$auxiliary:
        GOVCONS(i)$(USE(i,"GOVT"))    ! Real government consumption
        HC(f)                     ! Health composite
        EPR(f)                    ! Effective participation rate

$prod:X(i)      s:0  t:1  va:1
     O:PQ(j)    Q:Make(j,i)      A:YG T:PTAX(i) P:(1-PTAX0(i))
     I:PF(f)      Q:Mfactor(f,i)  A:YG T:ETAX(f) P:(1+ETAX0(f))  va:
     I:PFS(f,i)  Q:Sfactor(f,i)   A:YG T:ETAX(f) P:(1+ETAX0(f))  va:
     I:PD(j)    Q:Use(j,i)

$prod:CET(i)     s:0  t:2  arm:2
     O:PD(i)    Q:VD(i)        A:YG  T:CTAX(i) P:(VDN(i)/VD(i))
     O:PE(i)    Q:VE(i)
     I:PQ(i)     Q:(sum(j, Make(i,j))) arm:
     I:PM(i)     Q:VM(i)                  arm:
     I:PD("7")  Q:Make(i,"Margin")

$prod:ST        s:0
     O:PS       Q:(sum(i,Use(i,"inv")))
     I:PD(i)    Q:Use(i,"inv")

$prod:M(i)$VM(i)
     O:PM(i)    Q:VM(i)
     I:ER         Q:VM(i)

$prod:E(i)$VE(i)
     O:ER       Q:VE(i)
     I:PE(i)     Q:VE(i)

$demand:YG
     D:PYG     Q:SAM("gov","tax")

$demand:TR                  s:1
     E:PYG                  Q:(Mult*SAM("gov","tax"))
     E:PD(i)$Use(i,"GOVT")  Q:(-Mult*Use(i,"GOVT"))     R:GOVCONS(i)
     D:PTR                  Q:(sum(h,SAM(h,"gov")))
     E:ER                   Q:(Mult*(SAM("gov","row")-SAM("row","gov")))

$demand:Y(h)               s:1
     E:PF(f)               Q:(Mult*Fbar(h,f))         R:EPR(f)
     E:PFS(f,i)            Q:(Mult*SFbar(h,f,i))      R:EPR(f)
     D:PD(i)               Q:Use(i,h)
     D:PS                  Q:SAM("inv",h)
     E:PTR                 Q:(Mult*SAM(h,"gov"))
     E:PFWT$(1-alphar)      Q:(Mult*alphaf(h))

$demand:YF$SUM(i,SUM(f,FW(f,i)))      s:1
     E:PFS(f,i)$FW(f,i)         Q:(Mult*FW(f,i))   R:EPR(f)
     D:ER                        Q:alphar
     D:PFWT                      Q:(1-alphar)

$report:
     V:U(h)     W:Y(h)
```

```
     V:FD(f,i)    I:PF(f)         prod:X(i)
     V:SFD(f,i)  I:PFS(f,i)     prod:X(i)
     V:N(j,i)      I:PD(j)         prod:X(i)
     V:QS(i)       I:PQ(i)         prod:CET(i)
     V:QTM(i)  I:PD("7")      prod:CET(i)
     V:INV(i)    I:PD(i)          prod:ST
     V:C(i,h)    D:PD(i)          demand:Y(h)
     V:S(h)        D:PS              demand:Y(h)
     V:REM      D:ER              demand:YF
     V:FWT      D:PFWT         demand:YF

$constraint:GOVCONS(i)$Use(i,"GOVT")
GOVCONS(i)$(GCMult(i)<>2)+PFS("SKILL","10")$(GCMult(i)=2)=E=
1$(GCMult(i)=0)+(ER/PD(i))$(GCMult(i)=1)+ER$(GCMult(i)=2);

$constraint:HC(f)
        HC(f)      =E= prod[i, (CET(i)/Mult)**Upsilon(i,f)];
$constraint:EPR(f)
        EPR(f)     =E= 1-Eta0(f)/(HC(f)**Epsilon(f));
$offtext
$sysinclude mpsgeset SCGE

