"North-South Trade, Openness and Growth"

by

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It has long been thought that openness to international trade can be beneficial to a country in terms of growth, and that trade liberalisation can assist in enhancing countries growth rates. For a long time such arguments were based on static theories, in which trade raises the level of income, but not the long-run growth rate. Recently, models have emerged that show how countries can increase their long-run growth rates through trade. Trade can affect growth through a number of channels. For developing countries however, the primary benefit that trade provides is likely to be access to the technology of more advanced countries.

This study examines various aspects of the relationship between openness to trade and economic growth in developing countries. The study concentrates on North-South trade, since it is expected that imports from the North enhance growth by allowing access to more advanced knowledge and technology. It is shown that trade with the North can benefit countries in the South in terms of higher growth, through the importation of Northern goods. Evidence is also found to suggest that trade has a role in transferring to the South the benefits of Research and Development (R&D) conducted in the North, although these results tend not to be robust.

The second part of the study examines the impact of trade liberalisation on openness and growth. It is found that trade liberalisation has tended to lower openness to imports from the North, at least in the short-run. The results suggest the possibility of a J-curve effect whereby openness initially falls, but then recovers

somewhat. In the long-run we may expect openness to rise following liberalisation, but this cannot be shown in our dataset. The relationship between liberalisation and growth is also found to follow a J-curve, with liberalisation initially leading to a reduction in growth, but in the long-run increasing growth in per capita income.

Chapter One

Introduction

Chapter One

INTRODUCTION

1.1 Introductory Remarks

What determines a country's rate of growth? This has been a primary concern to economists since the birth of economics. This question was an important feature of Adam Smith's *An Inquiry into the Nature and Causes of the Wealth of Nation's* back in 1776 and was taken up by early economists such as Malthus (1798) and Ricardo (1817). Much later at the beginning of the twentieth century the theory of growth was formalised by Ramsey (1928), Harrod (1939) and Domar (1946).

The theory of growth was reoriented in the 1950s with the work of Solow (1956) and Swan (1956) who developed the so-called *neoclassical* model of growth. Interest in the causes of growth dwindled in the sixties however, largely because the theoretical models developed didn't explain a great deal; the causes of per capita income growth were assumed exogenous with the result that policy recommendations were limited. In the next twenty or so years attention turned from growth theory to explaining short-run fluctuations in a country's output, with a theoretical literature developed looking to explain the causes of business cycles. In the 1980s however, interest in growth theory was rekindled with the important contributions of Romer (1986) and Lucas (1988). Since then there has been an explosion of work looking to explain long-run growth, both theoretically and empirically[1].

Over the past two hundred years a great deal of effort has been expended in attempting to address the question of what causes economic growth. The reason for this interest is clear once you consider that minor variations in a country's growth rate can lead to substantial changes in income per capita over a relatively short space of time. The importance of understanding the causes of growth for developing countries cannot be understated. By understanding the causes of growth we understand why some countries are so much richer than others. Moreover, understanding the causes of growth allows the provision of policy prescriptions aimed at helping countries grow faster and become richer. Evidence also exists to suggest that growth aids poverty alleviation (see for example, Roemer and Gugerty (1997) and Dollar and Kraay (2000)). Isolating policies that improve growth can therefore help to reduce the high levels of poverty that are a feature of developing countries.

It has long been considered that openness to international trade is one policy that can positively affect a country's growth rate and this is the hypothesis that the remainder of the thesis addresses. The literature examining the impact of international trade on those countries that engage in trade is vast[2]. A great deal of this literature concentrates on the impact that trade has upon the growth rate of countries and whether countries that are more open perform better in terms of economic growth. This literature dates back to the birth of economics itself, yet

[1] One reason for this interest in growth theory must be due to Lucas (1987), who showed that welfare gains from higher long-run growth exceeded those from eliminating short-run fluctuations in output.

neither the theoretical or empirical literature developed provides unqualified support for the role of openness to trade in promoting growth for all countries at all times, which has led to widely differing attitudes towards openness over the past two hundred years.

Over this period there have been two waves of globalisation when highly open trade policies were pursued by large numbers of countries, but there have also been periods when countries attitudes towards international trade have been more sceptical. The first wave of globalisation occurred in the mid to late nineteenth century when a number of countries adopted what approximated to free trade. We are currently experiencing the second wave of globalisation. Since the end of World War Two, developed countries have become more and more open to international trade. This has happened for a number of reasons. Declining natural, technological and man-made barriers to trade along with the rapid recovery of these countries after the war and the development of the various Bretton Woods institutions have encouraged a more favourable attitude towards international trade. The trade to GDP ratio of these countries is now approaching the levels reached toward the end of the nineteenth century, suggesting that the impact of the two waves are quite similar.

The two waves however share a number of differences, one major difference being the extent to which the developing countries have played a role in international trade. During the first wave the role of the developing countries in international trade was limited and the beneficial impact of trade on them was

[2] For a review of thinking on attitudes towards free trade throughout the ages see Irwin (1996).

severely limited[3]. During this second wave however, developing countries are playing an increasing role in international trade. The emphasis on openness to international trade as a development strategy for developing countries is now strong, although such an emphasis occurred much later for developing than for developed countries. The majority of developing countries during the sixties and seventies looked to develop their domestic industries behind protective barriers. The lack of success of these so-called 'import-substituting' policies has been put forward as the reason for the movement towards more liberal trade policies in many developing countries[4]. It is to the impact of openness to trade in developing countries that this study is aimed.

There are numerous reasons for the widespread use of trade liberalisation as a development strategy in developing countries since the 1970s; these will be discussed in greater depth in subsequent chapters. Organisations such as the World Bank, the World Trade Organisation (WTO) and the International Monetary Fund (IMF) have clearly played a part in promoting the benefits of trade liberalisation however. The World Bank and IMF often require some form of trade liberalisation alongside a number of other policy reforms in order to receive loans. These policies have clearly been one factor encouraging developing countries to engage in international trade to a greater degree.

Apart from these two waves of globalisation, at other times during the past two centuries highly protectionist policies have been in place in most countries of

[3] Indeed, it has been argued that the open trade policies of developing countries in this period, which were often forced upon countries by colonial powers in Europe, resulted in a period of de-industrialisation for many such countries (see for example, Bairoch, 1993).

the world. Levels of protection began to rise toward the end of the nineteenth century, although other trade creating forces dissipated much of the effect of this rise in protection on trade volumes. In the interwar period however most countries adopted highly protectionist policies. These policies were largely predicated on increasing economic nationalism that had been building since the late nineteenth century and in response to rising unemployment. A rapid reduction in world trade set in with the onset of the great depression and protectionism reached its pinnacle during World War Two[5].

The theoretical arguments in favour of trade and its impact on economic growth for a long time focussed on the static benefits of trade. International trade was understood to facilitate specialisation in the production of goods in which a country has a comparative advantage. This has the effect of raising the level of per capita income, but it does not have any impact upon the long-run rate of growth. In the 'new' or 'endogenous' growth theories developed in the past fifteen years however, it has been shown that there are a number of channels through which international trade can influence long-run growth. The principal way through which this is achieved in developing countries is through the transfer of technology from rich, high technology countries. The transmission mechanism can take a number of forms. International trade speeds the absorption of frontier technologies and spurs innovation, such technological spillovers may take the form of imports of higher quality intermediate and

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[4] This negative view of import-substituting policies is not without controversy, Rodrik (1999) argues that most of the countries that did well in the late sixties and early seventies followed import-substitution policies.

[5] See Bairoch (1993) and Kenwood and Lougheed (1999) for a discussion of the history of trade policy and its impact upon economic performance.

capital goods as well as the imitation by poor countries of richer countries' products. These results suggest that empirical work should focus on the impact on growth of restrictions on capital and intermediate goods, and imports from more advanced countries more generally, but this is often not the case. A further implication of many of these models however is that international trade is not necessarily good for growth; examples exist that show how trade can actually harm a country's growth rate. Trade may reduce growth for example, if a country's comparative advantage lies in industries in which externalities are not present, a conclusion that may be particularly relevant for developing countries.

The aim of this chapter is to provide a brief background to the role that international trade may play in the growth process. This entails describing some of the more traditional arguments both for and against trade and also a brief overview of new arguments for the role of trade in the growth process. These are then discussed in much greater detail in Chapter Two. A brief overview of the empirical literature linking openness and growth is also provided. Chapter Three discusses this literature in greater detail. The rest of the chapter is organised as follows. Section 1.2 considers traditional arguments for and against trade, while section 1.3 looks at the role of trade in the new growth theories. Section 1.4 comments on the empirical literature considering the impact of trade on growth. Section 1.5 provides a brief overview of the remainder of the thesis, while section 1.6 provides some initial conclusions.

1.2 Traditional Arguments of the Role of Trade

Gains from trade arise from specialisation in accordance with comparative advantage, an argument formalised by Ricardo back in 1817. The notion of comparative advantage is based on the principles of specialisation and the division of labour. In the two-good, two-country case, Ricardo showed that trade would be beneficial in terms of increased world output of the two goods if the country with the comparative advantage in each good specialised in its production and exported the surplus to the other country. The only requirement for trade to benefit both countries is that the international rate of exchange between the two goods lies between the two countries autarkic rates. The reason for the existence of a comparative advantage in Ricardo's model is technological differences between the two countries[6], although Heckscher (1919) and Ohlin (1933) model comparative advantage as occurring because of differences in initial factor endowments. The notion of comparative advantage is a static concept; movement to free trade requires a reallocation of resources from goods in which a country doesn't have a comparative advantage to goods in which it does. This will lead to a one-off increase in world output; hence this notion cannot be used as a means of linking trade to economic growth, since adjustment is assumed to be instantaneous[7].

Given that comparative advantage implies benefits in terms of increased world output and consumption, why don't we see worldwide free trade? Firstly, the notion of comparative advantage is based on a number of restrictive assumptions. The model assumes that full employment exists in each country, that there is perfect competition and that factor endowments are fixed. Furthermore, the model doesn't take account of the effect that trade can have

[6] More correctly, Ricardo focussed on differences in labour productivity across countries, since however he didn't discuss the determinants of labour productivity it is generally interpreted that such differences are the result of differences in technology.
[7] In general, we may expect that adjustment may take some time, in which case growth would be positive in transition to the new steady state.

upon the terms of trade. Relaxing any of these assumptions can alter peoples' views concerning the benefits of trade[8].

In addition, the gains from trade need not be distributed equally both across countries and amongst factors of production[9]. It is often suggested that free trade acts against developing countries because of the goods in which these countries tend to have a comparative advantage - specialising in the production and export of primary products and importing manufactured goods from the developed economies. Evidence exists to suggest that the (net barter) terms of trade of primary products have tended to fall over the past century[10]. The reason for this decline can be attributed to both supply and demand conditions. As incomes rise, demand for primary products tends not to rise to the same degree, while advances in technology have dramatically increased the output of primary products in developing countries[11].

The result of this decline in the terms of trade of primary products can lead to a widening income gap between developing countries that specialize in these products and developed countries that specialize in the production of manufactured goods, an argument known as the Prebisch-Singer hypothesis

[8] Although concerns such as unemployment have been used as a justification for trade restrictions, such restrictions are in general not 'first best' solutions. Moreover, even in the presence of unemployment there will still be gains from trade.

[9] In Ricardo's model the unequal distribution of the gains from trade between factors is not an issue since it was assumed that labour was the only factor. With more than one factor however, reallocation of resources from one industry to another changes income distribution so that some gain and some lose. In this case welfare gains can take place if those that gain fully compensate those that lose.

[10] Examples include, Sparos, 1980; Sapsford, 1985, 1990, Grilli and Yang, 1988 and Bloch and Sapsford, 1997, 2000. Despite this literature there still remains controversy over whether such declines have taken place (see for example Bairoch, 1993, chapter 10).

[11] Examples include better irrigation, fertilisers, pesticides and drought resistant crops.

after the economist's who first advanced it[12]. This argument has been used as a justification for developing countries to look to industrialise behind a wall of protective trade restrictions, in the long-run shifting comparative advantage away from primary products to manufactured goods. By restricting imports of manufactured goods a country gives protection to domestic manufacturing industries, thereby encouraging domestic production. This argument is based on the familiar infant industry argument and is called 'import substitution industrialisation'[13,14].

One alternative to the inward looking import substitution policy is a policy of export promotion. A number of arguments have been put forward emphasising the potential benefits from export-oriented policies. It is argued that exports allow the manufacturing sector to reap economies of scale to a greater extent than import substitution policies, since production is not limited to the domestic market. Production for export also has exacting costs and quality control requirements and brings producers into contact with new technologies and business practices. This should make export-oriented economies more conducive than inward looking economies to innovation and to the lowering of costs. An alternative argument stresses the role that export growth can play in relieving a country of its balance of payments constraint on demand, so that the

[12] Prebsich (1950) and Singer (1950).

[13] Secular declines in the terms of trade have often been used as an argument for import-substitution. It should be noted however that a relative decline in the relative price of primary commodities need not result in a terms of trade decline, or a reduction in welfare.

[14] The infant industry argument is often used as an argument for protection. Its roots lie in the nineteenth century; economists such as List (1841) stressed the need for industry to develop behind protective barriers. Simply stated, if country A has a potential comparative advantage in an industry, but that because country B had an earlier start in this industry country A can't compete in the short-run, then some form of temporary protection would make both countries better off from a more appropriate long-run exploitation of comparative advantage.

faster exports grow, the faster output can grow without running into balance of payments difficulties.

1.3 New Arguments for the Role of Trade

The arrival of new growth theories has created a role for openness to have an impact on the long-run growth rate. The models developed however do not create a presumption that openness spurs technological capabilities and long-run growth. As will be discussed in greater detail in Chapter Two, the models demonstrate the benefits that countries can reap in terms of higher growth from participation in world markets and the importation of technology and knowledge. At the same time they also demonstrate that countries need not benefit in terms of growth from openness to international trade. Trade can lead to specialisation in technologically less dynamic sectors, sectors in which developing countries may well have an initial comparative advantage. These new growth theories therefore often lead to similar conclusions to the static theories considered above. Although the world as a whole is likely to benefit from free trade, individual countries need not. Some countries may lose in terms of growth from opening to trade and again therefore, these theories have been used to provide justifications for trade interventions[15].

It was argued above that export oriented policies could enhance a country's economic performance, through for example the exploitation of economies of scale and learning spillovers. In many of the new models of growth however it is not the exports of countries that are growth promoting, but their imports, suggesting that export's only role is to help pay for imports. Imports can impact upon a country in a variety of ways. One important role of trade is the importation of ideas; this is particularly important in developed countries where it helps facilitate future innovation, but also for developing countries who can borrow knowledge from abroad, avoiding the cost of creating the knowledge themselves.

It is not just through the importation of ideas however that countries benefit from being open; imports of goods also play an important role, in particular the importation of capital and intermediate goods. Investment in capital is widely acknowledged as an important source of growth, particularly for developing countries[16]. Most developing countries however do not have a comparative advantage in the production of capital goods and hence must import to benefit through investment. By imposing trade restrictions a developing country raises the domestic price of such capital goods, tending to reduce investment and growth. A second role of trade in goods is the importation of intermediate goods. Many such goods are produced with increasing returns to scale. Developing countries often cannot rely on local supplies of intermediates, which are produced with a great deal of technological sophistication. Restricting trade in intermediates can then have adverse effects on the productivity of domestic manufacturing activities again limiting growth.

[15] Although new growth theories show that trade can reduce growth for a country, it is often the case that welfare for the country would still be higher. The focus of this thesis however is on trade and growth, hence the welfare implications of these theories will not be considered.
[16] See De Long and Summers (1991) and Temple (1998).

1.4 The Relationship Between Openness and Growth

The theoretical literature examining the relationship between trade and growth provides us with ambiguous results; trade can be shown to enhance a country's growth rate, but this is not always the case. Given that the theoretical literature cannot provide definitive answers, does the empirical literature provide unambiguous support either for or against the role of trade in the growth process?

The empirical evidence on openness and growth will be discussed in greater detail in Chapter Three. There are however a number of general points that can be made regarding this literature. Numerous measures of openness or indices of trade restrictions have been developed and used. It has been shown that the measures developed are in general not highly correlated (Pritchett, 1996), leaving us with little confidence as to which is the most reliable measure of openness, or indeed whether openness is unidimensional and can be captured in a single measure. Furthermore, a number of the measures developed could be measuring a wide variety of economic policies or conditions within an economy (Rodriguez and Rodrik, 1999).

Despite the above and related problems the literature on growth and openness is voluminous. The results from such empirical studies tend to be mixed. As a generalization, cross-country studies tend to find a positive relationship between measures of openness and growth, while where a relationship is found in time-series studies, the direction of causality is often not found to be from trade to growth, but from growth to trade. Furthermore, studies that rely not on a single measure of openness, but various different measures find that only a subset of the measures are significantly related to growth. The evidence in favour of a relationship between trade liberalisation (i.e. an increase in openness) and growth is also mixed, with little evidence thus far found in time-series studies.

One important shortcoming of the empirical literature is that the majority of openness measures proposed do not seem to relate directly to the channels through which economic theory suggest are the likely links between openness and growth. New growth theory highlights the role of imports of ideas, capital goods and intermediate goods. There is however very little empirical evidence investigating specifically how restrictions on these imports affect growth. Empirical studies tend to rely on various measures of trade barriers, exports, total trade or subjective indices of openness. The evidence that does exist examining the relationship between growth and imports of knowledge, intermediate goods and capital goods has been the subject of much debate.

1.5 Thesis Overview

This study examines empirically the relationship between international trade and economic growth in developing countries[17]. We use as a basis for our empirical work the implications of the new growth theories. This emphasis leads this study to differ from many of the existing empirical studies. Many of the new growth theories emphasise the role of technological progress as a determinant of long-run growth. International trade can impact upon a country's growth rate by allowing access to advanced technology produced elsewhere.

[17] We concentrate throughout the thesis on a sample of 52 developing countries over the period 1976-1990. A data appendix at the end of the thesis provides further details on this sample.

Developing countries do little if any innovation[18], it would be expected therefore that it would be through trade with the more advanced countries that developing countries benefit from access to advanced technology, rather than through trade between themselves. As a result this study concentrates on North-South trade. Moreover, it would be expected that the major benefits to developing countries of such trade would come from the import side rather than the export side, importing goods that embody advanced technology. As a result the thesis concentrates on imports of manufactured goods from developed countries to developing countries, which are likely to consist largely of advanced goods. The following paragraphs provide a brief outline of the remainder of the thesis.

In Chapters Two and Three a more detailed overview of the existing literature on trade and growth is provided. Chapter Two considers the recent theoretical literature on the openness and growth debate. The chapter begins with the neoclassical growth model and shows that in this model trade does not affect the long-run growth rate. Following this, a number of the endogenous growth models are described. We then discuss the ways in which trade can impact upon the long-run growth rate in these models. The models emphasise a number of roles for trade, with trade in capital and intermediate goods and flows of knowledge being important in the growth process. Also emphasised are situations in which trade can actually be detrimental to growth.

[18] Coe, Helpman and Hoffmaister (1997) note that 96 percent of the world's Research and Development (R&D) expenditure is accounted for by the OECD. In fact, R&D is concentrated in a small number of advanced countries. Eaton and Kortum (1999) for example, note that in the late 1980s, 80 percent of OECD research scientists and engineers were employed in the United States (US), the United Kingdom (UK), Japan, Germany and France.

Chapter Three provides an overview of the literature testing the relationship between openness and growth. It begins with an overview of various measures of openness and trade liberalisation that have been employed in the existing empirical literature. We then summarise a sub-sample of results from studies that use these measures to estimate the relationship between growth and either openness or trade liberalisation. An important message from this review is that there tends to be a disjunction between the links that theory suggests exist between trade and growth and the measures of openness employed in the empirical literature.

In Chapter Four we begin by developing a measure of openness to North-South trade. This is achieved by constructing an empirical model to estimate the volume of manufactured imports from the North to the South. We use the fitted values from this model to produce a measure of openness to Northern imports for our sample of developing countries. Using this openness measure we estimate the impact of openness to North-South trade on growth for our sample of countries. The results suggest that openness to Northern imports enhances growth in the South. This result is found to be robust to the inclusion of additional variables in our model and the removal of potential outliers from our sample.

In Chapter Five we again look at flows between the North and South; this time however we consider flows of ideas as opposed to flows of goods. The notion that knowledge spillovers are important to growth may be more relevant to developed countries, where the knowledge of a country is used by other countries in their efforts to produce new innovative products. However, there is evidence that knowledge spillovers do occur between the North and South (see for example, Coe, Helpman and Hoffmaister, 1997). In terms of developing countries the knowledge of the more advanced countries may be used to produce innovative products. The innovative sector is often lacking in developing countries however, it is more likely therefore that knowledge spillovers are beneficial to final goods producers who import intermediate and capital goods that are of a higher quality than those available domestically, and to those that look to imitate the goods of advanced countries.

We test for the growth enhancing effects of foreign knowledge using constructed knowledge stocks for a sample of Northern countries. The knowledge stocks are weighted by various measures of trade or openness between the North and the South, including the measures of openness developed in Chapter Four. We then test for a relationship between these trade weighted knowledge stocks and growth. The results we obtain do not provide strong support for the presence of growth promoting foreign knowledge spillovers to our sample of countries. We do find evidence in support of foreign knowledge spillovers, but the results are not found to be robust. Our results however do provide a number of possible links between foreign knowledge and growth that are worthy of further study.

Chapter Six builds upon the previous two chapters by looking at the impact on countries of trade liberalisation, rather than the level of openness *per se*. We begin by reviewing arguments for trade liberalisation, along with the limitations of such a policy. We then proceed to examine the impact of trade liberalisation on openness in our sample of countries using the model of imports developed in

Chapter Four. The results suggest that openness to Northern imports falls following trade liberalisation. In particular, we find evidence of a J-curve type relationship whereby openness initially declines following liberalisation, but then begins to increase towards its pre-liberalisation value. We are not able to show in our data however that openness eventually rises above its pre-liberalisation level.

In the latter half of the chapter we examine the impact of liberalisation on growth by extending the work of Greenaway, Morgan and Wright (1998) (GMW), which found evidence of a J-curve relationship between trade liberalisation and subsequent growth. The main hypothesis we test is whether the J-curve relationship found between liberalisation and growth by GMW simply reflects the short-run negative impact of liberalisation on openness, or whether other factors are driving the relationship between liberalisation and growth. The results we obtain support the presence of a J-curve relationship between liberalisation and growth, with growth initially falling but then increasing above its pre-reform rate, which provides support for the long-run benefits of liberalisation. There is less support however for an indirect effect of liberalisation working through openness, which leads to the conclusion that liberalisation is affecting growth through channels other than openness.

Chapter Seven provides a summary of the results from the study and some overall conclusions. We also discuss the shortcomings of the results obtained and the methods employed. Finally, we provide some suggestions for future research.

1.6 Concluding Remarks

How does openness to international trade affect growth and what are the mechanisms through which such effects occur? These are the questions we address in this thesis and this introduction has set the context by reference to economic theory and empirical evidence. Theories have been developed for over two hundred years identifying a link between trade and output. For a long time these theories were predicated on static arguments, whereby trade can raise the level of income, but not the long-run growth rate. Only relatively recently have theories linking trade to long-run economic growth appeared. Many of these theories suggest that the primary benefit of trade to long-run growth is through allowing access to advanced technology produced elsewhere in the world. The two sets of theories have similar conclusions however, trade may well be good for either output or growth, but for certain countries and at certain times it need not be.

A literature has also built up looking to test for a relationship between trade or trade restrictions and growth. A variety of measures of openness have been employed, which may well add to the confusion and difficulty in finding credible evidence of a relationship between trade and growth. The results of such studies tend to be mixed and a number of problems exist when looking to interpret the results.

There still remains a great deal of controversy over the role of trade. While most economists agree that trade is good for growth there have been influential supporters of trade restrictions, particularly in the past few years. Many of these arguments have come from politicians and businessmen concerning the effects that trade with developing countries has upon domestic manufacturing and the wages of unskilled workers in developed countries. There remains however a small and vocal minority even in the economics profession, that are either sceptical or hostile as to the potential benefits to growth of openness and trade liberalisation (for example, Taylor, 1991; Rodrik, 1999).

It would appear then that there is still considerable scope in assessing the importance of trade on growth. The importance of developing strategies for growth in developing countries cannot be underestimated, the impact of growth on poverty in developing countries for example is well documented (see for example, Dollar and Kraay, 2000). International efforts to reduce by half the number of people living in extreme poverty by 2015 will be aided by identifying policies that are good for growth and the mechanisms through which such policies work. Openness to international trade may well be one such policy.

Chapter Two

Theories of Growth and International Trade

Chapter Two

THEORIES OF GROWTH AND INTERNATIONAL TRADE

2.1 Introduction

Economists have long considered the causes of economic growth important[1]. The hypothesis that trade is one factor that can enhance growth has existed for a similar length of time. To assess the impact of trade and trade liberalisation on growth it is important to understand the channels through which trade can impact upon growth. This chapter reviews the theory that links trade to growth and identifies the channels through which the relationship operates[2].

The first significant attempts to formalise models of economic growth appeared in the early part of the twentieth century characterised by the important contributions of Ramsey (1928), Harrod (1939) and Domar (1946). The model proposed by Harrod and Domar had a number of unappealing implications and as a result the theory of growth was redefined in the fifties. The model developed by Solow (1956) and Swan (1956) became known as the neoclassical growth model and was the dominant model of economic growth until the mid-eighties. Interest in the theory of growth dwindled in the sixties and seventies however, largely because the models developed, in particular the neoclassical

[1] It was noted in the previous chapter for example that a key focus of Adam Smith's *The Wealth of Nations* was on the factors that determine a country's growth rate.

model didn't provide adequate explanations for the causes of long-run growth[3]. Since the mid-eighties there has been a resurgence of interest, following the important contributions of Romer (1986) and Lucas (1988). These, along with an ever-growing number of theoretical papers, attempt to endogenise the causes of economic growth. New models focus upon the accumulation of capital, both physical and human, and the role of technological innovation as determinants of economic growth.

The rest of the chapter is organised as follows. In section 2.2 we examine the neoclassical growth model of Solow and Swan. In section 2.3 we extend the neoclassical model to examine the more recent endogenous growth models. The models examined in these two sections are closed economy models and hence cannot contribute to understanding the trade-growth relationship. The extensions to incorporate trade are then discussed in section 2.4. Section 2.5 provides some overall conclusions.

2.2 The Neoclassical Growth Model

The neoclassical growth model of Solow (1956) and Swan (1956) was developed partly in response to the shortcomings of the earlier Harrod-Domar model[4], in which all variables determining equilibrium are exogenous. This implies that equilibrium will only be found by chance and indicates the existence of a knife-edge solution. The neoclassical model shows that the

[2] A number of reviews of the theoretical literature on trade and growth exist. See for example, Grossman and Helpman (1995) and Wong and Long (1997).

growth rate of output per capita will in the long-run tend to zero unless there is continual technological progress that offsets the effects of diminishing returns. Technological progress is assumed exogenous in the basic neoclassical model however, and as such no scope is allowed for active policy interventions in influencing growth. Despite this it was widely acknowledged that technological progress was an important determinant of growth (see for example Solow, 1957). Moreover, despite the fact that in the long-run per capita growth will fall to zero, it is not clear what length of time the long-run refers to, with the implication that per capita income growth can continue for a long period of time.

The starting point is the simple aggregate production function:

$$Y = F(AL, K), \tag{2.1}$$

where Y is national output, L is the input of labour, K the input of capital and A is a variable representing labour-augmenting technological progress assumed exogenous in the neoclassical model. Output in the economy is assumed to consist of a single composite commodity that can either be consumed or accumulated as a stock of capital. It is assumed that the factors of production exhibit positive but diminishing marginal products and that the production function exhibits constant returns to scale, making output homogenous of degree one in capital and augmented labour.

[3] It is common to concentrate on the steady state or long-run equilibrium of an economy, this is the method followed here.
[4] We leave a discussion of the Harrod-Domar model to Appendix 2A.

Since technological progress is assumed exogenous we can ignore it in what follows. For convenience and without loss of generality we can let $A = 1$. Using the assumption of constant returns to scale, equation (2.1) can be rewritten in per capita terms as:

$$y = f(k), \quad (2.2)$$

where $y = Y/L$ is per capita output and $k = K/L$ is the capital-labour ratio. It is further assumed that the intensive form of the production function is well behaved, in that it adheres to standard neoclassical conditions, including the Inada conditions[5] (Inada, 1963). The first derivative of equation (2.2) is positive with respect to capital, since an increase in the capital-labour ratio will increase output. The second derivative is however negative, indicating that an increase in the amount of capital applied to a given labour force will have diminishing effects on per capita output.

Given the assumption of exogenous technological progress, output growth can only occur through increases in one or both factors of production. It is usually assumed that the growth of the labour force is exogenous and grows at a constant rate, which we will call l[6]. This leaves capital accumulation as the only remaining factor that can drive long-run growth. The amount of capital accumulation is given by gross investment minus depreciation. It is assumed that a constant fraction, δ, of the capital stock wears out at each point in time. It is further assumed that individuals save a constant fraction s of their gross

[5] See Appendix 2B.
[6] It is usual to denote the growth rate of the labour force as n. It is also common however to use n to denote the growth of innovative products in the endogenous growth models discussed later, to avoid confusion we use l here to denote labour force growth.

income Y and that all saving is invested. Given this we can write the net change in the stock of capital as:

$$\dot{K} = I - \delta K = sF(K, L) - \delta K, \qquad (2.3)$$

where a dot over a variable denotes its derivative with respect to time.

The growth path of an economy can now be analysed using equation (2.3). The rate of change of the level of capital intensity k can be written as the difference between the rate of growth of capital and the rate of growth of labour. This may be written as:

$$\frac{\dot{k}}{k} = \frac{\dot{K}}{K} - \frac{\dot{L}}{L} = \frac{\dot{K}}{K} - l. \qquad (2.4)$$

Multiplying through by k gives us the following:

$$\dot{k} = \frac{\dot{K}}{L} - lk. \qquad (2.5)$$

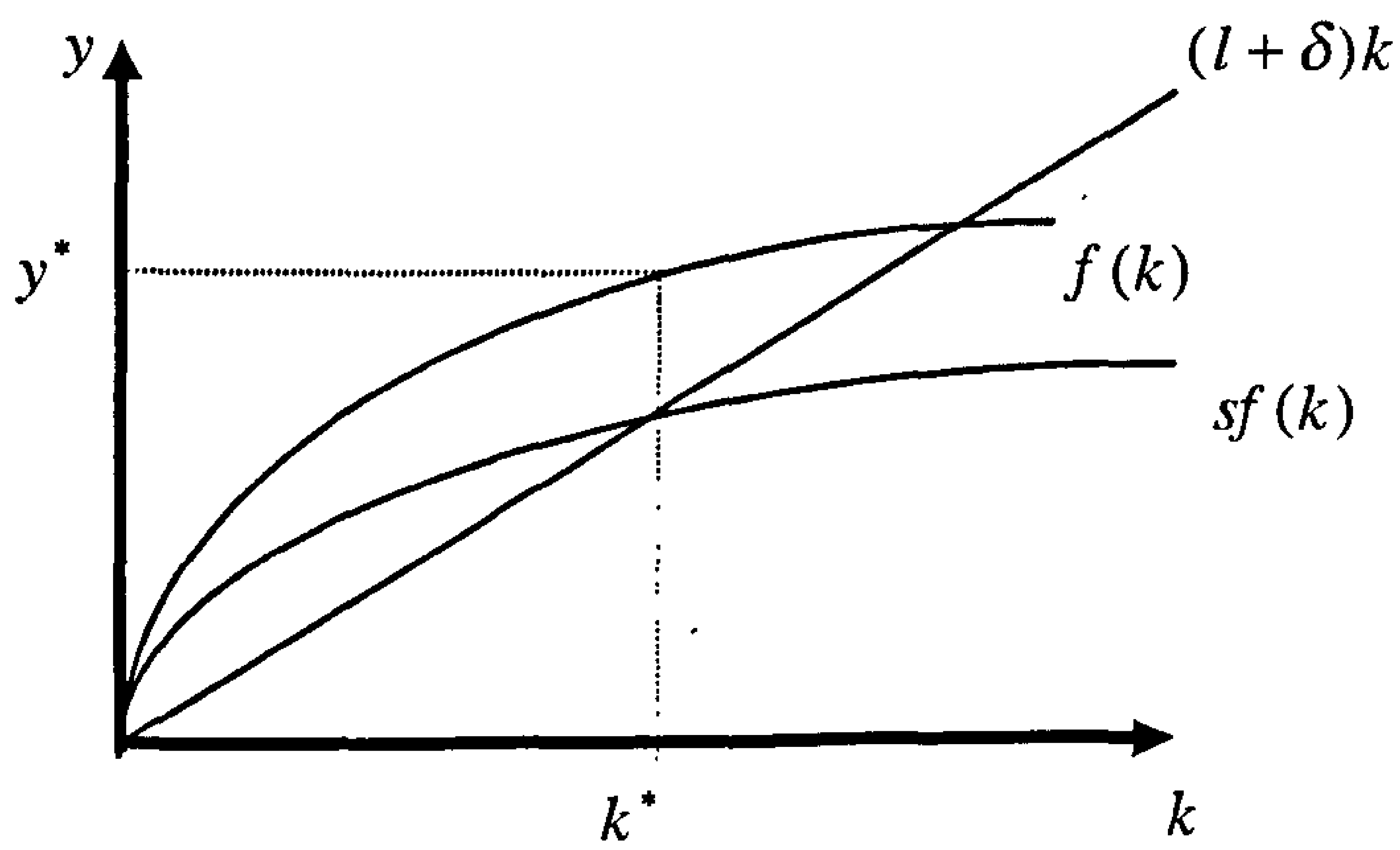
This states that the change in capital intensity is equal to the difference between net investment per capita and the rate of labour force growth multiplied by the level of capital intensity. This last term tells us the amount of additional capital necessary to maintain capital intensity at its existing level as the labour force grows. Equation (2.3) can be rewritten as $\frac{\dot{K}}{L} = sf(k) - \delta k$, which can then be substituted into equation (2.5) to give:

$$\dot{k} = sf(k) - (l + \delta)k. \qquad (2.6)$$

This is known as the *'fundamental equation of neoclassical growth theory'*. It states that capital intensity will be increasing through time if the level of savings per capita is greater than the amount needed to equip new entrants to the labour force with the same amount of capital as those already employed and to offset the reduction in the capital stock due to depreciation.

A steady state exists when the capital-labour ratio is constant. From equation (2.6) we find that such a steady state is achieved when $sf(k^*) = (l+\delta)k^*$, where k^* is the steady state capital-labour ratio. The steady state equilibrium is depicted in Figure 2.1. The curve $f(k)$ gives the per capita production function, while $sf(k)$ shows the per capita production function scaled by the savings rate, which will always lie below the per capita production function. These two curves are concave, which is a result of the assumption of a constant returns to scale production function and which is implied by diminishing marginal returns. Given that l and δ are constants $(l+\delta)k$ is a straight line through the origin with slope $(l+\delta)$. By the fact that $sf(k)$ is concave and $(l+\delta)k$ is a straight line there is a unique point of intersection at k^*, the intersection of the two lines determines the steady state capital-labour ratio.

Figure 2.1: Steady State Growth in the Neoclassical Growth Model



At k^*, we have capital and labour both growing at the same rate[7]. In steady state the labour force is growing at the rate l and the level of technology is constant by assumption. The stock of capital, K, is given by Lk and is growing at the rate l since the capital-labour ratio, k, is constant. Given the assumption of constant returns to scale and since both capital and labour are growing at the rate l, output, Y, is also growing at the rate l. In the absence of technological progress however, capital per worker and output per capita do not grow[8].

The model developed is a closed economy model, it has little to say about the role of trade and trade liberalisation in the growth process. Inevitably, since it is a closed economy model, savings equals domestic investment. In the absence of technological progress, output per capita in steady state does not grow, while, in the presence of technological progress, output per capita grows at the same rate as technology. In the neoclassical model however, technology is assumed exogenous. Trade liberalisation then like any other policy will not affect growth, unless it affects the growth rate of technology. Although trade liberalisation may well affect the growth rate of technology there is no mechanism in this model through which this occurs and so it is of limited use in explaining the relationship between trade, trade liberalisation and economic growth. Attempts have been made to extend the one-sector, homogenous-good model to examine the role of trade. This usually involves extending the one-sector model to two sectors, trade policy then affects the allocation of resources between the sectors

[7] In appendix 2C we discuss further properties of the neoclassical including the uniqueness and stability of the steady state.

[8] As an alternative to assuming no technological progress it can be assumed that technology grows at some exogenous rate, in which case capital per worker and output per capita will grow at this exogenous rate.

and hence the steady state level of saving and capital accumulation. Trade liberalisation can then have a one-off effect on the steady state level of output, which can be positive or negative, depending upon how saving and capital accumulation are affected by trade policy. The long-run rate of growth will not be affected by trade policy however, although trade can have transitional growth effects as the economy moves from one steady state to another. Lee (1993) for example assumes in a neoclassical growth model that capital goods are differentiated and foreign capital provides a vital input into domestic production. Trade distortions are found to lower the steady state level of income and lower growth in transition to the steady state, but not the long-run rate of growth, although the long-run may be quite some time.

2.3 Endogenous Growth Models

It was partly the inadequacies of the neoclassical model in explaining the causes of long-run growth that led to the resurgence of interest in growth theory. New growth models look to determine the rate of growth of output *within* the model. Endogenous growth models have tended to move in two directions, those that emphasise the accumulation of some broad measure of (physical or human) capital in the growth process and those that see innovation as the force behind growth. In these models an externality associated with one of these activities is the source of long-run growth, offsetting the assumption of diminishing returns that is a feature of the neoclassical model.

2.3-1: Physical Capital Accumulation in Growth Models

One of the simplest models of endogenous growth based on physical capital accumulation[9] is the so-called *AK* model. In this the production function takes the form $Y = AK$, where A is a positive constant reflecting the level of Hicks-neutral technology in the economy. The advantage with this type of production function is the absence of diminishing returns to capital, which although may seem unrealistic, may be plausible if we take a broad view of capital to include human capital for example. The *AK* model can be derived by extending the neoclassical model developed in section 2.2. Description of this model will be made easier by specifying a functional form for the production function. A convenient assumption to make is to assume a Cobb-Douglas production function:

$$Y = AK^{\alpha} L^{1-\alpha}, \qquad 0 \leq \alpha \leq 1. \tag{2.7}$$

If we let $\alpha = 1$ (i.e. labour has a zero share) we obtain a production function of the form:

$$Y = AK, \tag{2.8}$$

with output being proportional to the capital stock. This can be written in per capita terms as:

$$y = Ak. \tag{2.9}$$

Given this new per capita production function, equation (2.6) becomes:

$$\dot{k} = sAk - (\delta + l)k, \tag{2.10}$$

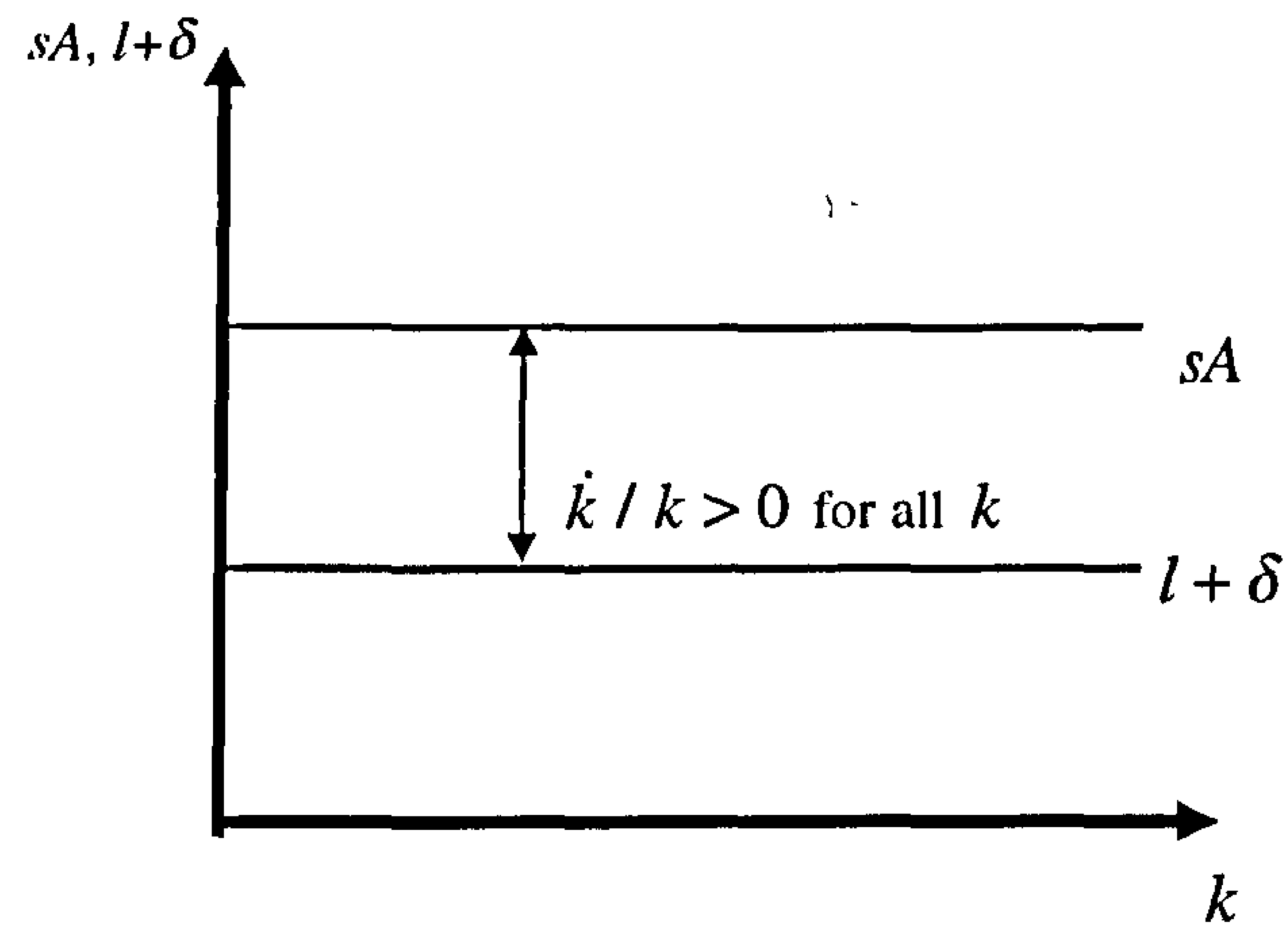
Rearranging equation (2.10) by dividing through by k, we can write:

[9] See Romer (1987) and Rebelo (1991) for a more detailed exposition of this kind of model.

$$\frac{\dot{k}}{k} = sA - (\delta + l). \qquad \textbf{(2.11)}$$

Equation (2.11) is analogous to equation (A2.7) in appendix 2B and gives an expression for the rate of growth of the capital-labour ratio. This equation is depicted in Figure 2.2 below.

Figure 2.2: Growth in the AK Model



The first term on the right hand side of equation (2.11) is a horizontal line given by sA, since both the level of technology and the rate of savings are assumed constant. Similarly the second term is also a horizontal line, since the rate of growth of the labour force and the rate of depreciation are also assumed constant. Figure 2.2 is plotted for the case when $sA > l+\delta$, which implies that growth in this economy will be positive[10]. The distance between the two lines gives the rate of growth of the capital-labour ratio. Since $y = Ak$, it is also the case that growth in per capita output will equal the growth in the capital-labour

[10] If a steady state exists in this model, then by definition $\dot{k}/k$ is constant, which implies that k grows without bound. Equation (2.11) implies that it is a necessary and sufficient condition that $A > \frac{\delta + l}{s}$ for $\dot{k}/k$ to be positive.

ratio at all points in time[11]. Growth in the capital-labour ratio and therefore growth in output per capita are determined by parameters in the model, in particular the savings rate, which determines investment. An increase in the savings rate or a decrease in the rate of population growth will increase growth. In the case depicted growth continues in the absence of technological progress, since the term A is assumed constant. A one-off increase in the level of technology however will permanently raise the rate of growth.

The key distinction between the neoclassical model and this model is the absence of diminishing returns to capital. The marginal product of capital in the above model will not be diminishing but will be constant at the level $A > 0$. The absence of diminishing returns is the key property of endogenous growth models. The model in effect includes the level of technology as a part of the capital stock, using this broader concept of capital prevents the marginal product of capital from falling to zero. The result is a constant and positive long-run growth rate of the capital-labour ratio and therefore output per capita. There is nothing in the model however explaining how the technology parameter is determined. Furthermore, the model assumes that technology is constant over time, there is no mechanism for technological progress. As a result this model has been extended in a number of ways, most importantly by Romer (1986) who builds upon the work of Arrow (1962) and Frankel (1962) to model how the technology term may grow over time.

[11] Since the technology term is still assumed constant, growth in output per capita will equal the growth rate of the capital-labour ratio (i.e. $\dot{y} = A\dot{k}$, which implies that $\dot{y}/y = \dot{k}/k$).

In Romer's model firms use knowledge as a capital good in a similar manner to that described above. Long-run growth is driven by the accumulation of knowledge, which is seen as an accidental by-product of investment. Although knowledge is assumed to exhibit diminishing returns there is assumed to be an externality associated with investments that result in new knowledge. The creation of knowledge by one firm is assumed to have a positive external effect on the productivity of other firms. It is this externality that removes the diminishing returns to capital associated with the neoclassical model and ensures positive steady state growth. Firms are assumed competitive, taking prices and the aggregate knowledge level as given. Given this, firms choose optimally the level of inputs they employ. We may write a production function for an individual firm in a similar manner to that for the aggregate economy. Assuming a Cobb-Douglas production function for the firm we have

$$Y_i = AK_i^{\alpha} L_i^{1-\alpha}, \qquad 0 \leq \alpha \leq 1. \qquad \textbf{(2.12)}$$

where we assume that firm i chooses the level of capital and labour it uses, but takes as given the aggregate level of knowledge. There are assumed to be constant returns to capital and labour, but since A is determined endogenously, overall the production function exhibits increasing returns.