* check benchmark replication:
SCGE.ITERLIM = 0        ;
HC.L(f)      = 1        ;
EPR.L(f)    = 1-Eta0(f);
GOVCONS.L(i) = 1        ;
ER.FX       = 1        ;
$include SCGE.GEN
solve SCGE using mcp;
abort$(SCGE.OBJVAL > 1e-3) "benchmark replication failed", SCGE.OBJVAL;

$libinclude store these X CET ST M E PQ PD PE PM PF PS ER YG TR Y PFWT YF
$libinclude store these GOVCONS HC EPR U PFS FD SFD N QS QTM INV C S REM FWT

$libinclude store calc utility (h)   = u.l(h)*[sum[i,Use(i,h)]+Sam('inv',h)];
$libinclude store calc welfare      = sum[h,utility(h)] + sum[i, GOVCONS.L(i)*Use(i,"govt")];
$libinclude store calc WelfareEx  = sum[h,utility(h)];

Table alphaG(i,h) Share of household h in public good provisioning of i
       HSE1     HSE2  HSE3  HSE4  HSE5
9       0.176    0.064   0.054   0.370   0.336
NHS  0.251    0.087   0.076   0.306   0.280
11      0.176    0.064   0.054   0.370   0.336;

$libinclude store calc Utility1 (h) = utility(h) + sum[i, alphaG(i,h)*GOVCONS.L(i)*Use(i,"govt")];

$libinclude store calc YHF (h,f) = PF.l(f)*Fbar(h,f)*EPR.l(f);
$libinclude store calc YHFS (h,f,i) = PFS.l(f,i)*SFbar(h,f,i)*EPR.l(f);
$libinclude store calc YHTR (h)  = PTR.l* SAM(h,"gov");

$libinclude store calc FE (h,f)  = Fbar(h,f)*EPR.l(f)  ;
$libinclude store calc WL (h,f) = Fbar(h,f)-FE(h,f)   ;
$libinclude store calc eta (f)      = 1-EPR.l(f)          ;

$libinclude store calc SFE (h,f,i)  = SFbar(h,f,i)*EPR.l(f)  ;
$libinclude store calc SWL (h,f,i) = SFbar(h,f,i)-SFE(h,f,i);
```

```
$libinclude store calc GEXP (i) = GOVCONS.L(i)*Use(i,"govt")*PD.l(i);

* Foreign worker income to household h, effective endowment (FWE), waiting list
* (FWL) and trade surplus TS (=TS1). The trade surplus is financed by government
* and fixed in value so it shouldn't change. Note also that M and E are
* normalised to 1 in benchmark so need to multiply by their benchmark values.
$libinclude store calc TF (h)      = alphaf(h)*FWT.l*PFWT.l;
$libinclude store calc FWE (f,i) = FW(f,i)*EPR.l(f);
$libinclude store calc FWL (f,i) = FW(f,i)-FWE(f,i);
$libinclude store calc TS        = YG.l-TR.l-sum(i,GEXP(i));
$libinclude store calc TS1       = sum(i, E.l(i)*VE(i)-M.l(i)*VM(i))-REM.l;

$libinclude store setmodel SCGE
$libinclude store base
$libinclude store setbase base

* numeraire check:
SCGE.ITERLIM = 1000;
ER.FX       = 2;
$include SCGE.GEN
solve SCGE using mcp;
abort$(abs(ST.l-1) > 1e-5) "numeraire check failed", SCGE.OBJVAL;

* homegeneity check:
ER.FX = 1;
MULT = 2;
$include SCGE.GEN
solve SCGE using mcp;
abort$(abs(PS.l-1) > 1e-5) "homegeneity check failed", SCGE.OBJVAL;
MULT  = 1;

$if not "%system.incparent%"=="" $goto end

* import skilled labour in health care: 10% of hc spec skilled labour
* if relevant income foreign workers is distributed over
* households according to share of spec factor. skilled wage in health
* care is endogenous and government expenditures are fixed in value.