New knowledge is generated as a by-product of firm investment, which is then available to all firms in the economy. The stock of knowledge in the economy is given by

$$A = \overline{A}K^{\beta}, \qquad 0 < \beta < 1, \qquad \textbf{(2.13)}$$

where $\overline{A}$ is some constant and K the economies' capital stock. This simply states that the level of knowledge in the economy is a function of the cumulative past investment of the economy. Combining equations (2.12) and (2.13) yields

$$Y_i = \overline{A}K^{\beta}K_i^{\alpha}L_i^{1-\alpha}. \quad \textbf{(2.14)}$$

Assuming that all firms have the same production function and employ capital and labour in the same proportions we can sum the individual production functions to give an aggregate production function

$$Y = \overline{A}K^{\alpha+\beta}L^{1-\alpha}, \quad \textbf{(2.15)}$$

which can be written in per capita terms as:

$$y = \overline{A}k^{\alpha}K^{\beta}. \quad \textbf{(2.16)}$$

Given this and using the fact that $\overline{A}$ is a constant we can calculate the rate of growth of output by taking logs of equation (2.16) and differentiating, which yields:

$$\frac{\dot{y}}{y} = \alpha\frac{\dot{k}}{k} + \beta\frac{\dot{K}}{K}. \quad \textbf{(2.17)}$$

In a steady state, if one exists, the capital-labour ratio is constant, which implies that growth in per capita output is proportional to the growth of knowledge capital, which accumulates through investment.

The existence of a positive steady state rate of growth of per capita output in this model depends crucially upon parameters in the model. In particular, if $\beta < 1-\alpha$ investment will not be a long-run source of growth, growth will vanish asymptotically and we will get back to the neoclassical solution. If $\beta > 1-\alpha$ the stock of knowledge capital will become infinite in finite time. This assumption of increasing returns to investment was thought to hold by Romer. His solution to the problem of the stock of knowledge becoming infinite and growth becoming unbounded was to assume that the investment technology was bound from above. The alternative to these two assumptions about parameter values is to assume that $\beta = 1-\alpha$ in this case we get back to the AK model in which we do have a constant steady state growth rate.

2.3-2: Human Capital Accumulation in Growth Models

An alternative way of modelling growth is to look at how human capital rather than physical capital accumulates. The quantity of labour in growth models is usually assumed to grow at some exogenous rate. In the models discussed so far however no account is made of the quality of the labour force, which may be as important as the actual number of workers. Unlike with physical capital, the role of human capital is constrained by the fact that individuals cannot go on accumulating knowledge forever since their lives are finite. Human capital can be important however if its accumulation has spillover effects affecting the productivity of future generations. There are in general two ways in which individuals can acquire human capital. They can take time out from work and receive education or they can gain experience through production, a process known as *'learning by doing'*.

In models of schooling, individuals accumulate knowledge by not working and undertaking education. The amount of human capital an individual accumulates is assumed to depend upon the amount of time spent in education and upon the prevailing level of knowledge in the economy. Lucas (1988) extends the model of Uzawa (1965) allowing for external effects of schooling that permits positive long-run growth. An externality arises since it is assumed that the level of knowledge in the economy expands as individuals undertake education. At any point in time we can denote the average level of human capital in the economy as h. Higher levels of human capital are associated with higher output levels, since it is assumed that higher skilled workers are more productive. It is further assumed that a fraction of an individual's non-leisure time ϕ is spent in work with the remaining fraction spent on education. For simplicity the assumption that there is no depreciation of human capital is made. Given this and ignoring technological progress, we can write a Cobb-Douglas production function as:

$$Y = K^{\alpha}(h\phi L)^{1-\alpha}, \quad \textbf{(2.18)}$$

where $h\phi L$ can be thought of as the effective labour force.

Lucas assumes that human capital evolves according to the following:

$$\dot{h} = g(1-\phi)h^{\gamma}, \qquad g'(1-\phi) > 0. \quad \textbf{(2.19)}$$

This equation states that the change in human capital depends positively upon the existing level of human capital and upon the fraction of time spent in education. If $\gamma = 1$, there are no diminishing returns to human capital accumulation. In this case we can rewrite equation (2.19) as:

$$\frac{\dot{h}}{h} = g(1-\phi), \quad \textbf{(2.20)}$$

which tells us that an increase in the fraction of time spent accumulating human capital will increase the growth rate of human capital.

Equation (2.18) can be rewritten in per capita form as:

$$y = k^{\alpha}(\phi h)^{1-\alpha}. \tag{2.21}$$

From this equation, the growth rate of per capita output is found in the usual way by taking logs and differentiating, this yields:

$$\frac{\dot{y}}{y} = \alpha\frac{\dot{k}}{k} + (1-\alpha)\frac{\dot{\phi}}{\phi} + (1-\alpha)\frac{\dot{h}}{h}. \tag{2.22}$$

This equation shows that growth in per capita output will depend upon the growth of the capital-labour ratio, the growth of time spent in work and the growth of human capital. By assumption ϕ is a constant meaning that the second term will drop out, the capital-labour ratio will no longer be constant however, while the growth rate of human capital will be given by equation (2.20).

We can rewrite equation (2.22) in terms of effective units of labour by letting $k' \equiv K / h\phi L$ and $y' \equiv Y / h\phi L$, where k' and y' are *capital per effective labour unit* and *output per effective labour unit* respectively. Equation (2.22) can now be written as

$$\frac{\dot{y}'}{y'} = \alpha\frac{\dot{k}'}{k'}. \tag{2.23}$$

In steady state k' will be constant because of the assumption of diminishing returns to capital, which implies that the growth in output per effective labour unit will be zero. The existence of a steady state[12] can be shown in a similar manner to that in the neoclassical model, namely by finding an expression for $\dot{k}'$. However, since in a steady state h grows at the rate given by equation (2.20)

[12] Caballé and Santos (1993) discuss the existence of a steady state in this model along with various other properties of the model.

and since ϕ is constant it must be the case that output per capita (*Y/L*) grows at the same rate as human capital[13]. Unlike the neoclassical model this implies that countries with the same technology levels may still grow at different rates in steady state. Any policy that leads to a permanent increase in the time individuals spend receiving education will generate a permanent increase in the growth of output per worker. In this model *h* acts just like the term *A* in the *AK* model, growing at a constant rate. Here though the rate of growth is not exogenous, but determined by endogenous skill accumulation.

An alternative channel through which human capital may accumulate is learning-by-doing (LBD). Here an individual's productivity is assumed to be increasing with experience in a particular activity. The idea dates back to Arrow (1962) who states that: "Learning is the product of experience. Learning can only take place through the attempt to solve a problem and therefore only takes place during activity." (p.155). Models of LBD are similar to models of schooling. With LBD however few resources are required for human capital accumulation, in particular workers don't have to take time out from production to accumulate human capital.

Lucas (1988) extends the work of Arrow to show how growth can depend upon human capital accumulation through LBD. Given that the labour force no longer

[13] From the definition of y' we can express the growth rate of output per capita as $\frac{\dot{Y}}{Y}-\frac{\dot{L}}{L}=\frac{\dot{y}'}{y}+\frac{\dot{h}}{h}+\frac{\dot{\phi}}{\phi}$. Since ϕ is constant and in steady state, growth in output per effective labour unit is zero, output per capita grows at the same rate as human capital.

has to take time out in order to accumulate human capital, the production function given by equation (2.20) can be rewritten as:

$$Y = K^{\alpha}(hL)^{1-\alpha}. \qquad (2.24)$$

This equation can be rewritten in per capita terms and expressed in terms of growth of per capita output, which yields,

$$\frac{\dot{y}}{y} = \alpha\frac{\dot{k}}{k} + (1-\alpha)\frac{\dot{h}}{h}. \qquad (2.25)$$

This equation states that the growth in output per capita is determined by the growth rates of physical and human capital. We can also write equation (2.24) in terms of per effective units of output, where we now define $y' = Y/hL$ and $k' = K/hL$. By taking logs and differentiating as we did for the education model we can get an expression for the growth rate of output per effective unit of labour:

$$\frac{\dot{y}'}{y'} = \alpha\frac{\dot{k}'}{k'}. \qquad (2.26)$$

The growth rate of output per effective unit of labour will once again be zero in steady state because of the assumption of diminishing returns to capital. Once again it is straightforward to show the existence of a steady state in a similar manner to that for the neoclassical model. Although output per effective unit of labour doesn't grow in steady state, as above the growth of output per capita will grow at the same rate as the growth in human capital.

To complete the model we need to specify how human capital accumulates. Lucas (1988, 1993) models the accumulated stock of human capital at any point in time as:

$$h = a\int_0^t \tau h dt, \qquad (2.27)$$

where a represents the efficiency of labour and is greater than zero, and τ is less than one and represents the fraction of time a worker spends in production[14], which is determined endogenously. We can calculate the growth rate of h by differentiating equation (2.27) with respect to t and dividing by $\dot{h}$. This implies that the growth rate of human capital is $a\tau$, that is, proportional to the amount of time individuals spend in production. The more time spent producing goods the faster human capital and per capita output grow. In steady state τ is constant, therefore the growth rate of human capital and per capita output are both equal to $a\tau$.

An alternative specification assumes that accumulated human capital depends upon accumulated experience, represented by accumulated output. Stokey (1988) assumes that the unit labour requirement for production depends upon the entire economy's cumulative experience in the production of all goods in all previous periods. The expression for accumulated human capital is then given by:

$$h = a\int_0^t Y dt, \qquad (2.28)$$

where Y is the output level. From equation (2.28) we can obtain an expression for the change in human capital, which is proportional to output:

$$\dot{h} = aY. \qquad (2.29)$$

[14] The remaining time may be spent on leisure. In the Lucas (1988) model there are two sectors and τ is the fraction of time spent working in this sector.

Rewriting equation (2.24) and substituting into equation (2.29) gives us:

$$\dot{h} = ak'^{\alpha}hL. \qquad \textbf{(2.30)}$$

In steady state when k' is constant, the growth rate of human capital and therefore per capita output will be given by $a\tilde{k}'^{\alpha}L$, where $\tilde{k}'$ is the steady state effective capital-labour ratio. This specification has the implication that the bigger a country is in terms of its labour force, the faster will be its growth rate. These so-called scale effects will be discussed later.

The simple model described above has one unappealing feature; it is assumed that there are constant returns to LBD in time spent in production. It is widely believed that the learning curve of a person in general rises rapidly initially, but then slows down and eventually becomes flat. Arrow (1962) who argued that "learning associated with repetition of essentially the same problem is subject to sharply diminishing returns" (p. 155) acknowledged this idea. He argues that for human capital to continue to accumulate new goods must be introduced and old ones disappear: "To have steadily increasing performance, then, implies that the stimulus situations must themselves be steadily evolving rather than merely repeating." (p. 156)[15]. Both Stokey (1988) and Young (1991, 1993) extend the simple model described above to take account of this deficiency. Stokey and Young assume that there does indeed exist diminishing returns to LBD within individual products, but that new products continually emerge in which LBD can continue. It is the introduction of new products in these models that allows long-run growth to continue.

2.3-3: Innovation and Growth

The models of endogenous growth we have considered so far retain the perfect competition assumption of the neoclassical model. Positive growth occurs in these models through the accumulation of knowledge, which is a by-product of some other activity. An alternative method of endogenising growth is to drop the assumption of perfect competition and assume that knowledge accumulation results from the intentional efforts of entrepreneurs who invest in R&D to create new or improved products. Models of this sort rely on imperfect competition; without the prospect of monopoly profits entrepreneurs would be unwilling to invest in R&D, since they would be unable to recover the costs of R&D. Entrepreneurs can either invest in R&D in order to create new products or they can invest in order to improve upon products that are already in existence. These are termed models of expanding product variety or horizontal innovation and models of improved product quality or vertical innovation respectively. Examples of models of horizontal innovation include Judd (1985), Romer (1990), Grossman and Helpman (1991a, Chapter 3) and Rivera-Batiz and Romer (1991b), while models of vertical innovation include Segerstrom *et al.* (1990), Grossman and Helpman (1991a, Chapter 4; 1991c) and Aghion and Howitt (1992). Models of vertical innovation are often termed Schumpeterian models, after Schumpeter (1934) who anticipated these kind of models.

As with other endogenous growth models some form of externality is required to sustain long-run growth. Here knowledge created by private R&D is not

[15] An alternative to the introduction of new products is likely to be the introduction of new processes of production, not related to LBD. In this case, growth is likely to continue even in the

wholly appropriable by the entrepreneur. Innovators are assumed able to appropriate the returns through monopoly profits to product specific knowledge enabling them to manufacture the product, but not the returns to general knowledge. The general knowledge created by R&D adds to a public stock that can be used by later generations as an input into R&D, lowering the cost of R&D and offsetting any tendency for diminishing returns to the primary factors. A distinction between product specific knowledge and general knowledge can be made due to the special characteristics of knowledge; it is non-rival and at least partially non-excludable.

Models of innovation often divide the economy into three sectors: the final good sector, the intermediate good sector and the research sector. The final good is a homogenous consumption good produced under conditions of perfect competition. The intermediate goods sector however, consists of differentiated products, whose number can expand, in models of horizontal innovation but is fixed in models of vertical innovation.

The production function for a firm producing the consumption good in models of horizontal innovation can be written following Spence (1976), Dixit and Stiglitz (1977) and Ethier (1982) as:

$$Y_i = L_i^{1-\alpha}\sum_{j=1}^{N}(X_{ij})^{\alpha}. \qquad \textbf{(2.31)}$$

Where L_i is the firm's employment of labour assumed to be the only primary factor employed and X_{ij} is the use of the *j*th type of intermediate good by firm *i*.

absence of the introduction of new goods, with LBD taking place within the new processes.

The production function specifies diminishing returns to each factor and constant returns to scale in all inputs. Assuming that all firms have the same production function we can aggregate final producers and obtain an aggregate production function, which is given by:

$$Y = L_C^{1-\alpha} \sum_{j=1}^{N} (X_j)^{\alpha}, \tag{2.32}$$

where L_C is the amount of labour employed in producing the consumption good. All intermediate goods enter the production function symmetrically, implying that new intermediates do not make any of the existing types obsolete. Assuming that the cost of each intermediate is identical implies that in equilibrium equal amounts of each intermediate product will be used in producing the consumption good.

In the Romer (1990) model intermediates are treated as different types of capital. The production of one unit of any kind of capital is assumed to be produced by sacrificing one unit of final output. Given this we can aggregate the consumption good and intermediate goods sector into a single manufacturing sector and write the aggregate production function for final output as:

$$Y = L_Y^{1-\alpha} (NX)^{\alpha}, \tag{2.33}$$

where L_Y is the labour force engaged in manufacturing production, X is the amount of each intermediate employed and N is the number of intermediates currently available. By taking logs and differentiating we can obtain an expression for the growth rate of output, as given by:

$$\frac{\dot{Y}}{Y} = (1-\alpha)\frac{\dot{L}_Y}{L_Y} + \alpha\frac{\dot{N}}{N} + \alpha\frac{\dot{X}}{X}. \tag{2.34}$$

In a steady state the distribution of labour between manufacturing production and research will be constant as will the amount of each intermediate employed, so that growth in output will be proportional to the growth in the number of intermediates. To complete the model we need to specify how the number of intermediates changes through time.

An increase in the number of available varieties of intermediates requires innovation. In the specification of Romer (1990) and Grossman and Helpman (1991a) it is assumed that an entrepreneur can add to the set of available intermediates by devoting a given amount of labour to R&D for an interval of time. The rate of increase in the number of intermediates depends upon the knowledge each research firm possesses and upon the amount of labour employed[16].

All research firms are assumed to have access to the same pool of knowledge, which is assumed proportional to the economy's cumulative experience in R&D at every moment in time[17]. Denoting the total labour force engaged in R&D as L_n and the public stock of knowledge as K_n, then the aggregate production function for new intermediates can be written as:

$$\dot{N} = aL_n K_n, \tag{2.35}$$

[16] The technology for producing new intermediates here depends upon the exiting level of knowledge. Rivera-Batiz and Romer call such a specification, the "knowledge driven" specification. They define an alternative production function for new intermediates, which uses the same inputs as final manufacturing in the same proportions. As such knowledge has no value in technology per se. This specification they term the "lab-equipment" model.

[17] Mansfield (1985) and Adams (1990) allow for lags in the dissemination of knowledge. Grossman and Helpman (1991a) note that a non-linear relationship between total investment in R&D and the knowledge stock that accumulates as a consequence may be specified.

where a now represents the productivity of labour in R&D. Since the public knowledge stock is taken to be proportional to the economy's cumulative experience in R&D, then with the appropriate choice of units we can write:

$$K_n = N. \tag{2.36}$$

The production function for new intermediates can then be expressed as:

$$\dot{N} = aL_n N. \tag{2.37}$$

The growth rate of the number of intermediates will then be given by aL_n. Since in steady state, output growth is proportional to the growth in the number of intermediates, output growth depends upon the resources devoted to inventing new intermediates and upon the efficiency of R&D.

In models of vertical innovation producers of the final good employ a number, N, of different intermediate products as before, but now N is fixed. Innovation is not undertaken to increase the number of available intermediates, but to improve the quality of those in existence. Each intermediate product has a quality ladder along which improvements are made, these improvements result from R&D and build upon the current 'state of the art' in each intermediate product. Successful researchers again receive monopoly rights to the intermediate products developed. Now however a research success that improves upon the previous 'state of the art' results in a cessation of profits to the previous producer and researchers when deciding upon their level of R&D must take account of this fact. Researchers are assumed to choose their level of R&D in order to maximise profits as in the previous model, taking account of their eventual demise.

The production function for a firm's output of the consumption good given by equation (2.31) must be modified to account for the effects of the quality of intermediates. The production function for a firm then takes the form,

$$Y_i = L_i^{1-\alpha} \sum_{j=1}^{N} \tilde{X}_{ij}^{\alpha}, \qquad (2.38)$$

where $\tilde{X}_{ij}$ is the quality-adjusted amount of intermediate *j* employed by firm *i*.

Each intermediate product *j* can be improved upon an infinite number of times. Each new generation provides λ as many services as the product of the generation before it, where λ is the same for all intermediate industries[18]. Production of the intermediate good is again achieved by sacrificing one unit of the final consumption good. As such the cost of intermediate production is the same regardless of quality, which implies that the 'state of the art' producer has an efficiency advantage over other producers in that industry. Letting q_j stand for the quality of intermediate *j* and setting the initial quality level equal to one for all intermediates implies:

$$q_{mj} = \lambda^m, \qquad (2.39)$$

where q_{mj} is the quality level of the *m*th generation of intermediate *j*. Given this, the quality-adjusted input from intermediate *j* is:

$$\tilde{X}_{ij} = \sum_{m=1}^{\overline{m}_j} (\lambda^m X_{ijm}), \qquad (2.40)$$

[18] This assumption of a fixed improvement in quality can be easily relaxed, see for example Grossman and Helpman (1991a, Chapter 4.2).

where X_{ijm} is the quantity used by the *i*th firm of intermediate good *j* of quality *m* and $\overline{m}_j$ is the highest quality level available in intermediate industry *j*. This tells us that the overall input from an intermediate industry is the quality-weighted sum of the amounts of each quality grade used. This equation also implies that different quality grades within a sector are perfect substitutes as inputs into production of the final consumption good.

A producer of the 'state of the art' in a particular industry competes as an oligopolist with the producer of the next highest quality intermediate. Following Grossman and Helpman (1991a) it is assumed that the technological leader in equilibrium sets a limit price, thereby driving the producer of the inferior quality product out of the market[19]. Assuming that the leader is always only one step ahead of its nearest rival then the leader will set the limit price as:

$$p_{j\overline{m}_j} = \lambda. \tag{2.41}$$

Given this limit price the quantity produced by the leader will be given by[20]:

$$X_{j\overline{m}_j} = L(\alpha/\lambda)^{1/(1-\alpha)}(\lambda^{\overline{m}_j})^{\alpha/(1-\alpha)}. \tag{2.42}$$

Since in equilibrium only the 'state of the art' intermediate of each industry will be used, the production function given by equation (2.38) can be rewritten as:

$$Y_i = L_i^{1-\alpha}\sum_{j=1}^{N}\left[\lambda^{\overline{m}_j}(X_{ij\overline{m}_j})\right]^{\alpha}, \tag{2.43}$$

[19] In an alternative specification the 'state of the art' producer charges a monopoly price, this is likely to be the case when the steps on the quality ladder are large, see for example Aghion and Howitt (1992).
[20] See appendix 2D for the derivation of this equation and the derivation of aggregate output in this model.

where $X_{ij\overline{m}_j}$ is firm i's use of the 'state of the art' intermediate j. Substituting equation (2.42) into equation (2.43) and aggregating over firms, gives an expression for aggregate output:

$$Y = L(\alpha/\lambda)^{\alpha/(1-\alpha)} \sum_{j=1}^{N} \lambda^{\overline{m}_j \alpha/(1-\alpha)}. \tag{2.44}$$

Given that the number of products (N) and the steps on the quality ladder (λ) are constant, then the growth of output per capita in this model will depend upon improvements in the 'state of the art' ($\overline{m}_j$) in the various intermediate industries.

It is assumed that the more resources devoted to R&D in an intermediate industry, then the greater the probability of a successful innovation. If we let $Z_{j\overline{m}_j}$ be the flow of resources used by the aggregate of potential innovators in intermediate industry j when the highest quality available is $\overline{m}_j$, and let $\pi_{j\overline{m}_j}$ be the probability per unit time of a successful innovation, then we can write:

$$\pi_{j\overline{m}_j} = \phi(\overline{m}_j) Z_{j\overline{m}_j}. \tag{2.45}$$

The probability of a successful innovation in intermediate industry j then is proportional to the resources expended on R&D in that industry. We may assume that ϕ is a constant or we may assume that the probability of success falls for a given Z_j as $\overline{m}_j$ increases, since it becomes harder to improve upon an intermediate over time.

The probability of success in intermediate industry j, given by equation (2.45) is a Poisson process, where the probability of success depends upon the amount of resources expended upon R&D in that industry. The time path for technological progress in a particular industry will be both lumpy and stochastic due to the randomness of R&D success. Assuming a large number of industries however implies that technological progress at the aggregate level will be smooth and non-random. Since the probability of success depends upon the amount of resources devoted to R&D, it is clear that growth in output will once again also depend upon the amount of resources expended on R&D.

2.3-4: Issues Arising from Endogenous Growth Theory

It is clear from the above discussion that endogenous models of growth have an advantage over the neoclassical model in that they provide a role for economic policy. A number of shortcomings with endogenous growth models have been highlighted however. One implication of many models, in particular the innovation-based models, is that we get so-called scale effects. A country that becomes larger in size will experience a higher growth rate, since the larger the knowledge base and the more resources devoted to research, the easier it is to accumulate knowledge. This feature is unappealing since it does not seem to be supported by the evidence. Jones (1995a, 1995b) for example argues that many countries have experienced a substantial increase in R&D spending, yet growth appears not to have increased in response. Models have been developed that attempt to eliminate scale effects. Examples include Jones (1995a), Kortum (1997), Segerstrom (1998) and Aghion and Howitt (1998, Chapter 12). In Segerstrom's model for example a positive rate of population growth implies that the rewards for innovating grows over time, but offsetting this is the assumption that innovation becomes more difficult over time. In steady state, growth proceeds at a constant rate and R&D employment grows at the same rate as total employment. As with many models without scale effects, the growth rate depends only upon exogenous parameters, such as the population growth rate. Jones (1998) notes that although these models eliminate scale effects in growth they create a new kind of scale effect, whereby the size of the economy affects the long-run level of income.

In order to sustain long-run growth, the models described above require some form of externality to offset the diminishing returns associated with the accumulation of capital. These spillovers take a number of forms with many of the results resting crucially upon the assumptions made. Long-run growth in Lucas's model of education requires an ever-increasing level of human capital. However, as McCallum (1996, p58.) states: "...never ending growth (in this model) is implausible because the skills in question are ones possessed by individual human beings and so are not automatically passed on to workers in succeeding generations." This argument may not be as strong for innovation-based models of growth since knowledge here is not possessed by individuals, it highlights however the importance attached to externalities of which we know very little.

We noted in the Romer (1986) model the importance of a certain combination of parameter values. If such values are not taken, growth will either vanish asymptotically or continue without bound. It is not just the Romer model that requires particular parameter values for the existence of positive steady state growth, many of the models require certain restrictions on parameters. For example, the Lucas model of education requires constant returns to capital. Solow (1994) argues that this makes these kind of endogenous growth models fragile; stating they cannot survive without constant returns to (human) capital and "you would have to believe in the tooth fairy to expect that kind of luck." (Solow, 1994, p.51). Although parameter values slightly above or below those required will result in the economy growing without bound or not at all in the long-run, this process may take a long period of time and growth may continue in the intervening period.

2.4 Trade in Endogenous Growth Models

The models developed so far assume a closed economy. In this section we summarise the results of extending the models to the open economy.

2.4-1: Trade and Growth with Physical Capital Accumulation

The role of trade in models of growth based on physical capital accumulation has not been examined in great depth. Jones and Manuelli (1990) construct a simple model of long-run growth based on physical capital accumulation, in which there are no increasing returns, but where the marginal product of capital is bounded above zero. They find that trade in this model can increase the growth rate. In their model trade by raising the rate of return on investment, increases investment and thereby increases growth.

Fisher (1995) extends the models of Jones and Manuelli (1990) and Rebelo (1991) to an overlapping generations setting. There are two sectors in the economy; one producing a perishable consumption good and one an investment good. Labour and capital produce the consumption good with production characterised by a Cobb-Douglas function, while the investment good is produced by capital only. Growth is found to depend positively on the savings rate. Fisher extends the model to include trade between two countries, where it is assumed that they have identical technologies and preferences, but can have different savings rates. Fisher finds that when both countries are diversified, factor price equalisation (FPE) occurs, both countries have the same capital-labour ratio and the world growth rate is between the autarkic rates of the two countries. This implies that the country with the higher savings rate suffers a drop in its growth rate, while the country with the lower savings rate experiences an increase in its growth rate.

Fisher and Vousden (1995) extend this model to consider the impact of changes in tariffs and of the formation of customs unions and free trade areas. They are able to show that trade policies that encourage the import of the consumption good by countries with high savings rates provide a source of increased outward foreign investment and will stimulate growth.

2.4-2: Trade and Growth with Human Capital Accumulation

Stokey (1991) extends the Uzawa-Lucas education model to include a continuum of individuals with different human capital levels and a continuum of products with different qualities. Only individuals with higher levels of human capital have the knowledge to produce higher quality products. As human capital grows, output growth consists of dropping lower quality goods from production and adding higher quality goods. The effects of free trade are examined for a small economy, where knowledge is assumed not to spill over across countries and where the small economy is assumed to have a different level of knowledge to the rest of the world. In the large economy a shift from autarky to trade doesn't alter wages, prices or the interest rate, and therefore doesn't alter the incentives to accumulate human capital. In the small economy however, the incentives to accumulate human capital do change. Stokey shows that if the economy is initially much less developed or much more developed than the rest of the world, then the shift to free trade from autarky slows its rate of human capital accumulation and growth.

If the economy is much more developed than the rest of the world then even with small levels of investment in human capital, an individual in the small economy will be highly skilled relative to individuals in the rest of the world. This implies that the opportunity cost of investment in human capital will be high and the optimal level of investment low. In the short-run, its stock of knowledge grows at a rate less than its steady state rate under autarky. Eventually the stock of knowledge falls to the level of the rest of the world and then its growth rate proceeds at the same rate as the world growth rate, which is lower than the autarkic rate for the small country. Alternatively, if the economy is less developed than the rest of the world, then high skilled labour will be relatively abundant in the rest of the world. Trade will lower the relative price of goods produced by high skilled labour and will lower the incentive for individuals in the small country to invest in human capital.

In the above example, changes in relative product prices following the opening of trade affect relative factor rewards and the incentive to accumulate human capital. In the situation described above where opening to trade for a small country lowers the incentive to invest in human capital and therefore reduces growth, there may be a role for trade interventions to raise the incentives for schooling, thereby increasing the growth rate[21]. Falvey (1997) notes that if schooling spillovers are at least partially international in scope, there exists the possibility for a small developing country to benefit from the higher level of human capital in the rest of the world. In such a situation restrictions on inputs to formal schooling activities, such as foreign educational materials and foreign educators would be inappropriate.

Lucas (1988) extends his one good model of LBD to a two-good model and considers the role of trade. The growth rate of human capital in each sector *i*, is assumed proportional to the fraction of workers in each sector. Learning is thus assumed not to display spillovers across goods. Following equation (2.28) the growth of human capital is given by $a_i \tau_i$, where τ_i is the fraction of workers in sector *i* and a_i is a measure of learning efficiency. Lucas assumes that $a_1 > a_2$, so that sector 1 is the high-technology sector. If the goods are good substitutes for each other, then the economy in autarky converges to specialisation in one of the goods, with the choice being determined by initial conditions. If the goods are poor substitutes, a steady state in which both goods are produced is reached, with the workforce allocated such that, $a_1 \tau_1 = a_2 \tau_2$.

[21] Such a role however would only be second-best; a subsidy to education would be the first-best solution.

Lucas considers the effect of free trade in both goods for a continuum of small economies. Given the learning technology assumed and given world prices, countries will accumulate skills by specialising in what they do best, intensifying the comparative advantage they begin with. Countries with relatively high levels of human capital in good 2 prior to trade, will following trade produce good 2; accumulation of human capital in good 1 will cease, while accumulation of human capital in good 2 will grow at the rate a_2. Over time this country will get relatively better at producing good 2. Similarly, for countries who are relatively good at producing good 1 prior to trade. They will following trade produce good 1, over time getting better at producing this good, locking in their initial comparative advantage. Given this result, Lucas finds that if the two goods are good substitutes, the producers of the high technology good, good 1, will enjoy higher than average output growth. Lucas notes however that there may be instances when producers switch from one good to the other. The terms of trade are moving against the high technology good since its supply is growing faster. Given this producers of the high technology good may switch production. This is likely to be the case if the degree of substitutability between the two goods is low. If the terms of trade effect dominates the productivity effect, then countries with the fastest rate of technological progress would have the slowest output growth.

In the examples above the potential for LBD is unbounded, implying that growth can continue indefinitely. Yet the evidence suggests that there are strongly diminishing returns to this type of learning, particularly when producing a single good. As discussed above both Young (1991) and Stokey (1991) have shown that despite diminishing returns to LBD in individual goods, growth may continue if new goods continually emerge and if there are spillovers of knowledge across goods. In Young's (1991) model for example, growth is generated by LBD which although bounded in each good exhibits spillovers across goods. He examines the impact on growth of a movement to free trade. In the model there is a continuum of goods, any of which could conceivably be produced at any given time. It is assumed that the knowledge generated from LBD is in the public domain. At any given time, LBD will have been exhausted in a subset of goods, but will continue in the remainder. Over time growth involves the production of a changing basket of goods, with both the quality and variety consumed increasing. Assuming there is no international diffusion of knowledge, the effect of trade upon technological progress and growth will depend upon whether static comparative advantage leads an economy to specialise in goods in which it has mostly exhausted LBD or in goods where LBD is still present.

Young examines the case of free trade for a developed country and a developing country, where the developing country hasn't obtained the level of knowledge through LBD to produce goods of as high a quality as those being produced in the developed country. Young finds that the developed country produces more technologically sophisticated goods. In terms of technological progress, the developed country experiences dynamic gains from trade, while the developing country experiences dynamic losses. Under free trade the keenest areas of competition between the developed and the developing country is in the most advanced developing country goods and the least advanced developed country goods. This competitive interaction has an asymmetric effect driving developed country's labour out of the developed country's low numbered industries into industries in which it still experiences LBD, while simultaneously forcing developing country labour out of high numbered industries into industries in which it has already exhausted LBD. In this case, although the developing country's comparative advantage is statically optimal it has detrimental effects on its rate of technical progress. Under free trade the developed country experiences faster technological progress and growth at the expense of the developing country. Young however, finds that if the initial difference between the two economies is small enough and the developing country's population large enough, the developing country can draw back the developed country and overtake it.

In the above cases, the effects of trade on growth depend crucially upon whether there exists scope for productivity growth through LBD in the sectors in which a country has a comparative advantage. If there is no such scope in these sectors a country can be worse off, in terms of growth, following trade. This conclusion is suggestive of the benefits of trade policy that look to develop industries in which LBD is present. Such a strategy of "picking winners" however is inherently risky, although it may be less so for imitators who can examine the pattern of foreign R&D. Moreover, to the extent that LBD spillovers occur across goods we may expect restrictions on trade to be detrimental to growth. For rapid growth we need a rapid turnover of goods produced, which is difficult when domestic production is tied to the slowly changing domestic consumption mix

(Lucas, 1993). We may expect international spillovers of knowledge to be limited in the above models since the knowledge gained is assumed to be embodied in the individual. If such spillovers can be transferred through foreign commercial contacts, foreign consultants, or foreign direct investment however, this is a further reason to reduce restrictions on such trade (Falvey, 1997).

2.4-3: Trade and Growth with Innovation

The models of growth based on innovation described above envisage growth as arising from the invention of new products or the improvement of existing products. According to Taylor (1996), trade may affect growth in these models through four channels. Firstly, there are scale effects on goods production and R&D activities; since trade provides access to a larger market for goods, factors and knowledge. Secondly, there are allocation effects of trade; trade by altering the set of prices facing domestic producers will lead to a reallocation of domestic resources. Thirdly, there are spillover effects; to the extent that trade facilitates the flow of knowledge across borders, we would expect it to affect innovation and growth. Finally, there are redundancy effects, trade would be expected to reduce the duplication of R&D, since innovation must be original for the world market and not just the local one.

When we introduce trade into models of horizontal innovation we can examine two cases; where intermediate goods flow across borders or where ideas or knowledge flow. In the knowledge driven specification of Romer (1990) and Grossman and Helpman (1991a), growth in new products and the growth of the economy depend upon the knowledge each research firm possesses (the public knowledge stock) and upon the number of workers they hire. If trade alters either of these factors then growth will be affected. If there is exchange of goods but not knowledge, such that the public knowledge produced by research firms spills over within a country but not between countries, then the stock of knowledge each research firm possesses will be the same following trade as it was prior to trade. Then the effects of trade on growth will depend upon the effects of trade on employment in R&D. Rivera-Batiz and Romer (1991a) show that for two identical economies, trade has no effect upon growth. Following trade the marginal product of labour in manufacturing increases as firms have access to double the amount of intermediates assuming no duplication in research, which would tend to shift labour out of R&D and into manufacturing. However, following trade the market for newly developed intermediates doubles in size, which raises the returns to R&D and encourages labour into the research sector. Overall these two effects are found to cancel each other out, so trade has no impact upon innovation or the rate of growth.

When knowledge flows are allowed but not trade in goods, the effect of trade on growth depends upon the extent of overlap between the ideas of each country. Rivera-Batiz and Romer (1991a) note that if there is no trade in goods, there is no incentive for researchers in each country to specialise in designs distinct from those available in other countries. If there is total overlap of designs in each country, then trade in ideas will have no impact upon the stock of knowledge available to research firms, and as such trade will have no impact on innovation or the rate of growth. If overlap is not complete however there may be a positive impact of flows of knowledge on the rate of innovation and growth, with the benefit being inversely related to the extent of overlap (Grossman and Helpman, 1991a, Chapter 9). Once knowledge flows are allowed, the stock of knowledge each country uses in research will depend upon the world stock of knowledge. In the case of two identical economies and assuming that the two countries' knowledge stocks are non-intersecting[22] then the knowledge stock in each country doubles following trade. Rivera-Batiz and Romer (1991a) show that this will have the effect of doubling the rate of innovation in each country and therefore growth. Furthermore, the higher stock of knowledge increases the productivity of R&D relative to manufacturing, which will have the effect of shifting labour from manufacturing into R&D, further increasing the rate of innovation and growth.

Grossman and Helpman (1991a, Chapter 8) consider the case of localised knowledge spillovers where it is assumed that the two countries may differ in size and prior research. They find that the country that inherits the greater stock of knowledge comes to dominate the world market for high technology goods. With free entry into R&D and a unified world capital market, investors will only finance R&D by firms operating in the country that has the lowest cost of R&D. If wage rates are the same, costs must be lower in the country that has the larger stock of knowledge, and thus the greater productivity in research. Given this the country with an initial technological advantage will undertake the entire world's R&D. Innovation and output growth increase in this country as resources move

[22] Trade in goods by reducing redundancy in research is likely to lead to this situation, whereby the two countries knowledge stocks do not intersect (Rivera-Batiz and Romer, 1991a).

from manufacturing into R&D[23]. For the lagging country trade results in stagnant productivity and output, when under autarky technological progress would take place. Due to the country's relative inexperience in R&D, research firms cannot compete successfully with those in the more advanced country, as such resources are reallocated to other activities. This result may be reversed if the technologically lagging country has a much larger endowment of labour than the technological leader. The wage rate and the cost of innovation may then be lower in the lagging economy. If this were the case the larger country would experience faster innovation, which would enable it to eliminate the technology gap and eventually capture the world market for high technology goods. Alternatively, an R&D subsidy in the technologically lagging country can reduce the cost of innovation and allow the country to experience faster innovation. Such a policy only need be implemented until the initial deficit in knowledge is eliminated.

Grossman and Helpman (1991a, Chapter 7) extend their simple knowledge driven model of horizontal innovation to a two-sector, two-factor economy. In addition to the research sector there are two sectors; a traditional goods sector and a manufacturing sector producing differentiated products. There is both skilled and unskilled labour in the economy, with skilled labour used most intensively in research and least intensively in the traditional goods sector. Grossman and Helpman find that with perfect international knowledge spillovers the country with a relative abundance of human capital conducts relatively more R&D in the steady state than its trade partner compared to its

[23] Feenstra (1996) derives similar results.

relative output of the traditional good. The model developed predicts equal rates of productivity growth in the sector that manufactures innovative goods in each country. However, high technology comprises a larger share of output in the human-capital rich country than in the unskilled labour rich country. It follows that real output growth is faster in the human capital rich country.

In the so-called lab-equipment model of Rivera-Batiz and Romer, intermediates enter directly into research, but the rate of innovation is independent of the existing knowledge stock. Since the knowledge stock doesn't affect the rate of innovation, trade in ideas will have no effect upon the rate of innovation and growth. Trade in goods however will affect the rate of innovation and growth by attracting labour into the research sector. Employment in the research sector increases following trade since it increases the size of the market and therefore the returns to R&D. Furthermore, trade in intermediates increases the productivity of research by increasing the variety of intermediate inputs used in R&D.

Grossman and Helpman (1991a, Chapter 7) also examine the effects of trade in models of vertical innovation. Following trade, entrepreneurs in each country are able to target their R&D efforts at state-of-the-art products manufactured locally or those manufactured abroad. All manufacturers of state-of-the-art products will earn higher profits if their nearest rival is from a country that has higher manufacturing costs. All entrepreneurs therefore would prefer to improve products that are manufactured in the high cost country. This implies that if one country exhibits higher costs of production it will lose competitiveness in all such goods over time, since all research effort will be aimed at displacing this country's products. In the case of international knowledge spillovers when countries aren't completely specialised, Grossman and Helpman find that in their two-country, two-factor economy, a human capital abundant country specialises relatively in R&D. Due to the relatively greater number of successes, this country captures leadership positions in a relatively large number of high technology industries compared to its output of traditional goods. The human capital rich country enjoys faster growth than its trade partner does in the steady state.

In the models described above, the role of trade in the growth process is examined for two polar cases. In the first the transfer of the public knowledge stock between countries is instantaneous and costless, while in the second public knowledge is assumed not to flow between countries. Neither of these two extremes is likely to be realistic. Knowledge embedded in products, what was termed product specific knowledge in section 2.3-3, is also likely to have many of the properties of a public good, in that it is non-rivalrous and non-excludable. It is likely that firms through examination of the product could appropriate some product specific information. These firms could be rival domestic firms, or alternatively foreign firms who gain access to the innovating firm's goods through trade. The diffusion of such product specific knowledge we term technology diffusion, which differentiates it from knowledge spillovers that occur when the public knowledge stock diffuses.

Once firms have examined the products of the innovating firm, they may be able to imitate the innovating firms goods and compete with these innovating firms. Clearly, innovating firms who develop new products want to retain a monopoly over the product they developed and prevent others from appropriating the technology. This may be achieved through patent protection for example. Rival firms however, have an incentive to try and imitate the innovating firm's goods in order to compete with it. Technology diffusion is likely to be prominent in the open economy where imitation is likely to take place in countries where manufacturing costs and patent protection are low. If firms operating in these low-cost countries can imitate goods they can capture market share at the expense of firms in the advanced countries. Technology diffusion is likely to be of much more importance in developing countries than knowledge diffusion. In developing countries R&D spending tends to be low, and the benefits from knowledge diffusion that lowers the cost of R&D are likely to be small.

In models of technology diffusion two types of outcome are possible depending upon the model used. In the model of horizontal innovation the result of technology diffusion is likely to be imitation of an advanced country's product by firms in developing countries. With the model of vertical innovation however a further complication may arise; a firm in an advanced country may improve upon a product that has been imitated by a firm in a developing country, with production shifting from the developing country back to the advanced country. We may then get what Vernon, (1966) described as a product cycle.

In the models of technology diffusion developed by Grossman and Helpman (1991a) a distinction is made between a model of imitation and a model of product cycles. They distinguish between the innovating North and imitating South. The North is assumed to invest in R&D to either develop new products or improve upon the quality of existing products, depending upon the model of innovation assumed. The South is assumed not to innovate however, but to imitate Northern firm's products. Imitation is achieved through investment in a similar manner to innovation by Northern firms. It is further assumed that there is only one primary factor, labour, and that wages in the South are less than those in the North. This assumption implies that if a firm in the South has been able to imitate the product of a Northern firm then it will supply the whole market, either by setting a limit price or if the difference in manufacturing costs is large, by setting a monopoly price.

The mechanism through which the diffusion of technology is assumed to take place is through trade; the South by importing goods from the North can examine these goods and learn how to produce them. In the model of imitation Grossman and Helpman (1991a, Chapter 11) find that the North grows faster when it trades with the South than when it remains economically isolated. Exposure to imitation shortens the expected duration of monopoly rents for the typical Northern innovator, but Northern producers enjoy higher rates of profits during their tenure as monopolists. Each surviving Northern firm benefits when a Southern producer takes over manufacturing from a rival Northern brand because it is able to hire some of the laid-off workers and thereby expand its sales and profits. The positive effect of imitation on profits serves to encourage innovation and therefore growth. The potential for imitation also allows the South to introduce new varieties at lower resource cost than if it had to develop the varieties from scratch. If the South has little or no capacity to invent new products this resource saving translates into more rapid growth. If the input requirements for imitation are sufficiently similar to those for inventing new goods in the South, then growth under trade could be less than that under autarky, although this is the least plausible of the two possible outcomes.

Vernon (1966) described what he considered to be the product cycle for a typical innovative product. According to Vernon, new goods are developed in the North and manufactured there until designs have been perfected and production techniques standardised. Then the innovating firms move the location of production to the South where wage rates and perhaps input costs are lower. In a final stage of a product's life, higher quality products developed by the North compete with the product and ultimately render it obsolete. As such Vernon envisaged a case whereby production of a commodity shifts from the North to the South periodically, with the quality of that product increasing over time. The transfer of technology from the North to the South was assumed by Vernon to occur through Foreign Direct Investment (FDI), others model imitation as the source of technology transfer however, examples include, Krugman (1979), Grossman and Helpman (1991a, Chapter 12) and Segerstrom (1991).

Grossman and Helpman (1991a, Chapter 12) develop a model of product cycles with vertical innovation. Again the South has a lower wage rate than the North, implying that if both regions have access to the same technology then only the

South will produce the good. Grossman and Helpman distinguish between three possible types of firm. There are Northern leaders who are competing with another Northern firm that can produce the next best quality, then there are others who compete with Southern firms that can produce the second best quality level. Finally, there are Southern firms who through imitation produce the state of the art product. In equilibrium, the various industries experience stochastic product cycles. If leaders enjoy a large productivity advantage over Northern followers, then followers conduct no research and will make no attempt to recapture markets lost to the South. In this case, an individual product might be manufactured for a while in the North before a Southern firm succeeds in its efforts to learn the technology and production would shift to the South. The Northern leader would then undertake R&D in order to make the product produced by the South obsolete. Once this was achieved production would shift back to the North until imitation by Southern firms once again meant that the product would be produced in the South. If however followers are relatively efficient in R&D they will undertake R&D and production may shift from one Northern firm to another. In this situation the history of any product may be complex, there may occur a succession of quality upgrades in the same product line without the manufacturing base ever shifting to the South, or alternatively production may periodically shift to the South.

The effect on the growth rate of the North of trade with the South is difficult to determine here. Trade opens the North to technological imitation that would otherwise not occur. The risk of having an innovation copied reduces an entrepreneur's incentive to engage in R&D. At the same time however, trade may raise the profit rate for firms that are lucky enough to escape imitation. In the model of quality improvements either effect can dominate and trade with the South may speed or slow growth in the North. The effects of trade for the South are found to be similar to those described above in the case of imitation, with the South benefiting from higher growth.

Chui, Levine and Pearlman (1999) examine this apparently counterintuitive result of Grossman and Helpman, that increased copying of new goods by the South may actually encourage innovation in the North and increase world growth. They develop a model similar to that of Grossman and Helpman, but include two factors of production, skilled and unskilled labour and include a traditional good alongside the manufacturing sector. They show that if R&D requires only skilled labour and if traditional manufacturing requires only unskilled labour, an increase in Southern imitation increases world growth, which corresponds to the result of Grossman and Helpman. If however traditional manufacturing also requires the use of skilled labour, then world growth may fall as Southern copying increases.

The discussion above concentrates on the impact of a shift from autarky to free trade on a country's growth rate, there has been much less discussion of the role of trade policies on growth in these models. Amongst the papers that do consider the role of trade policies is Rivera-Batiz and Romer (1991a). They examine the effects of trade restrictions on growth for two identical economies that each produce a distinct set of intermediate goods. They show that the growth rate is a non-monotonic function of the tariff rate. Growth falls as the tariff rises from zero, but after some positive value of the tariff, the growth rate rises, although the growth rate is always lower than that under free trade. The explanation for this result is that the tariff has two effects, a trade distortion effect and R&D resource allocation effect, with the size of the tariff determining the strength of these two effects. Grossman and Helpman (1991d)[24] show how it is possible for a tariff to raise world growth. In a two-country world, they show that a tariff by country A on the exports of country B, which has a comparative advantage in R&D, will tend to shift resources towards the R&D sector in country B. This will have the effect of increasing the growth rate in country B. Given perfect international spillovers however, both countries will grow at the same rate, as such the tariff will raise the growth rate in both countries. Grossman and Helpman (1991e) also study the effects of tariff policies for a small open economy. They show that the protection of a final good that uses human capital intensively will raise the reward to human capital and make R&D more costly, thus slowing growth.

One implication of the theories described above is that countries with a comparative disadvantage in R&D may suffer a decline in growth following opening to trade, which may be used as a justification for trade restrictions. Falvey (1997) notes however, that if intermediates can be traded internationally such a country would still benefit from the increased productivity gains from innovation that come through increased factor productivity in the final goods sector.