* no remittances abroad
FW("SKILL","10")   = 0.1*SUM(h,SFbar(h,"SKILL","10"));
alphar                    = 0;
alphaf(h)                 = SFbar(h,"SKILL","10")/SUM(g,SFbar(g,"SKILL","10"));
display alphaf;
$batinclude solve IM1a

* half of income foreign workers is remitted abroad
alphar = 0.5;
$batinclude solve IM2a

* all income foreign workers is remitted abroad
alphar = 1;
$batinclude solve IM3a

* import skilled labour in health care: 10% of hc spec skilled labour
* if relevant income foreign workers is distributed over households
* according to share of spec factor. government consumption of health care
```

```
* in real terms are endogenous and adjust so that skilled wage in health care
* does not change.

* no remittances abroad
alphar                    = 0;
GCMULT("NHS")             = 2;
$batinclude solve IM1b

* half of income foreign workers is remitted abroad
alphar = 0.5;
$batinclude solve IM2b

* all income foreign workers is remitted abroad
alphar = 1;
$batinclude solve IM3b

$libinclude store display changes percent

file myresults /'importlabour.csv'/;
put myresults;

$libinclude writecsv p_PF v_EPR v_ETA p_HC c_Utility1 p_Utility1 c_TF
$libinclude writecsv Results ResultsCh ResultsPer

Parameters p_FEunsk,p_FEsk,p_WLunsk, p_WLsk;
*p_Welfare, c_Welfare, c_TS;
p_FEunsk(h,sims)  = p_FE(sims,h,"unsk") ;
p_FEsk(h,sims)      = p_FE(sims,h,"skill");
p_WLunsk(h,sims) = p_WL(sims,h,"unsk") ;
p_WLsk(h,sims)     = p_WL(sims,h,"skill");
*p_Welfare(sims)   = ResultsPer("Welfare",sims);
*c_Welfare(sims)   = ResultsCh("Welfare",sims);
*c_TS(sims)           = ResultsCh("TS",sims);

$libinclude writecsv p_FEunsk p_FEsk p_WLunsk p_WLsk

Parameter c_WelfareEx, p_WelfareEx;
p_WelfareEx(sims)  = ResultsPer("WelfareEx",sims);
c_WelfareEx(sims)  = ResultsCh("WelfareEx",sims);

$libinclude writecsv c_Utility p_Utility c_WelfareEx p_WelfareEx
*p_Welfare c_Welfare c_TS

$label end
```

TECHNCHANGEFACTORSMODEL2.GMS

```
* This is model 2 with 2 forms of technical change: FNTC, SBTC
* Target variable to fix import price of pharmaceuticals is removed for simplicity

$offlisting
$include data.gms

Parameter FNTC(i)    Factor Neutral Technical Change
              SBTC(f,i)  Skill Biased Technical Change;
```

```
FNTC(i)    = 1  ;
SBTC(f,i)  = 1  ;

Parameter
GCMult(i)    Government consumption multiplier
Eta0         Non participation rate if health care does not affect WL
Fbar         Fixed endowment of factor f by household h
Upsilon(i,f)    Share parameter health composite
Epsilon(f)      Waiting list elasticity;

GCMult(i)    = 1;
Epsilon(f)    = 2;
Eta0("skill") = 0.0289;
Eta0("unsk")= 0.0434;
Fbar(h,f)      = SAM(h,f) * 1/(1-Eta0(f));
Upsilon("NHS","Unsk") = 0.960;
Upsilon("NHS","Skill")  = 0.834;
Upsilon("PHC","Unsk") = 1-Upsilon("NHS","Unsk") ;
Upsilon("PHC","Skill")  = 1-Upsilon("NHS","Skill");

$if not "%system.incparent%"=="" option sysout=off;option solprint=off;

$ontext
$model:SCGE
$sectors:
        X(i)          ! production of sector i
        CET(i)        ! armington aggregate demand (domestic and export)
        ST            ! total (real) savings
        M(i)$VM(i)    ! imports of commodity i
        E(i)$VE(i)    ! exports of commodity i
$commodities:
        PQ(i)              ! producer price commodity i
        PD(i)              ! domestic consumption price commodity i
        PE(i)$VE(i)    ! export price commodity i
        PM(i)$VM(i)  ! import price commodity i
        PF(f)          ! price of factor f
        PS             ! price of savings
        ER             ! exchange rate (price of foreign exchange)
        PYG            ! price of artificial commodity real tax income
        PTR            ! price of artificial commodity transfer
$consumers:
        YG             ! government income
        TR             ! transfers to households
        Y(h)           ! household income
$auxiliary:
        GOVCONS(i)$(USE(i,"GOVT"))    ! Real government consumption
        HC(f)                        ! Health composite
        EPR(f)                       ! Effective participation rate

$prod:X(i)      s:0  t:1  va:1
     O:PQ(j)  Q:Make(j,i)              A:YG T:PTAX(i)  P:(1-PTAX0(i))
     I:PF(f)    Q:(SBTC(f,i)*FNTC(i)*Use(f,i)/(1+ETAX0(f))) A:YG T:ETAX(f) P:(1+ETAX0(f))  va:
     I:PD(j)    Q:Use(j,i)

$prod:CET(i)     s:0  t:2  arm:2
     O:PD(i)    Q:VD(i)                A:YG T:CTAX(i) P:(VDN(i)/VD(i))
     O:PE(i)     Q:VE(i)
```

```
     I:PQ(i)      Q:(sum(j, Make(i,j)))       arm:
     I:PM(i)     Q:VM(i)                      arm:
     I:PD("7")  Q:Make(i,"margin")

$prod:ST        s:0
     O:PS       Q:(sum(i,Use(i,"inv")))
     I:PD(i)    Q:Use(i,"inv")

$prod:M(i)$VM(i)
     O:PM(i)    Q:VM(i)
     I:ER       Q:VM(i)

$prod:E(i)$VE(i)
     O:ER       Q:VE(i)
     I:PE(i)    Q:VE(i)

$demand:YG
     D:PYG      Q:SAM("gov","tax")

$demand:TR                 s:1
     E:PYG                        Q:(Mult*SAM("gov","tax"))
     E:PD(i)$Use(i,"GOVT")  Q:(-Mult*Use(i,"GOVT"))        R:GOVCONS(i)
     D:PTR                  Q:(sum(h,SAM(h,"gov")))
     E:ER                   Q:(Mult*(SAM("gov","row")-SAM("row","gov")))

$demand:Y(h)               s:1
     E:PF(f)               Q:(Mult*Fbar(h,f))           R:EPR(f)
     D:PD(i)               Q:Use(i,h)
     D:PS                  Q:SAM("inv",h)
     E:PTR                 Q:(Mult*SAM(h,"gov"))

$report:
     V:U(h)     W:Y(h)
     V:FD(f,i)   I:PF(f)        prod:X(i)
     V:N(j,i)    I:PD(j)        prod:X(i)
     V:QS(i)     I:PQ(i)        prod:CET(i)
     V:QTM(i) I:PD("7")     prod:CET(i)
     V:INV(i)   I:PD(i)        prod:ST
     V:C(i,h)   D:PD(i)       demand:Y(h)
     V:S(h)     D:PS           demand:Y(h)

$constraint:GOVCONS(i)$Use(i,"GOVT")
        GOVCONS(i) =E= GCMult(i) * ER/PD(i) + 1$(GCMult(i) = 0);

$constraint:HC(f)
        HC(f)      =E= prod[i, (CET(i)/Mult)**Upsilon(i,f)];

$constraint:EPR(f)
        EPR(f)     =E= 1-Eta0(f)/(HC(f)**Epsilon(f));

$offtext
$sysinclude mpsgeset SCGE

* check benchmark replication:
SCGE.ITERLIM = 0        ;
HC.L(f)      = 1        ;
EPR.L(f)    = 1-Eta0(f);
```

```
GOVCONS.L(i) = 1        ;
ER.FX              = 1        ;
$include SCGE.GEN
solve SCGE using mcp;
abort$(SCGE.OBJVAL > 1e-3) "benchmark replication failed", SCGE.OBJVAL;

$libinclude store these X CET ST M E PQ PD PE PM PF PS ER YG TR Y
$libinclude store these GOVCONS HC EPR U FD N QS QTM INV C S