[24] See also Grossman and Helpman (1991a, Chapter 10).

2.5 Concluding Remarks

A brief overview of different countries growth experience over history points to the conclusion that there seems to be systematic differences across countries in their growth rates. A great deal of effort has been expended trying to develop a theoretical model that can explain these differences. The aim of this chapter was to summarise the major theoretical models of economic growth, beginning with the neoclassical model and then moving on to endogenous growth models. Using these models we were able to examine the importance of trade in the growth process.

The neoclassical model was developed partly in response to the instability of the Harrod-Domar model, but suggested a steady state in which there was no per capita output growth. A further implication of the model was that government policies had no effect on long-run steady state growth. The model as originally developed also had the empirically unappealing implication that countries should in the long-run all grow at the rate given by the rate of population growth, assuming identical technology.

Since the influential papers of Romer (1986) and Lucas (1988) more attention has been paid to explaining the actual causes of economic growth. The major advantage of new growth theory is that it endogenises the determinants of growth. A variety of theoretical models have been developed, highlighting a role for several factors in the growth process. These include the accumulation of capital, learning by doing, education, and innovation. It is the case in these theoretical models that an externality associated with one or more of these factors is the source of long-run growth. An important implication of the externalities highlighted is that there may be a role for government in the growth process.

Once trade is introduced into the theoretical models the advantage of the endogenous growth models over the neoclassical model becomes clear. In the neoclassical model, trade policy, as with other government policies doesn't affect long-run output growth, which is determined by the exogenous rates of population growth and technology growth. When we introduce trade into endogenous growth models we obtain a diversity of results, depending upon assumptions made about the country, the extent of spillovers across countries and upon the type of model we are dealing with. The implication being that openness to trade and changes in trade policy may increase, retard, or leave growth unaffected. Openness to trade can have a number of beneficial effects on growth: it allows countries to employ a larger variety of intermediate or capital goods, which can enhance the productivity of domestic resources; it allows the international exchange of information that can lower the cost of R&D; it may also lead to the reallocation of resources towards the sector in which externalities are present[25]. Moreover, goods trade would be expected to reduce duplication in R&D, thereby increasing the efficiency of innovation. However, if a country has a comparative disadvantage in the sectors in which externalities are present, trade may lead this country to specialise in activities that are not

[25] This could be the education sector, the sectors in which LBD take place or the innovation sector for example.

conducive to growth. When knowledge spillovers are national in scope, countries that are small or that have historically conducted little R&D may come to specialise in sectors other than innovation following trade. Innovation would fall to zero under trade, where in autarky positive levels of innovation would have occurred.

The notion that some countries may not benefit from openness in terms of growth is not new. The theory of immiserising growth, based on the terms of trade (see Chapter One) suggests that some countries can become worse off following trade. As does the staples theory of growth (Innis, 1993), which argues that regions evolve according to their comparative advantage driven by their natural resource endowments for production of a specific commodity (usually natural resources, mining or agriculture). Over time these commodities that were originally the focus of development change in importance and the fortunes of the country change with them. The countries that tend to be made worse off in these models are countries that have a comparative advantage in the production of primary products. These theories have a number of implications for empirically testing the relationship between openness and growth. Given that the impact of openness on growth is likely to depend on the goods in which a country specialises, it is important to account for a country's structure of production, which will depend upon its resource endowments. It may also be necessary to split the sample of countries, since we would expect a positive impact of openness on growth in some cases, but not others. This result can even be true within countries. Take for example the United States; the Northern States have developed rapidly over the last two centuries, while the Southern states that tend to have a comparative advantage in the production of primary products have developed much less quickly.

In general, factor endowment composition, country size and research experience interact to determine long-run resource allocation and growth. The diversity of results obtained suggests caution in making policy recommendations regarding trade and trade liberalisation from growth theory alone, such recommendations should depend upon country characteristics and upon the characteristics of partner countries. Despite this, the new growth theories provide a rich area for empirical testing.

For developing countries a number of hypotheses concerning the trade-growth relationship stand out. The theory is ambiguous concerning the benefits to developing countries of trading with developed countries. In general, developing countries will have a comparative disadvantage in those sectors where externalities are likely to be important. This would tend to suggest that developing countries would be made worse off following trade, since they would become specialised in sectors that are not conducive to growth. On the other hand, trade with developed countries would encourage the importation of a wider variety and a higher quality of intermediate and capital goods, which would be expected to increase the productivity of manufacturing in developing countries. Moreover, openness to trade with developed countries may encourage the importation of products that have the potential to be imitated, which may improve growth.

International trade that fosters the transmission of knowledge across borders would be expected to encourage innovation and growth. Although such trade may increase the local stock of knowledge, this is not a sufficient condition for growth however. In many developing countries we may expect that the resources are not available to make use of such information generated by openness, with the consequence that growth isn't encouraged by trade. As such the resource composition of countries may determine the extent of benefits from trade.

Appendix 2A: The Harrod-Domar Model[26]

Both Harrod (1939) and Domar (1946) developed models of growth that extended Keynes' theory of demand-determined equilibrium. The most important assumption underlying the Harrod-Domar model is that of fixed proportions in the production function. It is this feature that leads to the predictions of unstable long-run growth rates and the potential perpetual growth of unemployment of either capital or labour.

Using a fixed proportions or Leontief[27] production function, we can write an aggregate production function for final output, Y, in the following form

$$Y = F(K,L) = \min(AK,BL), \qquad \textbf{(A2.1)}$$

where A and B are the reciprocal of the unit input requirements for capital and labour respectively and are both positive constants. With this production function, if the capital stock and the labour force happen to be such that $AK = BL$, then all workers and machines will be fully employed. If however we have the case that $AK > BL$, then only the quantity $(B/A)L$ of capital will be employed, with the remainder left idle. Similarly, if it is the case that $BL > AK$, then only the amount $(A/B)K$ of labour will be employed. The assumption of a fixed proportion's production function then leads to the probability of unemployed resources in the Harrod-Domar model.

We can re-write equation (A2.1) in per capita terms, which gives

$$y = \min(Ak, B). \qquad \textbf{(A2.2)}$$

[26] The following is based largely on Barro and Sala-i-Martin (1995).
[27] Leontief (1941) proposed this kind of fixed proportion's production function.

Equation (A2.2) states that output per person is proportional to the capital-labour ratio. Capital is assumed to accumulate through saving as in the neoclassical model. The change in the capital stock is given by investment minus depreciation, which we can write as

$$\dot{K} = I - \delta K = sY - \delta K. \tag{A2.3}$$

Given this function for investment, we can write the change in the capital-labour ratio as

$$\dot{k} = \frac{\dot{K}}{L} - lk,$$

which implies

$$\dot{k} = sy - (\delta + l)k. \tag{A2.4}$$

In equation (A2.2) we can either have $k < B/A$ in which case $y = Ak$, or we can have $k > B/A$, which implies that $y = B$. For the case $y = Ak$, equation (A2.4) becomes $\dot{k} = sAk - (\delta + l)k$ and the growth rate of capital becomes

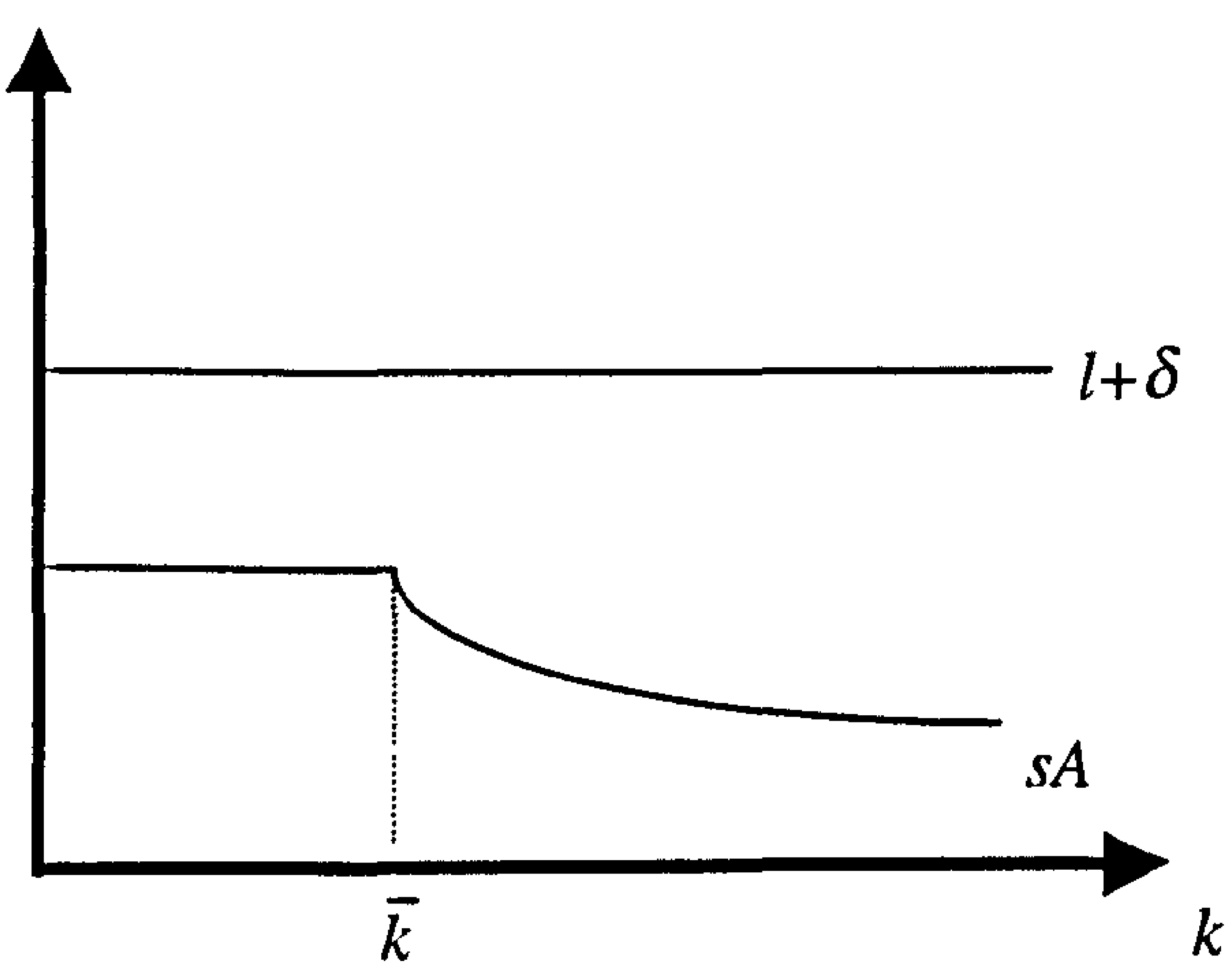
$$\frac{\dot{k}}{k} = sA - (\delta + l). \tag{A2.5}$$

Similarly for the case $y = B$ we have $\dot{k} = sB - (\delta + l)k$ and

$$\frac{\dot{k}}{k} = \frac{sB}{k} - (\delta + l). \tag{A2.6}$$

Equations (A2.5) and (A2.6) are illustrated in the following diagrams. In Figure 2.3 we assume that $sA < l+\delta$, while in Figure 2.4 we assume that $sA > l+\delta$. In the diagrams $\bar{k} = B/A$, to the left of this point therefore we have the situation depicted by equation (A2.5); while to the right we have that depicted by equation (A2.6). The first term on the right hand side of equation (A2.5) will be a horizontal line at sA, given that both of these terms are constants. The first term on the right hand side of equation (A2.6) however will be downward sloping and will approach zero as k tends towards infinity. We know from the discussion of the neoclassical model that the second term on the right hand side of equations (A2.5) and (A2.6) will be a horizontal line at $l+\delta$.

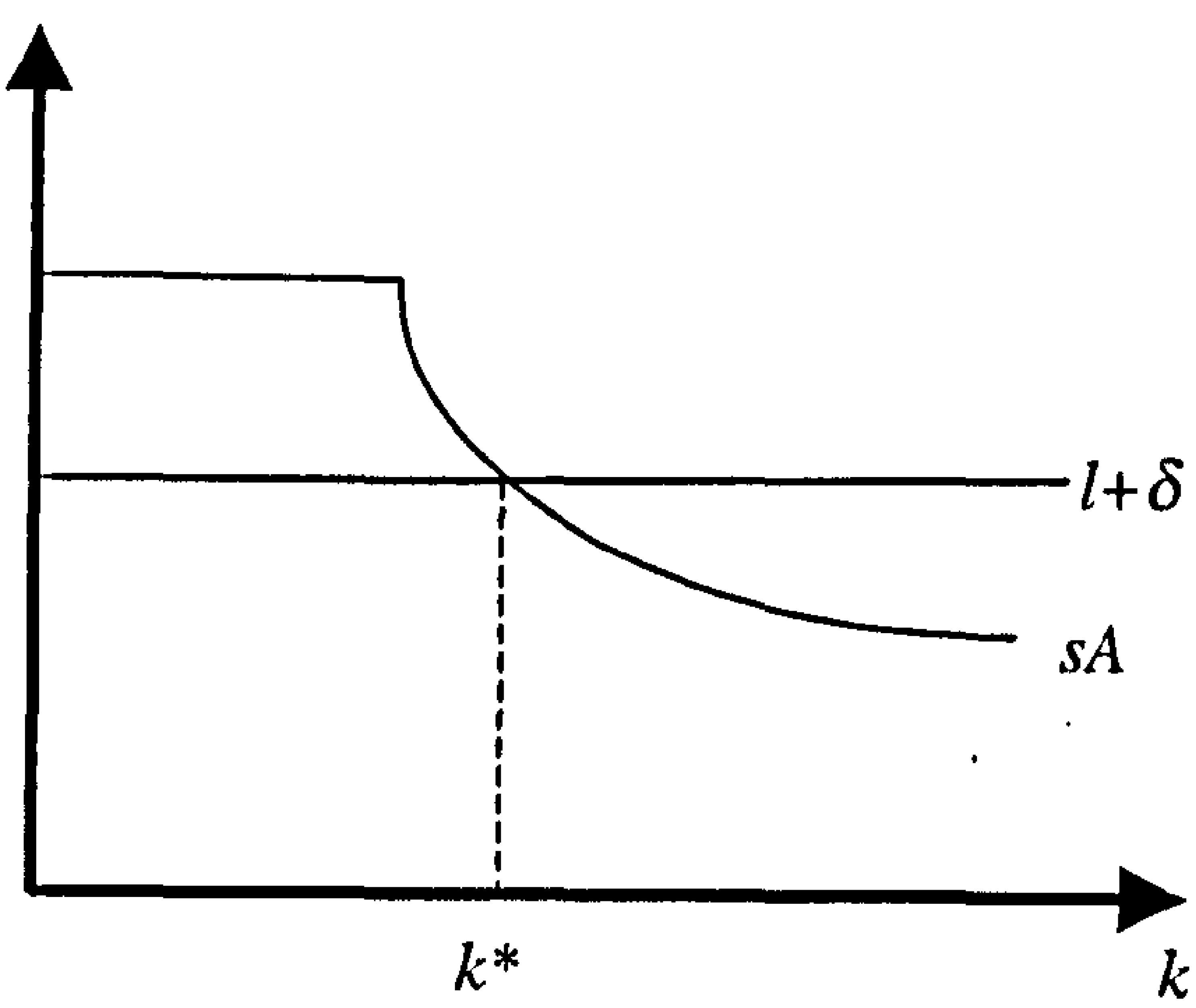
Figure 2.3: The Harrod-Domar Model (Scenario One)



In the situation depicted in Figure 2.3 when we assume $sA < l+\delta$, the savings curve never crosses the $l+\delta$ line, so there is no positive steady state value of k. Furthermore, $\dot{k}/k$ is always negative, so the economy shrinks in per capita terms, and k and y all approach zero. This implies that the economy ends up to the left of $\bar{k}$ and has permanent and increasing unemployment.

If however $sA > l+\delta$, as depicted in Figure 2.4 then the savings curve will cross the $l+\delta$ line[28] at some point $k^* > \bar{k}$. If the economy begins at a point to the left of k^*, then the growth of k will be given by the constant $sA - (l-\delta)$ until the point at which $k = \bar{k}$. At that point the growth of k begins to fall and reaches zero when $k = k^*$. If the economy begins to the right of k^*, the growth of k is initially negative and again approaches zero as k approaches k^*. In this case steady state features idle machines but no unemployed workers. Since k is constant in the steady state, the quantity of capital grows at the same rate as the quantity of labour, which is given by l. Furthermore, since the fraction of capital that is employed remains constant; the quantity of unemployed capital also grows at the rate l.

Figure 2.4: The Harrod-Domar Model (Scenario Two)



The only way to achieve a steady state in which all capital and labour are employed is if $sA = l+\delta$. Since all of these variables are exogenous however, this equality will only hold by chance. This led to the undesirable conclusion of the Harrod-Domar model that in all probability an economy would suffer from the perpetual growth of unemployment of either capital or labour.

[28] Given that the savings curve approaches zero as k approaches infinity this is bound to be true.

Appendix 2B: Properties of the Neoclassical Production Function

The intensive form of the neoclassical production function is assumed to have the following properties.

1. $f(k) = 0$ when $k = 0$

2. $f'(k) > 0$, that is, the marginal product of capital is positive for all levels of the capital labour ratio.

3. $f''(k) < 0$, that is, the marginal product of capital diminishes as capital per worker increases.

4. $\lim_{k \to \infty} f'(k) \to 0$, that is, at very high levels of the capital-labour ratio, the marginal product of capital becomes very small.

5. $\lim_{k \to 0} f'(k) \to \infty$, that is, as the capital-labour ratio tends towards zero, the marginal product of capital tends towards infinity.

The last two of these conditions are called Inada conditions.

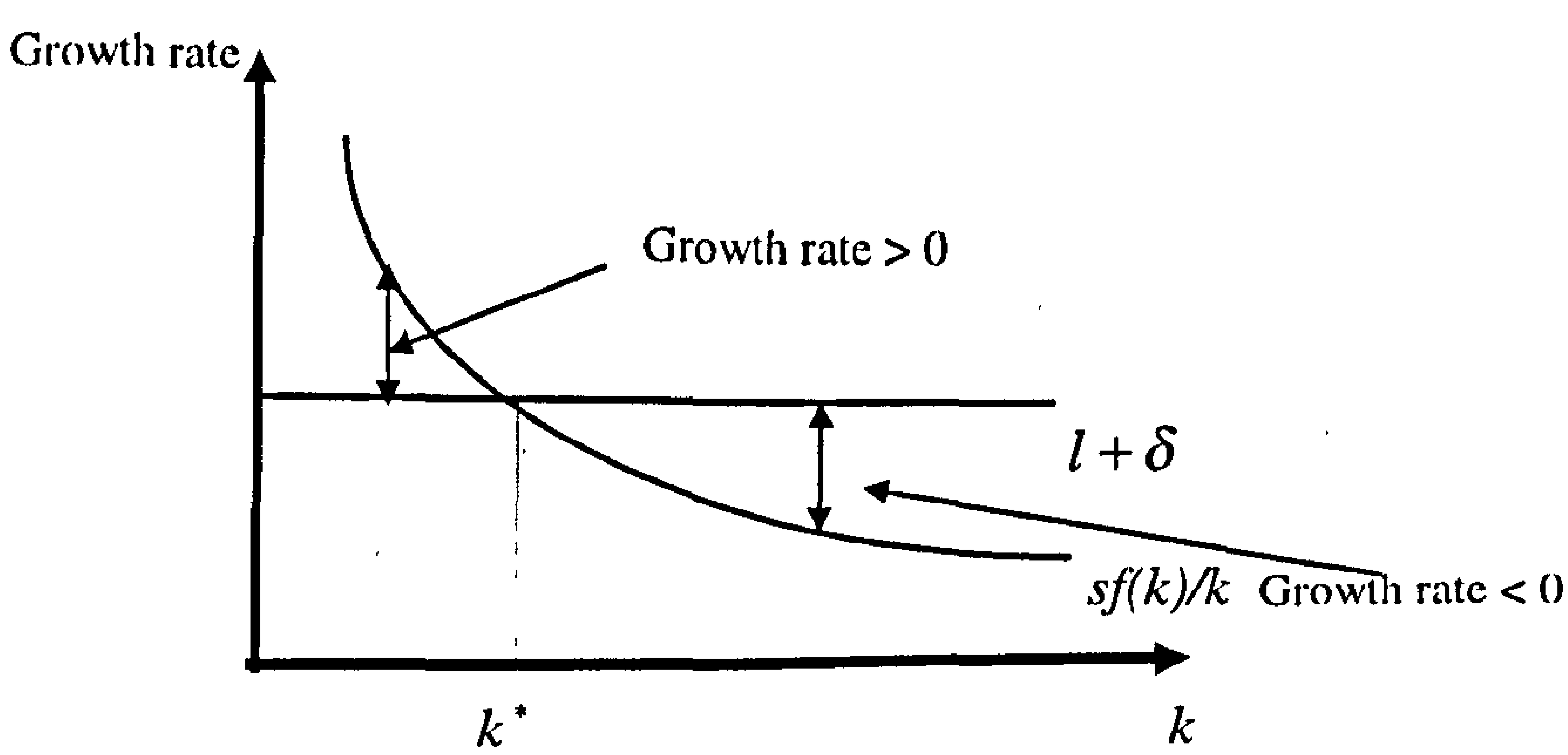
Appendix 2C: The Neoclassical Growth Model

An alternative way of writing equation (2.5) is to divide through by k to give the growth rate of the capital-labour ratio,

$$\frac{\dot{k}}{k} = \frac{sf(k)}{k} - (l + \delta). \quad \text{(A2.7)}$$

The growth in k is the difference between $sf(k)/k$ and $(l+\delta)$. These two terms are plotted in Figure 2.5. Since both labour force growth and the depreciation rate are assumed constant, $(l+\delta)$ is a horizontal line. The curve $sf(k)/k$ is downward-sloping however[29] which asymptotically tends towards infinity as k tends to zero, and tends to zero as k tends toward infinity. The vertical distance between the two curves is equal to the growth rate of capital per person. The curves intersect once and only once when $sf(k)/k=(l+\delta)$ which implies that a unique steady state exists.

Figure 2.5: The Dynamics of the Neoclassical Growth Model



[29] The derivative of $f(k)/k$ with respect to k equals $-[f(k) - kf'(k)]/k^2$. The expression in brackets equals the marginal product of labour, which is assumed positive. The derivative of this is negative however from the assumption of diminishing marginal returns, hence the curve is downward sloping.

At points to the left of the steady state, $sf(k)/k$ is greater than $(l+\delta)$ and $\dot{k}$ is positive, which implies that k is rising over time. As k increases however the growth rate of k begins to fall and approaches zero as k tends toward k^*. The converse applies at points to the right of the steady state, we have a negative growth rate of k and the economy over time moves towards k^*. As such, the steady state which we have already shown exists and is unique, is also stable.

The neoclassical model has a number of interesting implications for growth that can be tested empirically. The model implies that identical countries should tend to converge over time[30]. The steady state in this model depends upon the values of certain parameters, if countries share these parameters then they will have the same steady state. If we imagine two identical economies except that one has a higher initial capital-labour ratio than the other. Then assuming that both countries are below the steady state, the capital-labour ratios in both countries will be increasing over time. It will be growing faster in the country with the lower capital-labour ratio however, since its capital-labour ratio gives a bigger gap between $sf(k)/k$ and $(l+\delta)$ implying faster growth of the capital-labour ratio. Faster growth of the capital-labour ratio in this country implies that it catches up with the other country over time until in steady state both have the same capital-labour ratios and the same growth rate. This is known as '*absolute convergence*'.

[30] See Barro and Sala-i-Martin (1995) for a more detailed discussion of convergence, including a discussion of empirical evidence in favour of convergence.

A weaker kind of convergence is said to exist if the steady state is different in each country. This would be the case if countries didn't share the same parameter values for population growth for instance. In such a situation, an economy grows faster the farther away it is from its own steady state. This is known as '*conditional convergence*'.

Appendix 2D: Derivation of Aggregate Output

Here we show how to derive equation (2.42) in section 2.3-3 and how using this we can derive an expression for aggregate output in a model of vertical innovation. Since it is assumed that only the 'state of the art' product is used we can write equation (2.40) as

$$\tilde{X}_{ij} = \lambda^{\bar{m}_j} X_{ij\bar{m}_j}. \quad \text{(A2.8)}$$

Substituting this into equation (2.38) gives

$$Y_i = L_i^{1-\alpha} \sum_{j=1}^{N} \lambda^{\bar{m}_j \alpha} X_{ij\bar{m}_j}^{\alpha}. \quad \text{(A2.9)}$$

The marginal product of this intermediate is then given by

$$\delta Y_i / \delta X_{ij\bar{m}_j} = L_i^{1-\alpha} \lambda^{\bar{m}_j \alpha} \alpha X_{ij\bar{m}_j}^{\alpha-1}. \quad \text{(A2.10)}$$

Since final goods producers are assumed perfectly competitive we get the usual equality between the marginal product of an input and its price. Using equations (2.41) and (A2.10) and rearranging gives equation (2.42).

Making assumptions about the firm's production functions we can write an aggregate production function as

$$Y = L^{1-\alpha} \sum_{j=1}^{N} X_{j\bar{m}_j}^{\alpha}. \quad \text{(A2.11)}$$

Substituting equation (2.42) into equation (A2.11) gives the following expression

$$Y = L^{1-\alpha} \sum_{j=1}^{N} \left[L \lambda^{\bar{m}_j \alpha/(1-\alpha)} (\alpha / \lambda)^{1/(1-\alpha)} \right]^{\alpha}. \quad \text{(A2.12)}$$

Rearranging this gives the expression for aggregate output (equation (2.44)).

Chapter Three

Trade, Trade Liberalisation and Growth: The Empirical Evidence

Chapter Three

TRADE, TRADE LIBERALISATION AND GROWTH: THE EMPIRICAL EVIDENCE

3.1 Introduction

A vast quantity of empirical evidence has built up testing for a relationship between both openness and growth, and a change in openness (i.e. trade liberalisation) and growth. The evidence is not easily summarised for a number of reasons, including the wide variety of methods for testing such a relationship and the number of different measures of openness or liberalisation employed. The aim of this chapter is to discuss the empirical literature examining the relationship between the recent growth performance of countries and their openness, reviewing how openness is measured in these studies and summarising their results[1].

The remainder of this chapter is organised as follows. In section 3.2 we discuss various measures of openness used in the literature. Section 3.3 examines the results from some recent studies that employ these measures. In section 3.4 we examine the large and diverse literature built up examining the relationship between exports and growth. Section 3.5 considers the small but growing body of evidence testing the implications of endogenous growth models, while

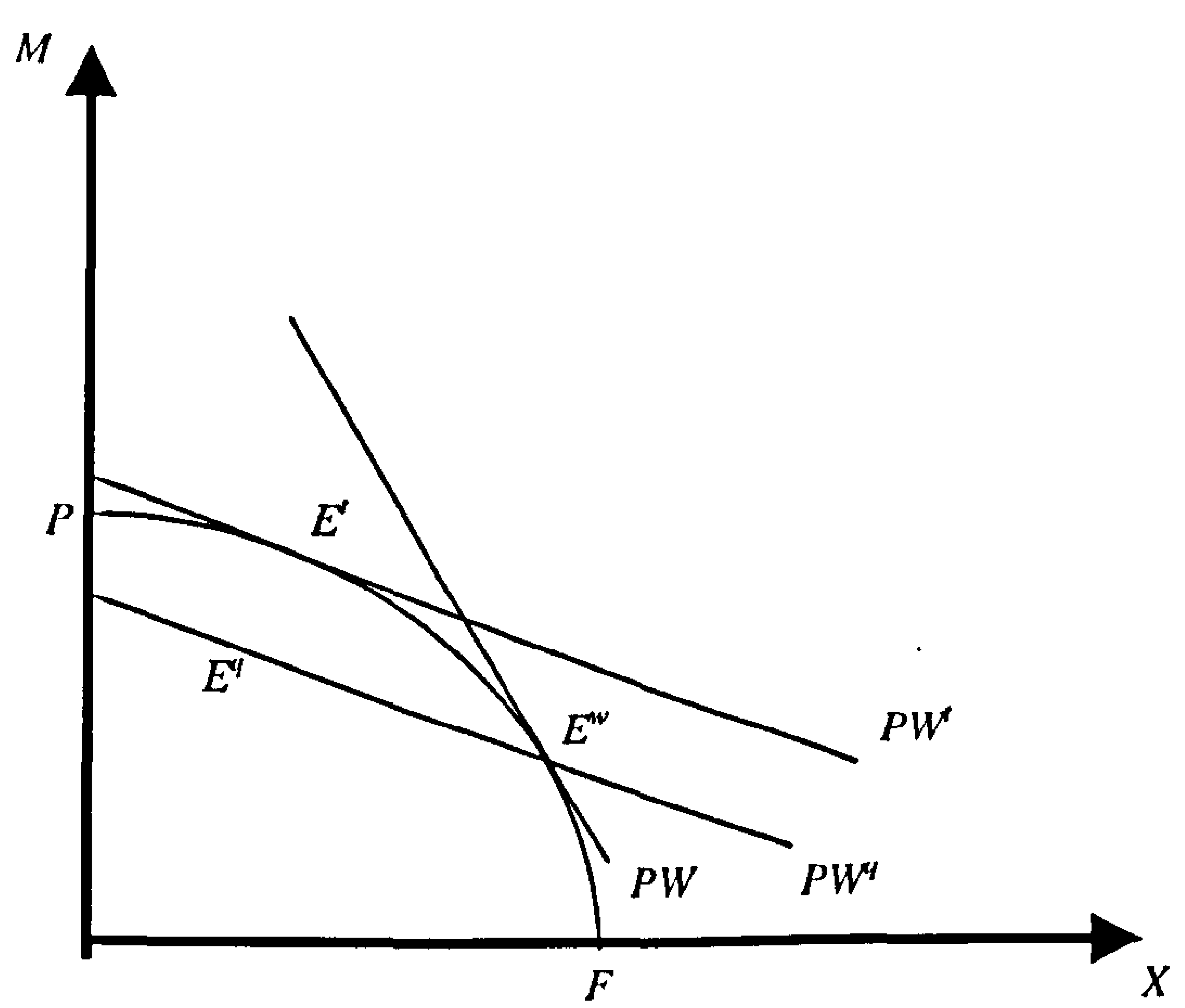
[1] There are a number of studies reviewing the empirical evidence on openness and growth. See for example Edwards (1993), Greenaway and Sapsford (1994), and Rodriguez and Rodrik (1999).

section 3.6 discusses some of the issues arising from the empirical literature on openness and growth. Section 3.7 provides some overall conclusions.

3.2 Measuring Openness

Defining openness, let alone measuring it is intrinsically difficult; trade policies tend to be complex and are not easily described in terms of a few dimensions that are easy to quantify. An initial problem is to decide what is actually meant by openness. An open economy may be defined as one that operates under a free trade regime. Alternatively it may be described as one that, although distorted, doesn't discriminate against the export sector, a situation known as neutrality. In a similar manner it is difficult to identify trade liberalisation episodes. This difficulty can be expressed in a simple diagram, shown below in Figure 1.

Figure 3.1: Concepts of Liberalisation



In the above diagram *PF* is a small country's production possibilities frontier. There are at least three concepts of trade liberalisation that can be identified from this figure. One notion involves the removal of all trade restrictions. In terms of the above diagram, suppose that the economy is operating with an import tariff, such that the domestic relative price ratio (between importables and exportables) is PW^t and production is at point E^t. The removal of trade restrictions involves removing the tariff, which restores the domestic price ratio to *PW*, the free trade price ratio, with production shifting to point E^W. Here production is more specialised in exports.

A second notion of trade liberalisation is one that removes the anti-export bias associated with the import tariff, thereby returning domestic relative prices to world relative prices. The price ratio *PW* can be considered as a *neutral* set of prices, that is, one that doesn't discriminate against either importables or exportables. Neutrality need not be obtained by removing the tariff. An alternative by Lerner Symmetry would be to introduce an equivalent export subsidy. This combination of policies would have the equivalent resource allocation effects of a free trade regime, assuming non-distorting taxes and subsidies, and can be considered a form of trade liberalisation.

A third notion is that of 'second best' liberalisation. This occurs when one instrument of protection is replaced by another less distorting instrument. In the diagram above, the relative price ratio PW^t may be achieved by a quota rather than a tariff. For a variety of reasons however quotas are considered more costly than tariffs. For example, bidding for quotas ties up real resources[2]. Quotas are

[2] Krueger (1974) estimated that quota rents accounted for 7.3 percent of India's GDP in 1964 and 15 percent of Turkey's in 1968.

also generally held to be less efficient than tariffs since they may preclude a potential importer from benefiting from technological progress abroad. In addition, they become increasingly restrictive as the importing economy grows, since imports cannot grow with income, whereas they would under a tariff. Since resources are used on unproductive activities in the presence of a quota, the resulting equilibrium will be inside the production function at a point such as E^q. The replacement of a quota by an equivalent tariff that moves the economy from E^q to E^t is considered another form of trade liberalisation.

Partly in response to the problems of identifying openness and liberalisation episodes numerous methods have been developed to measure the degree of openness (or change in openness) using a variety of different techniques and data.

3.2-1 Tariff Based Measures

Tariff averages have often been used as a proxy for a country's level of protection[3]. However, the increase in the use of NTBs (particularly in developing countries) has made the use of tariff averages suspect as a means of measuring a country's restrictions on international trade. In order to measure the impact of NTBs, coverage ratios have been suggested as a measure of trade restrictions[4]. Yet it is not possible to measure all NTBs and not all are equally restrictive. Furthermore, if countries employ both tariffs and NTBs, it is not

[3] Balassa (1982) for example, classifies 11 countries according to effective rates of protection, effective export subsidies and nominal protection. For the period 1960-73 he found that countries with a lower anti-export bias experienced faster growth.

[4] The coverage ratio of NTBs is the import-weighted percent of tariff code lines covered by various types of NTBs as a percentage of all tariff code lines in the aggregate.

clear how the two measures suggested should be combined, and in many cases one of the measures may not be binding. A number of different measures of the (average) level of tariffs exist; these range from simple averages to measures that include the effects of varying tariff rates and allow for the presence of NTBs. The nominal rate of protection (NRP) may be written as a simple average of the tariff rates:

$$NRP = (\sum_i w_i t_i)/N, \tag{3.1}$$

where t_i is the tariff rate on product i, w_i is the weight attached to product i and N is the total number of products with scheduled tariffs. One problem with this measure is that there are often a large number of scheduled tariffs, many of which are redundant. Furthermore, many imports will not attract the set tariff rate, either because the importer is entitled to exemptions or the source country is in a preferential trading arrangement.

A measure that deals with the problems associated with the nominal rate of protection is the implicit nominal tariff (INT) given by,

$$INT = \sum_i (T_i / M_i)/N, \tag{3.2}$$

where T_i is total tariff revenue on product i and M_i is the total value of imports of product i. This is a measure of the trade weighted average nominal protection. It is however only an average measure of gross protection on output, which fails to take account of the effect of tariffs on intermediate inputs. Moreover, prohibitive tariffs will receive zero weighting in the calculation.

The effective rate of protection considers the effect of tariffs on the net price or value added. The advantage of this measure is that it takes account of tariffs on intermediate goods. By accounting for tariffs on both the inputs and output it provides a measure of the protection afforded to value added. The effective rate of protection may be written as

$$ERP_j = (t_j - \sum_i a_{ij} t_i)/(1 - \sum_i a_{ij}) \qquad (3.3)$$

where t_j is the tariff on final good j, t_i is the tariff on intermediate good i and a_{ij} is the physical input coefficient representing the share of i in the unit cost of producing j in the absence of trade distortions. This can be extended to incorporate non-tradables and the taxing and subsidy effects of NTBs (See Greenaway and Milner, 1993). It is usually found that values for the effective rate of protection are higher than those found for the nominal rate of protection implying that tariffs are higher on outputs than inputs (see Deardoff and Stern, 1986).

3.2-2 Output Based Measures

One of the most obvious and most frequently used measures of openness is some measure of the trade flows of a country. Imports, exports and total trade have all been used as measures of openness. The problem with using measures of the extent of trade as a measure of openness is that the level of trade may be high or low for reasons other than trade policy; in particular they are likely to reflect differences in country characteristics, such as size and comparative advantage, rather than government intervention.

3.2-3 Structurally Adjusted Trade Based Measures

In response to the problems of output based measures, measures of openness have been constructed using the magnitudes of trade flows relative to GDP, corrected for certain structural characteristics of the country[5]. The characteristics controlled for include the level of GDP per capita, size (area and population), transport costs and resource endowment characteristics. The residuals of a regression of trade intensity[6] on these variables indicate the amount by which a country's trade intensity exceeds or falls short of that expected for a country with similar characteristics[7]. Leamer[8] (1988) developed a measure of openness similar in spirit to that described above. He however based his measure on theoretical grounds rather than the ad-hoc nature of the method described above. Leamer bases his measure of openness on a modified version of the Hecksher-Ohlin-Vanek model of trade flows. He predicts a country's net exports of 182 commodities as a function of the country's endowment of land, labour, capital, oil, coal, minerals, the distance to its markets and the country's trade balance. Leamer constructs an index of intervention based on the deviation between the actual and predicted pattern of trade, and an index of openness based on the difference between the actual and predicted level of trade.

Frankel and Romer (1999) argue that one problem with many studies of openness and growth is that countries whose incomes are high for other reasons may trade more. Furthermore, the use of a country's trade policy doesn't help,

[5] See for example Chenery and Syrquin (1975) and (1989).
[6] Where trade intensity is usually measured as the ratio of real exports to real GDP.
[7] See Balassa (1985) and Balassa and Noland (1988) for examples of the use of this measure as a measure of outward orientation.

since countries that adopt free market trade policies may also adopt free market domestic policies and stable fiscal and monetary policies. They argue that geography is a powerful determinant of bilateral trade and that the component of trade due to geography is unlikely to be correlated with other factors affecting income. They estimate a bilateral trade equation and aggregate the fitted values of the equation to estimate a geographic component of countries overall trade. This is done using two approaches. The first uses pure geographic variables (e.g. country size, distance from one another, whether they border, whether they are landlocked), the second uses information about partners' incomes in addition to geographic variables. Using these they show that trade has a positive and significant impact on income per person. Their results indicate that increasing the share of both imports and exports in GDP by one percent raises income per person by 2 percent or more.

3.2-4 Price Based Measures

Dollar (1992) constructs a measure of openness based on the real exchange rate distortion, by examining the distortion between domestic and international prices. He considers outward orientation to be a combination of two factors; a relatively low level of protection resulting in a sustainable level of the real exchange rate favourable to exporters, and relatively little variability in the real exchange rate such that incentives are consistent over time. He constructs his index using data on prices from the UN International Comparison Project (ICP) database. International differences in country's price levels reflect both

[8] Wolf (1993) extends the approach used by Leamer; including a greater number of factors of production and a more disaggregated set of commodities.

differences in the level of trade impediments and differences in the price of non-tradables. Differences in country price levels can then be used to construct an index of trade impediments if the effects of non-tradable prices can be extracted. Dollar argues that in the long-run, international differences in the prices of non-tradables primarily reflect differences in resource endowments. The residuals from a regression of differences in price levels on differences in resource endowments can then be used to construct an index of differences in trade impediments. Due to the lack of time-series data on resource endowments, Dollar uses real GDP per capita as a proxy. He argues that since GDP is the value of the factor services generated by an economy in a year, per capita GDP is a measure of relative per capita factor availability. Dollar also includes in his regression population density as a proxy for land availability relative to the labour force. He finds a strong positive relationship between the price level and GDP per capita, with the results suggesting that African countries tend to be the most inward-oriented and Asian countries the most outward-oriented. There were found to be some significant anomalies for individual countries, though these were reduced by combining the real exchange rate distortion with the variability of real exchange rates to produce a measure of openness.

Falvey and Gemmell (1999) look at the likely errors introduced by the use of differences in real GDP per capita as an approximation to the 'true' explanation of international differences in non-tradables prices. They do this by comparing the results of using per capita GDP with a model of non-tradable prices that they developed (Falvey and Gemmell, 1991). They show a number of possible limitations and biases that may be present in the approximation used by Dollar.

Overall however after empirically testing the two models they conclude that on the whole Dollar's approximation is likely to perform reasonably well in explaining non-tradable prices. For certain countries however the approximation is likely to classify some as substantially more open (or closed) than would use of the full set of explanatory variables. They show that land and labour appear to be the most important country characteristics neglected in Dollar's approximation.

Rodriguez and Rodrik (1999) argue that the measure developed by Dollar is an appropriate measure of openness only if the following conditions hold; no export taxes or subsidies; the Law of One Price (LOOP) holds continuously; no systematic differences in national prices due to transport costs and geographic factors. Furthermore, they argue that the variability index used is likely to have little to do with trade restrictions. The countries with the highest variability also tend to be those with the highest inflation rates, or those that have experienced political disturbances. The variability index then may be acting more as a measure of economic instability than openness.

Krueger (1978) proposes a measure of bias in the trade regime (B) based on the relative price effects of the incentive structure:

$$B = \frac{\sum_{i=1}^{m} w_i \left(\frac{P_{mi}}{Q_{mi}} \right)}{\sum_{j=1}^{n} w_j \left(\frac{P_{xj}}{Q_{xj}} \right)}, \qquad (3.4)$$

where P and Q refer to domestic and international prices respectively; m and x refer to importables and exportables respectively, w refers to weights, and i and j are product groups. The weights are defined as the share of these product groups in total imports and exports. This index measures the distortion of domestic prices relative to world prices in importables, compared to that in exportables; with 1 representing neutrality. An index in excess of one indicates inward orientation bias, while an index of less than one indicates outward orientation bias.

In the same vein as the measure proposed by Krueger is the use of effective exchange rates (see for example Balassa, 1982). The extent to which the incentive structure deviates from neutrality as between exporting and producing for domestic markets can be used as a means of classifying a country's trade regime. This is achieved by comparing the effective exchange rate facing exportables with that facing producers in the import competing sector. If the former exceeds the latter the country is thought to be following an outward oriented strategy, while if the reverse is true, the country is said to be following an inward oriented strategy. The difficulty with this approach is that the information requirements are likely to be formidable.

A further measure of openness also based on price distortions is the black market premium (BMP), which measures the extent of rationing in the foreign exchange market. The theoretical argument behind the use of the BMP is that under certain circumstances foreign exchange restrictions can act as a trade barrier, increasing the price of importables relative to exports. It is assumed in

Sachs and Warner (1995) for example that a BMP in excess of 20 percent for a period of time constitutes a closed economy. The use of the BMP as a measure of openness has been criticised by Rodriguez and Rodrik (1999) who argue that the BMP may reflect a wide range of policy failures. For example, a high BMP may indicate macroeconomic imbalances[9], which can arise when there is an inconsistency between domestic aggregate demand policies and exchange rate policies. Furthermore, since BMP tends to favour government officials who can trade exchange rate allocations for bribes, it is likely that a high BMP would also be related to high levels of corruption.

3.2-5 Multiple Indicator Measures

Multiple criteria studies attempt to categorise trade strategy by reference to a number of different criteria. Greenaway and Nam (1988) use information on effective rates of protection, reliance on direct controls, export incentives and exchange rate misalignment to classify 41 developing countries into four categories: strongly outward oriented, moderately outward oriented, moderately inward oriented and strongly inward oriented. Similarly, the study by Papageorgiou, Michaely and Choksi (1991) adopts a similar approach, using *inter alia* information on real effective exchange rates, effective tariffs, export subsidies, coverage of quotas, and BMP to assign an index ranging from 1 to 20 (20 being most open) for each country. Using this they identify 34 trade liberalisation episodes for a sample of 19 countries.

[9] Bhalla (1994) for example uses BMP as an indicator of macroeconomic instability.

Sachs and Warner (1995) create an openness dummy variable taking a value of zero if the economy was closed according to any of five criteria. These being that average tariff rates are higher than 40 percent, NTBs covered on average more than 40 percent of imports, the presence of a socialist economic system, state monopolies of major exports or a BMP in excess 20 percent in either the seventies or eighties. The above variables may all be considered methods of closing an economy to international trade. Yet if these were all included in a regression there may be problems of collinearity; hence, a method of combining them all into a single variable was employed.

A number of problems arise with the use of multiple criteria studies. It is not clear what weighting should be given to each of the criteria used in assessing a country's openness. Furthermore, in many cases the classification is highly subjective and often it is not possible to compare across countries or across the different studies, since different authors use different measures of openness and trade restrictions.

3.3 Results from Openness Studies

In this section we summarise a number of papers that estimate the impact of openness and trade liberalisation on growth. We concentrate on more recent studies that use a number of the above measures of openness. Table 3.1 in appendix 3A briefly summarises the results from the studies discussed.

3.3-1 Studies of Openness and Growth

Dollar (1992) uses the index of real exchange rate distortions he developed on a cross-section of 95 developing countries, with data averaged over the period 1976-1985. He estimates a model of per capita growth with the investment rate, the variability of the real exchange rate and the index of real exchange rate distortions included as explanatory variables. He finds a statistically significant relationship between growth and his measure of openness, which tended to be robust to the incorporation of regional dummy variables. Rodriguez and Rodrik (1999) use this index with an expanded number of countries (112 developing countries) and more recent data. They also include initial income and initial schooling in their model and find that the coefficient on the distortion index is now of the wrong sign and insignificant. They re-run the model using panel data techniques and find similar results. The coefficient on the variability index does tend however to be significant, although as discussed above this is not necessarily a measure of openness.

Sachs and Warner (1995) use their dummy variable as a proxy for openness[10] to examine its impact on growth for a cross-section of 79 countries over the period 1970-1989. A country is classed as open if it satisfied all of the five criteria for openness described above for both decades. The measure was included in a Barro-type regression[11], which included initial income, the investment rate, measures of educational attainment, population density and measures of political instability. The results suggest that open economies grow on average by 2.45

[10] Other studies using this measure of openness include Collins and Bosworth (1996), Sala-i-Martin (1997), Wacziarg (2000) and Hall and Jones (1998).

percent more than closed economies. Rodriguez and Rodrik (1999) include the individual indicators used by Sachs and Warner in a growth regression and find significant coefficients for only the BMP and the state monopoly of major exports variable. They show that it is these two variables that drive the results on the openness dummy used by Sachs and Warner. They argue that these are not necessarily good measures of openness; arguing that the state monopoly variable is indistinguishable from a Sub-Saharan Africa dummy, while the BMP may reflect a wide range of policy failures.

A number of authors have moved away from relying on a single indicator of openness and instead use a number of different indicators, testing the robustness of the openness-growth relationship. Harrison (1996) for example uses seven different openness measures in a panel study of the determinants of growth. In the model, GDP is a function of the capital stock, years of primary and secondary schooling education, population, labour force, arable land and technological change. Openness is assumed to affect output through its impact on technological change. The productivity term for a country consists of three terms; a country specific effect, a disturbance term and an effect due to openness. Openness was included in both levels and changes. Seven different proxies for openness were employed[12]. Annual observations were used for time periods within the period 1960-1988; the number of countries in the sample

[11] Barro (1991).

[12] These seven were an annual index of trade liberalisation for 1960-84, an index of trade liberalisation for 1978-88 using country sources on tariff and NTBs, the BMP, the share of trade in GDP, an index derived from the relative price of a country's tradables computed using current and constant national accounts price indexes, a modified version of the price distortion index of Dollar and an indirect measures of the bias against agriculture from industrial sector production and overvaluation of the exchange rate.

ranging from 17 to 51 depending upon the index used. The measures of openness tend not to be highly correlated, although a positive and significant correlation is found between the bias against agriculture and the share of trade in GDP. It is suggested that the measures may not be capturing the same aspects of openness.

Using panel data techniques, Harrison finds that 3 of the 7 measures exhibit a robust relationship with GDP growth. Furthermore, all coefficients were of the correct sign except for the trade share measure. The three were the BMP, a measure of the country's price of tradables relative to international prices and a measure of liberalisation from the World Bank. The sensitivity of the results obtained was tested with the inclusion of government consumption, the inflation rate and terms of trade shocks to the original specification, and also by using both period averages and five-year averages as opposed to annual data. When these are included the significance of the openness measures disappears in a number of cases.

Edwards (1998) uses nine different indicators of trade policy to test the robustness of the relationship between openness and Total Factor Productivity (TFP) growth[13]. TFP growth is modelled as a function of initial GDP, initial human capital stocks and openness. He considers average TFP growth during the eighties as his dependent variable, using both weighted least squares and

[13] The nine indicators used by Edwards were the Sachs and Warner openness indicator, the 1987 World Development Report outward orientation index, Leamer's openness index, the average BMP, a measure of tariffs on manufacturing, the average coverage of NTBs, the Heritage Foundation index of distortions in international trade, the collected trade taxes ratio and Wolf's index of import distortions.

instrumental weighted least squares and finds that in 17 of the 18 cases he obtains a coefficient on the openness variable that is of the correct sign; of these 13 are significant. He also constructs a composite index of openness using principal components on 5 of the 9 openness variables. This too is found to be significant and of the expected sign. These results were found to be robust to the addition of measures of institutions, political instability, macroeconomic instability, outliers, non-linearities and alternative time periods.

Levine and Renelt (1992) in their study of the sensitivity of results from growth regressions use a large number of measures of trade policy[14]. They find no robust relationship between openness and long-run growth. They do however find a robust, positive relationship between investment and trade shares, as well as between investment and Leamer's openness indices. The correlation between investment and trade leads them to conclude that the beneficial effects of trade reform may operate through enhanced resource accumulation rather than through a more efficient allocation of resources.

Wacziarg (2000) constructs an index of trade policy for a panel of 57 countries for four five-year periods between 1970-89, and uses this to test the relationship between openness and growth. The index is constructed by regressing a country's trade share on gravity components, factor endowments and three measures of trade policy. The three measures are the share of import duty revenue in total imports, the unweighted coverage ratio of NTBs and a dummy

[14] These include the two measures of Leamer (1988), the BMP, the growth of exports, imports and total trade, and the shares of exports, imports and total trade in GDP.

variable for a country's liberalisation status based on the Sachs and Warner index. The coefficients of these openness variables are used as weights in the construction of a trade policy index.

Trade policy is assumed to affect growth through a number of channels. Wacziarg identifies six channels through which trade policy may affect growth. Trade policy is assumed to affect government size and the quality of government policies, by encouraging governments to implement virtuous macroeconomic policies. It is further expected to affect a country's investment, reduce price distortions, facilitate the transmission of technology and affect the level of trade. He develops a structural model in which trade policy impacts on proxies for these six channels, which in turn affect economic growth. He finds that trade positively and significantly affects growth (at the 10 percent level) through three of the six channels, these being investment, the quality of macroeconomic policies and FDI, which is used as a proxy for technological transmission. He finds however, that by far the most important channel through which trade policy affects growth is investment, possibly by allowing the importation of capital goods that were previously unobtainable. This channel accounts for between 46 and 63 percent of the total impact of trade policy on growth.

3.3-2 Studies of Trade Liberalisation and Growth

Ben-David (1993) asks whether trade liberalisation leads to a reduction in the dispersion of income levels among liberalising countries. The expectation that trade liberalisation leads to income convergence is based on the theory of FPE. Ben-David concentrates on the European Economic Community (EEC) countries and argues that the observed convergence in these countries is not simply a construction of a long-term convergence trend that is unrelated to economic integration. Those countries that chose not to enter the free-trade agreement did not experience the same levels of convergence as those in the EEC. Furthermore, subsets of countries in other parts of the world, not economically integrated did not experience convergence. Slaughter (1997) however, has argued that recent convergence has occurred because of convergence in capital-labour ratios rather than FPE and it is not clear how this could be caused by trade liberalisation. Nor is it clear why there should necessarily be a relationship between the level of dispersion of incomes and growth rates.

Greenaway, Morgan and Wright (1998) use a panel dataset of up to 73 countries to test a relationship between economic growth and liberalisation. Three measures of liberalisation are employed; the Sachs and Warner index, a measure developed by Dean *et al* (1994) and a measure from the World Bank (1993). They estimate a dynamic panel model to examine the short-run impact of liberalisation and transition effects on GDP growth. The results they obtain suggest the presence of a J-curve effect, whereby growth at first falls but then increases following liberalisation. This result is found using all three measures of liberalisation; suggesting that liberalisation in the long-run is good for growth.

Greenaway, Leybourne and Sapsford, (1997) model the effects of trade liberalisation on growth more directly. They build upon a previous paper by

Greenaway and Sapsford (1994) who model liberalisation as a discrete break in the growth rate of countries. In this earlier paper, dummy variables were included to represent liberalisation episodes. The evidence they found in favour of liberalisation causing a break in a country's growth rate was disappointing. Greenaway, Leybourne and Sapsford attempt to model liberalisation as a smooth transition rather than as a discrete break. To do this they use an econometric technique proposed by Bacon and Watts (1971) and Maddala (1977) that allows the identification of any change as a smooth transition between regression regimes. The procedure used involved testing for a transition in the trend of real GDP per capita for 13 liberalising countries. It was found that all countries displayed evidence of a transition in either the intercept or the trend of their real output[15]; this transition in trend was positive in 4 cases and negative in 8 cases. The next stage of the procedure involved comparing the timing of the transitions with the timing of the liberalisation episodes. The results suggest that in only two of the twelve cases was there a possibility that liberalisation precipitated an increase in growth. In a further two cases liberalisation didn't appear to affect growth, while in the remaining eight cases there was some evidence of a negative effect of liberalisation on growth.

Maurer (1998) uses a similar method to Greenaway and Sapsford, by including dummy variables for trade liberalisation episodes in the sample of countries studied by Papageorgiou, Michaely and Choksi. He finds that a significant impact of liberalisation on real GDP per worker is found in only 3 of the 34 liberalisation episodes identified in the study; in 2 of these 3 cases the impact

[15] For Brazil the transition was restricted to the intercept term.

was to reduce growth. Maurer then tests for an unknown structural break in the data, since there may be lags between the date of liberalisation and the time that actual reforms take place. Again he finds no systematic effect of liberalisation on growth, although there are a number of possible exceptions.

3.4 The Relationship Between Exports and Growth

The use of exports as an explanatory variable in empirical studies of economic growth has been undertaken extensively. Exports have been included in growth studies as a proxy for openness, but are also included in their own right as a component of GDP. Export growth may represent an increase in demand for a country's output, serving to increase real output. Expansion of the export sector may also promote specialisation in the production of export goods, which may boost productivity and cause the general skill level in the export sector to rise. This can lead to a reallocation of resources from the non-traded sector to the export sector, which is often assumed more efficient. The improvement in productivity from shifting production to exports can lead to output growth, an effect often called Verdoorn's law, following Verdoorn (1949). Exports of certain goods in which a country has a comparative advantage may allow the exploitation of economies of scale that cannot be exploited in small domestic economies, which can also improve growth in the short-run. In the past it was thought that exports by providing a source of foreign exchange could allow the importation of capital and intermediate goods from abroad that can increase productivity[16]. There are therefore a number of hypotheses relating exports and export growth to economic growth. The empirical studies undertaken cannot discriminate between these, although evidence in favour of a relationship between exports and growth does provide some indication of the mechanisms through which trade may affect growth.

3.4-1 Exports and Growth Methodology

The simplest method and one used regularly during the 1970s was to look at the correlation between economic growth and export growth. Since the late 1970s however econometric studies have come to the fore, with cross-section, time-series and panel data studies all undertaken to examine the relationship between exports and growth.

Econometric studies testing for a relationship between exports and economic growth generally take two forms. One popular method whether in cross-section or time-series studies is the production function approach. This method originally used by Michalopoulos and Jay (1973) takes a simple aggregate production function and includes exports as a factor explaining output. The aggregate production function is then given by:

$$Y = f(K, L, X), \qquad (3.5)$$

where Y is a country's level of Gross National Product (GNP) and L, K and X are the stocks of labour and capital and the level of exports respectively. Calculating the rates of changes in these variables in real terms then gives an equation of the following form:

$$\frac{\dot{Y}}{Y} = \alpha\frac{\dot{L}}{L} + \beta\frac{\dot{K}}{K} + \delta\frac{\dot{X}}{X}, \qquad (3.6)$$

[16] This idea is based on the two-gap model of development of Chenery and Strout (1966).

where a dot over a variable indicates the change in that variable. The above equation then states that growth in output arises from growth in the labour force, the growth in the capital stock and the growth of exports. In most cases the share of investment in GDP is taken as a proxy for the growth rate of the capital stock. Using data on investment and on the growth rates of the remaining variables it is possible to estimate this equation. Support for the export-led growth hypothesis is found if a positive and significant coefficient is found on the export variable.

Feder (1983) proposes an alternative to this. He divides the gains from trade liberalisation into two. Firstly, the gains from shifting production from non-export sectors to export sectors; the latter assumed to have a higher productivity, and secondly the gains from beneficial externalities of exports that accrue to other sectors. Feder assumes that the economy consists of two sectors, one producing for the domestic market and one producing exports. Instead of an aggregate production function, output is a function of the factors allocated to each sector, while the output of the non-export sector is dependent on the value of the exports produced, due to an externality from exports. We then have two production functions, one for each sector;

$$N = f(K_N, L_N, X), \tag{3.7}$$

$$X = g(K_X, L_X), \tag{3.8}$$

where N is the output of the non-export sector, X is the output of the export sector, K is the capital stock, L is the labour force and the subscripts N and X refer to the non-export and export sectors respectively. Feder then assumes that the marginal factor productivity in the export sector exceeds that in the non-export sector by a constant factor δ, so that,

$$\frac{g_K}{f_K} = \frac{g_L}{f_L} = 1 + \delta, \tag{3.9}$$

where the subscripts denote partial derivatives. After some manipulation Feder obtains the following equation for the sources of growth:

$$\frac{\dot{Y}}{Y} = \alpha \frac{\dot{L}}{L} + \beta \frac{I}{Y} + [\frac{\delta}{(1+\delta)} + f_X]\left(\frac{\dot{X}}{X}\right)\left(\frac{X}{Y}\right), \tag{3.10}$$

where f_X is the marginal externality of exports. This equation states that the rate of growth of GDP is composed of the contributions of capital and labour accumulation, and from the gains brought about by shifting factors from the low productivity non-export sector to the high productivity export sector. Again a positive and significant coefficient on the export variable confirms the export-led growth hypothesis.

3.4-2 Results from Exports and Growth Studies

A large number of empirical studies estimating a relationship between exports and growth exist. What we do here is briefly summarise a small sub-sample of these studies, attempting to consider studies that use a variety of techniques. In appendix 3A, Table 3.2 summarises the data, technique and results of those studies discussed.

A number of early studies examining the relationship between exports and growth use simple rank correlation's between their measure of exports and economic growth. Two examples are Michaely (1977) and Balassa (1978).

These studies consider the relationship between growth and their measure of export growth for 41 and 11 developing countries respectively. As with most studies using this method they find a significant correlation between their measure of export growth and economic growth. Balassa found a coefficient that was much higher than that of Michaely (0.7 as opposed to 0.38). This was attributed to the greater homogeneity of the Balassa sample. Michaely included in his sample countries that rely mainly on primary products for exports, as well as countries whose main exports were services.

The use of correlation coefficients is problematic. Since only the two variables are considered, it may be that the observed correlation reflects underlying relationships via other economic variables. Cross-section studies by allowing the inclusion of other explanatory variables that determine growth attempt to deal with this. A large number of cross-section studies use the production function approach described in section 3.4-1; examples include Balassa (1978), (1985), Tyler (1981), Kavoussi (1984), Ram (1985) and Moschos (1989). The dependent variable tends to be real GDP or GNP growth. Explanatory variables included alongside a measure of export growth usually reflect a country's inputs of capital and labour, typical examples include investment and labour force (or population) growth. The time periods studied vary as do the number of countries, ranging from 10 to 73 in the studies cited above. Most studies concentrate on developing countries, although Tyler specifically examines the relationship for middle-income developing countries, arguing that "some basic level of development is necessary for a country to most benefit from export oriented growth" (p. 124). In general, these studies, as with those using correlation coefficients, tend to find a positive and significant association between export growth and economic growth, although the coefficients can differ to some extent. Balassa (1978) for example finds that a 1 percent increase in export growth will lead to a 0.04 of 1 percent increase in economic growth, while Tyler finds that a 1 percent increase in export growth is associated with a 0.057 of 1 percent increase in economic growth.

Feder (1983) uses the approach he developed to test for the growth promoting effects of exports. He tests his model on a sample of 31 'semi-industrialised' developing countries over the period 1964-73. The explanatory variables included were labour force growth, the share of investment in GDP and the growth of real exports multiplied by exports' share in GDP. His results supported the hypothesis that marginal factor productivities in the export sector are higher than those in the non-export sector, suggesting that countries that shift production to exports will gain more than inward-oriented economies. Furthermore, Feder also finds evidence of substantial externalities associated with exports. These, it is argued, are generated because the export sector confers positive effects on the productivity of the other sector; for example from the development of efficient and competitive management, the introduction of improved production techniques or the steadier flow of imported inputs.

Others however that adopt the Feder approach in their empirical analysis do not find support for the export led growth hypothesis. Helleiner (1986) amongst others finds no significant evidence of export led growth. The reason why such studies don't find evidence of export led growth, given Feder's results is not clear, but are likely to reflect differences in time periods and countries within the sample, and the use of different variables and different definitions for variables.

Williamson (1978) uses an alternative approach, adapting the 'two gap' model of growth of Chenery and Strout (1966). In this model export revenues and foreign financial inflows (FDI and other foreign capital flows) contribute towards filling gaps in the supply of imported goods and the total volume of investment, and in this way contribute to growth. His model was tested on 22 Latin American countries over the period 1960-74. Both cross-section and time-series models were estimated with the results being roughly similar. They suggested that GDP was significantly related to the three sources of foreign exchange, with exports being the most important of the three in explaining countries performance.

The use of time-series methods has increased a great deal since the mid-1980s. One advantage of time-series over cross-section methods is that it is possible to test for the direction of causality between exports and growth. Cross-section studies test the hypothesis that growth in exports is associated with growth in GDP. Whilst this may be true it is conceivable that the direction of causality could go either way. Growth is likely to lead to the enhancement of skills and technology; this enhanced efficiency is further likely to create a comparative advantage in certain goods, which may facilitate exports. Furthermore, it may be that there exists no causal relationship between exports and economic growth, the growth paths of the two series may be determined by other unrelated economic variables.

Jung and Marshall (1985) and Darrat (1987) use causality tests developed by Granger (1969) and White (1980) respectively to test for a relationship from exports to growth. They look at similar time periods, but the country samples differ a great deal. Jung and Marshall consider a sample of 37 countries, while Darrat concentrates on four 'growth miracle' economies. The results of the causality tests provide a number of contrasting results. Jung and Marshall find that in the majority of cases (24) no relationship exists between exports and growth, while in only four cases is there evidence of export-led growth. In the remaining cases either exports reduce growth or growth leads to exports. Darrat found similar results; evidence for export-led growth is found in only one case, with no relationship found between the two variables in two cases and a causally independent relationship found in the remaining case. Salvatore and Hatcher (1991) use a production function approach and time-series data (1963-1973) to study the relationship between exports and growth for 26 developing countries. The countries were grouped according to a classification published in the 1987 World Development Report. This classification followed work by Greenaway (1986) and classified a group of 41 countries according to their trade orientation. The countries were classified as strongly outward oriented, moderately outward oriented, moderately inward oriented and strongly inward oriented. The classification was made for two time periods, 1963-73 and 1973-85. Salvatore and Hatcher estimated their model separately for the four different categories and also for both the pooled outward oriented and the pooled inward oriented giving a total of six categories. The coefficient on the export variable was found to be positive for all six categories in both time periods, suggesting that openness benefits all of the countries in the study. Salvatore and Hatcher however noted that the coefficient on the export variable is only highly significant for the inward oriented countries in both periods, which is contrary to what they expected.

Greenaway and Sapsford (1994) test a model of growth with exports as one of its components and then use this to test how the relationship between exports and growth is affected by trade liberalisation. They regress the rate of growth of real GDP per capita on the rate of growth of real exports, the share of investment in output and the rate of growth of the workforce. Data were collected for 14 countries within the period 1957-85. The results suggest that for the export variable, the sign of the coefficient is generally positive, but rarely significant. They conclude that there appears to be little support for the export-led growth hypothesis in their sample. The authors then examine the effect that trade liberalisation has on the export-growth relationship, arguing that it may be expected that trade liberalisation will increase exports, in which case liberalisation would affect one of the explanatory variables in their model. To test this they include in their model intercept dummy variables and slope dummy variables on the export variable for each liberalisation episode of a country. In 8 of the 12 cases it appears that trade liberalisation has no discernible effect on the export-growth relationship through the intercept dummy. In 3 cases a positive and significant effect was found while in 1 case a negative and significant coefficient was found. For the slope dummy variables no effect was found for 10 of the countries, while a positive and significant coefficient was found in one case and a negative and significant coefficient found in the other. In general, these results suggest that trade liberalisation has no discernible impact upon the relationship between exports and growth.

There has recently been an increase in the use of panel data techniques in studies of economic growth. Greenaway, Morgan and Wright (1997) for example use panel data to examine whether recent liberalisations (post-1985) have been associated with faster or slower growth. They use data on 74 developing countries, 30 of which are recent liberalisers, regressing the growth of per capita GDP upon lagged per capita GDP growth, investment growth, labour force growth and the growth of exports. Also included in the model is a dummy variable taking a value 1 for all years after and including the year liberalisation was undertaken. A positive and significant coefficient is found on the export variable. The sign on the liberalisation variable however is consistently negative and usually significant, suggesting that liberalisation has a negative impact on growth. The authors argue that one reason for this may be that there exists a "J curve" effect of liberalisation; since these countries are recent liberalisers it may be expected that growth has deteriorated, but that it will improve over time. It is also noted that liberalisation may have effects on growth through other variables, for example exports and investment.

The question of a so-called 'threshold effect' is also addressed in many of the above studies. It is thought by some that countries need a threshold level of development before they can benefit in terms of higher growth from exports.

The evidence in favour of a threshold effect tends to be mixed however. Michaely (1977) divided his sample into two groups; a (relatively) low-income group and a (relatively) high-income group. He found the correlation coefficient for the higher income group was positive and significant, while for the lower income group it was practically zero. These results led Michaely to conclude that 'growth is affected by export performance only once countries achieve some minimum level of development' (p. 52).

Kavoussi (1984) finds using a production function approach that export expansion in low-income countries tends to be associated with better economic performance, but that the contribution of exports is greater amongst the more advanced developing countries. Ram (1985) using dummy variables on both the slope and intercept terms to differentiate between middle-income and low-income developing countries finds that the effect of export performance on economic growth is numerically smaller in the low-income developing countries, but that the difference is not statistically significant.

Moschos (1989) however, also using a production function approach finds that the coefficients on the export variable are positive and significant under both regimes, but the effect of export expansion on aggregate growth appears to be stronger under the low income regime than under the high income regime. This result conflicts with the notion of a threshold effect, since in this case it is the low-income developing countries that benefit most from export oriented growth.

3.4-3 Issues Arising From Export and Growth Studies

There are a number of issues and problems with this method of testing the openness and growth relationship. Firstly, we noted above that studies testing for a relationship between exports and growth are possibly testing a number of hypotheses, for example it could be that they are testing for a relationship between exports and growth or a more general relationship between openness and growth. If it is not clear what these studies are testing then their importance to policy discussion is limited.

The use of cross-section studies to test the export-led growth hypothesis provides information about the correlation between exports and growth, but we have to infer the direction of causality from economic theory and not the data. Ram (1985) for example, notes that "it is evidently important to be able to make a reasonably satisfactory transition from statements about the correlation patterns to some judgements about the causal structure" (p. 416). It would appear therefore that the use of time-series, where causality could be tested would be a more advantageous way to proceed. Causality tests such as the one proposed by Granger (1969) attempt to determine whether movements in exports tend to follow or precede movements in GDP growth. Lal and Rajapatirana (1987) have criticised the role of such tests in the debate on openness and growth however. They argue that a small country that is developing in line with its comparative advantage will begin to specialise and be forced to turn to export markets in goods that use the country's most abundant factor most intensively. According to the Granger causality test this would be seen as growth causing exports; yet if the economy were closed the country's growth would have been stunted due to a lack of domestic markets[17].

The choice of exports as a measure of openness may also seem odd given the discussion in Chapter Two of the theoretical role of trade in the growth process. The major channels through which trade affects growth in the theory discussed is through the importation of capital and intermediate goods and through the importation of foreign knowledge. Exports do not therefore seem to provide the main benefits of trade in terms of economic growth; these benefits tend to be on the import side. Rodrik (1999) argues therefore that the role of exports is limited solely to pay for a country's imports[18].

The views of Rodrik are rather extreme and follow from a strict interpretation of the new growth theories. Others acknowledge that exports may provide important benefits, through for example some form of knowledge spillovers. Grossman and Helpman (1991a) and World Bank (1993, ch. 6; 1998, ch. 2) for example suggest that exports may be a source of learning and technological spillovers from sophisticated markets abroad. Some studies have used imports rather than exports in their growth regressions; examples include Humphries (1978), Esfahani (1991) and Feenstra et al (1997). These studies also tend to find positive and significant results suggesting that this problem may not be too

[17] An alternative approach would be to use dynamic panel data methods, which use an instrumental variable technique. Here exports could be instrumented using either lagged values of exports, as in time-series studies, or external instruments if they are available.

[18] "... exports are important only insofar as they allow imports to be paid for. Exports are the "price" an economy pays for having access to imports; they are a means not an end." (Rodrik, 1999, p. 24).

important. Levine and Renelt (1992) also find that the results they obtain using the share of exports in GDP could be found using total trade or import shares.

There are a number of econometric problems when testing any growth model, including those testing for a relationship between exports and growth. Examples of such problems will be discussed in greater detail in section 3.6, but include problems of collinearity, causality, heterogeneity and autocorrelation. The problem of the exclusion of relevant variables is also likely to be an important factor. The models of growth described in Chapter Two highlight in addition to the accumulation of physical capital; the accumulation of human capital and the role of R&D in the growth process. Measures of these variables are often not included alongside capital, labour and exports in production type models or in the approach proposed by Feder.

The use of exports as a proxy measure of trade liberalisation is often defended on the grounds that it would be expected that trade liberalisation by increasing the returns to exporters would increase the output and growth of the export sector. However, the correlation between trade liberalisation and export growth may not be perfect. Furthermore, export growth is only one possible outcome of trade liberalisation as it may be the case that exports do not respond to liberalisation episodes, due for example to credibility problems with the reforms (see for example Rodrik, 1989a; 1989b).

A further issue that arises with this methodology is the choice of measure for each variable. Studies divide between measuring economic growth in terms of the change in either GNP or GDP or in GNP or GDP per capita, adjusted by an appropriate price index. The most obvious measure of export (growth) is the actual (change in) value of exports from time period to time period. Not all writers however agree that these are the appropriate measures to use. Michaely (1977) for example argues that "since exports are themselves part of the national product, an autocorrelation is present; and a positive correlation of the two variables is almost inevitable, whatever their true relationship to each other." (p. 50). He then uses the rate of change of the proportion of exports in the national product as his measure of exports, arguing that this is a measure of export bias.

Finally, using exports to measure openness would be misleading if countries at the same time as promoting exports also encourage protection. The method of using exports as an openness measure would then imply that such a country would be classed as open when in fact it wasn't. The estimation of a relationship between export growth and economic growth also assumes that the higher the export growth, then the closer a country is to its optimal trade policy for growth. This assumption ignores the possibility of export promotion beyond optimal levels, in which case the relationship between exports and growth may not be linear.

3.5 Tests of Endogenous Growth Models

It is clear from the above discussion that a great deal of effort has been expended looking for a relationship between economic growth and some measure of openness. Yet the tests described above are often not directly related to the implications of new or endogenous growth theories. Much of the literature has its roots embedded in static theories of the gains from trade, in which we would only expect a one-off gain in income from trade liberalisation. Empirical testing of endogenous growth both at the national and international level is very much in its infancy. At the national level studies have attempted to measure the level of knowledge spillovers across industries, examples include Terleckyj (1980) and Bernstein and Nadiri (1988). Although many such studies precede models of endogenous growth, they are directly related to the new growth theories and to the role of knowledge spillovers in the growth process.

There is also a growing literature looking to test for the existence of knowledge spillovers in an international context. Recently studies have begun to examine whether the cumulative R&D of a country, which is used as a proxy for the knowledge stock of that country, has an impact on growth in other countries. These studies also examine whether such spillovers of knowledge are related to trade. The studies of Coe and Helpman (1995) and Coe, Helpman and Hoffmaister (1997) conclude that spillovers are an important source of productivity growth, both between developed countries and also between developed and developing countries. Furthermore, they argue that trade is an important conduit for the spillovers of such knowledge. This evidence has been the subject of a great deal of criticism and discussion however. In Chapter Five we discuss these studies in greater detail and estimate the effects of knowledge spillovers from advanced countries on growth in our sample of developing countries.

A further implication of the endogenous growth literature that has been tested is in the existence of scale effects. As discussed in Chapter Two, many models of growth based on R&D imply that the bigger is the knowledge base and the more resources devoted to R&D then the easier it is to accumulate knowledge and therefore the higher is the growth rate. Backus, Kehoe and Kehoe (1992) find little empirical evidence of a relationship between the growth rate of GDP per capita and several measures of scale implied by the theory, although they do find a significant relationship between output per capita and scale variables. Jones (1995a) argues that there have been no significant changes in the growth rate of the US even though there have been certain changes in government policies that should have growth effects (examples include trade liberalisation, increases in investment and a substantial increase in R&D expenditures). Furthermore, Jones (1995b) shows that while the number of scientists and engineers employed in R&D has increased five-fold between 1950 and 1988, growth in TFP has been constant or negative over the same period.

The studies of knowledge spillovers apart, there has been little empirical investigation into the implications of trade on growth in endogenous growth models. Lee (1995) develops and tests an endogenous growth model of an open economy. In this, lower income countries by importing relatively cheaper capital goods from higher income countries can increase the efficiency of capital accumulation, thereby increasing their growth rates. Growth will be higher therefore in countries that use imported inputs relatively more than domestically produced inputs for investment. Lee empirically tests the implications of his model on a cross-country sample of up to 89 countries for the period 1960-1985.

He includes in his growth regression alongside traditional variables the ratio of imported to domestic capital goods. He finds a positive and significant relationship between the ratio of imports in investment and per capita growth; suggesting that imported capital goods increase growth rates by directly enhancing the productivity of capital. Furthermore, he finds that when the share of imports in GDP is included in this regression its coefficient is insignificant, suggesting that it is not total imports that links openness to growth, but openness to capital goods imports.

3.6 Issues Arising from the Empirical Literature

The first point to note from the above survey is that the empirical literature on openness and growth and the theoretical literature on trade and growth tend to be disjoint. Much of the empirical literature on openness and growth predates the new growth theories. These empirical studies were based on static arguments concerning the benefits of openness, in which the level but not the growth of income should be affected in the long-run. Furthermore, the measures of openness used in the empirical literature do not always relate to the channels through which openness should affect growth. New growth theories point to certain activities as being the sources of growth, in particular technology accumulation. Here openness is thought to affect growth through the importation of knowledge, capital and intermediate goods. The measures of openness outlined above however concentrate on total trade or exports, tariff averages and distortions in the exchange rate, rather than on measures of restrictions on capital and intermediate goods.

Rodriguez and Rodrik (1999) take a rather pessimistic and sceptical view of much of the recent literature linking openness and trade policy to growth. The main conclusion from their study of the existing literature is that the indicators of openness developed are not necessarily good measures of trade barriers. In many cases the measures developed are highly correlated with other sources of poor performance, such as poorly functioning institutions and macroeconomic imbalances. They suggest a number of avenues for future research, one being to examine the effects of different types of trade policies, such as whether restrictions on imports of capital and intermediate goods are more harmful to growth than other types of trade restrictions.

Pritchett (1996) notes that a large number of different measures of openness have been used in the empirical literature. He argues that if these were all highly correlated, then it "would create confidence that some significant, well-understood aspect of countries trade policy is being captured" (p. 308). He examines six measures of openness and finds that in general they are not highly correlated. There are (at least) two interpretations of this. It may be argued that at best there is only one measure of openness; the problem being that we do not know which (if any) of the available measures it is. Alternatively, it could also be argued that openness has many aspects, with different variables accounting for the differing aspects of openness.

There also exist a number of issues to be considered when attempting to interpret the results from growth regressions, a number of econometric questions in particular[19]. One particular problem is that there is likely to be a large degree of parameter heterogeneity between countries. Countries differ in many respects and it is unlikely that the social, political and institutional characteristics of different countries would result in countries sharing the same parameters concerning sources of growth[20]. The parameters obtained in cross-country studies are averages for all countries and while they may be important it is not always clear what implications such results have for individual countries. The fact that the models estimated explain a significant portion of the variance in growth rates however does indicate that the models have some explanatory power.

A further problem with growth regressions is that it is uncertain what the true model to be estimated is. Sala-i-Martin (1997) notes that more than 60 variables have been found to be significant in growth regressions. Levine and Renelt (1992) however find that very few of these results are robust, in the sense that including a different set of explanatory variables results in the coefficient of a previously significant variable becoming insignificant. Temple (1999) argues however that many of the regressors used by Levine and Renelt are likely to be endogenous and that finding that a particular variable is not robust to the inclusion of a particular explanatory variable may in itself be of importance. Sala-i-Martin argues that the test applied by Levine and Renelt is too strong and that as a result "giving the label of non-robust to all variables is all but guaranteed" (Sala-i-Martin, 1997, p. 179). Proposing a different approach to that

[19] For a more detailed discussion of the econometric issues that exist in growth regressions, see Temple, 1999.

used by Levine and Renelt, whereby confidence levels for the entire distribution of coefficients for different determinants of growth are constructed, Sala-i-Martin finds that a much larger number of variables are significantly related to growth. Although the only measure of openness that is robust using this test is the Sachs and Warner dummy variable, a variable that as we have already discussed may be not be a satisfactory measure of openness.

One of the major issues when looking to test for a relationship between some measure of openness and growth is the choice of econometric technique. Many of the early studies use a cross-section analysis often with the data averaged over a large number of years. One advantage often put forward in favour of conducting cross-section studies is that external factors such as the state of the world or supply shocks are common to all of the countries involved and can therefore be excluded from the analysis. This however assumes a similarity of countries in the study; it assumes that all countries will react in the same way to world supply shocks and that in the case of production function type models all countries have identical production functions.

Furthermore, it is only with time-series studies that attempts have been made to test for the direction of causality between openness measures and growth, by using lagged values as instruments. In contrast identification in cross-sectional studies is more difficult and studies generally rely on economic theory to highlight the direction of causality. Instrumental variable techniques could

[20] Durlauf and Johnson (1995) provide some evidence in favour of parameter heterogeneity in growth models.

however also be used in these cases if a suitable instrument for openness could be found.

The use of time-series techniques to investigate openness and growth however is not without problems. One obvious shortcoming, particularly when looking at developing countries is that data may not be available for a sufficient period of time, thus making it difficult to discern the long-run effect and severely reducing the number of degrees of freedom in the econometric analysis. The problem of a lack of degrees of freedom is compounded by the fact that long lags of the independent variables are needed to avoid short-run business cycles driving the results. Moreover, although it is possible to test for causality by examining whether a change in one independent variable precedes a change in the dependent variable, this is not without its problems. Finding that one event occurs before another is not conclusive evidence that the first event causes the second.

An approach that is being used more frequently is panel data techniques, which have both a cross-section and a time-series element. These methods have a number of advantages that are briefly discussed in the econometrics appendix. In terms of growth regressions however, the problem of business cycle effects may still be important. As a result, it is often the case that 5 or 10 year averages of the variables are used to attempt to remove these effects, but this can remove much of the time-series variation.

3.7 Concluding Remarks

In this chapter we have summarised the empirical literature concerning the relationship between openness and growth, and trade liberalisation and growth. The review began by looking at a number of proxies of openness or liberalisation in the empirical literature. A large number exist; some consider restrictions on trade, for example measures of nominal or effective rates of protection. Others look at the level of trade as a measure of openness, often controlling for certain structural characteristics of the country, such as resource endowments, trade costs and size. One potentially worrying fact of these measures of openness is that they are not highly correlated with each other, suggesting that openness is multidimensional, with different measures capturing different aspects of openness. A recent criticism to emerge on many of these measures is that many are not good measures of trade restrictions or that they could be acting as proxies for a variety of sources of poor performance.

The choice between the existing measures of openness is not an easy one to make. The use of trade values has the advantage that the data are readily available, but it is not clear how well trade volumes proxy for trade policy. Trade could be high for a number of reasons other than trade policy, such as country size, distance from markets and capital inflows. Openness measures exist that do adjust for certain structural characteristics of countries, but it is not clear that what remains is solely determined by trade policy. Direct measures of trade barriers, such as tariffs and non-tariff barriers are also used, but problems arise in trying to aggregate these into a single index and because it is not always clear what effect the presence of restrictions has upon trade. An approach that is being used increasingly to bypass these problems is to use a number of different openness measures and test whether they yield similar results.

The empirical studies that use these measures may be split into two groups; those that look at the relationship between one measure of openness and growth and those that use a variety of different measures and test the robustness of the relationship. In general, cross-country studies that consider a single measure tend to find a significant relationship between openness and growth. While studies that look at a variety of different openness measures find that only a subset of the measures used show a robust relationship with growth.

A number of studies also look at the impact of trade liberalisation on growth, often using time-series data. In general the results of these studies suggest that liberalisation has no discernible impact on growth. There are exceptions when liberalisation does have a significant positive impact on growth, but there are equally as many when liberalisation is found to reduce growth. This has led some to suggest the possibility of a 'J-curve' effect, whereby in the short-run liberalisation reduces growth, but in the long-run once resources have responded to relative price changes, growth improves. The general conclusion that liberalisation tends not to improve growth should not be taken as evidence of no relationship between openness and growth however; a number of possible explanations for the lack of a relationship exist.

One important point to note from the empirical literature reviewed is that the measures used tend not to relate directly to the theoretical literature concerning trade and growth. The recent theoretical literature on openness and growth emphasises the role of imports of capital and intermediate goods and the transmission of knowledge across borders in the growth process. Measures based on restrictions on advanced goods would be expected to feature prominently amongst proxies for openness, yet there appears to be very little empirical evidence using such measures. This is where this thesis takes a departure from much of the existing literature, since it concentrates on imports of goods in to developing countries and whether such imports affect growth. Moreover, we concentrate on imports of goods from developed countries to developing countries. It would be expected that such North-South trade would embody advanced technology to a much greater extent than South-South trade, or trade in general.

Appendix 3A: Summary Tables

Table 3.1: Empirical Studies on the Relationship Between Openness and Growth

Study	Dataset	Openness Measure	Results
Dollar (1992)	Cross-Section 95 Developing Countries Average 1976-1985	Exchange Rate Distortions	• Average per capita growth in the least distorted quartile of countries was 2.9%; the next quartile had a growth rate of 0.9%, the third quartile 0.2% and the most distorted quartile 1.3%. • Reduction of the real exchange rate distortion to the Asian level would add 0.7% to Latin American growth and 1.8% to African growth.
Levine and Renelt (1992)	Cross-Section 119 Countries (Mixed Sample) Average 1960-1989	Sensitivity analysis using a large number of openness measures.	• Robust positive correlation between growth and the share of investment in GDP. • Robust positive correlation between the share of investment in GDP and the share of trade in GDP. • Two-link chain between trade and growth through investment.
Sachs and Warner (1995)	Cross-Section 79 Countries (Mixed Sample) Average 1970-1989	A country is deemed to be closed if any one of the following criteria is satisfied: 1. Average tariff rate above 40% 2. NTBs on more than 40% of imports 3. Socialist economic system 4. State monopoly on major exports 5. BMP on exchange rate exceeding 20%	• Open economies grow faster than closed economies by 2.45% • Open economies have higher investment ratios, better macroeconomic balance, and a larger role of the private sector as the engine of growth.
Harrison (1996)	Panel Data Up to 51 Developing Countries 1960-1988	Seven indices of openness or liberalisation: • Two liberalisation indices • BMP • Trade shares • Real exchange rate distortions • Movements towards international prices • Bias against agriculture	• A subset of the openness measures are significantly related to growth. • All statistically significant indexes show a positive relation between a liberal trade regime and growth. • The direction of causality between a liberal trade regime and growth runs both ways.

Edwards (1998)	Panel Data 93 Countries (Mixed Sample) 1960-1990	Nine indices of openness and or liberalisation: • Sachs and Warner index • World Bank (1987) index • Leamer's (1988) index • BMP • Average import tariffs on manufactures • Coverage of NTBs • Heritage foundation index of trade distortions • Collected trade taxes ratio • Wolf's (1993) index of import distortions	• The openness indices are positively correlated with TFP growth, and the mirror image of trade distortion indices are negatively correlated. • Trade is not the most important variable for explaining cross-country differences in growth; initial GDP and human capital are more important. • The data exhibits (weak) conditional convergence.
Wacziarg (2000)	Panel Data 57 Countries (Mixed Sample) 1970-1989	Measure based on the policy component of trade shares. This index is assumed to affect growth through six channels.	• Openness is found to positively affect growth • Openness affects growth mainly through its impact on the rate of physical capital accumulation. • Two other channels are found to be important; these are technological spillovers and the quality of macroeconomic policies.

Note: Much of this table was reproduced from Ben-David, Nordström and Winters (1999).

Table 3.2: Empirical Studies on the Relationship Between Exports and Economic Growth

Study	Dataset	Economic Growth	Export Growth	Method	Other Variables	Results
Michalopoulos and Jay (1973)	Cross-Section 39 LDCs Average 1960-69	Real GDP growth	Real export growth	OLS	Import to GNP ratio, Labour force growth, Domestic and external real investment	Export led growth
Michaely (1977)	Cross-Section 41 Countries Average 1950-73	Per capita GNP growth	Growth in export share	Rank Correlation	None	Export led growth
Balassa (1978)	Cross-Section 10 Countries Averages 1956-67 and 1967-73	GNP growth	Export growth or real export growth	Rank Correlation Production function	Labour force growth, Domestic investment Foreign investment/output	Export led growth
Williamson (1978)	Cross-Section 22 Countries Average 1960-74	Change in GDP	Lagged exports	OLS Two gap model	Country Dummies Direct Investment Other foreign capital	Export led growth
Fajana (1979)	Time-series 1 Country 1954-74	GDP growth	Export shares	OLS	Trade balance, Current account	Export led growth
Tyler (1981)	Cross-Section 55 Countries Average 1960-77	GDP growth	Export growth	OLS Production function	Labour force growth, Investment growth	Export led growth
Feder (1983)	Cross-Section 31 Countries Average 1964-73	Real GDP growth	Export growth multiplied by exports share in GDP	OLS Feder approach	Labour force growth Investment/output	Export led growth

Kavoussi (1984)	Cross-Section 73 Countries Average 1960-78	GDP growth	Export growth	Rank Correlation OLS Production function	Labour growth rate Capital growth rate	Export led growth
Balassa (1985)	Cross-Section 10 Countries Average1973-79	GNP growth	Export growth	OLS Production function	Labour force growth, Ratio of output to domestic investment	Export led growth
Jung and Marshall (1985)	Time-series 37 Countries 1950-81	Real GNP (or GDP) growth	Lagged real export growth	Granger causality test	Lagged GNP (GDP) growth	Limited support for export led growth
Ram (1985)	Cross-Section 73 LDCs 1960-70, 1970-77	GDP growth	Export growth	OLS	Labour force growth Investment	Export led growth
Darrat (1987)	Time-series 4 'growth miracle' economies 1955-82	Real GDP growth	Real export growth Lagged export growth	White causality test	None	Limited support for export led growth
Rana (1988)	Cross-Section 43 Countries 1960-73,1973-81	Change in GNP between initial and end period as a % of initial GNP	Change in merchandise exports	OLS Feder approach	Sum of gross domestic investment from initial to end period as a % of initial GNP	Export led growth
Moschos (1989)	Cross-section 71 LDCs 1970-80	Real GDP growth	Real export growth	OLS Production function	Labour force growth, Real domestic investment growth	Export led growth
Salvatore and Hatcher (1991)	Time-series 26 Countries by trade orientation 1963-73	Real per capita GDP growth	Real export growth	OLS Production function	Capital input growth Growth in industrial production	Export led growth

Greenaway and Sapsford (1994)	*Time-series* 14 Countries 1957-85	*Real GDP per* capita (or non-export GDP)	*Real* export growth	Dummies for liberalisation episodes	Investment share in output growth of workforce	Little support for export led growth
Greenaway, Morgan and Wright (1997)	Panel Data 74 Countries	Real per capita GDP growth	Real export growth	With and without country dummies	Lagged GDP per capita growth Investment growth Labour force growth	Export led growth

Chapter Four

Openness and Growth: The Role of North-South Trade in Goods

Chapter Four

OPENNESS AND GROWTH: THE ROLE OF NORTH-SOUTH TRADE IN GOODS

4.1 Introduction

Until recently the theories highlighting the benefits of trade were based on models emphasising static gains from trade. In these models outward orientation shifts a country's internal allocation of resources more in line with its comparative advantage, but while this raises the level of income per capita it has no obvious impact upon economic growth in the longer term. The recent literature on endogenous growth, reviewed in Chapter Two, has shown however that openness can affect a country's growth rate through several channels. The new theories emphasise a number of channels through which trade can affect growth, by providing access to foreign markets, technology and resources.

In addition to the theoretical literature, there is a vast empirical literature on openness and growth. As discussed in Chapter Three, a variety of different measures of openness have been employed, with many studies finding a positive relationship between some measure of trade openness and growth. Despite these findings however there still remains considerable controversy over the interpretation of such studies. There remains considerable debate over the openness measures themselves, problems in identifying the direction of causality between openness and growth, and various econometric problems, including problems of robustness.

This chapter develops a measure of openness to the North for our sample of developing countries and examines the impact of this measure on growth. We emphasise the role of manufactured imports from developed to developing countries, since we expect that it is through trade with developed countries, rather than through trade between developing countries, that developing countries should benefit from advanced technology. Historically a large share of North-South trade has consisted of imports of manufactured goods, which are likely to embody advanced technology[1]. This suggests that it is primarily through North-South trade that developing countries can benefit from trade through the importation of advanced technology.

The remainder of this chapter is organised as follows. In section 4.2 we develop an empirical model that predicts trade flows from the North to the South. The model developed can explain a large proportion of the cross-country variation in imports from the North. Using the predicted values from this model we construct a measure of openness to manufactured imports from the North. In section 4.3 we use this measure to estimate the impact of openness on the growth rate of our sample of Southern countries. We find that those countries that are ranked as more open enjoy significantly higher growth rates than those countries classed as closed to Northern imports. Section 4.4 provides some overall conclusions.

[1] Wood (1994) for example finds that during the period 1955 to 1989 between 73 and 79 percent of the total exports of the North to the South consisted of manufactures.

4.2 Measuring Openness to Northern Imports

4.2-1 Background

A large number of openness measures have been used in the empirical literature. Often a summary indicator of trade is employed, for example, exports, total trade or the trade to GDP ratio. Others use data on tariff rates, while some use data on a number of indicators to form an index of trade distortions. One shortcoming of many of these measures is that often they do not relate directly to the theories linking growth to trade. The theory emphasises the role of imports and in particular the role of imports of capital, intermediates and technology in the growth process. For developing countries we would expect that the benefits to growth of such imports would arrive through trade with more advanced countries, where most R&D is undertaken.

In this chapter we construct a measure of openness to manufactured imports from a sample of OECD countries[2] to our sample of developing countries[3], by estimating an empirical model that predicts manufactured imports from the North to the South using data on various characteristics of both the importer and exporter. The extent of deviation of actual trade from that predicted is taken as an indicator of the extent of trade restrictions on Northern imports. A number of others have attempted to measure openness in a similar manner, although they tend to look at exports rather than imports. Chenery and Syrquin (1989)[4] for example measures openness for a sample of up to 108 countries for 1965 and 1980 using the observed share of merchandise exports in GDP relative to the

[2] Appendix 4A lists the sample of OECD countries used in this chapter.
[3] The data appendix at the end of the thesis provides a list of the developing countries in the sample.

predicted share. The predicted share is constructed by adjusting (in an *ad-hoc* fashion) for such things as the level of GDP per capita, size, transport costs and various resource endowments. A high relative export level led to an outward oriented classification, while a low level resulted in an economy being classed as inward oriented. They showed that the ranking of countries corresponded fairly well with that of the World Development Report 1987. Furthermore, they found that GDP growth was higher in the outward oriented group than in the inward oriented group.