$libinclude store calc Utility (h)= u.l(h)*[sum[i,Use(i,h)]+Sam('inv',h)];
$libinclude store calc Welfare = sum[h,utility(h)] + sum[i, GOVCONS.L(i)*Use(i,"govt")];
$libinclude store calc WelfareEx = sum[h,utility(h)];

Table alphaG(i,h) Share of household h in public good provisioning of i
        HSE1     HSE2 HSE3   HSE4  HSE5
9        0.176    0.064   0.054   0.370   0.336
NHS  0.251    0.087   0.076   0.306   0.280
11      0.176    0.064   0.054   0.370   0.336;

$libinclude store calc Utility1 (h) = utility(h) + sum[i, alphaG(i,h)*GOVCONS.L(i)*Use(i,"govt")];

$libinclude store calc YHF (h,f) = PF.l(f)*Fbar(h,f)*EPR.l(f);
$libinclude store calc YHTR (h)  = PTR.l* SAM(h,"gov");

$libinclude store calc FE (h,f)= Fbar(h,f)*EPR.l(f)  ;
$libinclude store calc WL (h,f)= Fbar(h,f)-FE(h,f)   ;
$libinclude store calc eta (f) = 1-EPR.l(f)          ;

$libinclude store calc GEXP (i) = GOVCONS.L(i)*Use(i,"govt")*PD.l(i);

$libinclude store setmodel SCGE
$libinclude store base
$libinclude store setbase base

* numeraire check:
SCGE.ITERLIM = 1000;
ER.FX        = 1.5;
$include SCGE.GEN
solve SCGE using mcp;
abort$(abs(ST.l-1) > 1e-5) "numeraire check failed", SCGE.OBJVAL;

* homegeneity check:
ER.FX  = 1;
MULT  = 1.5;
$include SCGE.GEN
solve SCGE using mcp;
abort$(abs(PS.l-1) > 1e-5) "homegeneity check failed", SCGE.OBJVAL;
MULT  = 1;

$if not "%system.incparent%"=="" $goto end

* FNTC in health care:
* 10% more output (X) given factor inputs (V) implies 1/11 less inputs (V) given output (X)
FNTC("10") = 10/11;
$batinclude solve FNTC
FNTC("10") =1;
```

```
* SBTC in health care: skilled labour is 10% more productive
SBTC("SKILL", "10")= 10/11;
$batinclude solve SBTC
SBTC("SKILL", "10")=1;

$libinclude store display changes percent
file myresults /'FactorTechnCh.csv'/;
put myresults;
$libinclude writecsv  p_PF v_EPR v_ETA p_HC c_Utility1 p_Utility1 Results ResultsCh ResultsPer

Parameters p_FEunsk,p_FEsk,p_WLunsk, p_WLsk;
*p_Welfare, c_Welfare
p_FEunsk(h,sims)  = p_FE(sims,h,"unsk") ;
p_FEsk(h,sims)      = p_FE(sims,h,"skill");
p_WLunsk(h,sims) = p_WL(sims,h,"unsk") ;
p_WLsk(h,sims)    = p_WL(sims,h,"skill");
*p_Welfare(sims)  = ResultsPer("Welfare",sims);
*c_Welfare(sims)  = ResultsCh("Welfare",sims);

$libinclude writecsv p_FEunsk p_FEsk p_WLunsk p_WLsk

Parameter c_WelfareEx, p_WelfareEx;
p_WelfareEx(sims)  = ResultsPer("WelfareEx",sims);
c_WelfareEx(sims)  = ResultsCh("WelfareEx",sims);

$libinclude writecsv c_Utility p_Utility c_WelfareEx p_WelfareEx
*p_Welfare c_Welfare

$label end
```

TECHNCHANGEPHARMAMODEL2.GMS

```
* This is the same as model2.gms with Technical Change (TC) in Pharmaceuticals (Pharma):

$offlisting
$include data.gms

Parameter
TCQ(i,j)   TC Intermediate Inputs - intermediate inputs more productive
TP(i)       Input Neutral TC           - increase productivity of all inputs;