Leamer (1988)[5] conducts a similar exercise, but bases his measure of openness on a modified version of the Hecksher-Ohlin-Vanek model of trade flows. The dependent variable in the empirical model estimated is net exports, which is assumed to be a function of a country's endowment of land, labour, capital, oil, coal, minerals, the distance to its markets and the country's trade balance. The model is estimated for 1982 on 182 commodities at the 3-digit SITC level for up to 65 countries. Two measures of openness are developed; the first is simply the actual trade intensity ratio minus the predicted trade intensity ratio, while the second is the ratio of actual to predicted trade. Leamer states that the first of these is analogous to a measure of welfare loss, indicating the percentage of GDP lost as a result of trade barriers, while the second is analogous to a tariff average that suggests how much trade is deterred by barriers. Leamer appears to be sceptical of the results obtained, questioning whether the adjusted trade intensity ratio is actually measuring barriers to trade or is more an indicator of tastes, omitted resources and historical accidents. He does state however that

[4] See also Chenery and Syrquin (1975).
[5] This builds upon Leamer (1984).

many of the "unusual aspects of patterns of net exports occur mostly from the export side and are related to historical factors or to special resources, and not to trade barriers. It may well be that a separate study of the import side would be productive." (p. 179). Since we are considering imports, many of these problems may be overcome. Furthermore, the fact that we use more aggregated data may remove the influence of tastes, and also of historical accidents and special resources that result in some countries specialising in particular commodities.

4.2-2 Predicting Trade Flows

To measure openness we construct a model that explains the extent of trade and in particular manufactured imports from the North. Leamer (1974) identifies three predictors of imports; resistance, the stage of development and resource supplies. Resistance includes such things as transport costs and the level of tariffs and trade restrictions. Transport costs have for a long time been considered an important determinant of trade. Limao and Venables (1999) have shown for example that doubling transport costs can reduce trade flows by around 80 percent. Various proxies are often used to capture the impact of resistance on trade; these include distance, the presence of common borders and language and whether countries are landlocked or not. More recently it has been proposed that the internal infrastructure of both the importer and exporter may affect the level of trade through its impact on internal transport costs (for example, Bougheas *et al*, 1999 and Limao and Venables, 1999).

Leamer also suggests the stage of development would affect imports; *ceteris paribus* the more developed a country is, the higher are its imports expected to be. In general, poor countries do tend to trade less; this may be because imports are superior goods or because trade involves a variety of transactions costs that are particularly high in poor countries (see Collier, 1987 and Coe and Hoffmaister, 1998). A variety of proxies for stage of development have been suggested in the literature, examples include the level of GDP and per capita income. Finally, resource supplies are also considered to be an important determinant of a country's imports. These include such things as the stock of capital, the labour force, the level of human capital, natural resources and the level of R&D. These factors determine a country's comparative advantage and the extent of specialisation. This is likely to affect the composition of exports, with labour rich countries for example importing goods that embody capital. Given that we expect that the North is relatively well endowed with capital, we may also expect that the resource endowments of the South will affect the level of imports from the North. For example, we may expect that labour rich Southern countries will import more from the North than Southern countries relatively well endowed with capital.

To predict imports we use a variant of the gravity model that is augmented with various measures of the factor endowments of the Southern countries. The use of the gravity model as a means of estimating trade flows has increased a great deal following the development of a theoretical foundation for the model by amongst others Anderson (1979), Bergstrand (1985) and Helpman and Krugman (1985). The model relates a country's imports, exports or total trade to the size of the importer and exporter and to the distance between the two. Trade flows are seen as being the result of supply conditions at the origin, demand conditions at the destination, and trade stimulating and trade restricting forces between the two countries. These determinants are usually proxied by the GDP of the exporter and importer, their per capita incomes and their distance from each other. Trade stimulating forces are other factors that can enhance trade between countries; examples include common language, preferential trading arrangements, former colonial ties and direct land borders. Trade restricting forces are factors that drive a wedge between supply and demand and consist of three elements; transport costs, transport time (which represents problems of perishability, adaptability to market conditions and irregularities in supply) and psychic distance (which represents familiarity with laws, institutions and habits).

Applied papers[6] estimate some variant of the following simple version of the gravity equation

$$\ln(EX_{xm}) = \alpha + \beta_1 \ln(GDP_x.GDP_m) + \beta_2 \ln(GDPC_x.GDPC_m) + \beta_3 \ln(Dist_{xm}) + \beta_4 (Others), \quad \textbf{(4.1)}$$

where EX_{xm} are exports from the exporter (x) to the importer (m), GDP_x and GDP_m are the gross domestic product's of the exporter and importer respectively, $GDPC_x$ and $GDPC_m$ are the per capita GDP's of the exporter and importer respectively and $Dist_{xm}$ is the distance between the importer and exporter. Other variables often included are dummy variables for common languages and common borders, for landlocked countries and for trade bloc

[6] Examples include, Wang and Winters (1992), Bayoumi and Eichengreen (1995), Frankel (1997) and Helliwell (1998).

participation. The first is included since it is expected that being adjacent to another country increases familiarity with the culture, institutions and preferences of the trade partner; while a common language facilitates communication between trade partners and reduces the search costs of international trade. A common language may also be due to former colonial ties, which for historical reasons may result in greater trade flows[7]. Entering GDP and per capita incomes multiplicatively can be justified by modern trade theory that predicts larger trade volumes between more similar countries in terms of size and their factor endowments (It is not uncommon however to include the GDP's and per capita GDP's of the importer and exporter separately).

4.2-3 Estimation Issues

We estimate for each Southern country in our sample, manufacturing imports from a sample of 21 Northern countries over a 15-year period (1976-1990). To do this we estimate a model of trade that depends upon gravity determinants and factor endowments. We estimate two different versions of the model; the first simply uses the (logged) total value of manufactured imports from each Northern country as the dependent variable, while the second uses the share of manufactured imports in GDP from each Northern country as the dependent variable. The reason for the distinction is that we may expect that the model using the value of trade will tend to predict trade better for larger than for smaller countries. We expect that the value of imports will be larger for larger countries and although we include variables such as the level of GDP to take account of the importer's size we may still expect that the econometrics will

[7] For some evidence of this see Kleiman (1976).

dictate minimising the residuals from the bigger countries, while ignoring to some degree those of smaller countries. As a result we expect to find larger countries ranked in the middle of the distribution, since the deviation of actual from predicted trade using trade volumes will tend to be relatively small for the larger countries[8].

For a few country pairs and years, reported trade was zero. Four methods have been proposed to deal with this issue (see Frankel, 1997, Chapter 6). Firstly, we could exclude all zeros. This however leads to sample selection bias and doesn't use information about why trade may be low in these cases. Secondly, we could substitute the zero with an arbitrarily small number; this is *ad-hoc* but does allow estimation by conventional methods. Thirdly, we could add 1 to all the dependent observations and estimate the log-linear. Finally, we could use Tobit estimation techniques. This considers that exports are limited dependent variables censored at zero, and as such conventional estimation techniques can lead to a large bias[9]. Given that the number of zero observations relative to the total number of observations in our sample is very small (192 of 16245 observations), the resulting bias is also going to be small. As a result we didn't feel the extra complexity of using Tobit estimation was justified, and we chose the second of the above options and added one to all the zeros[10].

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[8] Similarly when using trade shares, we may expect that the econometrics will dictate minimising the residuals from countries with large trade shares. It is often observed that smaller countries tend to have higher trade shares than larger countries, since larger countries need not specialise to the same extent as smaller countries. In this case we may expect that smaller countries will be ranked in the middle of the distribution.

[9] Greene (1981) shows that this bias is inversely related to the sample proportion of non-zero observations.

[10] Adding a small number to the zero values leads to a further possibility. OLS in effect gives larger weights to extreme value, whether large or small As a result the zero values may receive too large a weight in the estimation. Removing the zero values was found not to affect the results a great deal however.

The models estimated in this chapter make use of panel data techniques[11] and for all of the reported results a random effects model is assumed. There are a number of *a-priori* reasons to favour a random effects model. Most importantly, a fixed effects model makes it impossible to identify the impact of time-invariant variables such as common language, distance and landlockedness, which are often found to impact significantly on trade. Moreover, since individual country and time dummy variables may capture differences in trade distortions across countries and time, the use of a fixed effects model is inappropriate since we assume that the residuals from our model capture trade distortions. As a practical justification for the use of random effects models, fixed effects models are considered to be less efficient than random effects models, since the use of dummy variables is costly in terms of the loss of valuable degrees of freedom. Furthermore, for many of the results presented the Hausman test and the Breusch-Pagan test, which are tests of fixed versus random effects support the use of a random effects model[12].

One shortcoming of random effects models is that it assumes that country-specific effects are uncorrelated with independent variables included, and hence it may be subject to omitted variable bias and inconsistency. This may well be an important shortcoming of the model estimated when we come to look at the impact of openness on growth. If the omitted variables in the model of imports are the same as those in the model of growth, then the measure of openness will be correlated with the error term. It will therefore not be exogenous and the

[11] A review of the various panel-data techniques is reserved for the econometrics appendix.

assumptions of the random effects model will be invalid. Given however the importance of time invariant factors such as distance and common languages in explaining trade in previous studies, the assumption of a random effects model is necessary.

4.2-4 Results

For each importing country in the South we estimate annual manufactured imports from each of 21 OECD countries between 1976 and 1990. The panel is quite large with potentially 16380 observations[13], with each observation representing imports from a particular Northern country to a particular Southern country in a particular year. We estimate a number of specifications using both import volumes and import shares, the specifications making use of data on factor endowments and gravity determinants[14]. The results using import volumes and import shares are reported in Table 4.1 and 4.2 respectively.

We begin in Table 4.1 by including just measures of the Souths' factor endowments (Column 1). These are the capital stock (*Capital*), the labour force (*Labour*), area (*Area*) and the value of primary exports[15] (*PriX*) of the importing country. In other specifications we also include a measure of skilled (*Skilled*) and unskilled (*Unskilled*) labour, using data on the labour force and on the percentage of people over 25 with higher education. We find that a relatively small proportion of the variation in imports is explained when only factor

[12] The Hausman test tends to support the use of a fixed effects model while the Breusch-Pagan test supports the use of a random effects model.
[13] Because of missing observations on various explanatory variables the final number is 16245.
[14] The data appendix at the end of the thesis provides details on variable names, data sources and information regarding the construction of the various variables.
[15] This is included as a measure of the availability of natural resources.

endowments of the importing country are included. The coefficients however are all significant. We find that countries with high levels of capital and labour tend to import more from the North, as do countries that are large exporters of primary products. These results suggest that bigger countries tend to import more than smaller countries, a result that would be expected. Countries that are land abundant however tend to import less than countries that are small in terms of area.

The use of gravity determinants greatly improves the fit (Columns 2 and 3), with the model explaining over 60 percent of the variation in imports. The gravity determinants included are the distance between the importer and exporter (*Dist*), the GDP and per capita GDP of the importer and exporter interacted (*GDPIN* and *GDPPC* respectively) and dummy variables for a common language between the importer and exporter (*Comlang*), for a landlocked exporter (*LockX*) and for a landlocked importer (*LockM*). As expected distance is found to be negatively related to a country's imports. The level of GDP and per capita incomes of the importer and exporter interacted are also found to be significant and positive, suggesting that the bigger and the wealthier a country in the South is, the more it trades with the North. We find that the presence of a common language encourages imports, which is a common result. We also find that being landlocked reduces imports, again a standard result. Being landlocked for the exporting country tends to encourage exports however, which is a surprising result[16].

[16] The reason for this result is not clear. It is a standard result that landlocked countries tend to trade less, due to higher transport costs for example. The positive and significant coefficients are only found using data on trade volumes and not using trade shares. The results may reflect a scale effect therefore, whereby the volume of trade of the two landlocked exporting countries,

Table 4.1: Results Using Import Volumes

Import Volume	*1*	*2*	*3*	*4*	*5*	*6*
Area	-0.18 (-4.26)*			-0.06 (-1.99)**	-0.14 (-4.54)*	-0.14 (-4.4)*
Labour	0.13 (2.73)*			-0.75 (-15.37)*		
Capital	0.17 (7.81)*			-0.01 (-0.47)	0.04 (1.7)***	0.04 (1.99)**
PriX	0.63 (27.92)*			0.56 (26.02)*	0.46 (20.52)*	0.38 (15.57)*
Skilled					-0.04 (-15.84)*	-0.4 (-14.62)*
Unskilled					-0.14 (-2.35)**	-0.12 (-2.04)**
Dist		-1.17 (-14.38)*	-1.19 (-14.98)*	-1.21 (-15.79)*	-1.04 (-13.53)*	-1.04 (-13.57)*
GDPIN		0.73 (35.58)*	0.73 (35.76)*	1.12 (35.61)*	1.13 (36.13)*	1.13 (36.28)*
GDPPC		0.13 (3.65)*	0.11 (3.12)*	-0.57 (-11.74)*	-0.26 (-4.95)*	-0.22 (-4.1)*
LockM			-0.96 (-7.4)*	-0.68 (-4.95)*	-0.75 (-5.51)*	-0.72 (-5.31)*
LockX			0.013 (0.09)	0.51 (3.77)*	0.38 (2.83)*	0.37 (2.71)*
ComLang			0.82 (6.29)*	0.79 (6.31)*	0.69 (5.57)*	0.72 (5.79)*
DTTI						0.003 (8.29)*
Constant	1.23 (2.01)**	-17.67 (-16.31)*	-17.08 (-15.9)*	-17.13 (-16.14)*	-27.82 (-21.9)*	-29.32 (-22.86)*
Wald-Test[17]	930.9*	2214.3*	2472.5*	3778.4*	4059.9*	4140.4*
Breusch-Pagan	79150*	48270*	46120*	45051*	44537*	45117*
Hausman	98.03*	1172.5*	1158.2*	497.3*	372.7*	327.2*
Overall R^2	0.26	0.64	0.65	0.65	0.65	0.66

Note: All models are estimated using Huber/White/Sandwich robust standard errors. Values in parentheses are t-values. *, **, *** indicates significance at the 1, 5 and 10 percent level respectively.

Austria and Switzerland, is high relative to other exporters after controlling for various factors, but the share of exports in GDP is not significantly higher than for other exporters.

When we include both factor endowments and gravity determinants together (columns 4 – 6) we find that the coefficients tend to remain significant and of the same sign. This is true for all variables except for the labour force[18] and the per capita income interacted, which both change from a positive to a negative sign. One possible explanation for the result on per capita income interacted is that when included without factor endowments, per capita income may be acting as a proxy for non-labour factor endowments[19], whereas when factor endowments are included separately in the regression, income per capita is acting as a proxy for something else. One possibility is that per capita income is acting as a proxy for excluded factor endowments. Using our approximation for skilled and unskilled labour we find that countries with high levels of skilled and unskilled labour tend to have lower imports[20] (Columns 5 and 6). Changes in the terms of trade for the importer (*DTTI*) are also found to positively affect the level of imports (Column 6). This is what we would expect since an improvement in the terms of trade allows a country to import a greater amount of goods for a given level of exports.

[17] This is a Wald test of the joint significance of all the regressors in the model, and follows a chi-squared distribution.

[18] The change in the sign of the coefficient on the labour force (and indeed that on per capita income) may represent a problem of multicollinearity. Table A1.2 in the data appendix shows a relatively high correlation between income per capita and the labour force. One result of multicollinearity is that coefficients change sign. Given however that the model is to be used only for prediction purposes multicollinearity need not be a major concern (see Greene, 1993).

[19] We noted in Chapter Three for example that Dollar (1992) uses per capita income as a proxy for factor endowments, arguing that since GDP is the values of the factor services generated by an economy in a year, then GDP per capita is a measure of per capita factor availability.

[20] It is not clear why both high levels of unskilled and skilled labour should reduce imports. However it is possible that the sign of the coefficients may be due to multicollinearity. Table A1.2 in the data appendix shows that there is a relatively high level of correlation between the level of skilled and unskilled labour.

The results using the scaled data (Table 4.2) are broadly similar to those in Table 4.1, although the model has lower explanatory power. We begin again by including only factor endowments of the South (Column 1). We also scale the various factor endowments of the importer, including capital per worker (*K/Worker*), the ratio of skilled to unskilled labour (*Skill/Unskill*), the ratio of land to workers (*Land/Worker*) and share of primary exports in GDP (*PriX/GDP*). All of the coefficients are found to be significant. We find that having a high ratio of capital to workers results in a higher share of imports from the North. Again this may reflect the fact that wealthier countries tend to import more. We find that a high share of primary exports in GDP and a high ratio of land to labour tends to increase the share of imports from the North in GDP. We find that developing countries with high shares of skilled labour to unskilled labour import less.

When the model of imports is based on gravity determinants (Columns 2 and 3) the R^2 increases substantially. The coefficients all tend to have the expected sign and are significant, although the coefficient on per capita incomes is significant only in specification 2 and then only at the 10 percent level. The coefficient on the variable for a landlocked exporter is never significant.

Table 4.2: Results Using Import Shares

Import Share	*1*	2	*3*	*4*	*5*
K/Worker	0.006 (5.82)*			-0.002 (-1.49)	-0.001 (-1.2)
Skill/Unskill	-0.09 (-5.0)*			-0.29 (-14.89)*	-0.28 (-14.65)*
Land/Worker	0.04 (3.43)*			0.06 (5.24)*	0.05 (4.59)*
Prix/GDP	0.47 (19.56)*			0.4 (17.22)*	0.28 (10.81)*
Dist		-0.05 (-13.49)*	-0.06 (-14.14)*	-0.06 (-15.92)*	-0.06 (-15.58)*
GDPIN		0.02 (20.4)*	0.02 (20.56)*	0.03 (25.03)*	0.03 (26.65)*
GDPPC		0.003 (1.75)***	0.003 (1.49)	0.007 (3.59)*	0.008 (4.02)*
LockM			-0.04 (-5.49)*	-0.04 (-5.33)*	-0.03 (-4.95)*
LockX			-0.004 (-0.52)	-0.004 (-0.52)	-0.003 (-0.4)
ComLang			0.04 (6.35)*	0.05 (7.4)*	0.05 (7.48)*
DTTI					0.0002 (11.22)*
Constant	0.22 (18.65)*	-0.14 (-2.72)*	-0.13 (-2.42)**	-0.47 (-8.88)*	-0.58 (-10.76)*
Wald-Test	610.5*	849.8*	988.8*	1949.5*	2085.8*
Breusch-Pagan	79416*	55608*	53630*	51307*	52329*
Hausman	152.1*	1008.5*	1013.9*	607.1*	486.3*
Overall R^2	0.05	0.47	0.48	0.43	0.46

Note: All models are estimated using Huber/White/Sandwich robust standard errors. Values in parentheses are t-values. *, **, *** indicates significance at the 1, 5 and 10 percent level respectively.

When both factor endowments and gravity determinant are included (Columns 4 and 5) the R^2 of the model tends to remain at approximately the same level as when just gravity determinants are used. The coefficients on most of the variables remain significant, although that on capital per worker now becomes negative and insignificant, possibly reflecting the high degree of correlation between capital per worker and per capita income. The coefficient on per capita incomes remains positive however, and is highly significant when the two sets of variables are included.

4.2-5 Measuring Openness

Openness is measured as the deviation of actual imports from that predicted by our model. We expect that all of the countries in our sample have some form of trade restrictions in place, the fitted values therefore do not give an estimate of imports in the absence of trade restrictions, but an estimate of imports for a country after controlling for certain characteristics (size, resource endowments, distance to markets) and some level of (average) protection[21]. The extent then to which a country's actual level of imports from each Northern country differs from that predicted gives an estimate of the extent of trade restrictions relative to the average. The estimates above tend to explain a relatively large proportion of the variation of imports from the North, leaving a relatively small amount of variation to be explained by trade restrictions[22]. The fact that the models estimated explain a much greater portion of the cross-country variation compared to the time-series variation may indicate that the measure of openness developed will be better at explaining relative levels of openness across countries rather than changes in openness within countries.

The statistic we use to measure openness is:

$$open_{xmt} = \frac{Actual_{xmt}}{Fitted_{xmt}}. \qquad (4.2)$$

[21] The openness measure developed is a relative rather than an absolute measure of openness.
[22] The models developed explain up to 66% of the variation in imports. Moreover the models explain over 80% of the cross-country variation in imports, with much less of the within country variation (i.e. the time-series variation) explained.

This is one of the methods used by Leamer (1988) and is suggestive of how much trade is deterred by barriers. A value in excess of one indicates that a Southern country (m) imports more from this Northern country (x) than would be predicted by the model, a value less than one indicates that it imports less. Higher values of this statistic then are associated with increased levels of openness across countries and time.

We construct our measure of openness using specification 6 in Table 4.1 for the unscaled model (*open1*) and specification 5 in Table 4.2 for the scaled model (*open2*). The statistic is calculated for each Southern country's imports from each Northern country, for each of the 15 years in the sample. The overall measure of openness for each Southern country is given by:

$$openi_{mt} = \frac{\sum_{x=1}^{21} open_{xmt}}{21}, \qquad i = 1, 2. \qquad (4.3)$$

i.e. the measure of openness for country m at time t is given by the sum of the openness index to each Northern country, x, divided by the total number of Northern countries (which is 21)[23].

Figures 4.1 and 4.2 in appendix 4B plot average values over the period 1976-1990 of actual against fitted imports for each Southern country using the

[23] This is an unweighted average value of openness to each Northern country, suggesting that being open to any of the Northern countries results in the same benefits. As a first approximation this may be sufficient; most of the Southern countries in our sample are some way from the technological frontier and imports from any of the 21 OECD countries would likely embody more advanced technology than that available domestically. It may however be that goods from some countries in the North embody more advanced technology than goods from others, in which case it would be right to weight the openness measure by a measure of the level of technology in each Northern economy. This in effect is what we do in Chapter Five, where we weight the openness measures for each Northern country with a measure of its knowledge stock.

unscaled (*open1*) and scaled (*open2*) data respectively. It is clear from these figures that both the average level and the average share of trade over this period has differed widely for different countries. The figures also suggest however that the models estimated explain the majority of the variation in trade, with the majority of the points being close to the 45-degree line. If anything the plots suggest that the model using the scaled data (Figure 4.2) explains less of the variation across countries, since the points are not so tight to the 45-degree line. This initial view is confirmed by looking at the correlation between the actual and the fitted values, 0.9 for the unscaled model and 0.7 for the scaled model, as well as the R^2 values of the models estimated above.

In Figure 4.3 we plot the average annual values of the two openness measures against each other. An OLS regression of *open1* on *open2* and a constant results in a coefficient on *open2* insignificantly different from one and an insignificant constant term, suggesting that there is little difference between the two measures of openness[24]. The R^2 of this simple regression is 0.64. There are however one or two outliers that are evident in Figure 4.3. The one striking outlier is Panama, which is found to have a very high level of openness in comparison to the other countries using both measures[25]. India and Brazil, the two largest countries in the sample are some distance below the 45-degree line, which indicates that they are less open using the share of imports in GDP (*open2*) than using the value of imports (*open1*). In contrast, two of the smaller countries in the sample,

[24] Table A1.4 in the data appendix reports the correlation between *open1* and *open2* using five-year averages as 0.83.
[25] This result is in stark contrast to Leamer who found that although Panama was very trade dependent, her resources would suggest that she should be even more so. One possible explanation for Panama having such a high level of openness according to our measure is that transhipments are high for Panama.

Malawi and Malta, are some distance above the line, suggesting that they are more open according to *open2* than *open1*.

Table 4.5 in appendix 4B, ranks the countries according to the two averaged measures. There are some significant differences in the rankings of countries and the Spearman rank correlation between the two rankings is low at 0.15. Figure 4.4, in appendix 4B, plots the difference between the two openness measures for each country. The number on the horizontal axis represents the ranking according to *open1*, such that 1 refers to Panama and so on. The two horizontal lines are one standard deviation away from zero, with the standard deviation being that of *open1*. It is clear from this figure and Table 4.5 that for a number of countries, the value of openness differs a great deal depending upon the openness measure employed. Indeed, for six of the countries, the value of openness changes by more than one standard deviation from the average value of *open1*[26].

An interesting similarity in the measures of openness is that a number of African countries are ranked quite high in terms of openness, contrary to conventional wisdom. Our results suggest that once various gravity determinants and factor endowments are controlled for, many African countries are indeed relatively open to imports from the North, which supports the results of Rodrik (1988) and Coe and Hoffmaister (1998). The latter finds that if anything the average African country tends to 'overtrade' compared with

[26] The six countries are Brazil, India, Mauritius, Malawi, Israel and Malta. The larger countries, such as Brazil and India, tend to be ranked higher according to *open1*, while the smaller countries tend to be ranked higher according to *open2*. This is what we expect, and indeed, this was the justification for scaling the data to begin with.

developing countries in other regions, and suggest that economic size, geographical distance and population can explain the low level of trade in Africa.

4.3 The Role of North-South Trade in Economic Growth

4.3-1 Empirical Specification

To test the hypothesis that openness to the North increases growth in the South we specify a regression model with per capita GDP growth as the dependent variable. We follow previous studies in specifying our model of growth, but it should be noted that there are a number of shortcomings with this methodology, many of which were outlined in Chapter Three and in more detail by Temple (1999). The approach is *ad-hoc* employing previous results in deciding upon which variables to include in the model. The method also assumes that each country has a common production function. It is unlikely that countries with widely differing social, political and institutional characteristics would share the same production function, although to the extent that averages are important the results are likely to provide important information. A further problem with this type of study relates to the fact that many of the variables are likely to be endogenous, and although instruments can be used to account for this, there is often a shortage of potential instruments. Other potential problems relate to the possibility of measurement error and as already discussed to the robustness of the results.

The model is estimated using panel data techniques and once again a random-effects model is employed[27]. The advantage of using a panel over a cross-section is that it expands the sample information, with the time-series element often providing important additional information. A problem arises in selecting the time interval over which to study growth however. The theory that relates long-run growth, and the precise timing between growth and its determinants is not well specified at the high frequencies characteristic of business cycles. It is likely therefore that relationships using annual data will be dominated by mistiming and effectively measurement error (Barro, 1998, p. 15). Moreover, variables such as educational attainment rates are often only measured at five-year intervals. It is common therefore to use five or ten year averages, although this has the effect of removing much of the time-series variation. We proceed by using data on five-year averages for all of the variables, with data being collected for 1976-1980, 1981-1985 and 1986-1990.

The model we estimate includes standard variables[28] used in the empirical growth literature augmented with our measure of openness. The regression model is specified as follows:

$$Avgrow_{mt} = \alpha + \beta_j I_{jmt} + \gamma openi_{mt} + \varepsilon_{mt}, \qquad (4.4)$$

where *Avgrow* is the average growth in per capita real GDP of Southern country m in time period t, α is a constant, I is a vector of additional explanatory variables, *openi* is one of our two measures of openness to imports from the North and ε is an error term. Included amongst the additional variables are two time dummies (*T1* and *T2*) to take account of differences in growth between the

[27] The Hausman and Breusch-Pagan tests in general support the use of a random effects model.

different periods. The model estimated therefore assumes that only the individual country effects are random.

A large number of explanatory variables have been included in growth regressions and found to be significant[29]. The majority of these however tend not to be robust in the sense that adding additional variables to the regression results in an original variable becoming insignificant (see Levine and Renelt, 1992, and Sala-i-Martin, 1997). We begin with a small number of explanatory variables, but include additional variables to test for robustness. Initially we include just two additional variables alongside openness, the initial level of GDP (*InitGDP*) and the average investment rate (*Inv*). The former is included as a catch-up term, since many believe that countries that are initially away from the world technological frontier can benefit by learning from the technological leaders (see Gerschenkron, 1962 and Kuznets, 1973). The notion that countries that are initially poor will eventually catch up with the richer countries is also one implication of the neoclassical model, discussed in Chapter Two. Openness is one channel through which catch-up may occur, the inclusion of this variable therefore is to account for forms of catch-up other than openness. The investment rate is included as a measure of the growth in the capital stock, which we would expect to be positively related to per capita GDP growth. Including the investment rate as an explanatory variable in growth regressions may be problematic however, since investment is likely to be endogenously

[28] See for example Barro (1991, 1998), Levine and Renelt (1992) and Sala-i-Martin (1997).
[29] Sala-i-Martin (1997) collects data on around 60 variables that have found to be significant in growth regressions. We include just a small number of these variables. One variable that is omitted from our regression is the terms of trade, which have often been stressed as important for developing countries who tend to specialise in a few primary products. The terms of trade variable is a cyclical variable and so is not likely to vary a great deal using five-year averages.

determined. The results we obtain however differ very little when investment is excluded.

Another variable included is the rate of population growth (*PopGrow*). *Ceteris paribus*, countries with high population growth would be expected to have lower per capita growth[30]. We also experiment with a number of variables that proxy human capital[31]. Initially we include average years of secondary schooling in the male and female population (*SyrM* and *SyrF* respectively). Following these we include average number of years of primary schooling in the male and female population (*PyrM* and *PyrF*) to examine whether different levels of education affect growth differently. The inclusion of various measures used to control for a country's resource endowments (for example, investment, population growth and measures of education) also reflects the fact that movements from agriculture to industry are likely to be an important source of growth. Including measures of resource endowments can therefore be justifies since they are likely to dictate the structure of production[32].

To control for a country's attractiveness to investment we include an index of political rights (*Polrit*) and civil liberties (*Civlib*)[33]; we would expect that

We do however include the variable in a later chapter using annual data and find it to be significant.

[30] Kormendi and Meguire (1985), Levine and Renelt (1992) and Mankiw, Romer and Weil (1992) all report negative coefficients for population growth, although Levine and Renelt find the variable not to be robust.

[31] Many authors include measures of human capital, examples include Barro (1991, 1998), Levine and Renelt (1992), Mankiw, Romer and Weil (1992) and Sala-i-Martin (1997).

[32] Including variables to account for the redistribution of resources between sectors has generally not been attempted in the growth literature, although Dowrick and Gemmell (1991) include such variables as the growth of both the agricultural and industrial labour force, the agricultural labour force share and the agricultural output share.

[33] These variables are included in the models of Barro and Lee (1994b) and Sala-i-Martin (1997). They both find that greater political rights spurs growth, but find differing effects for civil liberties.

improvements in either of these factors would boost growth. Many analysts control for macroeconomic conditions. Thus, we include a measure of government consumption (*Gov't*) and inflation (*Inflation*). Higher levels of government spending would be expected to lower growth due to higher taxes that reduce saving and investment, and possibly through crowding out[34]. The measure of government expenditure used is intended to approximate unproductive government expenditure, but may not be the best measure to account for potential crowding out, with measures such as the debt ratio and the budget deficits more likely to account for this. We would expect inflation to be negatively related to growth, since it can negatively affect saving and investment (See Temple, 2000). Inflation may also to some extent proxy for macroeconomic instability.

Dummy variables for different regions are often found significant in growth regressions[35]. These are intended to capture a wide variety of political, social and economic conditions that are specific to particular regions, but not captured by other variables. The problem with regional dummy variables is that we don't know what effects they are capturing, which has led some to term such regional dummies, *dumb variables*[36]. However, regional dummies have been included in growth regressions elsewhere and have been found to be significant. Moreover, Temple (1999) argues that regional dummies can be used in place of fixed effects models in empirical growth models employing panel techniques, since much of the variation in efficiency levels occurs between rather than within continents. Finally therefore, we include dummy variables for Latin America

[34] See Argimon, Gonzalez Paramo and Roldan (1997) for some evidence of this.
[35] Examples include Barro (1991, 1998), Barro and Lee (1994b) and Sala-i-Martin (1997).

(*DLAT*), East Asia (*DEAS*) and Sub-Saharan Africa (*DSSA*) to see if the coefficients on openness are sensitive to their inclusion.

As mentioned above, few explanatory variables have been found to be robustly related to growth, in the sense that adding additional variables to a growth regression makes some of the original variables insignificant. We test the robustness of the relationship between our measure of openness and growth in a number of ways. Firstly, we use two different measures of openness. Secondly, we add incrementally quite a large number of variables in our growth model to examine the impact on the size and significance of existing coefficients, including those on openness, to the inclusion of additional variables. Thirdly, we remove potential outliers from our sample. This is done in two ways. Firstly, we drop the observations on Panama from our model. Panama was found to have much higher levels of openness than any other country in our sample[37], removing this observation will allow us to examine whether it is this observation that is driving the results obtained. Secondly, we use an econometric technique developed by Hadi (1992, 1994) to search for potential outliers in our growth model. The results of these tests consistently suggest that for all three periods Kuwait is an outlier, almost certainly reflecting the fact that it is a major oil exporter, with Nicaragua in the period 1986-90 also being an outlier. Finally, therefore we also remove these four observations to examine whether it is these observations that are driving any observed relationship between the measures of openness and growth.

[36] Srinivasan (2000) for example argues that such variables simply quantify our ignorance.

4.3-2 Results

The model is estimated using data on each variable for the three five-year periods for each of the 52 Southern countries giving a total of 156 observations. In Table 4.3 we report results from the growth regression using the unscaled openness measure (*open1*), while Table 4.4 reports results using the scaled measure (*open2*).

If we begin with the core variables, most coefficients have the anticipated sign and the majority are significant. The coefficient on initial GDP is negative, as expected, and tends to be significant. The impact of investment on growth is positive and highly significant, a result that is robust across specifications. Population growth is found to affect growth in the manner expected, being both significant and robust across the different specifications.

The results relating to human capital are mixed[38]. We find that male secondary schooling has a positive and significant impact upon growth, but that female secondary schooling has a negative and significant impact, suggesting that investment in female secondary education actually retards growth. The result on the female schooling variable is quite surprising, but not without precedent. Barro and Lee (1994b) amongst others have also found a negative and significant coefficient on female schooling and argue that one explanation for this result "is that a high spread between male and female schooling attainment is a good measure of backwardness; hence, less female attainment signifies

[37] Using both openness measures and for all three periods, Panama's openness was more than 2.7 standard deviations greater than the average value of openness.

more backwardness and accordingly higher growth potential through the convergence mechanism" (p. 18)[39]. Barro and Lee also show that female schooling has beneficial impacts on other indicators of economic development such as infant mortality, fertility and life expectancy. It is likely therefore that female education has an indirect impact upon economic growth through these channels.

When we include male and female average years of primary schooling, the coefficients are the opposite sign of those for the secondary schooling variables. We find that an increase in average years of primary schooling for females is positively related to growth, while the average years of primary schooling for males is negatively related to growth, although neither is significant. The coefficients on the average years of secondary schooling for males and females remain unchanged when the primary school variables are included.

The coefficients on civil liberties and political rights are not found to be significant (and in the case of political rights the coefficient has the wrong expected sign). The coefficients on both government consumption and inflation have the expected sign, but only that on the government consumption variable is significant[40]. Finally, the coefficients on the regional dummy variables all have

[38] When the average years of secondary schooling in the total population is included in place of the male and female secondary schooling variables separately, the coefficient is found to be insignificant.
[39] The level of initial GDP is included in the model to account for backwardness and so it is not clear whether backwardness is actually being captured in the female education variable (or the spread between female and male education). An alternative factor that it might be capturing is religious and cultural differences across countries, with some cultures and religions having a less favourable attitude to educating the female population. To the extent that differences in culture and religion affect growth, this may explain the coefficient on female schooling.
[40] The coefficient on inflation becomes significant when the government consumption variable is removed.

the expected sign. The coefficients are only significant for Sub-Saharan Africa and Latin America however, suggesting that East Asia's relatively high growth over the period can be explained by the variables in our model.

Turning now to openness we see that for both measures the coefficient is positive and large, suggesting that growth is positively related to openness to imports from the North. Furthermore, the coefficients are all significant at least at the 10 percent level, and once regional factors have been taken account of, coefficients are significant at the 1 percent level. The value of the coefficient however is variable, falling when the various measures of human capital are included. The coefficient on *open1* tends to be higher than that on the scaled measure of openness, *open2*. The results suggest that an increase in openness by one standard deviation would increase growth by between 0.39 and 0.72 percent using *open1* as our openness measure and between 0.51 and 0.82 percent using *open2* as our measure of openness.

The results suggest that whichever of the two openness measures is used, a positive and significant relationship between openness and growth is found, suggesting that our measure of openness is quite robust. Moreover, the inclusion of a large number of additional variables into our model doesn't alter the sign or significance of the openness measure. The value of the coefficient does change to some extent, particularly when human capital is included, but the relationship between openness and growth is always positive and significant.

Table 4.3: Regression Results for Growth Model Using *open1*

Avgrow	1	2	3	4	5	6	7
InitGDP	-1.35 (-2.98)*	-1.45 (-3.42)*	-0.89 (-1.64)***	-0.93 (-1.6)	-1.11 (-1.94)**	-0.89 (-1.75)***	-0.50 (-0.99)
Inv	1.98 (3.57)*	1.88 (3.58)*	1.78 (3.67)*	1.83 (3.46)*	1.97 (4.03)*	1.49 (3.09)*	1.2 (2.62)*
PopGrow		-0.78 (-2.44)**	-0.94 (-3.15)*	-0.91 (-2.57)*	-0.89 (-2.94)*	-0.96 (-3.42)*	-1.05 (-3.95)*
SyrF			-4.08 (-3.43)*	-4.68 (-3.04)*	-4.57 (-3.71)*	-4.09 (-3.62)*	-2.69 (-2.41)**
SyrM			3.57 (3.94)*	4.06 (3.49)*	3.88 (4.26)*	3.39 (3.97)*	1.54 (1.64)***
PyrF				0.46 (0.62)			
PyrM				-0.51 (-0.74)			
Polrit					0.06 (0.25)		
Civlib					-0.36 (-1.17)		
Gov't						-9.41 (-2.38)**	-12.57 (-3.16)*
Inflation						-3.36 (-1.43)	-2.31 (-0.99)
open1	6.95 (2.12)**	6.65 (2.11)**	5.42 (1.77)***	5.84 (1.81)***	4.48 (1.69)***	7.24 (2.41)**	8.22 (2.78)*
DEAS							0.06 (0.06)
DLAT							-2.45 (-3.25)*
DSSA							-1.47 (-1.99)**
T1	-2.59 (-5.19)*	-2.7 (-5.34)*	-2.81 (-5.27)*	-2.78 (-5.13)*	-2.73 (-5.02)*	-2.99 (-5.32)*	-2.74 (-4.82)*
T2	-1.16 (-2.28)*	-1.38 (-2.66)*	-1.4 (-2.36)**	-1.34 (-2.19)**	-1.23 (-1.93)**	-1.18 (-2.00)**	-1.03 (-1.77)***
Constant	0.05 (0.01)	3.37 (0.78)	0.39 (0.08)	0.51 (0.09)	3.59 (0.64)	1.31 (0.26)	0.98 (0.2)
Wald-Test	56.87*	64.16*	87.92*	87.16*	91.12*	106.23*	134.73*
Breusch-Pagan	15.97*	9.56*	3.37***	3.26***	3.15***	1.14	0.04
Hausman	0.31	3.28	3.7	3.79	4.55	6.14	7.49
Overall R^2	0.26	0.32	0.40	0.41	0.42	0.45	0.50

Note: All models are estimated using Huber/White/Sandwich robust standard errors. Values in parentheses are t-values. *, **, *** indicates significance at the 1, 5 and 10 percent level respectively.

Table 4.4: Regression Results for Growth Model Using *open2*

Avgrow	*1*	*2*	*3*	*4*	*5*	*6*	*7*
InitGPP	-1.41 (-3.09)*	-1.50 (-3.49)*	-0.86 (-1.59)	-0.88 (-1.49)	-1.14 (-2.01)**	-0.86 (-1.70)***	-0.51 (-1.04)
Inv	2.15 (3.9)*	2.05 (3.91)*	1.92 (3.97)*	2.03 (3.77)*	1.85 (3.77)*	1.63 (3.48)*	1.33 (2.95)*
PopGrow		-0.75 (-2.33)**	-0.93 (-3.11)*	-0.93 (-2.62)*	-0.90 (-2.97)*	-0.94 (-3.41)*	-1.01 (-3.87)*
SyrF			-4.4 (-3.63)*	-5.09 (-3.25)*	-4.3 (-3.56)*	-4.57 (-4.01)*	-3.23 (-2.89)*
SyrM			3.75 (4.18)*	4.31 (3.73)*	3.72 (4.04)*	3.62 (4.34)*	1.81 (1.99)**
PyrF				0.48 (0.64)			
PyrM				-0.59 (-0.86)			
Polrit					0.07 (0.27)		
Civlib					-0.39 (-1.27)		
Gov't						-10.63 (-2.67)*	-13.47 (-3.41)*
Inflation						-3.23 (-1.38)	-2.22 (-0.56)
open2	5.39 (1.92)***	4.82 (1.79)***	4.96 (1.91)***	5.66 (2.01)**	5.19 (1.68)***	7.13 (2.78)*	7.7 (3.19)*
DEAS							0.06 (0.07)
DLAT							-2.39 (-3.27)*
DSSA							-1.71 (-2.36)**
T1	-2.58 (-5.18)*	-2.7 (-5.33)*	-2.77 (-5.18)*	-2.71 (-4.96)*	-2.75 (-5.08)*	-2.91 (-5.14)*	-2.66 (-4.68)*
T2	-1.14 (-2.25)**	-1.37 (-2.62)*	-1.32 (-2.2)**	-1.22 (-1.94)**	-1.27 (-2.02)**	-1.05 (-1.76)***	-0.90 (-1.53)
Constant	1.63 (0.41)	5.09 (1.26)	0.24 (0.05)	-0.06 (-0.01)	3.6 (0.64)	0.93 (0.19)	1.33 (0.29)
Wald-Test	55.89*	62.35*	88.68*	88.4*	91.17*	110.33	141.28*
Breusch-Pagan	16.39*	9.94*	3.38*	3.22*	3.16*	0.87	0.14
Hausman	0.67	3.95	3.97	3.85	4.64	6.48	7.75
Overall R^2	0.26	0.31	0.41	0.41	0.42	0.46	0.51

Note: All models are estimated using Huber/White/Sandwich robust standard errors. Values in parentheses are t-values. *, **, *** indicates significance at the 1, 5 and 10 percent level respectively.

The results of removing the various outliers in the sample are reported in Tables 4.6 through 4.8 in appendix 4C. Once removed the one striking outlier according to the measure of openness, Panama, has very little effect on the initial variables in the growth model, although initial GDP becomes insignificant in a number of cases (See Tables 4.6 and 4.7). More importantly, the coefficients on the openness measures are still positive and often increase in size. In one case the coefficient on our measure of openness is insignificant, but it is often the case that the coefficients have a higher level of significance after removing Panama. Tables 4.8 and 4.9 report the results after removing all three observations on Kuwait and the final observation on Nicaragua. The results are broadly similar to those found for the full sample of countries, with both measures of openness always being positive and significant.

4.4 Concluding Remarks

For a long time it has been suggested that openness to international trade can have a positive impact on growth. The theory that relates openness to growth however is not conclusive on this hypothesis, openness can be shown to increase or reduce growth depending upon the country in question and upon the goods in which the country specialises following trade liberalisation.

We examine one particular aspect of trade, namely North-South trade, and its impact on economic growth. Such a focus is justified by the endogenous growth theories, which suggest that countries benefit from trade through the importation of capital and intermediate goods, and technology. We began by constructing a measure of openness based on the deviation of actual from predicted imports from the North. We modelled imports as being determined by the factor endowments of the importer and by various gravity determinants. The model developed explained a large proportion of the cross-country variation in the level of imports of the South.

Using this measure we estimated the impact of openness to goods from the North on economic growth. We showed that openness to goods from the North was positively and significantly related to economic growth, with the positive impact being quite large. We were also able to show that this relationship was robust in the sense that the coefficient was always positive and significant. This was true regardless of the openness measure employed, the additional variables included in the model and the removal of influential outliers. The coefficient on openness did vary however, depending upon the measure used and the variables included in the model.

One important caveat of the measure of openness developed is that it is based on the deviation of actual trade from that expected given a country's factor endowments and geographical characteristics. While this may be a good indicator of government trade restrictions, it may also be measuring other trade limiting forces, such as poor internal infrastructure[41]. An implication of these results then is that lowering impediments to imports from the North can be helpful to growth. One such impediment is trade restrictions, but the removal or reduction of these may not be sufficient to enhance growth. Other impediments not captured in the empirical model may also be important. If imports from the

[41] A lack of data on measures of internal infrastructure for our sample of countries precluded us from including a variable capturing this in our model of imports.

North are low because of poor internal infrastructure for example, reducing trade restrictions may not improve growth. In this case, governments should also look to improve the level of infrastructure within the economy, which can enhance imports by reducing internal transport costs.