TP(i)       = 1  ;
TCQ(i,j)  = 1  ;

Parameter
Target(i)       If target(i)>0 commodity i's price is set by world price
GCMult(i)     Government consumption multiplier

Eta0            Non participation rate if health care does not affect WL
Fbar            Fixed endowment of factor f by household h
Upsilon(i,f)  Share parameter health composite
Epsilon(f)    Waiting list elasticity;

Target(i)       = 0;
Target("2")   = 1;
GCMult(i)    = 1;
```

```
Epsilon(f)      = 2;
Eta0("skill")  = 0.0289;
Eta0("unsk") = 0.0434;
Fbar(h,f)       = SAM(h,f) * 1/(1-Eta0(f));

Upsilon("NHS","Unsk")  = 0.960;
Upsilon("NHS","Skill")   = 0.834;
Upsilon("PHC","Unsk")  = 1-Upsilon("NHS","Unsk") ;
Upsilon("PHC","Skill")   = 1-Upsilon("NHS","Skill");

$if not "%system.incparent%"=="" option sysout=off;option solprint=off;

$ontext
$model:SCGE
$sectors:
        X(i)          ! production of sector i
        CET(i)         ! armington aggregate demand (domestic and export)
        ST               ! total (real) savings
        M(i)$(VM(i) and Target(i)=0)    ! imports of commodity i
        E(i)$VE(i)   ! exports of commodity i
$commodities:
        PQ(i)         ! producer price commodity i
        PD(i)         ! domestic consumption price commodity i
        PE(i)$VE(i)      ! export price commodity i
        PM(i)$VM(i)    ! import price commodity i
        PF(f)         ! price of factor f
        PS            ! price of savings
        ER            ! exchange rate (price of foreign exchange)
        PYG           ! price of artificial commodity real tax income
        PTR           ! price of artificial commodity transfer
$consumers:
        YG            ! government income
        TR            ! transfers to households
        Y(h)          ! household income

$auxiliary:
        QM(i)$(VM(i) and Target(i))   ! Auxiliary var imports
        NET(i)$(VM(i) and Target(i))  ! Auxiliary var foreign exchange
        GOVCONS(i)$(USE(i,"GOVT"))    ! Real government consumption
        HC(f)                       ! Health composite
        EPR(f)                       ! Effective participation rate

$prod:X(i)       s:0  t:1  va:1
     O:PQ(j)  Q:(Make(j,i)*TP(i))            A:YG T:PTAX(i)  P:(1-PTAX0(i))
     I:PF(f)    Q:(Use(f,i)/(1+ETAX0(f)))  A:YG T:ETAX(f)  P:(1+ETAX0(f))  va:
     I:PD(j)    Q:(Use(j,i)*TCQ(j,i))


$prod:CET(i)     s:0  t:2  arm:2
     O:PD(i)    Q:VD(i)                  A:YG T:CTAX(i) P:(VDN(i)/VD(i))
     O:PE(i)    Q:VE(i)
     I:PQ(i)      Q:(sum(j, Make(i,j)))       arm:
     I:PM(i)     Q:VM(i)                     arm:
     I:PD("7")  Q:Make(i,"margin")

$prod:ST        s:0
```

```
     O:PS       Q:(sum(i,Use(i,"inv")))
     I:PD(i)    Q:Use(i,"inv")

$prod:M(i)$(VM(i) and Target(i)=0)
     O:PM(i)    Q:VM(i)
     I:ER       Q:VM(i)

$prod:E(i)$VE(i)
     O:ER       Q:VE(i)
     I:PE(i)    Q:VE(i)

$demand:YG
     D:PYG      Q:SAM("gov","tax")

$demand:TR                 s:1
     E:PYG                     Q:(Mult*SAM("gov","tax"))
     E:PD(i)$Use(i,"GOVT")  Q:(-Mult*Use(i,"GOVT"))       R:GOVCONS(i)
     D:PTR                  Q:(sum(h,SAM(h,"gov")))
     E:ER                   Q:(Mult*(SAM("gov","row")-SAM("row","gov")))
     E:PM(i)$Target(i)      Q:(Mult*VM(i))                R:QM(i)
     E:ER#(i)$Target(i)     Q:(-Mult*VM(i))               R:NET(i)