Appendix 4A: List of Northern Countries in the Sample

1. Canada
2. United States of America
3. Japan
4. Austria
5. Belgium-Luxembourg
6. Denmark
7. Finland
8. France
9. Germany
10. Greece
11. Ireland
12. Italy
13. Holland
14. Norway
15. Portugal
16. Spain
17. Sweden
18. Switzerland
19. United Kingdom
20. Australia
21. New Zealand

Appendix 4B: Tables and Figures

Figure 4.1: Plot of Actual against Fitted Values (Import Values)

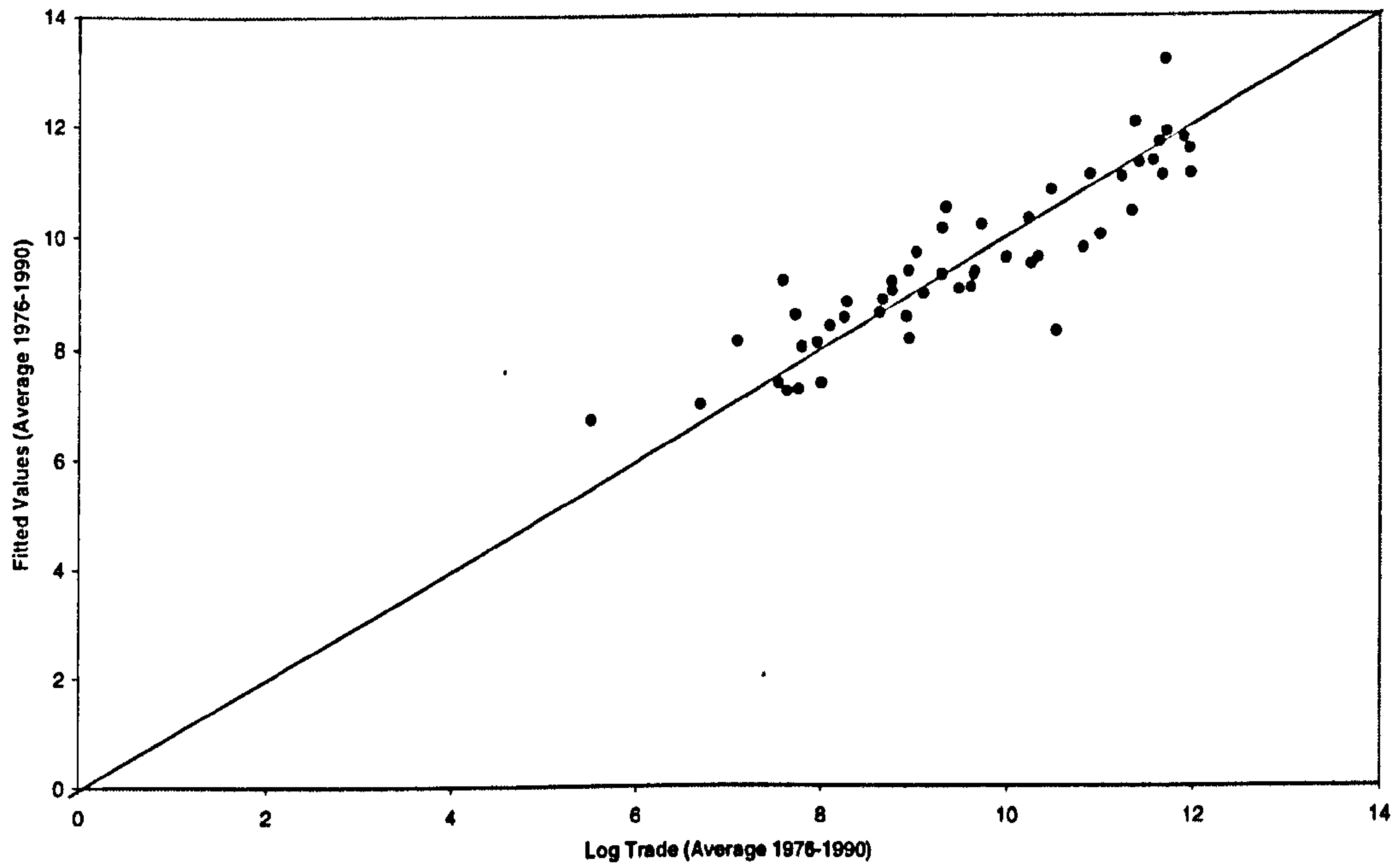


Figure 4.2: Plot of Actual against Fitted (Import Shares)

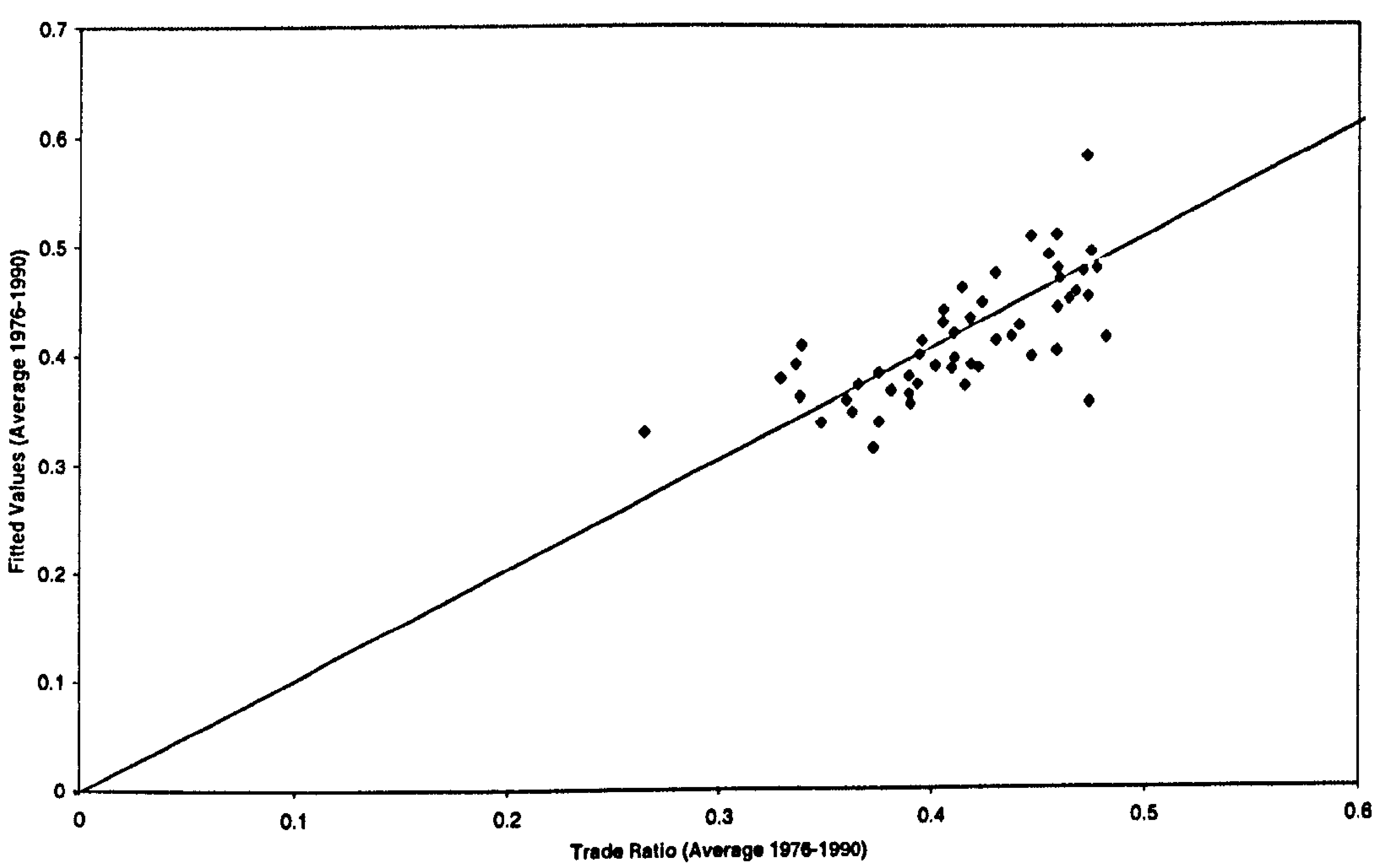


Figure 4.3: Plot of *open1* against *open2*

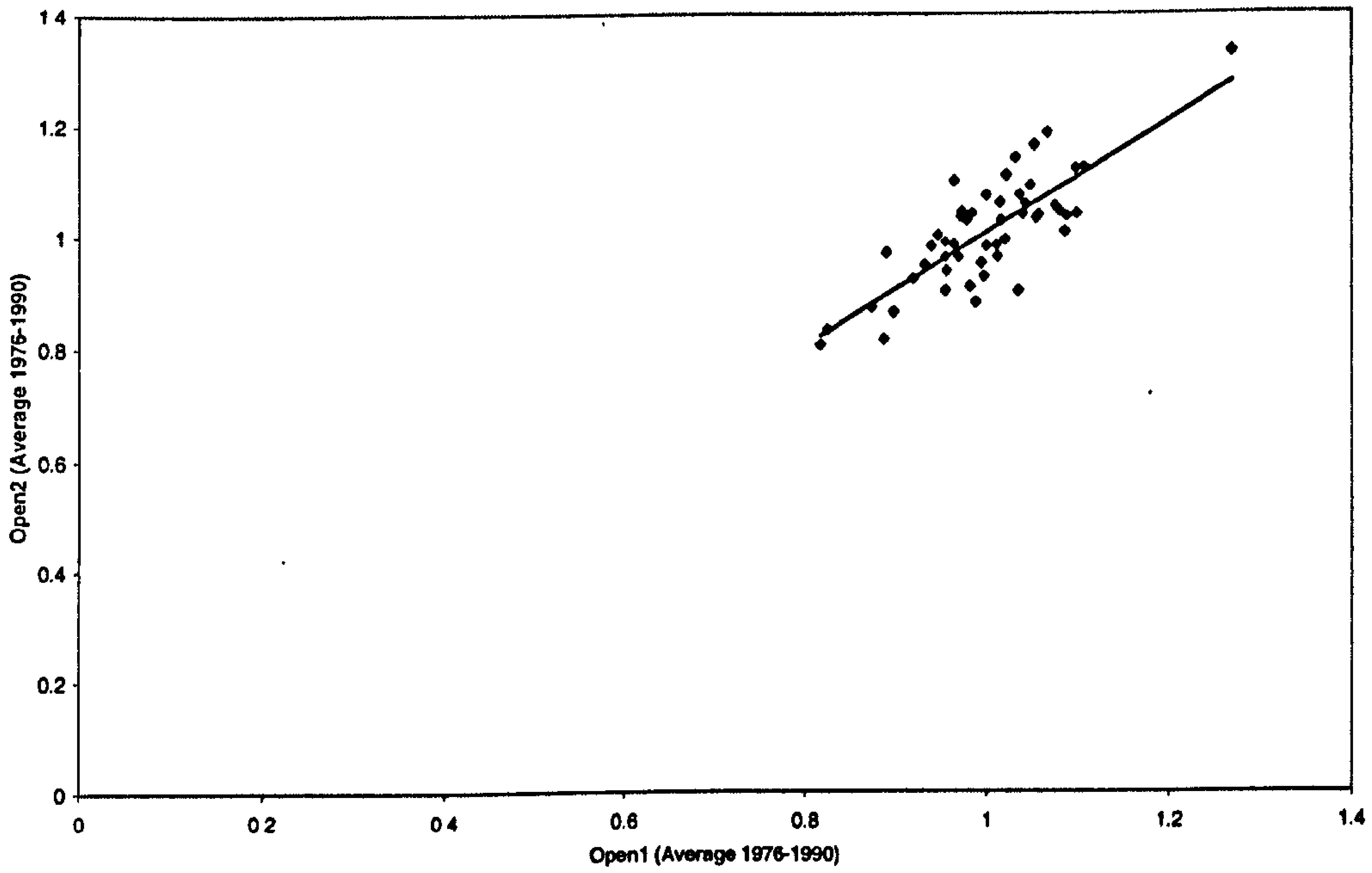
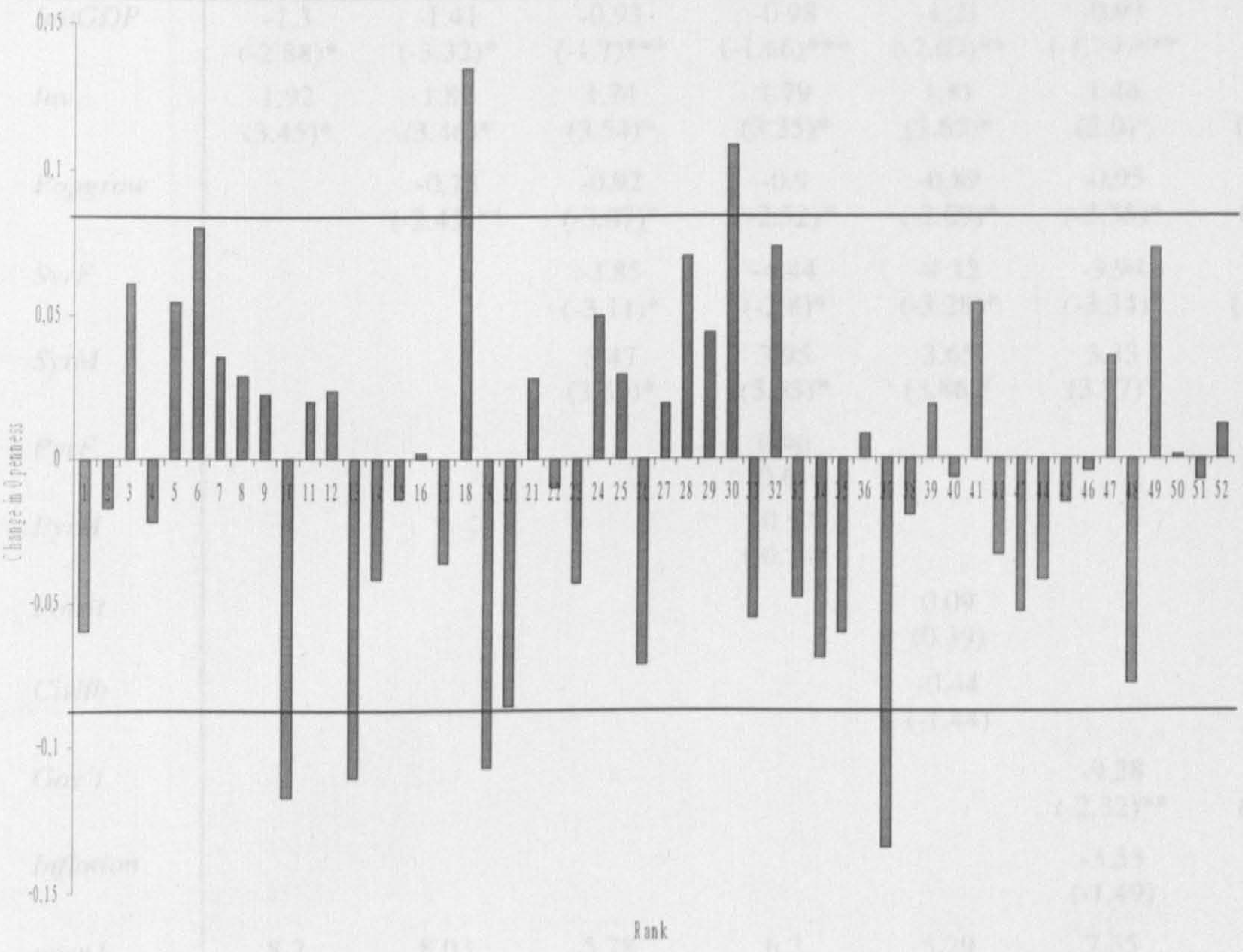


Table 4.5: Ranking of Countries by Openness Measure

Rank	*open1*	*open2*
1	Panama	Panama
2	Philippines	Malawi
3	Pakistan	Israel
4	Zambia	Malta
5	Thailand	Philippines
6	Bolivia	Zambia
7	Peru	Sierra Leone
8	Korea	Mauritius
9	Chile	Sri Lanka
10	Malawi	Ecuador
11	Bangladesh	Costa Rica
12	Paraguay	Dominican Republic
13	Israel	Uruguay
14	Sri Lanka	Chile
15	Uruguay	Korea
16	Kenya	Peru
17	Ecuador	Haiti
18	India	Togo
19	Malta	Pakistan
20	Sierra Leone	Kenya
21	Venezuela	Bangladesh
22	Malaysia	Thailand
23	Dominican Republic	Jamaica
24	South Africa	Paraguay
25	Indonesia	El Salvador
26	Costa Rica	Malaysia
27	Zaire	Bolivia
28	Mexico	Kuwait
29	Colombia	Venezuela
30	Brazil	Guatemala
31	Togo	Nicaragua
32	Argentina	Indonesia
33	El Salvador	Honduras
34	Haiti	Zaire
35	Jamaica	Trinidad and Tobago
36	Tunisia	South Africa
37	Mauritius	Senegal
38	Nicaragua	Tunisia
39	Guyana	Colombia
40	Senegal	Ghana
41	Sudan	Guyana
42	Guatemala	Mexico
43	Kuwait	Cameroon
44	Honduras	Argentina
45	Ghana	India
46	Cameroon	Sudan
47	Myanmar	Brazil
48	Trinidad and Tobago	Niger
49	Algeria	Myanmar
50	Niger	Zimbabwe
51	Zimbabwe	Algeria
52	Central African Republic	Central African Republic

Figure 4.4: Difference in Openness Between *open1* and *open2*



Appendix 4C: Additional Regression Results

Table 4.6: Regression Results Omitting Panama Using *open1*

Avgrow	*1*	*2*	*3*	*4*	*5*	*6*	*7*
InitGDP	-1.3 (-2.88)*	-1.41 (-3.32)*	-0.93 (-1.7)***	-0.98 (-1.66)***	-1.21 (-2.09)**	-0.93 (-1.79)***	-0.51 (-1.01)
Inv	1.92 (3.45)*	1.82 (3.46)*	1.74 (3.54)*	1.79 (3.35)*	1.81 (3.65)*	1.46 (3.0)*	1.17 (2.53)**
Popgrow		-0.78 (-2.45)**	-0.92 (-3.07)*	-0.9 (-2.52)*	-0.89 (-2.89)*	-0.95 (-3.35)*	-1.05 (-3.89)*
SyrF			-3.85 (-3.11)*	-4.44 (-2.8)*	-4.12 (-3.28)*	-3.94 (-3.34)*	-2.64 (-2.29)**
SyrM			3.47 (3.69)*	3.95 (3.33)*	3.65 (3.86)*	3.33 (3.77)*	1.53 (1.6)
PyrF				0.46 (0.61)			
PyrM				-0.52 (-0.74)			
Polrit					0.09 (0.39)		
Civlib					-0.44 (-1.44)		
Gov't						-9.28 (-2.32)**	-12.55 (-3.11)*
Inflation						-3.53 (-1.49)	-2.45 (-1.04)
open1	8.2 (2.32)**	8.03 (2.35)**	5.78 (1.73)***	6.3 (1.78)***	5.29 (1.56)	7.35 (2.25)**	7.81 (2.45)*
DEAS							0.1 (0.11)
DLAT							-2.45 (-3.22)*
DSSA							-1.49 (-2.0)**
T1	-2.58 (-5.12)*	-2.69 (-5.27)*	-2.84 (-5.27)*	-2.81 (-5.13)*	-2.76 (-5.06)*	-3.04 (-5.34)*	-2.78 (-4.85)*
T2	-1.07 (-2.09)**	-1.29 (-2.35)**	-1.37 (-2.29)**	-1.31 (-2.13)**	-1.2 (-1.89)**	-1.14 (-1.92)***	-0.98 (-1.67)***
Constant	-1.37 (0.76)	1.85 (0.41)	0.42 (0.08)	0.44 (0.08)	4.09 (0.69)	1.44 (0.28)	1.51 (0.3)
Wald-Test	56.1*	63.71*	84.6*	83.84*	88.31	102.67*	131.01*
Breusch-Pagan	15.58*	9.33*	3.54***	3.4***	3.42***	1.27	0.03
Hausman	0.09	2.8	3.43	3.65	4.36	5.86	7.33
Overall R^2	0.27	0.32	0.40	0.40	0.42	0.45	0.50

Note: All models are estimated using Huber/White/Sandwich robust standard errors. Values in parentheses are t-values. *, **, *** indicates significance at the 1, 5 and 10 percent level respectively.

Table 4.7: Regression Results Omitting Panama Using *open2*

Avgrow	1	2	3	4	5	6	7
InitGDP	-1.38 (-3.01)*	-1.47 (-3.41)*	-0.9 (-1.65)***	-0.92 (-1.54)	-1.17 (-2.02)**	-0.89 (-1.74)***	-0.52 (-1.04)
Inv	2.1 (3.81)*	2.01 (3.82)*	1.89 (3.85)*	2.01 (3.68)*	1.94 (3.91)*	1.61 (3.38)*	1.29 (2.84)*
Popgrow		-0.75 (-2.31)**	-0.91 (-3.03)*	-0.92 (-2.57)*	-0.88 (-2.86)*	-0.93 (-3.33)*	-1.01 (-3.81)*
SyrF			-4.19 (-3.35)*	-4.86 (-3.05)*	-4.39 (-3.47)*	-4.41 (-3.74)*	-3.16 (-2.76)*
SyrM			3.65 (3.97)*	4.21 (3.59)*	3.82 (4.09)*	3.55 (4.15)*	1.78 (1.93)***
PyrF				0.48 (0.63)			
PyrM				-0.62 (-0.87)			
Polrit					0.09 (0.36)		
Civlib					-0.41 (-1.34)		
Gov't						-10.52 (-2.61)*	-13.48 (-3.37)*
Inflation						-3.4 (-1.44)	-2.36 (-1.01)
open2	6.63 (2.18)**	6.05 (2.07)**	5.34 (1.89)***	6.19 (2.02)**	4.61 (1.6)	7.33 (2.67)*	7.49 (2.91)*
DEAS							0.1 (0.11)
DLAT							-2.41 (-3.24)*
DSSA							-1.72 (-2.65)**
T1	-2.57 (-5.09)*	-2.68 (-5.25)*	-2.79 (-5.18)*	-2.73 (-4.95)*	-2.73 (-5.0)*	-2.95 (-5.16)*	-2.69 (-4.7)*
T2	-1.04 (-2.03)**	-1.26 (-2.39)**	-1.29 (-2.12)**	-1.17 (-1.86)***	-1.15 (-1.79)***	-1.0 (-1.67)***	-0.84 (-1.43)
Constant	0.28 (0.07)	3.72 (0.88)	0.23 (0.04)	-0.24 (-0.04)	4.04 (0.69)	0.97 (0.19)	1.67 (0.36)
Wald-Test	55.36*	61.84*	85.47*	85.27*	88.44*	106.87*	137.61
Breusch-Pagan	16.41*	10.1*	3.57***	3.39***	3.44***	1.0	0.11
Hausman	0.26	3.33	3.78	3.75	4.57	6.25	7.66
Overall R^2	0.26	0.31	0.40	0.52	0.42	0.46	0.51

Note: All models are estimated using Huber/White/Sandwich robust standard errors. Values in parentheses are t-values. *, **, *** indicates significance at the 1, 5 and 10 percent level respectively.

Table 4.8: Regression Results Using *open1* and Omitting Outliers

Avgrow	*1*	2	*3*	*4*	*5*	*6*	7
InitGDP	-1.05 (-2.15)**	-1.47 (-2.91)*	-0.92 (-1.62)	-0.79 (-1.25)	-1.12 (-1.87)***	-1.04 (-1.91)***	-0.4 (-0.78)
Inv	2.0 (3.7)*	1.97 (3.77)*	1.82 (3.72)*	1.98 (3.77)*	1.91 (3.86)*	1.52 (3.1)*	1.09 (2.39)**
Popgrow		-0.85 (-2.22)**	-0.91 (-2.4)**	-0.92 (-2.34)**	-0.94 (-2.47)**	-1.03 (-2.8)*	-0.81 (-2.35)**
SyrF			-3.72 (-2.98)*	-3.97 (-2.3)**	-4.08 (-3.17)*	-3.78 (-3.14)*	-1.82 (-1.53)
SyrM			3.38 (3.67)*	3.81 (3.23)*	3.54 (3.76)*	3.26 (3.68)*	1.27 (1.36)
PyrF				0.24 (0.31)			
PyrM				-0.54 (-0.78)			
Polrit					0.13 (0.53)		
Civlib					-0.40 (-1.31)		
Gov't						-9.22 (-2.26)**	-12.36 (-3.12)*
Inflation						-2.64 (-0.75)	-1.24 (-0.35)
open1	6.88 (2.13)**	7.14 (2.27)**	5.56 (1.77)***	6.27 (1.94)***	5.64 (1.78)***	7.31 (2.31)**	7.1 (2.36)**
DEAS							-0.07 (-0.08)
DLAT							-2.91 (-3.69)*
DSSA							-1.72 (-2.29)**
T1	-2.46 (-4.98)*	-2.54 (-5.11)*	-2.68 (-5.04)*	-2.61 (-4.85)*	-2.58 (-4.76)*	-2.83 (-4.58)*	-2.61 (-4.22)*
T2	-0.92 (-1.8)***	-1.12 (-2.17)**	-1.23 (-2.05)**	-1.11 (-1.82)***	-1.04 (-1.64)***	-1.15 (-1.92)***	-1.09 (-1.86)***
Constant	-2.15 (-0.5)	2.87 (0.61)	0.21 (0.04)	-1.05 (0.86)	2.63 (0.54)	2.22 (0.43)	1.05 (0.22)
Wald-Test	53.56*	59.28*	77.52*	77.9*	79.7*	87.28*	119.1*
Breusch-Pagan	14.27*	10.44*	3.64***	3.46***	3.49***	1.46	0.09
Hausman	2.22	2.72	3.87	4.14	0.84	6.17	8.27
Overall R^2	0.25	0.29	0.37	0.38	0.38	0.41	0.47

Note: All models are estimated using Huber/White/Sandwich robust standard errors. Values in parentheses are t-values. *, **, *** indicates significance at the 1, 5 and 10 percent level respectively.

Table 4.9: Regression Results Using *open2* and Omitting Outliers

Avgrow	*1*	*2*	*3*	*4*	*5*	*6*	*7*
InitGDP	-1.09 (-2.22)**	-1.46 (-2.87)*	-0.86 (-1.51)	-0.62 (-0.98)	-1.04 (-1.71)***	-0.97 (-1.8)***	-0.36 (-0.72)
Inv	2.16 (4.02)*	2.13 (4.1)*	1.95 (3.98)*	2.22 (4.15)*	2.03 (4.09)*	1.65 (3.45)*	1.17 (2.64)*
Popgrow		-0.78 (-2.01)**	-0.86 (-2.31)**	-0.9 (-2.31)**	-0.89 (-2.36)**	-0.97 (-2.72)*	-0.73 (-2.22)**
SyrF			-4.06 (-3.17)*	-4.34 (-2.5)**	-4.34 (-3.32)*	-4.25 (-3.48)*	-2.29 (-1.93)***
SyrM			3.58 (3.94)*	4.11 (3.51)*	3.74 (4.02)*	3.51 (4.09)*	1.49 (1.66)***
PyrF				0.21 (0.27)			
PyrM				-0.67 (-0.96)			
Polrit					0.13 (0.53)		
Civlib					-0.37 (-1.21)		
Gov't						-10.31 (-2.52)**	-13.33 (-3.45)*
Inflation						-2.44 (-0.69)	-0.76 (-0.22)
open2	5.64 (2.07)**	5.35 (2.01)**	5.11 (1.95)***	6.4 (2.3)**	4.89 (1.84)***	7.04 (2.66)*	6.91 (2.9)*
DEAS							-0.1 (-0.11)
DLAT							-2.92 (-3.84)*
DSSA							-1.97 (2.73)*
T1	-2.45 (-4.96)*	-2.53 (-5.09)*	-2.65 (-4.96)*	-2.52 (-4.65)*	-2.56 (-4.71)*	-2.74 (-4.43)*	-2.49 (-4.02)*
T2	-0.89 (-1.75)***	-1.09 (-2.1)**	-1.15 (-1.9)***	-0.95 (-1.53)	-0.99 (-1.55)	-1.03 (-1.71)***	-0.96 (-1.64)***
Constant	-1.02 (-0.25)	4.0 (0.86)	-0.26 (-0.05)	-2.79 (-0.48)	2.15 (0.36)	1.68 (0.33)	0.78 (0.17)
Wald-Test	53.23*	57.77*	78.52*	80.31*	79.99*	90.55*	127.51*
Breusch-Pagan	14.37*	10.81*	3.6***	3.36***	3.46***	1.13	0.28
Hausman	2.24	3.04	4.44	4.0	5.25	7.06	9.37
Overall R^2	0.24	0.28	0.38	0.39	0.38	0.42	0.48

Note: All models are estimated using Huber/White/Sandwich robust standard errors. Values in parentheses are t-values. *, **, *** indicates significance at the 1, 5 and 10 percent level respectively.

Chapter Five

International Knowledge Spillovers and Economic Growth

Chapter Five

INTERNATIONAL KNOWLEDGE SPILLOVERS AND ECONOMIC GROWTH

5.1 Introduction

In the previous chapter we examined the impact of North-South trade in manufactured goods on growth in a sample of developing countries. We found that countries that were more open to imports from the North experienced higher rates of growth. In this chapter we focus on the impact of flows of ideas on growth for our sample of countries. Following recent developments in growth theory interest has emerged in to the existence of international knowledge spillovers and in to the role of trade in the transfer of such knowledge. New growth theory demonstrates that spillovers are important to growth, with goods trade being one mechanism through which such knowledge may be transferred across countries. A growing number of empirical papers look to test for such a relationship.

The notion that countries may be able to gain access to the knowledge or technology of other countries is not new. Gerschenkron (1962) and Kuznets (1973) discussed the so-called 'advantage of backwardness', whereby countries situated away from the world technological frontier can benefit by learning from the technological leaders. Abramovitz (1986) argued that to gain such 'advantages of backwardness' certain preconditions must be in place that allow countries to absorb the inflow of foreign ideas and knowledge. These he termed 'social capability' and include such things as a skilled workforce, high levels of investment and appropriate macroeconomic policies.

New growth theory highlights the role of knowledge accumulation as a long-run source of economic growth. For example, externalities are associated with human capital accumulation through either education or learning by doing and technological advance through explicit R&D activities. Trade in goods is one transfer mechanism for such externalities. For example, it may allow firms to employ a wider variety of intermediate and capital goods in production, thereby increasing productivity, or allow firms to imitate the technology of foreign firms, or provide knowledge about a particular product upon which subsequent innovations may build.

There is a growing empirical literature examining the effects of access to foreign knowledge on a country's growth rate. One method that has proved popular since the influential paper of Coe and Helpman (1995) is to create a national knowledge stock using cumulative R&D spending. This is then weighted by some measure of the extent of trade between countries to create a variable showing "access" to another country's knowledge stock. The results of these studies tend to be mixed in terms of finding evidence of significant growth promoting knowledge spillovers between countries.

In this chapter we test for the presence of North-South knowledge spillovers to our sample of 52 developing countries in a model of economic growth. By defining alternative specifications for the variable representing foreign knowledge spillovers we test the robustness of the results obtained and identify different channels through which spillovers may occur. We test for the presence of growth promoting foreign knowledge spillovers using a method similar to that employed by Coe and Helpman. We use data on the manufacturing R&D expenditure of five OECD[1] economies, testing for the presence of trade related knowledge spillovers from these five 'donor' countries to our sample of 52 'recipient' countries.

The remainder of this chapter is organised as follows. In section 5.2 we discuss the theoretical background concerning knowledge spillovers and the role of trade as a mechanism for the transmission of knowledge. Section 5.3 reviews the existing empirical literature. We discuss the method employed for testing for the presence of knowledge spillovers and describe the data used in section 5.4, while section 5.5 describes the results. In section 5.6 we examine the role of education in facilitating knowledge spillovers, while section 5.7 provides some overall conclusions.

5.2 Theoretical Background

It has long been recognised that technology transfer is an important source of growth, and that the progress of both developed and developing nations may be determined in part by its extent. Yet until the arrival of new growth theory little systematic empirical analysis of this issue had been undertaken.

[1] The five countries being the United States of America (US), the United Kingdom (UK), Japan, Germany and France. Eaton and Kortum (1999) note that in the late 1980s, 80 percent of OECD

During the 1960s and 1970s a number of authors, in particular Gerschenkron (1962) and Kuznets (1973) talked of the so-called 'advantage of backwardness'. They argued that being a technological laggard had certain advantages in that it would be possible to 'borrow' new technology from the leading edge countries. Gerschenkron states that "Industrialisation always seemed the more promising the greater the backlog of technological innovations which the backward country could take over from the more advanced country" (1962, p. 8). Abramovitz (1986) argues that the advantages of such technology transfer in terms of improvements in productivity and growth may not be automatic. The ability of a country to adopt such technology may be important in order to benefit in terms of higher growth and productivity; this ability is likely to depend on a large number of factors and is termed 'social capability'[2].

During this period the process of international technology transfer was modelled largely in terms of the product life cycle[3]. This cycle begins with production in the industrialised countries and continues there until production techniques become standardised. In a second stage, the innovating firms move the location of production to developing countries where wages are lower. Finally, new and superior products may be developed that take market share and render the original product obsolete. The mechanism through which knowledge is transferred in this model is assumed to be FDI. Others however have modelled imitation as being the source of technology transfer, examples include, Krugman

research scientists and engineers were employed in these five countries.

[2] An equivalent term 'absorptive capacity' is also often used.

(1979), Grossman and Helpman (1991a, ch. 12; 1991b), Segerstrom (1991) and Barro and Sala-i-Martin (1995, ch. 8). In these types of models it is natural to link the ease of imitation to openness, since we may expect that more open economies have a greater ability to copy new product lines.

The role of international technology transfer received little attention in models of growth until recently. In the neoclassical growth model, there is no role for endogenous spillovers of knowledge, either domestically or internationally. Technological progress is assumed exogenous with the result that long-run growth is driven entirely by exogenous factors[4]. However, despite this it was still acknowledged that technological progress accounted for a significant portion of economic growth. Solow (1957) for example, found that 87.5 percent of the growth rate of output was not accounted for by the growth rates of measured inputs, and as such a substantial amount was assigned to technological progress. This figure has been reduced by adjusting for changes in the quality of labour and various measurement errors, but the figure still remains about one third of growth accounted for by technological progress[5].

In the new growth models a number of sources of long-run growth have been considered, these include human capital accumulation and technological advance through explicit R&D activities. To sustain long-run growth in these models some form of externality is required to offset the assumption of diminishing returns to capital. In the case of the accumulation of technology

[3] The product life cycle was described by Vernon (1966).

through R&D, an externality arises due to the public good characteristics of technology.

Recent theories of endogenous technological change (for example, Romer (1986), Aghion and Howitt (1992) and Grossman and Helpman (1991a)) provide a rationale for examining international knowledge spillovers. We saw in Chapter Two that in a simple variant of these models, final output is produced using a number of intermediate inputs, which may be horizontally differentiated, in which case output is proportional to the aggregate employment of intermediates, with the factor of proportionality being an increasing function of the number of available varieties. R&D affects output by increasing the number of available varieties. In an alternative scenario intermediates are vertically differentiated. In this case the productivity of an intermediate depends upon its quality, with R&D being undertaken to improve the quality of the fixed number of varieties.

In the absence of trade in intermediates, a countries output in both of these models is determined by the cumulative past R&D expenditure of that country, which determines either the number of available intermediates or the average quality of the intermediates. When we introduce trade however, countries can use intermediates produced by their trade partners. If all intermediates are traded then a relationship between cumulative R&D and output remains, but now the relevant measure of cumulative R&D is not the domestic R&D stock but the

[4] The neoclassical model implicitly assumes that technology transfer is costless, since a common production function across countries is specified.

world R&D stock. These theories then provide the basis for testing the hypothesis that those countries that import from countries with a high level of technological knowledge should have higher rates of output growth than countries that are either closed to international trade, or that trade with countries that do not have high levels of technological knowledge.

When examining the impact of trade on growth in these models, a comparison between autarky and free trade is usually made; few papers examine how trade policy and changes in openness affect growth. The implication of these theories is that a movement from autarky to openness will result in positive knowledge spillovers, with the actual volume of trade being unimportant[6]. Imports of any quantity of a new intermediate, no matter how small, will result in positive spillovers (see Keller, 2000). Yet, there are a number of reasons to believe that the level of trade may be important in facilitating foreign knowledge spillovers. The level of trade for example may assist in the internal diffusion of knowledge. Alternatively, for developing countries, it is likely that final goods producers will be the main beneficiaries of knowledge spillovers, rather than the innovation sector, which is often missing in developing countries. Trade will allow the importation of advanced intermediate and capital goods, which are either not available or too costly domestically, and which can enhance productivity. In this situation the level of imports may be important by allowing a greater number of firms to benefit from imported technology. The importance

[5] See for example Denison (1962) and Jorgenson and Griliches (1967).

[6] In the models of innovation and growth discussed in Chapter Two for example, growth depends upon the number of intermediates employed, not on the amount of each intermediate employed. Openness by allowing the importation of a greater variety of intermediates in to a country would

of openness as opposed to the level of trade in facilitating knowledge spillovers is one of the hypotheses tested in this chapter.

5.3 Evidence on International Knowledge Spillovers

An empirical literature has been in existence for a number of years examining knowledge spillovers within countries. Griliches (1984) for example, examines whether investment in R&D in one industry affects TFP in other industries. Recently however in response to the new theories of trade and growth, a literature looking to test for international knowledge spillovers has emerged. Many studies follow Coe and Helpman (1995) and use cumulative past R&D expenditures to create a proxy for the stock of knowledge of a country. To examine the role of trade in facilitating spillovers between countries this knowledge stock is weighted by some measure of the extent of trade between countries, to give a measure of the access a country has to the knowledge stock of another country[7].

Coe and Helpman (1995) test for the presence of international knowledge spillovers among a sample of 22 developed countries over the period 1971-1990. They study the extent to which a change in a country's productivity depends upon both domestic and foreign knowledge stocks, where cumulative R&D expenditures are used as a proxy for the knowledge stock of a country. The foreign knowledge stock is constructed using the weighted sum of trade

be expected to raise a country's growth rate, while the level of trade, which indicates the volume of intermediates imported would not affect growth in these models.

partner's cumulative R&D spending. The weights used are bilateral import shares, since it is assumed that it is a country's imports that act as the conduit for knowledge spillovers. The import share weighted foreign knowledge stock is also interacted with the level of imports to examine the importance of the level of trade as opposed to its distribution. They find both the domestic and foreign knowledge stocks to be important sources of productivity growth, although the former has a much larger impact on productivity in the larger countries. Smaller countries, it is argued, tend to be more open and benefit more from foreign knowledge than larger countries. Coe and Helpman find that the elasticity of productivity with respect to a foreign country's knowledge is largest with respect to the knowledge stocks of the major countries, because knowledge stocks of the major countries are relatively large and these countries account for a high share of other countries imports. The estimated spillover elasticities are largest for the US and Japan, with a 1 percent increase in the R&D capital stock of the US increasing trade partner's productivity by an average of 0.04 percent. From these results Coe and Helpman conclude that a relationship between productivity and both the foreign and domestic knowledge stocks exists, with the countries gaining most from foreign knowledge being those that are most open to trade.

Coe, Helpman and Hoffmaister (1997) (CHH) adapt the analysis of Coe and Helpman to examine the extent of North-South R&D spillovers. They test for the presence of knowledge spillovers through international trade from the 22

[7] Furthermore, in a multi-country setting the question of which countries confer the greatest spillover benefits arises, as a result import weights are often used when constructing the

developed countries in the Coe and Helpman study to a sample of 77 developing countries over the period 1971-1990. The method used is similar to that by Coe and Helpman, except that they use data averaged over four five-year periods rather than yearly data. They also include a measure of human capital, and in one specification interact this with the knowledge spillover variable, which is found not to be significant. It is assumed by CHH that no R&D is undertaken in the developing countries, so that no domestic knowledge stock is created. The foreign knowledge stocks for the developing countries are created using a weighted average of the knowledge stocks of the industrial countries. The weights being bilateral import shares of machinery and equipment, used as a measure of the imports of capital and intermediate goods. As with the Coe and Helpman study, this import share weighted foreign knowledge stock is also interacted with the level of imports. They find that knowledge spillovers from the industrial North to the developing South are substantial. On average, a 1 percent increase in the knowledge stocks of the industrial countries raises output in the developing countries by 0.06 percent, with spillovers from the US again found to be the largest.

The Coe and Helpman results have been controversial. Keller (1998) re-examines them; in particular the assertion that a country's benefit from knowledge created abroad is taken to be a trade weighted average of foreign countries knowledge stocks. He compares the estimated results of Coe and Helpman with those obtained from assigning bilateral trade partners randomly and finds that regressions based on simulated data generate on average larger

variables measuring foreign knowledge spillovers.

estimated foreign knowledge spillovers, as well as a better fit in terms of R^2. These results then suggest that a country's trade and trade partners may not be related to the extent of foreign knowledge spillovers, or alternatively that there are no spillovers.

Coe and Hoffmaister (1999) re-examine the work of Keller (1998) noting that the bilateral import shares he constructs are similar to equal weights, or simple averages of trading partners knowledge stocks, suggesting that Keller's weights are not in fact random. Coe and Hoffmaister derive three alternative sets of random weights that do not exhibit this property. When these are used to define the foreign knowledge stock, the estimated foreign knowledge spillover estimates are extremely small and the equations explain less of the variation in productivity than when the true bilateral import shares are used. From these results they conclude that randomly created trade patterns do not give rise to positive foreign knowledge spillovers. They argue that using bilateral import weights or even simple averages to create a measure of foreign knowledge performs better than using random weights, suggesting that a country's productivity is related to its trading partners' knowledge stock. It is conceded however, that the actual intensity of the trading relationship may not be important because of the public good nature of knowledge, suggesting that openness to trade is important but that the level of such trade need not be. Alternatively, it may be that the relationship between openness and knowledge spillovers is not linear.

Maurer (1998) re-estimates the Coe and Helpman model using the original data and finds evidence of strong positive autocorrelation, implying that the standard errors are calculated incorrectly. Maurer then estimates an error correction model that eliminates autocorrelation with an appropriate lag structure and finds contrary to Coe and Helpman that foreign knowledge has no significant impact on domestic productivity growth. Instead of using data on total imports, Maurer uses various different import shares that he argues are measures of imports of capital goods. In total Maurer uses six different import shares, and finds that only when data on electrical and non-electrical machinery, transport equipment, and industrial chemicals are used does he obtain a significant coefficient. He concludes that it is these activities that play the dominant role in the transmission of foreign knowledge, suggesting that only certain goods facilitate the transmission of knowledge.

Coe and Helpman in their original analysis find that all of their data exhibited a clear trend, but that a co-integrating relationship existed between the variables, which allowed them to consider a relationship between the levels of the variables without having to transform the data. They chose not to report *t*-statistics for their results, because at the time the asymptotic distribution of the *t*-statistic was unknown. Kao *et al* (1999) argue that since the estimated coefficients are quite small it is not clear whether the estimated coefficients are different from zero. Moreover, given the potential bias in the estimation technique, it is not even clear whether the coefficients have the expected sign. Given recent advances in the understanding of the distribution of the estimators in panel models, Kao *et al* examine whether there are indeed significant positive foreign knowledge spillovers. They use a dynamic ordinary least squares estimator, which is found to be superior to OLS, and find that the coefficient on the foreign knowledge spillover variable is positive, but insignificant even at the 10 percent level. The impact of domestic knowledge on TFP remains positive and significant however.

Engelbrecht (1997) extends Coe and Helpman (1995) in an attempt to test the robustness of their results. He includes a general human capital variable to account for innovation outside the R&D sector and other aspects of human capital not captured by formal R&D. Also included is a catch-up variable to take account of other sources of productivity catch-up. The model was estimated for 21 developed countries over the period 1971-1985. The addition of the human capital variable was found to reduce the coefficient estimate for international R&D spillovers by about 30 percent, but had little impact on other coefficient estimates. The inclusion of the catch-up term was found to have no effect on the estimated coefficients for international R&D spillovers. The inclusion of the interaction between the catch-up and human capital terms however did result in a positive and significant coefficient, which led Engelbrecht to conclude that there is a role for human capital alongside R&D in Coe and Helpman's study; human capital has a role in both domestic innovation and in the absorption of international spillovers.

All of the above studies look at the impact of foreign knowledge spillovers on TFP. Some however examine the impact of spillovers on GDP growth, one example being Evenson and Singh (1997). They examine the contribution that international knowledge spillovers make to growth for a sample of 11 Asian countries over the period 1970-1993. They regress the growth rate of GDP on the growth of the labour force, investment, and the domestic and foreign knowledge stock. The foreign knowledge stock is the import share weighted average of the domestic knowledge stocks of each countries trade partners. It is included in the regression on its own, but also interacted with both import shares and the secondary school enrolment ratio. After correcting for serial correlation, they find that the foreign knowledge variable is positive and significant, suggesting that knowledge spillovers to Asian countries are indeed important for growth. The foreign knowledge variable interacted with import shares is also positive and significant, while the coefficient on the foreign knowledge stock interacted with education is found not to be significant and has a variable sign. They are also able to show that knowledge spillovers are greater in magnitude for the high performing economies when compared with the medium performing economies.

Overall then the evidence in favour of international knowledge spillovers using this method is mixed. Some studies find a positive effect of foreign knowledge on productivity and growth, both among developed countries and also from developed to developing countries. These results tend to be controversial however, with other studies finding no such relationship. From existing results it is not clear whether the volume of trade plays an important role in the transmission of knowledge. It was noted in section 5.2 that in theoretical models a movement from autarky to openness should raise growth, but that the level of trade should be unimportant. Yet Coe and Helpman in their conclusions state that "Foreign R&D may have a stronger effect on domestic productivity the more open an economy is to international trade." (p. 875). This raises questions about what the constructed variables are actually measuring. The results of Keller (1998) and Coe and Hoffmaister suggest that the level of trade may be unimportant, since significant foreign knowledge spillovers were found using averages, rather than the true trade volumes. If the volume of trade is important however, it is not clear that goods trade in general facilitates foreign knowledge spillovers. The results of Maurer suggest that only trade in certain products, capital goods in particular, result in significant foreign knowledge spillovers.

Factors other than trade are also likely to be important for the diffusion of knowledge between countries. A number of these channels are discussed in the 1999 World Development Report. Along with trade the report highlights the role of FDI, technology licensing and the international movement of people as important channels. The report also notes that factors such as strategic alliances, technical assistance and electronic interchange are possible channels through which knowledge flows across countries.

A further complication with this approach involves the construction of the foreign knowledge variables. If it is the case that knowledge flows across borders then constructing the donor country's knowledge stock using data on its past domestic R&D expenditure alone may exclude relevant information. If knowledge does flow across borders through trade, then the knowledge available to countries trading with this donor may not only depend upon the donor's domestic knowledge stock, but also on that which the donor has received from other countries through it importing knowledge itself. So for example, the knowledge available to countries trading with Japan will depend on Japan's cumulative R&D, but also on the knowledge that Japan has gained from the R&D expenditure of Germany, France and other countries, which may in turn depend on Japan's trade with these countries[8].

5.4 Estimating the Impact of Knowledge Spillovers

In this chapter we test for the growth enhancing effects of foreign knowledge. In particular, we examine the impact of the knowledge stocks of 5 OECD economies on growth in our sample of 52 developing countries[9]. We adopt the Coe and Helpman method to create foreign knowledge stocks and then test for the presence of growth enhancing foreign knowledge spillovers in a model of economic growth similar to that used in the previous chapter. We use a number of different specifications for the foreign knowledge spillover variable in order to test the robustness of our results and to test alternative hypotheses concerning the channels through which knowledge spillovers occur. We control for the scale of the donor and examine how different trade weightings alter the results.

The majority of existing empirical studies examine the impact of knowledge spillovers on TFP rather than output growth. TFP is that part of economic growth unaccounted for after the contributions of labour and capital have been taken account of, and is often assumed to measure the level of technological

[8] This would be the case unless only 'indigenous' knowledge spills over in this way. For example, trade with Japan provides access to unique Japanese knowledge only.
[9] This is the same sample of developing countries used in the previous chapter, and throughout the thesis.

progress in an economy. The formula for TFP can be obtained from a Cobb-Douglas production function of the form

$$Y = AK^{\omega_1}L^{\omega_2}. \tag{5.1}$$

Expressing this formula in logs and differentiating with respect to time gives,

$$\dot{A} = \dot{Y} - \omega_1\dot{K} - \omega_2\dot{L}, \tag{5.2}$$

where A is TFP, Y is output, K and L are capital and labour respectively, ω_1 and ω_2 are weights, and a dot over a variable indicates its growth rate. The share of output or income accruing to capital and labour usually act as the weights for ω_1 and ω_2 respectively. One implication of this method is that the residual (i.e. $\dot{A}$) is often quite large, which suggests that actual output growth is not well explained by input growth. It has been suggested that additional factors should be included to account for more of the actual output growth[10], examples suggested include economies of scale, R&D expenditure, technical progress based on innovation and the reallocation of labour between sectors. Acknowledging the possibility of economies of scale also suggests the possibility of interactions between the rate of growth of the primary factors and TFP, which could introduce measurement error.

Rather than using TFP growth we adopt a method similar to that employed by Evenson and Singh (1997), examining the impact of foreign knowledge spillovers on output growth. The choice between the two should not be too important since an empirical relationship between productivity growth and GDP growth has been found by amongst others, Chenery et al, (1986). Moreover, we include a number of independent variables in our model to account for input growth. A number of issues arise however when modelling GDP growth in empirical studies, many of which were discussed in the previous two chapters, (e.g. time interval over which growth should be modelled, choice of explanatory variables and the robustness of results). Moreover, some of the variables included in the growth regression may themselves be important conduits for diffusion. For example, we may expect that the level of human capital would help facilitate knowledge spillovers, since a more educated population is likely to be better able to take advantage of the knowledge available. If this is the case, the coefficients on variables included in a growth model to represent diffusion may be underestimated[11].

5.4-1: Empirical Estimation

We estimate a growth model for our sample of 52 countries, using data on three five-year periods, namely 1976-1980, 1981-1984, 1985-1989. Following CHH we assume that negligible R&D is undertaken in our sample of countries, so that no domestic R&D stock is included. This is assumed due to a lack of reliable data on R&D for many of the countries in our sample, but would appear to be a reasonable assumption. The specification for our growth model is analogous to equation (4.4) and takes the following form:

$$Avgrow_{mt} = \alpha + \beta_j I_{jmt} + \gamma KS_{mt} + \varepsilon_{mt}, \qquad m=1,...,52 \qquad (5.3)$$

[10] See the entry by John Cornwall on Total Factor Productivity, in volume 4 of the New Palgrave Dictionary (1987) edited by Eatwell *et al.*

[11] Moreno and Trehan (1997) however, use measures representing diffusion based on geographical variables and find that including measures of investment, schooling, population growth and initial income in their model alters their estimates on the diffusion variables very little.

where $Avgrow_{mt}$ is the average growth in real per capita GDP of country m in time period t, α is a constant, I_{jmt} is a matrix of j additional explanatory variables, KS_{mt} is our measure of the (trade-weighted) foreign knowledge stock for country m, and ε_{mt} is a normally distributed error term with constant variance. Two time dummy variables for the second and third periods are included.

Once again we have to make a choice as to which additional explanatory variables should be included in our model. The way we proceed is to use as a basis for this choice the results of Chapter Four and include alongside the foreign knowledge spillover variable those that were found to be significant in the previous chapter[12]. As an additional exercise, we also examine whether there exists a non-linear relationship between foreign knowledge spillovers and growth by including the squared value of the foreign knowledge spillover variable. The equation that we estimate in this case is therefore of the form,

$$Avgrow_{mt} = \alpha + \beta_j I_{jmt} + \gamma KS_{mt} + \varphi KSSQ_{mt} + \varepsilon_{mt}, \qquad (5.4)$$

where $KSSQ_{mt}$ is the squared value of the knowledge spillover variable. This specification will allow us to examine whether a country benefits more from knowledge spillovers, the more open a country is, or the more a country trades with the five donors, depending upon the specification of the knowledge spillover variable used.

[12] We don't report the results from including measures of primary schooling, political rights and civil liberties that were included in Chapter Four. These were found not to be significant in Chapter Four, and they were not significant when included in this model either. Moreover, their inclusion wasn't found to alter the results on other variables included in the model significantly.

The growth equations were estimated using panel data techniques, and a choice between a fixed effects and a random effects specification needs to be made. The choice is not a trivial one and can make a great deal of difference in terms of parameter estimates when the number of countries is large and the number of time periods small[13]. When estimating the impact of foreign knowledge spillovers however, a further consideration arises when choosing between the two. Verspagen (1997) finds that the results on foreign knowledge spillovers are more significant in a panel than in a cross-section. He argues that one of the reasons for this is that panel studies often include country dummies (i.e. fixed effects models) that are likely to pick up differences in time-invariant factors, such as for instance absorptive capacity (i.e. social capability), which can then affect the extent of foreign knowledge spillovers. As Aghion, Garcia-Penalosa and Howitt (2000) argue, "to take advantage of technical progress generated elsewhere, a country must invest in education and in local public goods such as infrastructure" (p. 18). Clearly factors other than education and infrastructure are likely to affect the diffusion of knowledge within a country and country dummies may well capture these factors. The way we proceed therefore is to estimate our model both with and without country dummies[14]. If there are important country specific effects that affect the ability of countries to take advantage of foreign knowledge, we should find larger and more significant

[13] See the econometrics appendix for a discussion of the choice between fixed and random effects models.

[14] Also estimated are models where we exclude the time dummy variables. The exclusion of these variables is not found to affect the results a great deal and the results are therefore not reported.

coefficients on the variable representing foreign knowledge spillovers when such country effects are included[15].

5.4-2: Constructing Foreign Knowledge Stocks

Knowledge stocks for the five OECD countries were constructed using data on their cumulative past (total manufacturing) R&D expenditure and using a method proposed by Griliches (1979) and used by Coe and Helpman. Data for R&D expenditure was taken from the ANBERD dataset, produced by the OECD. This data was in International Standard Industrial Classification (ISIC) revision 2. The data on R&D expenditure was in current PPP dollars, and was deflated using a GDP deflator for each donor. The initial period stock of knowledge was calculated using the following formula,

$$S_0 = \frac{R_0}{(g+\delta)}, \tag{5.5}$$

where S_0 is the initial period stock of knowledge, R_0 is the deflated R&D expenditure in the first period for which data is available, namely 1973, δ is the depreciation rate[16] set at 5 percent following Coe and Helpman[17], and g is the annual log growth rate of R&D expenditures. Given this initial value, the stock of knowledge for the remaining years is calculated as,

$$S_t = (1-\delta)S_{t-1} + R_{t-1}. \tag{5.6}$$

[15] The Hausman and Breusch-Pagan tests tend to give contrasting results. The Hausman test suggests the use of a random effects model, while the Breusch-Pagan test supports the use of a fixed effects model.

[16] A depreciation rate is included since it is assumed that newly developed knowledge makes some old knowledge obsolete.

[17] We also tried using a depreciation rate of 10 percent, this was not found to affect the results a great deal.

Using this method a stock of knowledge was created for each year for all of the donor countries.

To create a variable measuring the access each recipient has to the knowledge stocks of the five donors, the constructed knowledge stocks are weighted by various measures of the extent of trade or openness between each donor and recipient. Five different specifications for these trade weighted knowledge stocks are defined, in order to test the robustness of the results to the spillover variables and to test a number of different hypotheses. The first specification used is that employed by Coe and Helpman. Here the trade weighted knowledge stock of a recipient is the import share weighted knowledge stock of the donors, written as

$$KS1_{mt} = \sum_{x=1}^{5} R_{xt} S_{xt}, \qquad (5.7)$$

where S_{xt} is the knowledge stock of donor country x at time t, and $R_{xt} = \dfrac{T_{xmt}}{\sum_{d=1}^{5} T_{dmt}}$

is the share of donor country x's imports in total imports from the five donors to recipient country m. This equation states that the greater the share of imports from a donor, and the greater the knowledge stock of the donor, then the greater would be foreign knowledge spillovers. This measure is only concerned with the distribution of trade with these five OECD economies. For example, two countries, one who trades only with these countries and one that has hardly any trade with these countries will have the same value of *KS1* if the distribution of trade is the same, the level of trade is unimportant. Coe and Helpman argue that this specification may not adequately capture the role of international trade, since the weights on the knowledge stocks are "fractions that add up to one and therefore do not properly reflect the *level* of imports" (p. 863).

The second specification is one that takes account of the level of trade, this can be written as

$$KS2_{mt} = \sum_x T_{xmt} S_{xt}. \tag{5.8}$$

Here two considerations, the level of trade and the level of the donor's knowledge stocks determine the extent of spillovers. A recipient that trades more with a donor relative to another recipient will gain more in terms of spillovers. Furthermore, a recipient that trades with a donor that has a relatively high knowledge stock will gain more than if it traded with one with a lower stock of knowledge. Comparing the results from the above two specifications allows us to examine whether the level of trade, rather than its distribution is important in facilitating foreign knowledge spillovers. Support for the notion of knowledge spillovers being related to the level of trade would suggest that such spillovers are not pure public goods, but depend on the extent of interaction between the producer and user of the knowledge.

The third specification used is one proposed by Lichtenberg and van Pottelsberghe de la Potterie (1998). They argue that specifications such as those described above are subject to a problem of aggregation, since a merger between donor countries would always increase the stock of knowledge, yet it is not clear why such a merger would be expected to increase the level of knowledge in the world. They propose an alternative specification that removes the importance of the scale of the donor economy from the trade weighted knowledge stock, written as

$$KS3_{mt} = \sum_x \left(\frac{T_{xmt}}{Q_{xt}} \right) S_{xt} = \sum_x T_{xmt} \left(\frac{S_{xt}}{Q_{xt}} \right), \quad (5.9)$$

where Q_{xt} is donor country x's total manufacturing production. Such a formulation reflects the intensity of R&D as well as the direction of international knowledge spillovers. This specification states that the spillover of knowledge from the donor to the recipient is equal to the R&D stock of the donor multiplied by the fraction of the donor's output that is exported to the recipient. Alternatively, it can be interpreted in a similar manner to *KS2*, where the extent of foreign knowledge spillovers depends upon the level of trade, but now the knowledge intensity of production instead of the knowledge stock. Comparing the coefficients on *KS2* and *KS3* allows us to infer whether it is the stock or intensity of knowledge of the donor that is important for knowledge spillovers.

In addition to these three specifications, we are also able to use the results from the previous chapter to create two alternative specifications, which use the two measures of openness developed there and can be written as,

$$KS4_{mt} = \sum_x open1_{xmt} \frac{S_{xt}}{Q_{xt}}, \quad (5.10)$$

and

$$KS5_{mt} = \sum_x open2_{xmt} \frac{S_{xt}}{Q_{xt}}. \quad (5.11)$$

Here the intensity of knowledge (S_{xt}/Q_{xt}) of each donor is weighted by our measures of openness to the imports of each donor[18]. These specifications state that recipients that are more open to the imports of a particular donor will gain more from foreign knowledge. Similarly, countries that are more open to the imports of the donors with relatively large knowledge intensities will gain more than countries that are more open to donors with relatively low knowledge intensities.

5.5: Results

Data was collected on all variables for three different time periods, 1976-80, 1981-85 and 1986-90 giving a total of 156 observations. All of the data are in the form described in the data appendix at the end of the thesis, with logs being taken of the weighted foreign knowledge stocks. The results from the estimated growth regressions are summarised in Tables 5.1 to 5.5. Each table corresponds to one of the five specifications for foreign knowledge spillovers constructed.

We begin by considering the results when country effects are excluded from the model. Turning first of all to the coefficients on the core variables in our model, there appears to be many similarities with results reported in the previous chapter. The coefficient on initial GDP is negative as expected and is significant in about half of the cases. Investment is found to be positive and significant, a result that is robust across specifications. Population growth is negative and significant as expected, and again this is the case across all specifications. The

[18] Similar results are found when the stock of knowledge rather than the intensity of knowledge is used. For brevity we only report the results using the intensity of knowledge.

negative and positive relationship for female and male schooling respectively is again found, with the coefficients tending to be significant. The coefficient on government spending tends to be significant, with a negative coefficient as expected. The coefficient on the inflation rate is also negative, although only significant when the model includes *KS1*. Finally, the coefficients on the regional dummies have the expected sign, and are significant in a number of cases for Latin America and Sub-Saharan Africa, but not for East Asia.

The results concerning the foreign knowledge variables are mixed. In Table 5.1, where *KS1* is our measure of foreign knowledge, we find that its coefficient is negative, although in general not significant. This may not be too surprising, since CHH find negative coefficients on this variable in a number of their specifications, and in their preferred specification drop this variable, preferring to concentrate on the case where the level of trade also affects the extent of foreign knowledge spillovers. These results therefore suggest that the distribution or composition of trade is not the relevant measure to be using to measure foreign knowledge spillovers. In the cases where the level of trade as opposed to its distribution affects the extent of foreign knowledge spillovers (i.e. Tables 5.2 and 5.3) we find some evidence in favour of positive and significant foreign knowledge spillovers. The significant coefficients disappear when regional dummies are included[19], suggesting the possibility of a regional

[19] In many cases, finding out which variables make others insignificant is informative, for example, by providing information as to which factors facilitate knowledge spillovers. Unfortunately, finding out that the inclusion of regional dummies makes our spillover variable insignificant is not informative, since it is not clear what these regional dummies are actually capturing. The insignificant coefficient on the spillover variables after including dummies however, may simply reflect the high correlations between both *KS2* and *KS3* and a number of the regional dummies (see table A1.9, Data Appendix).

dimension to knowledge spillovers. The significant coefficients also disappear when the squared foreign knowledge term is included, suggesting that a linear specification is preferable to a non-linear one. The final two cases, where the foreign knowledge stock is weighted by our measures of openness, provide the strongest support for foreign knowledge spillovers. The coefficients are always positive, and in the case of *KS5* are significant both when regional dummies and the squared term are included in the model. The results are not quite so strong for *KS4* however, with insignificant coefficients found in a number of cases.

When country effects are included in the model, many of the significant coefficients on the core variables disappear. The coefficients do tend to be of the expected sign, except in a number of specifications for population growth and government spending. The one variable that does remain positive and significant is investment. Turning to the foreign knowledge variables, we find a negative coefficient on *KS1*, although the coefficient is insignificant. We again find evidence of positive and significant spillovers using *KS2* and *KS3*, although the significance of the coefficient disappears when the squared term is included. The size of the coefficients on the spillover variable are higher when country dummies are included, suggesting that after country specific characteristics have been taken account of, there is more evidence of foreign knowledge spillovers. This supports the view of Verspagen who suggests that such country dummies are capturing time-invariant factors that help facilitate the absorption of foreign knowledge. Once again the coefficients on *KS4* and *KS5* are positive, both when the squared term is included and when it is excluded, but are only significant in the case of *KS5*. Once again the coefficients are higher when country dummies are included, suggesting that these may be capturing country-specific factors that assist in the absorption of foreign knowledge.

Finally, the results when the squared value of the foreign knowledge spillover is included in the model suggests a tendency for there to be a positive coefficient on the foreign knowledge variable and a negative coefficient on the squared term, although the coefficients tend not to be significant, either individually or jointly. This is true for the first three specifications, but not for the last two where we find a positive and significant coefficient on the spillover variable and a negative and insignificant coefficient on the squared term. In these cases therefore, we find some evidence to suggest that low levels of openness result in growth promoting foreign knowledge spillovers, but that higher levels do not provide the same benefits. This has the implication that moving from a closed-economy to some degree of openness is important in order to benefit from foreign knowledge spillovers, but that shifts from one level of openness to a higher level of openness may not lead to greater spillovers[20].

In general, the results do not provide overwhelming support for the presence of significant foreign knowledge spillovers in our sample of countries. In 13 of the 24 cases however, we do find positive and significant coefficients on the

[20] One explanation for this result would be that the level of trade is important for spillovers, and that the level of openness is positively related to the level of trade. In this case, an increase in openness from an initially low level may result in a large increase in imports, which would then facilitate spillovers. Whereas, an increase in openness from a relatively high level may have a much smaller impact on the level of imports, and therefore spillovers. The literature on national diffusion of knowledge (see Karshenas and Stoneman, chapter 7 in Stoneman (1995) suggests the possibility of a sigmoid or S-shaped relationship between diffusion and time. It is not clear immediately why we may expect an S-shaped relationship between diffusion and the level of trade or openness, but it is one further possibility.

spillover variable. We find evidence of foreign knowledge spillovers when *KS2* and *KS3* are used. These are the only two specifications that use the level of trade from the donors to the recipients when constructing the foreign knowledge spillover variables. These results, along with the fact that the coefficients on KS1 tend to be negative and insignificant, are supportive of the notion that the level of trade is important to benefit from foreign knowledge. This outcome is consistent with the results of CHH, who could only find strongly significant results for foreign knowledge spillovers when the foreign knowledge stock was interacted with the level of imports of machinery and equipment, and who often found negative coefficients when the foreign knowledge stock was weighted only by the share of imports. This would suggest therefore that foreign knowledge spillovers are not a pure public good, but are dependent on the degree of interaction between the donor and recipient.

Table 5.1 Results of Estimated Growth Regression using $KS1$[21]

Avgrow	1	2	3	4	5	6
InitGDP	-0.72		-0.63	-0.72		-0.63
	(-1.36)		(-1.23)	(-1.37)		(-1.23)
Inv	1.66	3.43	1.23	1.65	3.49	1.23
	(3.53)*	(2.64)*	(2.59)*	(3.49)*	(2.68)*	(2.57)*
PopGrow	-1.05	0.21	-0.95	-1.06	0.28	-0.95
	(-3.74)*	(0.28)	(-3.45)*	(-3.75)*	(0.36)	(-3.42)*
SyrF	-3.28	-3.0	-2.98	-3.68	-3.51	-2.98
	(-3.34)*	(-1.22)	(-2.52)*	(-3.24)*	(-1.39)	(-2.51)*
SyrM	3.52	2.39	2.42	3.44	2.78	2.4
	(4.19)*	(0.87)	(2.44)**	(3.88)*	(0.99)	(2.38)**
Gov't	-8.61	0.7	-7.82	-8.81	-1.2	-7.86
	(-2.24)**	(0.07)	(-2.01)**	(-2.26)**	(-0.12)	(-1.99)***
Inflation	-4.12	-6.6	-4.08	-4.18	-6.32	-4.14
	(-1.73)***	(-1.96)**	(-1.64)***	(-1.74)***	(-1.87)***	(-1.65)***
KS1	-1.44	-3.17	-1.5	17.52	-113.1	9.21
	(-2.16)**	(-0.99)	(-1.56)	(0.28)	(-0.98)	(0.15)
KSSQ				-0.36	2.05	-0.2
				(-0.29)	(0.95)	(-0.17)
DEAS			1.05			1.04
			(1.03)			(1.01)
DLAT			-0.86			-0.82
			(-0.83)			(-0.77)
DSSA			-1.69			-1.69
			(-2.2)**			(-2.18)**
T1	-3.13	-2.79	-3.04	-3.12	-2.71	-3.03
	(-5.58)*	(-3.72)*	(-5.41)*	(-5.52)*	(-3.57)*	(-5.37)*
T2	-1.13	0.09	-1.03	-1.09	0.19	-0.99
	(-1.86)***	(0.08)	(-1.65)***	(-1.74)***	(0.16)	(-1.53)
Constant	45.08	76.69	47.83	-207.41	1551.37	-94.34
	(2.62)*	(0.89)	(1.93)***	(-0.25)	(1.0)	(-0.11)
Country Effects	No	Yes	No	No	Yes	No
Wald Test	106.15*	202.29*	122.13*	105.66*	202.29*	120.67*
Breusch-Pagan	0.54		0.0	0.41		0.0
Hausman	8.27		8.51	10.18		9.81
KS = 0 and KSSQ = 0	N/A	N/A	N/A	0.08	0.96	0.02
Overall R^2	0.45	0.68	0.48	0.45	0.68	0.48

Note: All models are estimated using Huber/White/Sandwich robust standard errors. Values in parentheses are t-statistics. *, **, *** indicate significance at the 1, 5 and 10 percent levels respectively.

[21] When we include country effects in our model it is necessary to remove time invariant variables from our model. In terms of our model therefore we can't include initial GDP and the regional dummy variables when country effects are included.

Table 5.2 Results of Estimated Growth Regression using *KS2*

Avgrow	*1*	2	*3*	*4*	*5*	*6*
InitGDP	-1.4		-1.01	-1.36		-0.93
	(-2.56)*		(-1.85)***	(-2.47)**		(1.68)***
Inv	1.34	2.85	1.15	1.34	2.89	1.16
	(2.57)*	(2.12)**	(2.31)**	(2.58)*	(2.12)**	(2.33)**
PopGrow	-0.97	0.05	-1.02	-0.98	0.05	-1.04
	(-3.41)*	(0.06)	(-3.62)*	(-3.42)*	(0.06)	(-3.68)*
SyrF	-3.35	-3.23	-2.24	-2.51	-3.2	-2.39
	(-2.84)*	(-1.35)	(-1.89)***	(-2.93)*	(-1.33)	(-1.99)**
SyrM	3.23	1.72	1.78	3.34	1.75	1.87
	(3.57)*	(0.62)	(1.8)***	(3.64)*	(0.63)	(1.88)***
Gov't	-5.25	2.67	-7.67	-5.7	2.29	-8.28
	(-1.3)	(0.28)	(-1.94)***	(-1.39)	(0.23)	(-2.06)**
Inflation	-2.99	-3.36	-2.41	-2.63	-3.26	-1.99
	(-1.24)	(-1.06)	(-0.99)	(-1.08)	(-1.02)	(-0.81)
KS2	0.39	1.18	0.28	5.75	4.3	6.56
	(1.75)***	(1.74)***	(1.24)	(0.92)	(0.29)	(-1.07)
KSSQ				-0.07	-0.04	-0.08
				(-0.86)	(-0.21)	(-1.02)
DEAS			0.3			0.44
			(0.29)			(0.42)
DLAT			-1.99			-2.01
			(-2.58)*			(-2.59)*
DSSA			-1.38			-1.22
			(-1.74)***			(-1.49)
T1	-3.2	-2.66	-3.04	-3.15	-2.66	-2.98
	(-5.75)*	(-3.59)*	(-5.74)*	(-5.63)*	(-3.57)*	(-5.28)*
T2	-1.63	-0.69	-1.5	-1.58	-0.67	-1.45
	(-2.79)*	(-0.79)	(-2.57)*	(-2.69)*	(-0.77)	(-2.48)**
Constant	-4.1	-53.23	-0.2	-112.09	-114.08	-126.73
	(-0.49)	(-2.04)**	(0.02)	(-0.89)	(-0.39)	(-1.02)
Country Effects	No	Yes	No	No	Yes	No
Wald Test	100.96*	208.63*	119.08*	101.2*	206.58*	119.6*
Breusch-Pagan	1.14		0.0	1.2		0.0
Hausman	9.07		11.32	8.83		10.29
KS = 0 and KSSQ = 0	N/A	N/A	N/A	0.85	0.09	1.14
Overall R^2	0.44	0.69	0.48	0.44	0.69	0.48

Note: All models are estimated using Huber/White/Sandwich robust standard errors. Values in parentheses are t-statistics. *, **, *** indicate significance at the 1, 5 and 10 percent levels respectively.

Table 5.3 Results of Estimated Growth Regression using *KS3*

Avgrow	*1*	2	*3*	*4*	*5*	*6*
InitGDP	-1.46 (-2.72)*		-1.06 (-1.93)***	-1.4 (-2.59)*		-0.95 (-1.7)***
Inv	1.21 (2.35)**	2.85 (2.11)**	1.08 (2.15)**	1.23 (2.37)**	2.69 (1.94)***	1.11 (2.2)**
PopGrow	-1.01 (-3.6)*	0.03 (0.05)	-1.01 (-3.63)*	-1.02 (-3.62)*	0.04 (0.05)	-1.04 (-3.71)*
SyrF	-3.02 (-2.54)*	-3.09 (-1.28)	-2.19 (-1.84)***	-3.24 (-2.68)*	-3.06 (-1.27)	-2.4 (-1.99)**
SyrM	2.96 (3.25)*	1.68 (0.6)	1.77 (1.8)***	3.11 (3.36)*	1.54 (0.55)	1.9 (1.92)***
Gov't	-5.5 (-1.41)	1.81 (0.19)	-7.51 (-1.89)***	-5.86 (-1.49)	2.91 (0.29)	-8.07 (-2.03)**
Inflation	-2.81 (-1.17)	-3.75 (-1.2)	-2.45 (-1.02)	-2.39 (-0.99)	-4.09 (-1.29)	-1.96 (-0.81)
KS3	0.56 (2.2)**	1.17 (1.64)***	0.35 (1.39)	3.02 (1.17)	-2.11 (-0.4)	3.28 (1.29)
KSSQ				-0.09 (-0.96)	0.15 (0.63)	-0.12 (-1.16)
DEAS			0.4 (0.4)			0.51 (0.49)
DLAT			-1.77 (-2.27)**			-1.82 (-2.33)**
DSSA			-1.41 (-1.8)***			-1.29 (-1.63)
T1	-3.24 (-5.83)*	-2.81 (-3.88)*	-3.08 (-5.49)*	-3.19 (-5.71)*	-2.85 (-3.91)*	-3.02 (-5.36)*
T2	-1.63 (-2.81)*	-0.58 (-0.67)	-1.49 (-2.57)*	-1.59 (-2.72)*	-0.59 (-0.69)	-1.44 (-2.48)**
Constant	5.79 (1.39)	-23.74 (-2.43)	7.68 (1.87)***	-9.86 (-0.59)	-1.78 (-0.06)	-11.23 (-0.67)
Country Effects	No	Yes	No	No	Yes	No
Wald Test	105.1*	207.6*	120.2*	105.9*	206.6*	121.8*
Breusch-Pagan	0.84		0.0	0.73		0.0
Hausman	8.54		10.71	8.55		10.36
KS = 0 and KSSQ = 0	N/A	N/A	N/A	1.39	0.15	1.68
Overall R^2	0.45	0.69	0.48	0.45	0.69	0.49

Note: All models are estimated using Huber/White/Sandwich robust standard errors. Values in parentheses are t-statistics. *, **, *** indicate significance at the 1, 5 and 10 percent levels respectively.

Table 5.4 Results of Estimated Growth Regression using *KS4*

Avgrow	*1*	2	*3*	*4*	*5*	*6*
InitGDP	-0.85 (-1.57)		-0.36 (-0.67)	-0.96 (-1.75)***		-0.45 (-0.83)
Inv	1.62 (3.31)*	3.21 (2.44)**	1.28 (2.74)*	1.63 (3.33)*	3.2 (2.42)**	1.3 (2.76)*
PopGrow	-0.93 (-3.23)*	-0.03 (-0.03)	-1.01 (-3.69)*	-0.92 (-3.19)*	-0.05 (-0.07)	-0.99 (-3.61)*
SyrF	-4.11 (-3.54)*	-3.19 (-1.32)	-2.73 (-2.39)**	-3.98 (-3.4)*	-3.16 (-1.3)	-2.66 (-2.31)**
SyrM	3.53 (4.04)*	1.83 (0.65)	1.52 (1.56)	3.57 (4.08)*	1.66 (0.58)	1.59 (1.62)
Gov't	-9.12 (-2.18)**	0.31 (0.03)	-12.94 (-2.98)*	-8.8 (-2.09)**	1.06 (0.1)	-12.47 (-2.84)*
Inflation	-2.95 (-1.22)	-4.35 (-1.42)	-1.63 (-0.67)	-3.12 (-1.29)	-4.42 (-1.43)	-1.84 (-0.75)
KS4	5.97 (1.44)	10.75 (1.38)	8.79 (2.11)**	12.51 (1.74)***	9.48 (1.07)	13.99 (1.96)***
KSSQ				-10.18 (-1.11)	4.11 (0.31)	-8.05 (-0.89)
DEAS			0.13 (0.13)			0.17 (0.17)
DLAT			-2.55 (-3.18)*			-2.48 (-3.05)*
DSSA			-1.67 (-2.2)**			-1.34 (-2.14)**
T1	-4.84 (-3.92)*	-5.95 (-2.65)*	-5.36 (-4.4)*	-4.32 (-3.27)*	-6.56 (-2.18)**	-4.97 (-3.81)*
T2	-2.44 (-2.79)*	-2.53 (-1.59)	-2.77 (-3.2)*	-2.36 (-2.69)*	-2.79 (-1.54)	-2.71 (-3.11)*
Constant	6.07 (1.38)	-8.88 (-1.92)***	5.69 (1.34)	5.73 (1.3)	-8.81 (-1.89)***	5.33 (1.24)
Country Effects	No	Yes	No	No	Yes	No
Wald Test	98.83*	205.13*	126.42*	100.1*	203.3*	126.3*
Breusch-Pagan	1.49		0.0	1.38		0.0
Hausman	7.62		8.44	6.76		7.66
KS = 0 and KSSQ = 0	N/A	N/A	N/A	0.19	1.26	1.27
Overall R^2	0.44	0.68	0.49	0.44	0.68	0.49

Note: All models are estimated using Huber/White/Sandwich robust standard errors. Values in parentheses are t-statistics. *, **, *** indicate significance at the 1, 5 and 10 percent levels respectively.

Table 5.5 Results of Estimated Growth Regression using *KS5*

Avgrow	*1*	*2*	*3*	*4*	*5*	*6*
InitGDP	-0.81 (-1.5)		-0.34 (-0.65)	-0.9 (-1.65)***		-0.4 (-0.76)
Inv	1.75 (3.59)*	3.33 (2.58)**	1.44 (3.07)*	1.75 (3.57)*	3.25 (2.49)**	1.47 (3.14)*
PopGrow	-0.91 (-3.17)*	-0.07 (-0.09)	-0.96 (-3.57)*	-0.91 (-3.17)*	-0.05 (-0.07)	-0.97 (-3.61)*
SyrF	-4.46 (-3.7)*	-3.58 (-1.49)	-3.21 (-2.76)*	-4.2 (-3.47)*	-3.43 (-1.42)	-2.99 (-2.56)*
SyrM	3.73 (4.32)*	1.91 (0.69)	1.79 (1.9)***	3.63 (4.2)*	1.97 (0.71)	1.69 (1.79)***
Gov't	-9.93 (-2.3)**	0.05 (0.01)	-13.84 (-3.18)*	-9.45 (-2.19)**	-1.12 (-0.11)	-13.54 (-3.11)*
Inflation	-2.95 (-1.22)	-4.23 (-1.39)	-1.68 (-0.7)	-3.03 (-1.26)	-4.04 (-1.31)	-1.73 (-0.73)
KS5	5.21 (1.64)***	13.17 (1.68)*	7.42 (2.4)**	15.31 (2.13)**	15.83 (1.68)***	17.72 (2.47)**
KSSQ				-11.49 (-1.57)	-4.95 (-0.51)	-11.43 (-1.59)
DEAS			0.16 (0.16)			0.04 (0.04)
DLAT			-2.55 (-3.26)*			-2.62 (-3.34)*
DSSA			-1.88 (-2.48)**			-1.84 (-2.42)**
T1	-4.56 (-4.65)*	-6.53 (-2.95)*	-4.88 (-5.23)*	-4.25 (-4.26)	-5.91 (-2.34)**	-4.63 (-4.9)*
T2	-2.22 (-3.04)*	-2.84 (-1.84)***	-2.39 (-3.4)*	-2.28 (-3.13)*	-2.61 (-1.63)	-2.49 (-3.54)*
Constant	5.37 (1.19)	-10.61 (-2.22)**	5.1 (1.21)	3.88 (0.85)	-10.61 (-2.22)**	3.31 (0.76)
Country Effects	No	Yes	No	No	Yes	No
Wald Test	99.8*	207.98*	129.9*	102.74*	206.62*	132.9*
Breusch-Pagan	1.37		0.03	1.66		0.0
Hausman	8.5		9.38	6.16		6.97
KS = 0 and KSSQ = 0	N/A	N/A	N/A	1.31	1.45	3.94**
Overall R^2	0.44	0.69	0.50	0.45	0.69	0.51

Note: All models are estimated using Huber/White/Sandwich robust standard errors. Values in parentheses are t-statistics. *, **, *** indicate significance at the 1, 5 and 10 percent levels respectively.

It is also the case however that the results for the last two specifications provide support for the notion of foreign knowledge spillovers. Yet these two specifications do not depend directly upon the level of trade, but upon the degree of openness to imports from the various donor economies. From our results therefore, we cannot say whether it is the level of trade or the level of openness that is important in facilitating spillovers[22]. We find limited support to suggest that both the level of trade and the level of openness are important for knowledge spillovers to take place. Indeed, the only case in which we don't find any evidence in favour of growth promoting foreign knowledge spillovers is for *KS1*, which depends only upon the distribution of imports and not on the level of imports or openness.

A further inference that may be drawn from these results is that the relationship between foreign knowledge spillovers and growth is not necessarily linear. If this is the case then we may not expect to obtain strongly significant coefficients when we estimate a linear regression. The inclusion of the squared value of the knowledge spillover variable in the model provides support for the notion of a non-linear relationship between foreign knowledge spillovers and growth, using the final two specifications for the knowledge spillover variable, *KS4* and *KS5*. Here the evidence suggests that an increase in openness will result in greater foreign knowledge spillovers if the economy began from a lower level of openness, than if the economy was initially relatively open. This would support the notion that some level of openness is important for foreign knowledge spillovers to take place, but that higher and higher levels of openness do not

[22] To the extent that higher levels of openness are associated with higher levels of imports, we may expect that the final two measures of foreign knowledge variables are indirectly dependent upon the level of trade. The correlations between the two measures of openness and either the level of imports or the share of imports in GDP range between 0.54 and 0.74, suggesting that higher levels of openness are indeed associated with higher levels of trade.

result in equal benefits from foreign knowledge spillovers, possibly because the impact on the level of imports of higher and higher levels of openness are diminishing.

Comparing the results from using *KS2* and *KS3* in our model allow us to examine whether there are significant differences in results from using the stock of knowledge as opposed to the intensity of knowledge when constructing the foreign knowledge variables. The sign and significance of the coefficients on *KS2* and *KS3* don't differ too much, suggesting that the distinction between the two methods may not be important. Finally, although we find evidence of foreign knowledge spillovers in over half of the cases, the robustness of the results needs to be questioned. The results tend to be robust to the inclusion of country dummies, but it is often the case that the inclusion of regional dummies results in insignificant coefficients on the spillover variables. This may suggest that there is a regional dimension to knowledge spillovers. In the models that use *KS2* and *KS3*, the inclusion of the squared term in the regression also removes the significance of the foreign knowledge spillover variable. This would suggest that a linear relationship between knowledge spillovers and growth is preferable to a non-linear relationship, when the foreign knowledge variables depend directly upon the level of trade.

5.6: Is Education Important for Knowledge Spillovers?

The inclusion of regional and country dummies in the above models often changes the size and significance of the coefficients on the foreign knowledge variables. The inclusion of regional dummies often makes the coefficients on foreign knowledge variables insignificant, while the inclusion of country dummies often increases the size of the coefficients on foreign knowledge. As Verspagen (1997) argues, one explanation for the impact of country dummies is that they pick up differences in time invariant factors, such as social capability. The notion of social capability, suggests that only those countries in our sample that have in place the appropriate policies and institutions, that have adequate infrastructure and that have sufficient levels of human capital will be able to benefit from foreign knowledge spillovers. Simply stated the idea behind social capability is that the ability of a country to catch-up with the technological leaders through technology diffusion is determined by its ability to adopt such technology. The problem with this concept is as stated by Abramovitz "that no one knows just what it means or how to measure it." (p. 388). Abramovitz identifies three elements to social capability, namely the facilities for the diffusion of knowledge, conditions that facilitate or hinder structural change, and finally macroeconomic and monetary conditions that encourage investment. Facilities for the diffusion of knowledge will include such things as interpersonal links with other countries, international trade and foreign investment. Conditions encouraging structural change may depend on such things as learning capability, for example literacy. Conditions encouraging investment are likely to be influenced by the existence of property rights, the rule of law and the degree of corruption. Thus a measure of social capability depends on a large number of factors, making quantification difficult. Adelman and Morris (1965) attempted to measure 'social development' for 71 countries for the year 1965 using factor analysis on a number of indicators of the political and social structure of these countries. Temple and Johnson (1998) have since shown that economic growth since the 1960s is strongly related to this proxy for the initial level of social development.

Other factors that could explain the mixed results in terms of foreign knowledge spillovers when regional and country dummies are included may relate to the ability of countries to imitate the knowledge of the donor economies. Important here may be how strictly enforced domestically are intellectual property rights; imitation may be encouraged if enforcement of property rights isn't strict. Alternatively, it may be that only countries that are themselves undertaking R&D will be able to gain from the R&D undertaken elsewhere[23], because countries with a domestic R&D sector find it easier to imitate, or because spillovers enhances their ability to make innovations of their own. One factor that is clearly important for social capability, and which may well be important for knowledge spillovers to take place is the education of the population, since a better educated population would be expected to allow a country to better take advantage of foreign knowledge. Indeed, if knowledge is a purely public good we may not expect trade or openness to influence the extent of knowledge spillovers, but we may expect education to be important if certain skills are required to make use of this knowledge.

CHH include in one specification the interaction of the secondary enrolment ratio and the import-share weighted foreign knowledge stock. They argue that a positive coefficient on this variable would indicate that the impact of foreign knowledge on productivity is higher the better educated the workforce is, and education would have a greater impact on productivity, the greater the stock of foreign knowledge. The results on the interaction terms tend not to be significant, and they cannot reject the hypothesis that a higher secondary school enrolment rate has no effect upon the marginal benefit of foreign knowledge. They argue that this is because of multicollinearity between the interaction term and the enrolment ratio included separately and show that the coefficients on the two variables are jointly significant.

We include in our model the interaction between the various trade-weighted foreign knowledge stocks and average years of secondary schooling for the male population (*SyrM*)[24], calculated as follows,

$$SMKSi_{mt} = KSi_{mt} Syrm_{mt} \qquad i = 1, 2, \ldots, 5 \qquad \textbf{(5.12)}$$

This variable can be interpreted as implying that there is a stock of knowledge available in the world that all countries have access to, but that only those countries with a sufficiently skilled workforce can make use of. A positive and significant coefficient on this variable would imply that education is important for knowledge spillovers to take place. The model to be estimated therefore is,

$$Avgrow_{mt} = \alpha + \beta_j I_{jmt} + \gamma KSi_{mt} + \phi SMKSi_{mt} + \varepsilon_{mt}, \qquad \textbf{(5.13)}$$

The results of incorporating this new variable in to our regression are reported in Tables 5.6 and 5.7 below. In Table 5.6 we report the results when a random effects model is employed, while in section 5.7 the results of including country dummies are reported. The major change to the coefficients on the core

[23] See Rosenberg (1982).

variables in the model when country effects are excluded (Table 5.6) is that the coefficient on the male schooling often becomes insignificant. Similarly, the coefficients on the core variables differ very little from those reported above when country effects are included (Table 5.7), with investment being positive and significant, but little else being significant. The size and sign of the coefficients on the foreign knowledge spillovers do not change a great deal from those reported above[25]; we find a negative and significant coefficient when *KS1* is used to measure foreign knowledge, and positive coefficients in the remaining specifications. The coefficients tend not to be significant however. Only in two cases do we find positive and significant coefficients on the foreign knowledge spillover variables, these are for *KS3* in the random effects model and for *KS5* when country dummies are included.

Turning to the coefficients on the education weighted foreign knowledge variable, the results tend to be similar to CHH, in that they don't support the notion that education is important in facilitating knowledge spillovers[26]. When country effects are excluded from the regression, the education interaction terms are actually negative, although never significant. Similarly, when country effects are included in the model the coefficients on the education interaction terms are never significant, although they are positive.

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[24] Other measures of education were also used, and were found not to alter the results on the interaction term a great deal.

[25] Not reported are the results when the squared term is also included. This has no impact on the education interaction term, and has an identical impact on the various knowledge spillover variables reported above.

[26] In addition to including this education weighted foreign spillover variable we also tested for a threshold effect of education by examining a subset of countries whose level of education (i.e. *(SYRM)* was relatively high. The evidence again didn't provide support for a role of education in facilitating knowledge spillovers.

Table 5.6: Inclusion of Education Interaction Term (No Country Effects)

Avgrow	*KS1*	*KS2*	*KS3*	*KS4*	*KS5*
InitGDP	-0.74 (-1.37)	-1.43 (-2.55)*	-1.48 (-2.72)*	-0.89 (-1.55)	-0.80 (-1.43)
Inv	1.66 (3.51)*	1.32 (2.53)**	1.20 (2.30)**	1.62 (3.30)*	1.73 (3.58)*
PopGrow	-1.05 (-3.72)*	-0.96 (-3.32)*	-1.00 (-3.50)*	-0.93 (-3.22)*	-0.92 (-3.26)*
SyrF	-3.68 (-3.22)*	-3.36 (-2.82)*	-3.04 (-2.54)**	-4.05 (-3.38)*	-4.49 (-3.61)*
SyrM	10.51 (0.34)	6.36 (0.62)	4.10 (1.03)	3.84 (2.34)**	3.52 (2.12)**
Gov't	-8.61 (-2.23)**	-5.19 (-1.28)	-5.46 (-1.39)	-9.08 (-2.16)**	-10.12 (-2.37)**
Inflation	-4.13 (-1.73)***	-2.89 (-1.19)	-2.70 (-1.11)	-2.94 (-1.21)	-2.95 (-1.22)
KS	-1.26 (-1.17)	0.46 (1.49)	0.63 (1.79)***	6.29 (1.44)	4.84 (1.35)
SMKS	-0.26 (-0.22)	-0.08 (-0.31)	-0.08 (-0.29)	-0.67 (-0.83)	0.44 (0.15)
T1	-3.13 (-5.57)*	-3.21 (-5.74)*	-3.24 (-5.82)*	-4.79 (-3.78)*	-4.55 (-4.63)*
T2	-1.11 (-1.82)***	-1.64 (-2.79)*	-1.65 (-2.81)*	-2.43 (-2.77)*	-2.21 (-3.03)**
Constant	40.26 (1.45)	-6.56 (-0.57)	4.99 (1.01)	6.17 (1.39)	5.57 (1.26)
Wald Test	105.18*	100.03*	104.08*	98.08*	101.19*
Overall R^2	0.45	0.44	0.45	0.44	0.44
SyrM = 0 and *SMKS* = 0	0.11	0.39	1.16	2.86***	5.61**
SMKS = 0 and KS = 0	4.02**	2.80***	4.49**	1.59	2.41

Note: All models are estimated using Huber/White/Sandwich robust standard errors. Values in parentheses are t-statistics. *, **, *** indicate significance at the 1, 5 and 10 percent levels respectively.

Table 5.7 Inclusion of Education Interaction Term (With Country Effects)

Avgrow	KS1	KS2	KS3	KS4	KS5
Inv	3.43	2.83	2.79	3.16	3.32
	(2.65)*	(2.08)**	(2.04)**	(2.38)**	(2.56)*
PopGrow	0.13	0.05	0.05	-0.01	-0.06
	(0.17)	(0.07)	(0.07)	(-0.02)	(-0.07)
SyrF	-4.49	-3.32	-3.15	-3.3	-3.72
	(-1.62)	(-1.36)	(-1.30)	(-1.34)	(-1.49)
SyrM	-1.26	-2.59	-1.15	1.17	1.44
	(-1.12)	(-0.12)	(-0.14)	(0.34)	(0.41)
Gov't	-0,86	2.94	2.36	0.54	0.32
	(-0.09)	(0.30)	(0.24)	(0.05)	(0.03)
Inflation	-6.87	-3.43	-3.91	-4.34	-4.27
	(-2.04)**	(-1.07)	(-1.24)	(-1.42)	(-1.39)
KS	-6.26	1.10	1.02	10.72	12.98
	(-1.51)	(1.42)	(1.24)	(1.37)	(1.65)***
SMKS	2.78	0.10	0.21	1.13	0.78
	(1.16)	(0.20)	(0.36)	(0.31)	(0.23)
T1	-2.57	-2.66	-2.80	-6.16	-6.62
	(-3.31)*	(-3.57)*	(-3.85)*	(-2.62)*	(-2.93)*
T2	0.44	-0.67	-0.54	-2.57	-2.84
	(0.36)	(-0.77)	(-0.61)	(-1.61)	(-1.84)***
Constant	154.61	-53.29	-21.74	-8.82	-9.17
	(1.41)	(-1.71)***	(-1.92)***	(-1.53)	(-1.63)
Wald Test	204.39*	206.56*	205.77*	203.3*	205.95*
Overall R^2	0.69	0.69	0.69	0.68	0.69
SyrM = 0 and SMKS = 0	1.26	0.01	0.01	0.52	0.52
SMKS = 0 and KS = 0	1.18	3.02***	2.78***	1.91	2.75***

Note: All models are estimated using Huber/White/Sandwich robust standard errors. Values in parentheses are t-statistics. *, **, *** indicate significance at the 1, 5 and 10 percent levels respectively.

One potential reason for these results is that the male schooling variable and the male schooling variable interacted with foreign knowledge are highly correlated (0.92 to 0.99)[27] suggesting a problem of multicollinearty. Also reported in the tables are tests of the joint significance of male schooling and the education

[27] Removing the male schooling variable from the model resulted in positive and significant coefficients on the education interaction term in all of the five cases using a random effects model, but positive and insignificant coefficients when country effects were included. The coefficients on the trade weighted foreign knowledge spillover variables tended to be positive (except for *KS1*) although insignificant. This possibly reflected the fact that the correlation

interaction term (i.e. *SyrM* = 0 and *SMKS* = 0) and of the joint significance of the two foreign knowledge spillover variables (i.e. *SMKS* = 0 and *KS* = 0). The tests of joint significance suggest that the education variables are jointly significant for the last two specifications of the foreign knowledge spillover variable, *KS4* and *KS5*, in the case where country effects are excluded from the model, but insignificantly different from zero in the other three cases and when country effects are included. One potential explanation for why country dummies make a previously significant coefficient insignificant is that although education is important in facilitating foreign knowledge spillovers, it is only one of a large number of factors. In this case it is likely that country dummies would be better at explaining these factors than including variables that only account for one of the many factors facilitating spillovers. The results of the test for the joint significance of the two foreign knowledge spillover variables suggest that in the majority of cases the two foreign knowledge spillover variables are jointly significant, suggesting that there are significant growth promoting foreign knowledge spillovers, with both education and trade being important in facilitating knowledge spillovers.

5.7 Concluding Remarks

It has long been thought that foreign knowledge spillovers may be important to the growth process, with trade being one mechanism through which spillovers occur. New growth theory suggests that a country whose trade partners have

between the trade weighted foreign knowledge variable and the education weighted foreign knowledge variable is also quite high, ranging from 0.3 to 0.56.

high levels of technology should grow faster, since through trade they gain access to the knowledge produced in these countries. With the arrival of new growth theories, studies began to test for a relationship between productivity and foreign knowledge, where the latter is taken to be cumulative R&D expenditures. It is assumed in these studies that either import shares or import volumes determine access to such knowledge. International trade is seen as important for knowledge spillovers by allowing the importation of products that embody advanced technology and knowledge, and through the provision of information that could otherwise not be acquired. The results of these studies are mixed, evidence in support of the notion of foreign knowledge spillovers has been found, but problems exist with the results.