$demand:Y(h)               s:1
     E:PF(f)            Q:(Mult*Fbar(h,f))          R:EPR(f)
     D:PD(i)            Q:Use(i,h)
     D:PS               Q:SAM("inv",h)
     E:PTR              Q:(Mult*SAM(h,"gov"))

$report:
     V:U(h)      W:Y(h)
     V:FD(f,i)   I:PF(f)       prod:X(i)
     V:N(j,i)    I:PD(j)       prod:X(i)
     V:QS(i)     I:PQ(i)       prod:CET(i)
     V:QTM(i) I:PD("7")        prod:CET(i)
     V:INV(i)    I:PD(i)       prod:ST
     V:C(i,h)    D:PD(i)       demand:Y(h)
     V:S(h)      D:PS          demand:Y(h)

$constraint:QM(i)$(VM(i) and Target(i))
       PD(i) =E= Target(i) * ER;

$constraint:NET(i)$(VM(i) and Target(i))
       NET(i)=E= QM(i)* PM(i)/ER;

$constraint:GOVCONS(i)$Use(i,"GOVT")
        GOVCONS(i) =E= GCMult(i) * ER/PD(i) + 1$(GCMult(i) = 0);

$constraint:HC(f)
        HC(f)      =E= prod[i, (CET(i)/Mult)**Upsilon(i,f)];

$constraint:EPR(f)
        EPR(f)     =E= 1-Eta0(f)/(HC(f)**Epsilon(f));

$offtext
$sysinclude mpsgeset SCGE

* check benchmark replication:
```

```
SCGE.ITERLIM = 0       ;
QM.L(i)      = Target(i);
NET.L(i)     = Target(i);
HC.L(f)      = 1       ;
EPR.L(f)     = 1-Eta0(f);
GOVCONS.L(i) = 1       ;
ER.FX        = 1       ;
$include SCGE.GEN
solve SCGE using mcp;
abort$(SCGE.OBJVAL > 1e-3) "benchmark replication failed", SCGE.OBJVAL;

$libinclude store these X CET ST M E PQ PD PE PM PF PS ER YG TR Y QM NET
$libinclude store these GOVCONS HC EPR U FD N QS QTM INV C S

$libinclude store calc Utility (h)= u.l(h)*[sum[i,Use(i,h)]+Sam('inv',h)];
$libinclude store calc Welfare   = sum[h,utility(h)] + sum[i, GOVCONS.L(i)*Use(i,"govt")];
$libinclude store calc WelfareEx = sum[h,utility(h)];

Table alphaG(i,h) Share of household h in public good provisioning of i
        HSE1    HSE2  HSE3   HSE4  HSE5
9        0.176   0.064   0.054   0.370   0.336
NHS  0.251   0.087   0.076   0.306   0.280
11      0.176   0.064   0.054   0.370   0.336;

$libinclude store calc Utility1 (h) = utility(h) + sum[i, alphaG(i,h)*GOVCONS.L(i)*Use(i,"govt")];

$libinclude store calc YHF (h,f) = PF.l(f)*Fbar(h,f)*EPR.l(f);
$libinclude store calc YHTR (h)  = PTR.l* SAM(h,"gov");

$libinclude store calc FE (h,f) = Fbar(h,f)*EPR.l(f)  ;
$libinclude store calc WL (h,f)= Fbar(h,f)-FE(h,f)   ;
$libinclude store calc eta (f)     = 1-EPR.l(f)          ;

$libinclude store calc GEXP (i) = GOVCONS.L(i)*Use(i,"govt")*PD.l(i);

* Sectoral outputs need to be recalculated: X is normalised to 1 so needs
* to take into account technical progress which affects the benchmark
* quantity field! Note $report block reports values (not normalised to 1) and
* so does not have this problem.
$libinclude store calc X1 (i) = X.L(i) * sum[j, Make(j,i)*TP(i)];

$libinclude store setmodel SCGE
$libinclude store base
$libinclude store setbase base

* numeraire check:
SCGE.ITERLIM = 1000;
ER.FX        = 1.5;
$include SCGE.GEN
solve SCGE using mcp;
abort$(abs(ST.l-1) > 1e-5) "numeraire check failed", SCGE.OBJVAL;

* homegeneity check:
ER.FX = 1;
MULT = 2;
$include SCGE.GEN
solve SCGE using mcp;
```

```
abort$(abs(PS.l-1) > 1e-5) "homegeneity check failed", SCGE.OBJVAL;
MULT  = 1;

$if not "%system.incparent%"=="" $goto end

* TC in pharma which increases the cost-effectiveness of pharma in health care:

*   The domestic consumer price of pharmaceuticals rises by 20% as in exp 2a.
*   Government budget is fixed in value as in exp 2a: negative welfare effect!
*   From exp 2a we know pharma sector expands just a little so domestic pharma
*   sector does not expand too much in response to p increase i.e. do not need
*   to curb production by imposing: TP("2") = 100/(100+20);
Target("2")  = 1.1;
$include SCGE.gen
solve SCGE using mcp;
Target("2") = 1.2 ;

*   TC makes pharma and other inputs in health care more effective,
*   i.e. the better quality pharmaceuticals make the health service more
*   efficient in use of pharma and other inputs: Productivity of pharma and
*   other inputs in health care rises by beta% and gamma% respectively
*   In Exp 5a gamma=0. Beta is 20% is needed approx for health care
*   to expand (techn change is adopted). Beta is 30% is needed approx for
*   welfare effects to be positive.
*   In Exp 5b. vary gamma and beta: gamma=1%, beta=9% is sufficient for welfare
*   effects to be positive. gamma=2%, then beta=0% already yields welfare gains

*   Beta/gamma is 33.1% over three years is equivalent to 10% a year

$ontext
TCQ("2","10")= 100/(100+(beta-0));
$batinclude solve Exp5a

TP("10")         = 1+gamma/100  ;
TCQ("2","10")= 100/(100+(beta-gamma));
$batinclude solve Exp5b
$offtext

TCQ("2","10")= 100/(100+(20-0));
$batinclude solve Exp5a20

TCQ("2","10")= 100/(100+(30-0));
$batinclude solve Exp5a30

TCQ("2","10")= 100/(100+(40-0));
$batinclude solve Exp5a40

TCQ("2","10")= 100/(100+(50-0));
$batinclude solve Exp5a50

TCQ("2","10")= 100/(100+(100-0));
$batinclude solve Exp5a100

TP("10")      = 1+5/100  ;
TCQ("2","10")= 100/(100+(20-5));
$batinclude solve Exp5b20
```

```
TCQ("2","10")= 100/(100+(30-5));
$batinclude solve Exp5b30

TCQ("2","10")= 100/(100+(40-5));
$batinclude solve Exp5b40

TCQ("2","10")= 100/(100+(50-5));
$batinclude solve Exp5b50

TCQ("2","10")= 100/(100+(100-5));
$batinclude solve Exp5b100

$libinclude store display changes percent

file myresults /'TCPharma.csv'/;
put myresults;
$libinclude writecsv  p_PF v_EPR v_ETA p_HC c_Utility1 p_Utility1 Results ResultsCh ResultsPer
Parameters p_FEunsk,p_FEsk,p_WLunsk, p_WLsk;
p_FEunsk(h,sims)  = p_FE(sims,h,"unsk") ;
p_FEsk(h,sims)      = p_FE(sims,h,"skill");
p_WLunsk(h,sims) = p_WL(sims,h,"unsk") ;
p_WLsk(h,sims)     = p_WL(sims,h,"skill");

$libinclude writecsv p_FEunsk p_FEsk p_WLunsk p_WLsk

Parameter c_WelfareEx, p_WelfareEx;
p_WelfareEx(sims)  = ResultsPer("WelfareEx",sims);
c_WelfareEx(sims)  = ResultsCh("WelfareEx",sims);

$libinclude writecsv c_Utility p_Utility c_WelfareEx p_WelfareEx

$label end
```