We test for the presence of spillovers from the five leading OECD economies in terms of R&D expenditure to our sample of countries in a model of growth, following closely the methodology of Coe and Helpman and CHH to construct the variables representing foreign knowledge. We test the robustness of the results we obtain to different specifications of the spillover variable. The results suggest that foreign knowledge spillovers are important for growth, but that the results tend not to be robust. The results suggest that the level of trade is important in facilitating spillovers, with the specification that doesn't depend upon the level of trade being negative and usually insignificant. Although we find evidence to suggest that openness as opposed to the level of trade facilitates knowledge spillovers, the distinction between the two may not be important, since higher levels of openness are correlated with high levels of imports. Comparing the results that use the level of the knowledge stock (i.e. the specification of Coe and Helpman, 1995) with those using the intensity of knowledge (i.e. the specification of Lichtenberg and Van Pottelsberghe de la Potterie, 1998) suggest that the distinction may not be important, since the results are similar.

The results also suggest that the relationship between growth and those specifications that are dependent upon the level of trade are better modelled as a linear relationship. This is not necessarily the case for those measures based on openness to trade however. In these specifications, modelling the relationship between growth and knowledge spillovers as a non-linear relationship may also be suitable. An increase in openness at low levels of openness results in greater benefits than an increase in openness at a relatively high level of openness. The results after including the regional dummies suggest that foreign knowledge spillovers are insignificant. This would suggest that there are certain region specific factors that assist in the absorption of technology.

The final hypothesis we examined related to the importance of education in facilitating knowledge spillovers. Education is found to be an important determinant of growth in our sample of countries. When weighted with foreign knowledge stocks however, both the coefficient on the education term and its interacted term tend to be insignificant. This result is likely to reflect multicollinearity between the variables. The fact that the two are occasionally jointly significant however, may suggest that education is important to growth, both in general and also by enhancing the ability to absorb technology. Similarly, the coefficients on the education term interacted with the foreign knowledge stock and the trade weighted foreign knowledge stock are in general individually insignificant, but jointly significant, suggesting that foreign knowledge spillovers are important to growth, with both education and trade (or openness) facilitating knowledge spillovers.

The results while not strongly supportive of foreign knowledge spillovers, do provide such evidence in a number of cases. Moreover, the results obtained provide a number of questions that may require further research. A question that arises is whether the relationship between knowledge spillovers and growth is linear or non-linear, evidence was presented suggesting that foreign knowledge spillovers are important at low levels of openness, but not at higher levels. A further issue that requires investigation is in to the factors that facilitate the absorption of foreign knowledge. We have concentrated on trade, and to some extent education, but there are numerous other factors that may facilitate spillovers. Obvious candidates as mentioned above are social capability, education, the level and composition of trade, FDI, migration and the presence of a domestic R&D stock. The fact that regional dummies often result in the spillover variables becoming insignificant suggest that region specific factors may be important in facilitating knowledge spillovers. Further research in to what these factors are may be worthwhile.

Chapter Six

The Impact of Trade Liberalisation on Openness and Economic Growth

Chapter Six

THE IMPACT OF TRADE LIBERALISATION ON OPENNESS AND GROWTH

6.1 Introduction

This chapter moves away from an emphasis on differences in openness across countries and considers the role of trade liberalisation, that is a movement within a country to a more open trade regime. In Chapter One we discussed how import substitution was adopted by most developing countries immediately following independence and how in recent years there has been a shift away from the import substitution policies of the sixties and seventies towards freer trade, with a large number of countries undergoing some kind of trade reform. Our previous results suggest that countries that undergo trade liberalisation should benefit in terms of higher growth, since more open economies on average perform better in terms of growth. There are however a number of reasons why trade liberalisation may not actually result in higher growth: the credibility of reforms, and their timing, sequencing and sustainability may result in reforms not having the desired impact. The impact that trade liberalisation has upon a country is ultimately an empirical issue, thus our focus in this chapter.

In the first half of the chapter, we examine the impact that trade liberalisation has had upon openness in our sample of countries. This is in fact rarely explored, but if liberalisation doesn't have an impact upon openness, we may expect that its impact on economic performance would also be muted. In the latter half of the chapter we examine the impact of trade liberalisation on growth, by extending the work of Greenaway, Morgan and Wright (1998). The rest of the chapter therefore is organised as follows. In section 6.2 we discuss the potential benefits and limitations of trade liberalisation, while section 6.3 reviews some of the evidence linking trade liberalisation to both openness and growth. Section 6.4 examines the impact of trade liberalisation on our measure of openness developed in Chapter Four, while section 6.5 examines the impact of liberalisation on growth. Section 6.6 provides some overall conclusions.

6.2 The Benefits and Limitations of Trade Liberalisation

There are a large number of potential benefits from trade liberalisation and a large number of channels through which such benefits may accrue[1], many of which have been emphasised throughout the thesis. Trade liberalisation would be expected to lead to static gains through an improved resource allocation, which should raise the level although not the long-run growth rate of income. The static gains from liberalisation may not be limited to such resource allocation gains however. Krueger (1998) identifies the gains from the reduction in rent seeking for import licenses and from reductions in corruption and smuggling as additional static gains from trade liberalisation.

In addition to the static gains however, liberalisation would be expected to lead to improvements in the long-run growth rate of a country. In terms of the endogenous growth theories discussed in Chapter Two, trade liberalisation in

[1] Dornbusch (1992) and Krueger (1998) provide a survey of the gains from trade liberalisation.

developing countries would be expected to raise growth by facilitating the importation of capital and intermediate goods, and advanced technology that are not available domestically. Such imports raise the productivity of manufacturing production and can affect growth. Moreover, trade liberalisation would be expected to facilitate knowledge spillovers, which may enhance productivity and growth. In addition, Krueger (1998) argues that exporters in developing countries may acquire more knowledge from their interactions with foreign buyers than from interactions with domestic consumers, implying that firms that engage in trade are likely to have higher productivity. Similarly, she argues that LBD may be more rapid in export industries, providing further benefits from trade liberalisation.

Gains from liberalisation may also result from economies of scale and improved competition. The ability to take advantage of economies of scale may be severely limited in protected developing countries, where the potential market for a particular good is small. Liberalisation by increasing the potential size of the market may enable industries to benefit from economies of scale. The small size of the market in protected developing countries may also limit competition and foster oligopoly and inefficiency.

A further gain from liberalisation that is likely to be important is through competition. Trade liberalisation forces domestic firms to be competitive, otherwise domestic industry will disappear. Liberalisation by increasing the extent of competition would be expected to reduce market power for domestic firms built up in protected markets, which should have the effect of reducing prices, as well as increasing the variety and quality of goods. Further advantages for consumers may arise due to improved sales effort, delivery times and marketing techniques, as firms compete on non-price grounds. At the same time however, it should be noted that countries with poor domestic competition policy prior to liberalisation might find that once opened to international competition, domestic industry suffers since it cannot compete with foreign competitors.

Given that trade reform can potentially lead to significant benefits, why have so many countries been reluctant to undertake liberalisation, unless in response to pressure from international financial institutions, and why have so many reforms that have been undertaken, subsequently been reversed? A number of potential costs and limitations of trade liberalisation have been advanced[2], often based upon political economy arguments. It should also be remembered however, that the theory relating trade and growth is not unambiguous concerning the benefits of openness, with examples existing to suggest that trade liberalisation for some countries might lead to a lower long-run growth rate.

Trade reforms are usually undertaken in times of crisis, often characterised by high and variable inflation, and fiscal and balance of payments problems. Many trade liberalisation episodes in the recent past have been undertaken as part of a package of reforms that countries were obliged to negotiate if they wanted to receive funds from the World Bank and the IMF to help alleviate such crises.

For example over the period 1980-1989, 79 percent of all loans from the World Bank had conditions attached to trade policy (Greenaway, 1998). Papagergiou, Michaely and Choksi (1991) (PMC) note that of the 36-liberalisation episodes they identified, 15 had been preceded by a balance of payments crisis. It can be argued that the worst time to undertake liberalisation is in a time of crisis (Rodrik, 1992). Trade reform is meant to work by correcting distortions in relative prices, which leads to a shift in resources from import substituting activities to export activities. High and variable inflation can confound price signals, making it difficult to disentangle relative price changes from changes in the price level, thereby blunting the incentives to move resources between industries. Moreover, the slowdown in domestic activity associated with crises can exacerbate transitional unemployment associated with trade reform as resources move between sectors, increasing opposition to the reforms and increasing the likelihood of reforms being reversed. On the other hand however, a time of crisis often enables a country to undertake radical reforms that wouldn't be possible at other times[3].

The credibility of the reforms is also likely to be an important factor affecting success. There are a number of reasons why trade reforms may not be credible to private agents, many of which are discussed by Rodrik (1989b). Lack of credibility is often associated with conditions laid down by the World Bank and the IMF. In the absence of a crisis and World Bank intervention it would be clear to the private sector, that a government that undertook trade reform would

[2] Rodrik (1992) and Ocampo and Taylor (1998) provide surveys of the costs and limitations of trade liberalisation.

be committed to such reforms. In the presence of intervention from international financial institutions however, there is an incentive for governments not committed to reforms to undertake reform temporarily in order to receive funds from these institutions[4]. In this situation it is difficult for the private sector to distinguish between a government that is committed to trade reform and one that is undertaking reforms only temporarily.

Alternatively however, support from such institutions can act as an external anchor, strengthening their credibility and providing much needed finance that can alleviate the short-term costs of reform. Morrissey (1995) discusses the role of political commitment and administrative capacity and argues that if the success of the reforms is not guaranteed or if there is strong opposition to the reforms, governments may not be willing to take ownership, even if they are committed to the reforms. The presence of an outside agency, such as the World Bank and the IMF willing to take ownership, can provide the necessary commitment and credibility and enable the government to benefit from the success of the reforms, while at the same time minimising their losses if the reforms fail.

Trade reform that is met with scepticism by the private sector can in many cases lead to reforms being reversed. If the private sector does not respond to the changed incentives, which is particularly likely when there are sunk costs associated with shifting resources between import competing and export

[3] The PMC study argues that reforms undertaken in times of crisis tend to be radical and sustained. Others, such as Morrissey (1995), argue that once the crisis has passed the reforms are often reversed.
[4] A model of this kind of behaviour is presented in Rodrik (1989a).

oriented sectors, then the efficiency gains from liberalising trade will be delayed. In such a situation there will be few that gain from reform, while some will lose due to markets being lost to foreign competitors, which is likely to make it politically difficult to sustain the reforms. Moreover, if reforms are expected to be reversed, consumers will perceive that imports are currently cheap relative to the future. This will lead to substitution of consumption from the future to today, which in turn will create an increase in the current account deficit and may increase the chances of the reform being reversed. Moreover, the increase in current consumption will result in lower saving, which in turn may have a negative impact upon domestic investment and growth.

A further factor is timing and sequencing. An inappropriate timing and sequencing of trade reforms may deter the private sector from responding and can lead to reforms becoming unsustainable. The importance of these are discussed in detail by Falvey and Kim (1992) who conclude that reforms should be undertaken at times when they are most likely to succeed. For example, if macroeconomic instability is present it is desirable to initiate only those trade reforms that will directly contribute to stabilisation, such policies include the conversion of QRs to tariffs that raise revenue, but not tariff cuts that don't. They also suggest that reforms should be implemented in a way that signals commitment and ties the government's hands, making reversal difficult. A problem arises however, since it is likely that reforms have been attempted before, leaving the government with a lack of reputation. What may be needed in this case is rapid and decisive action. Mussa (1986) suggests two arguments why rapid reform is desirable; it gives strong signals to economic agents who will then respond quickly; and it does not provide opponents with time to mobilise. Rodrik (1989b) however points out that such radical reforms when undertaken on too wide a front will not be credible, since the breadth of the reform programme will create such opposition that it is likely to be reversed. He argues that credibility is increased by reforms that are "large in magnitude but narrow in scope" (p. 12). Moreover, a number of arguments can favour gradualism. Adjustment costs, particularly unemployment, are likely to be higher if reform is rapid (see Greenaway, 1993). A further argument in favour of a gradual approach is based on income distribution. A more gradual approach slows down the rate at which rents to the factors used intensively in the (post-liberalisation) unfavoured sector are reduced, which may then limit opposition to the reforms in the early stages. A gradual approach to trade reform can also be defended on the grounds that it allows governments to build up credibility through a series of small successful reforms.

Sequencing of reforms here can be important in building up a coalition of winners early on in the reform process, something described as building up political capacity (Morrissey, 1994). As an example, he describes the differing cases of Turkey and Tanzania. Turkey was quick to provide export promotion, but much slower to liberalise imports, while Tanzania liberalised imports, but did little to promote exports. The effect in Turkey was to complement the supporters of the reform and boost growth through the rapid export expansion, while in Tanzania reforms had little success and were slow in being implemented.

6.3 Evidence Linking Reforms to Openness and Growth

An issue that is very rarely systematically addressed when considering the impact of liberalisation on a country's subsequent economic performance relates to its impact on a country's openness. The reasons for this lack of interest are not clear, but are likely to relate to problems in identifying trade liberalisation, in measuring openness and in disentangling liberalisation from other policies. One of the few exceptions is Andriamananjara and Nash (1997) who examine changes in trade restrictiveness, using a variety of measures of openness. They concentrate on 88 developing countries, the majority of which were recipients of policy-based loans with significant trade policy components. They proceed to examine movements in a variety of indicators following liberalisation, which is defined as the period of the first trade related adjustment loan. They consider the change in the value of these indicators between the three years after liberalisation and the three years prior to reform. They also examine the change in the measure of openness between the latest three years for which they have data, which is usually the three years up to 1992, and the three years prior to liberalisation, in order to examine whether any movement in the measure has continued. For the countries not subject to trade related loans, they compare the change in the measure for the latest three years in the sample with the earliest three years, which is usually 1980-1982.

The sample of 88 countries is divided in to five regions; Asia, Europe, Latin America and the Caribbean, the Middle East and North Africa, and Sub-Saharan Africa. Within each region, countries are grouped as Trade-Adjustment Lending countries (TALs) or non-TALs. A large number of variables representing openness are examined; these are the Real Effective Exchange Rate (REER), the Black Market Premium (BMP), imports as a fraction of GDP, consumer imports as a percentage of imports, non-food consumer imports as a fraction of non-food imports, the tariff equivalent of import restrictions, incentives for importable production (defined as the REER plus the tariff equivalent of import restrictions), and measures based on structural models[5]. The average and median value of the change in each openness measure is calculated for each region. In general, the results using the various indicators suggest that liberalisation leads to an increase in openness, that is, the various openness measures three years after liberalisation suggest more openness than in the three years prior to liberalisation. Moreover, it would appear that openness increases further over time, that is, the results suggest that the change in openness between the latest period and the period prior to reform is greater than the change between the period following liberalisation and the period prior to it. From these results it is concluded that liberalisation has led to greater openness, with the change in openness being incremental rather than abrupt.

A further study that looks, albeit indirectly, at the impact of liberalisation on openness is that of Ben-David and Papell (1997), who examine whether the import to GDP and the export to GDP ratios have experienced a structural break in the post-war period for 48 and 47 (mainly developed) countries respectively. They use a test for structural breaks developed by Vogelsang (1994) to test for a shift in either of the trade to GDP ratios. They find that over two thirds of all

[5] Constructed using the percentage deviation of actual from predicted exports as a percentage of GDP (or, non-mineral exports per capita), where the predicted values are found using a model that has as independent variables; income per capita, total population, mineral exports and the distance to the major five export markets.

countries in the sample have experienced a structural break in the trend of either the import to GDP or the export to GDP ratios. Of these structural breaks, in over 80 percent of the cases the break had the effect of increasing the trade ratios. Moreover, the majority of the increases in the trade ratio occurred after the implementation of the Kennedy Round multilateral trade liberalisation in 1968. It would appear from these results that the general trend towards trade liberalisation in the period after 1968 did tend to lead to an upward shift in the import to GDP ratios of a number of countries. The results of Ben-David and Papell suggest that openness does indeed respond to liberalisation, although they don't try and relate the breaks in the two series to actual liberalisation episodes, possibly because of the difficulty in identifying liberalisation episodes.

Although there are relatively few studies that examine the impact of liberalisation on openness, there are a large number that examine the impact of liberalisation on growth[6]. A number of problems arise when looking to examine the impact of liberalisation on growth however that need to be mentioned. Firstly, it is not clear what the counterfactual to liberalisation should be. Should it simply be assumed that there would be a continuation of existing policies and performance in the absence of liberalisation? There may be no alternative to this, but as already mentioned many liberalisation episodes are conducted in response to a crisis, implying that existing policies and performance are not sustainable. Secondly, since most liberalisation episodes are undertaken alongside other reforms, it is not clear how to disentangle the different policies.

A number of comparative cross-country studies have been conducted; examples include Little, Scitovsky and Scott (1970), Balassa (1971), Kreuger (1978), Bhagwati (1978) and PMC (1991). According to Greenaway (1998) the results of the cross-country studies do lead to a degree of consensus regarding the impact of liberalisation, with the exception of the World Bank study of PMC. This study provides strong support for trade liberalisation[7]; liberalisation is found to result in more rapid growth of exports and GDP, while not resulting in significant transitional costs of unemployment. Greenaway summarises the conclusions of the remaining studies as follows[8]: liberalisation tends to lead to an improvement in the current account of the balance of payments and the growth of exports, although the fact that the former is greater than the latter implies that some of the improvement in the current account balance arises because of import compression; many countries appear to show an improvement in investment following liberalisation, although a significant proportion suffer an investment slump; the impact on growth may be positive or negative, but there are more cases of a positive growth effect than a negative effect. Although this suggests that some countries do suffer lower growth following liberalisation, it is not clear whether the detrimental effect would have been greater if the countries hadn't reformed.

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[6] A number of econometric studies, in particular time-series studies, were discussed in Chapter Three.
[7] A critique of these strong results is provided by Collier (1993) and Greenaway (1993).
[8] Other than the PMC study, few studies spend a great deal of time examining the impact of reform on unemployment. Krueger and Balassa argue however, that exportables are more labour-intensive than import competing goods, and as such more outward-oriented economies would be better at generating employment.

6.4 Trade Liberalisation and Openness

In this section we examine the impact of trade liberalisation on openness. The way we proceed to address this issue is to employ the model of imports developed in Chapter Four. We include in this model a number of now standard indicators of trade liberalisation, and examine the impact that the inclusion of these indicators has upon imports from the North to the South.

6.4-1 Background

Much of what has previously been written in the thesis has emphasised the importance of openness for growth, with imports of manufactured goods given particular emphasis. If liberalisation doesn't improve openness, we may expect that its benefits to growth would be muted. This then may be one of the reasons for the widely differing impact that liberalisation has been found to have on growth in different countries. A number of reasons were discussed in section 6.2 that suggest that trade liberalisation may have a different impact on openness than that anticipated, examples related to credibility, and to the timing and sequencing of reforms. If trade liberalisation is not credible, then the private sector may not respond to the resulting changed incentives. In this case we wouldn't expect any change in openness (as measured by the extent of trade) following liberalisation. Alternatively, if liberalisation is not credible and imports become temporarily cheaper, we may expect consumers to intertemporally substitute consumption from the future to now, which would initially increase imports and our measure of openness, but because of the ensuing balance of payments problems may lead to the reversal of reforms with openness falling back to pre-reform levels. Yet what has been noticed in many of the multi-country case studies is that import compression often follows trade liberalisation (see Greenaway, 1993). A potential explanation for this is that many trade reforms are undertaken in response to crises of various kinds, and usually balance of payments crises, with the World Bank and IMF offering funds if the crisis country is willing to undertake a number of reforms, including trade liberalisation. Another such reform often implemented alongside trade liberalisation is a reduction in the current account deficit of the balance of payments, which unless accompanied by rapid export growth implies that imports must fall, which would imply that openness when measured by looking at the import side of the economy would also fall.

The above discussion suggests that there a number of possible impacts of trade liberalisation on openness. Liberalisation would be expected to increase openness if the reforms are credible, but if they are not, a number of possibilities exist. Openness may not respond initially if reforms lack credibility, over time however as the reforms gain credibility the private sector is likely to respond to the changed incentives and openness would increase. Alternatively, openness may initially increase as imports are seen by the private sector to be temporarily cheap. The ensuing balance of payments crisis however may lead to reforms being reversed and openness falling again. A further possibility is that openness initially falls (when measured from the import side) as countries look to reduce balance of payments problems, but then increases after some time once such problems have been alleviated. Finally, it may be that openness doesn't respond at all to liberalisation, which is possible if reforms are not credible and this lack of credibility leads to reforms being reversed. The fact that theory suggests a number of possible effects of liberalisation on openness makes this an interesting empirical issue.

6.4-2 The Impact of Liberalisation on North-South Openness

We begin by using the measure of openness developed in Chapter Four and follow the methodology of Andrianmanajara and Nash (1997), examining the change in the measure of openness over time. We examine the change in the average value of openness between the three years prior to reform and the three years following reform. In addition, and where possible, we examine the change in the value of openness between the three years prior to reform and the last three years in the sample to examine whether any trend is evident.

To make these comparisons we need some indicator of trade liberalisation. Rather than using a single indicator we use three different liberalisation indicators, namely those of the World Bank (1993), Dean *et al* (1994) and Sachs and Warner (1995). The World Bank indicator takes the first year of a Structural Adjustment Loan (SAL) as being the first year of liberalisation. Greenaway, Morgan and Wright (1998) note that there are problems with using this definition, relating to the fact that conditions attached to such loans vary between SALs, and the required reforms may take a number of years to be implemented. The indicator of Dean *et al* is more qualitative in nature. In order to identify the year of liberalisation, they use information on average nominal tariffs, coverage of QRs, and average BMP. The final indicator of Sachs and Warner is more an indicator of openness than liberalisation, and is constructed based on five criteria[9]. The date of liberalisation using this indicator is taken as the year in which the country is first classed as open. Table 6.1 below provides details as to when the countries in the sample liberalised according to the three indicators of liberalisation[10].

Table 6.1: Number of Countries Liberalising According to Indicators Employed[11]

	World Bank	*Dean et al*	*Sachs*
Pre-1976	0	0	5
1976-1980	20	0	1
1981-1985	16	4	3
1986-1990	14	17	12
Post 1990	2	0	8
Total	**52**	**21**	**29**

What is clear from Table 6.1 is that there are differences between the indicators of liberalisation employed. Indeed, the correlation between the three indicators is not all that high (see Table A1.2 in the Data Appendix). According to the World Bank indicator all of the countries in our sample have been the subject of trade liberalisation, while according to Sachs and Warner only 31 countries have, and according to Dean *et al* less than half have been subject to liberalisation episodes. At the same time however, Table 6.1 points to the fact

[9] An economy is classed as closed if any one of the following criteria is met; average tariff rates higher than 40 percent, NTBs cover on average more than 40 percent of imports, the presence of a socialist economic system, state monopolies of major exports or a BMP in excess 20 percent in either the seventies or eighties.

[10] A problem arises here due to the fact that the measures of liberalisation are constructed for different periods and samples of countries (for example Dean *et al* only consider recent liberalisers), although the fact that the results are similar for all measures suggest that this may not be an important issue. Tables 6.15 through 6.17 in Appendix 6A list the countries that were classified as liberalising according to each measure and the period in which they liberalised.

[11] It should be noted that the three measures of liberalisation developed were developed for different time periods and samples of countries. The tables in appendix 6A list the countries and the time at which they liberalised according to each of the three measures.

that many countries sought to liberalise their trade regimes in the 1980s, although the World Bank indicator suggests that a large proportion also initiated liberalisation in the late 1970s and Sachs and Warner find that a number have liberalised since 1990.

Table 6.2: Change in the Value of Openness Following Liberalisation

	After	*Recent*
World Bank		
Average Change in *open1*	-0.014	-0.006
No. of Countries	33	26
Dean *et al*		
Average Change in *open1*	0.0003	0.025
No. of Countries	20	11
Sachs and Warner		
Average Change in *open1*	0.0003	0.05
No. of Countries	13	5

Notes: *After* refers to the change in the average value of openness between the three years prior to liberalisation and the three years following liberalisation and *Recent* refers to the change in openness between the three years prior to reform and the last three years, which is usually the three years up to 1990. The value for the last period is not calculated for those countries for which the last three periods also coincides with the three years after liberalisation, which explains why the number of countries is lower for the *Recent* than for the *After* comparison.

For those countries that liberalised their trade regime in the period 1976-1990 we examine the change in the value of the index of openness (*open1*) that we constructed in Chapter Four. We simply look at the average change in the index between the three years prior to reform and the three years after liberalisation and between the three years prior to reform and the last three years in our sample[12]. Table 6.2 reports the average changes in openness for each of the liberalisation indicators. It would appear that there has been a differential impact of liberalisation on openness according to the three indicators. According to the World Bank indicator, the average value of openness was lower immediately after liberalisation than it was prior to liberalisation, although it had recovered to some extent by the end of the period studied[13]. While according to the other two indicators of liberalisation the average value of openness was higher following liberalisation than prior to liberalisation and that openness increased further between the time of liberalisation and the end period.

The results for the World Bank indicator suggest that liberalisation has an initial negative impact upon openness, but that over time openness recovers somewhat. The results for the Dean *et al* and Sachs and Warner indicators suggest that openness increases following reform, and over time increases further, suggesting that the impact of liberalisation on openness is gradual rather than abrupt. The values of the changes in openness are small for all three indicators however and may not be significant. We therefore proceed to examine whether there is a significant relationship between the various definitions of trade liberalisation and openness, by including the indicators of liberalisation in the model developed in Chapter Four constructed to predict imports from the North. The estimating equation takes the following form.

$$IMP_{mxt} = \alpha + \beta_1 GD_{mxt} + \beta_2 RE_{mt} + \beta_3 LIB_{mt} + \varepsilon_{mt}, \qquad (6.1)$$

[12] We only report the results for *open1*, since those from using the second measure of openness, *open2*, result in essentially similar results.
[13] This may simply reflect the fact that as a part of the SAL other policies, such as reducing the deficit of the current account of the balance of payments were implemented at the same time as trade reform, and reflects a problem of disentangling different policies.

where *IMP* refers to imports (either the import volume or the import share) from country x to country m at time period t, *GD* refers to gravity determinants, *RE* refers to resource endowments, and *LIB* refers to a variable representing liberalisation, which takes the value one for all years after and including the year of trade liberalisation and zero otherwise.

The model is also extended to look at the short-run impact of trade liberalisation on imports. Here the liberalisation dummy takes the form of a dummy that takes the value 1 only in the year in which reform takes place. Also included in the model however are lags of this liberalisation dummy, which then examine the impact of reform in subsequent years, for example, the liberalisation dummy lagged once gives an estimate of the impact of trade reform on imports in the year after reform took place. The estimating equation is then of the form,

$$IMP_{mxt} = \alpha + \beta_1 GD_{mxt} + \beta_2 RE_{mt} + \beta_3 \sum_{i=0}^{3} LIB_{m,t-i} + \varepsilon_{mt}. \qquad (6.2)$$

These two equations were estimated using the same data and same techniques as those employed in Chapter Four. A random effects model was employed to estimate the equations as in Chapter Four due to the problems of including time invariant factors, such as distance, in fixed effects models[14]. The results are summarised in Tables 6.3 and 6.4 below. The majority of the variables are identical to those used in Chapter Four, with one or two additions. Firstly, *LIBDUM* is the dummy variable for liberalisation according to one of our three indicators. A positive and significant coefficient on the liberalisation variable indicates that trade liberalisation leads to an increase in imports from the North.

[14] The results of the Breusch-Pagan and Hausman tests are once again mixed regarding which specification to employ.

The other new variables are *LIB0, LIB-1, LIB-2* and *LIB-3. LIB0* is the dummy variable that takes the value one in the year of liberalisation only, *LIB-1, LIB-2* and *LIB-3* are simply lags of *LIB0,* with the variable being lagged by up to three years[15]. It is worth noting that if liberalisation increases imports, then it is also associated with higher values of our openness measure, *ceteris paribus.* The measure of openness we use is calculated as *actual / fitted.* If trade liberalisation is found to be positive and significant, this tells us that the fitted values would be lower (for liberalising countries) in the original specification than when trade liberalisation was included in the model. This implies that in the original model openness would be higher for those countries that liberalised compared with those countries that did not.

The results concerning the original variables in the model are similar to those in Chapter Four and do not need discussing any further. With the results on the liberalisation variables, we find a similar story using both trade volumes and shares, and using the three different liberalisation indicators. With the dummy variable that takes a value of one in all years after liberalisation we see that imports from the North are significantly lower following liberalisation. This result is found using all three indicators of liberalisation. The coefficient is highest for the World Bank index, suggesting that those countries that liberalised according to the World Bank indicator experienced a larger decline in imports than those that liberalised according to the other two indicators.

[15] The fact that the majority of the countries liberalised in the late eighties makes it difficult to look at lags of more than three years in our sample.

Table 6.3: Impact of Liberalisation on Import Volumes

Import Volume	*World Bank*	*World Bank*	*Dean et al*	*Dean et al*	*Sachs*	*Sachs*
Area	-0.16 (-5.23)*	-0.13 (-4.26)*	-0.15 (-4.78)*	-0.15 (-4.89)*	-0.15 (-4.84)*	-0.14 (-4.46)*
Capital	0.03 (1.23)	0.04 (1.88)***	0.02 (0.83)	0.02 (1.05)	0.04 (1.88)***	0.03 (1.43)
Prix	0.32 (13.28)*	0.38 (15.82)*	0.37 (15.45)*	0.37 (15.6)*	0.38 (15.6)*	0.37 (15.25)*
Skilled	-0.34 (-12.28)*	-0.39 (-14.38)*	-0.38 (-14.09)*	-0.38 (-14.09)*	-0.39 (-14.16)*	-0.37 (-13.67)*
Unskilled	-0.07 (-1.19)	-0.14 (-2.35)**	-0.07 (-1.16)	-0.084 (-1.4)	-0.11 (-1.75)***	-0.13 (-2.06)**
Dist	-1.06 (-13.84)*	-1.04 (-13.69)*	-1.05 (-13.65)*	-1.05 (-14.02)*	-1.03 (-13.44)*	-1.05 (-13.68)*
GDPIN	1.13 (36.39)*	1.13 (36.46)*	1.14 (36.38)*	1.14 (37.26)*	1.13 (36.29)*	1.13 (36.34)*
GDPPC	-0.12 (-2.24)**	-0.23 (-4.33)*	-0.15 (-2.83)*	-0.17 (-3.26)*	-0.21 (-3.92)*	-0.21 (-4.01)*
LockM	-0.58 (-4.29)*	-0.73 (-5.41)*	-0.66 (-4.84)*	-0.66 (-4.98)*	-0.68 (-5.05)*	-0.7 (-5.19)*
LockX	0.32 (2.4)**	0.37 (2.76)*	0.34 (2.51)**	0.35 (2.64)*	0.36 (2.69)*	0.36 (2.7)*
ComLang	0.75 (6.08)*	0.72 (5.82)*	0.73 (5.92)*	0.73 (6.06)*	0.71 (5.76)*	0.73 (5.87)*
TOT	0.003 (6.87)*	0.003 (7.89)*	0.003 (7.46)*	0.003 (7.69)*	0.003 (7.93)*	0.003 (8.36)*
LIBDUM	-0.28 (-12.56)*		-0.19 (-6.46)*		-0.14 (-3.96)*	
LIB0		-0.14 (-4.92)*		-0.3 (-6.6)*		-0.38 (-6.93)*
LIB-1		-0.19 (-6.51)*		-0.21 (-4.52)*		-0.25 (-4.34)*
LIB-2		-0.15 (-4.89)*		-0.09 (-1.7)***		-0.02 (-0.22)
LIB-3		-0.1 (-3.18)*		-0.07 (-1.04)		-0.26 (-0.31)
Constant	-30.85 (-24.05)*	-28.83 (-22.57)*	-30.51 (-23.58)*	-30.14 (-23.73)*	-29.62 (-23.08)*	-29.16 (-22.79)*
Wald Test	4334.87*	4271.5*	4195.6*	4380.8*	4168.5*	4227.7*
Breusch-Pagan	45789.9*	45304.2*	45460.7*	45425.7*	44893.7*	45159.1*
Hausman	255.5*	348.0*	282.61*	308.2*	329.8*	311.1*
Overall R^2	0.66	0.66	0.66	0.66	0.66	0.66

Note: All models are estimated using Huber/White/Sandwich robust standard errors. Values in parentheses are t-statistics. *, **, *** indicate significance at the 1, 5 and 10 percent levels respectively.

Table 6.4: Impact of Liberalisation on Import Shares

Import Share	*World Bank*	*World Bank*	*Dean et al*	*Dean et al*	*Sachs*	*Sachs*
K/Worker	-0.002	-0.001	-0.002	-0.002	-0.001	-0.002
	(-1.89)***	(-1.34)	(-2.21)**	-(2.06)**	(-1.23)	(-1.48)
Skill/Unskill	-0.25	-0.29	-0.27	-0.27	-0.28	-0.27
	(-12.7)*	(-15.29)*	(-13.58)*	(-14.01)*	(-13.8)*	(-13.65)*
Land/Worker	0.02	0.045	0.05	0.05	0.05	0.04
	(2.09)**	(4.33)*	(4.41)*	(4.3)*	(4.26)*	(4.24)*
Prix/GDP	0.22	0.28	0.27	0.27	0.28	0.27
	(8.73)*	(10.92)*	(10.73)*	(10.65)*	(10.85)*	(10.62)*
Dist	-0.069	-0.06	-0.06	-0.06	-0.06	-0.06
	(-15.65)*	(-15.65)*	(-15.56)*	(-15.71)*	(-15.59)*	(-15.65)*
GDPIN	0.028	0.027	0.028	0.028	0.027	0.027
	(28.19)*	(26.6)*	(27.26)*	(27.46)*	(26.86)*	(26.85)*
GDPPC	0.01	0.008	0.009	0.009	0.0078	0.0077
	(5.62)*	(4.19)*	(4.92)*	(4.76)*	(4.02)*	(3.97)*
LockM	-0.02	-0.03	-0.03	-0.03	-0.03	-0.03
	(-3.51)*	(-4.91)*	(-4.65)*	(-4.69)*	(-4.82)*	(-4.8)*
LockX	-0.003	-0.003	-0.003	-0.003	-0.003	-0.003
	(-0.49)	(-0.44)	(-0.45)	(-0.44)	(-0.39)	(-0.39)
Comlang	0.05	0.05	0.05	0.05	0.05	0.05
	(7.64)*	(7.46)*	(7.59)*	(7.63)*	(7.51)*	(7.53)*
TOT	0.0002	0.0002	0.0002	0.0002	0.0002	0.0001
	(9.43)*	(10.78)*	(10.27)*	(10.49)*	(11.01)*	(11.25)*
LIBDUM	-0.013		-0.0084		-0.0031	
	(-12.89)*		(-6.32)*		(-1.92)**	
LIB0		-0.007		-0.013		-0.015
		(-5.44)*		(-6.51)*		(-6.16)*
LIB-1		-0.009		-0.009		-0.01
		(-7.12)*		(-4.39)*		(-3.77)*
LIB-2		-0.007		-0.005		0.001
		(-5.26)*		(-2.21)**		(0.47)
LIB-3		-0.004		-0.0032		0.0015
		(-3.15)*		(-1.12)		(0.39)
Constant	-0.68	-0.57	-0.64	-0.63	-0.59	-0.58
	(-12.49)*	(-10.67)*	(-11.69)*	(-11.65)*	(-10.9)*	(-10.77)*
Wald Test	2277.03*	2203.9*	2129.2*	2173.6*	2104.9*	2153.0*
Bresuch-Pagan	52950.4*	52478.7*	52808.9*	52733.2*	51642.7*	52603.8*
Hausman	555.7*	504.7*	433.5*	450.7*	556.8*	467.1*
Overall R^2	0.48	0.45	0.46	0.46	0.46	0.46

Note: All models are estimated using Huber/White/Sandwich robust standard errors. Values in parentheses are t-statistics. *, **, *** indicate significance at the 1, 5 and 10 percent levels respectively.

Turning now to the results on the dummy that takes a value of 1 in the year of liberalisation only and the various lags of this dummy, it appears that there is evidence of a J-curve type effect. Imports from the North decline initially but then recover, although not reaching a level significantly higher than that prior to liberalisation even three years after liberalisation. The results for each of the liberalisation indicators are generally similar using both trade volumes and the trade share as the dependent variable.

According to the World Bank indicator, imports fall in the year of liberalisation and fall further in the first year after liberalisation. In the second year after liberalisation, imports had recovered to a level around that in the year of liberalisation. Three years after liberalisation, the coefficient on the liberalisation dummy was still negative and significant, but smaller than the coefficients from previous years, suggesting that imports had started to recover from their post-liberalisation slump. The results on the Dean *et al* indicator point to a greater initial slump in imports following liberalisation. The negative coefficient then begins to get smaller in the first and second year after liberalisation, and by the third year the coefficient was insignificantly different from zero. The initial slump in imports following liberalisation was even greater for the Sachs and Warner indicator. The recovery of imports however was also quicker according to this indicator. By the second year after liberalisation imports were insignificantly different from zero. In the case where import volumes were the dependent variable the coefficient was still negative, but where import shares were used, the coefficient had become positive. These results are suggestive therefore of a short-run negative impact of liberalisation on imports (and openness), and the implication that it may take some time before trade reforms actually increase openness (or at least imports from the North).

It is possible that the results obtained, suggesting that openness falls following trade reform could be due in part to policies other than trade liberalisation. It was noted above for example that liberalisation is often undertaken in response to a crisis, with attempts to reduce the current account deficit often undertaken alongside liberalisation. To account for policies other than trade liberalisation that could be affecting imports, we include in the above model a dummy variable that takes the value 1 for all years in which a country has a World Bank Structural Adjustment Loan (SAL). This is included to capture the impact of policies that are being undertaken simultaneously alongside trade liberalisation. The results from incorporating this variable (*SAL*) in the model predicting imports are reported in Tables 6.5 and 6.6 below. The coefficients on *SAL* are always negative and significant, suggesting that SALs and the policies undertaken as a part of them reduce imports from the North. The coefficients on the liberalisation dummies do not change in terms of sign, size or significance however, suggesting that even after controlling for policies undertaken alongside liberalisation, trade reform still results in a negative impact on imports from the North.

Table 6.5: Impact of Structural Adjustment Loans on Import Volumes

Import Volume	*World Bank*	*World Bank*	*Dean et al*	*Dean et al*	*Sachs*	*Sachs*
Area	-0.18 (-5.31)*	-0.14 (-4.42)*	-0.16 (-4.86)*	-0.16 (-4.97)*	-0.16 (-4.88)*	-0.15 (-4.48)*
Capital	0.03 (1.19)	0.04 (1.94)***	0.02 (0.75)	0.02 (1.03)	0.04 (1.93)***	0.03 (1.49)
Prix	0.34 (12.73)*	0.39 (14.97)*	0.38 (14.73)*	0.39 (14.88)*	0.39 (14.90)*	0.38 (14.52)*
Skilled	-0.37 (-12.99)*	-0.42 (-14.73)*	-0.42 (-14.68)*	-0.42 (-14.69)*	-0.42 (-14.72)*	-0.41 (-14.22)*
Unskilled	0.03 (0.45)	-0.04 (-0.72)	0.03 (0.48)	0.02 (0.25)	-0.01 (-0.20)	-0.03 (-0.51)
Dist	-1.12 (-13.58)*	-1.1 (-13.52)*	-1.11 (-13.37)*	-1.11 (-13.71)*	-1.09 (-13.13)*	-1.11 (-13.36)*
GDPIN	1.14 (36.01)*	1.15 (36.4)*	1.15 (35.91)*	1.15 (36.75)*	1.15 (35.80)*	1.15 (35.89)*
GDPPC	-0.07 (-1.18)	-0.18 (-3.27)*	-0.08 (-1.47)	-0.11 (-1.97)**	-0.15 (-2.72)*	-0.16 (-2.85)*
LockM	-0.38 (-2.74)*	-0.54 (-3.93)*	-0.47 (-3.39)*	-0.47 (-3.50)*	-0.51 (-3.65)*	-0.52 (-3.79)*
LockX	0.35 (2.52)**	0.39 (2.91)*	0.35 (2.56)*	0.36 (2.71)*	0.38 (2.77)*	0.38 (2.80)*
ComLang	0.79 (6.33)*	0.75 (6.04)*	0.76 (6.07)*	0.76 (6.20)*	0.74 (5.90)*	0.76 (6.02)*
TOT	0.002 (5.77)*	0.003 (7.10)*	0.003 (6.27)*	0.003 (6.53)*	0.03 (6.86)*	0.03 (7.33)*
LIBDUM	-0.28 (-12.15)*		-0.21 (7.12)*		-0.14 (-4.02)*	
LIB0		-0.14 (-4.65)*		-0.32 (-6.80)*		-0.38 (-6.75)*
LIB-1		-0.20 (-6.29)*		-0.23 (-4.81)*		-0.25 (-4.25)*
LIB-2		-0.17 (-5.10)*		-0.12 (-2.13)**		-0.02 (-0.23)
LIB-3		-0.11 (-3.35)*		-0.09 (-1.40)		-0.03 (0.72)
SAL	-0.21 (-2.48)**	-0.14 (-1.74)***	-0.14 (-1.62)	-0.14 (-1.71)***	-0.13 (-1.54)	-0.14 (-1.62)
Constant	-32.63 (-24.27)*	-30.74 (-23.10)*	-32.58 (-23.97)*	-32.14 (-24.09)*	-31.53 (-23.38)*	-31.05 (-23.10)*
Wald Test	4361.03*	4364.6*	4220.6*	4399.06*	4181.94*	4243.2*
Breusch-Pagan	39758.6*	39605*	39703.2*	39684.4*	39256.9*	39542.3*
Hausman	374.2*	435.2*	363.65*	398.82*	397.82*	386.3*
Overall R^2	0.68	0.67	0.68	0.68	0.67	0.68

Note: All models are estimated using Huber/White/Sandwich robust standard errors. Values in parentheses are t-statistics. *, **, *** indicate significance at the 1, 5 and 10 percent levels respectively. Data on the variable *SAL* was not available for all countries, which reduced the sample size somewhat (15049 as opposed to 16245).

Table 6.6: Impact of Structural Adjustment Loans on Import Shares

Import Share	*World Bank*	*World Bank*	*Dean et al*	*Dean et al*	*Sachs*	*Sachs*
K/Worker	-0.003 (-2.60)*	-0.002 (-1.90)***	-0.003 (-2.77)*	-0.003 (-2.62)*	-0.002 (-1.80)***	-0.002 (-2.00)**
Skill/Unskill	-0.28 (-12.94)*	-0.32 (-14.87)*	-0.29 (-13.19)*	-0.29 (-13.64)*	-0.30 (-13.49)*	-0.29 (-13.25)*
Land/Worker	0.02 (2.04)**	0.05 (4.33)*	0.05 (4.49)*	0.05 (4.44)*	0.05 (4.42)*	0.05 (4.38)*
Prix/GDP	0.25 (9.06)*	0.30 (10.95)*	0.30 (10.94)*	0.30 (10.88)*	0.31 (11.07)*	0.30 (10.83)*
Dist	-0.06 (-14.34)*	-0.06 (-14.25)*	-0.06 (-14.21)*	-0.06 (-14.32)*	-0.06 (-14.25)*	-0.06 (-14.31)*
GDPIN	0.03 (28.69)*	0.03 (27.40)*	0.03 (27.82)*	0.03 (27.99)*	0.03 (27.53)*	0.03 (27.56)*
GDPPC	0.01 (4.41)*	0.006 (2.70)*	0.008 (3.66)*	0.008 (3.45)*	0.006 (2.71)*	0.006 (2.62)*
LockM	-0.01 (-1.81)***	-0.02 (-3.31)*	-0.02 (-3.11)*	-0.02 (-3.16)*	-0.02 (-3.31)*	-0.02 (-3.28)*
LockX	0.001 (0.11)	0.002 (0.24)	0.001 (0.16)	0.001 (0.19)	0.002 (0.25)	0.002 (0.27)
Comlang	0.05 (7.48)*	0.05 (7.22)*	0.05 (7.34)*	0.05 (7.38)*	0.05 (7.29)*	0.05 (7.32)*
TOT	0.0001 (7.98)*	0.0002 (9.60)*	0.0002 (8.88)*	0.0002 (9.09)*	0.0002 (9.71)*	0.0002 (9.93)*
LIBDUM	-0.013 (-12.58)*		-0.009 (-6.41)*		-0.002 (-1.43)	
LIB0		-0.008 (-5.40)*		-0.014 (-6.51)*		-0.015 (-5.90)*
LIB-1		-0.01 (-7.10)*		-0.01 (-4.44)*		-0.009 (-3.55)*
LIB-2		-0.008 (-5.58)*		-0.006 (-2.32)**		0.002 (0.61)
LIB-3		-0.005 (-3.42)*		-0.003 (-1.17)		0.002 (0.47)
SAL	-0.02 (-3.99)*	-0.015 (-3.58)*	-0.015 (-3.45)*	-0.015 (-3.52)*	-0.015 (-3.51)*	-0.015 (-3.52)*
Constant	-0.78 (-13.36)*	-0.68 (-11.68)*	-0.74 (-12.62)*	-0.73 (-12.56)*	-0.69 (-11.88)*	-0.68 (-11.77)*
Wald Test	2251.05*	2184.07*	2104.9*	2145.31*	2086.26*	2134.6*
Bresuch-Pagan	47780.3*	47670.9*	47914.9*	47644.1*	46561.8*	47657.6*
Hausman	452.5*	386.84*	335.4*	347.75*	446.03*	365.1*
Overall R^2	0.50	0.48	0.49	0.49	0.48	0.49

Note: All models are estimated using Huber/White/Sandwich robust standard errors. Values in parentheses are t-statistics. *, **, *** indicate significance at the 1, 5 and 10 percent levels respectively. Data on the variable *SAL* was not available for all countries, which reduced the sample size somewhat (15049 as opposed to 16245).

6.5 Trade Liberalisation and Economic Growth

In previous chapters we have shown that openness is good for growth, now we wish to examine whether a movement from one level of openness to a higher level of openness results in such gains.

6.5-1 Estimation

Our approach is to extend the work of Greenaway, Morgan and Wright (GMW) (1998) who address this issue using panel data techniques. They estimate a standard growth equation with investment, population growth, initial per capita GDP, initial human capital and a terms of trade variable included as explanatory variables. To these variables they add a dummy variable representing liberalisation, employing the same three indicators of liberalisation used above. The equation they estimate therefore is,

$$\Delta \ln y_{it} = \beta_1 \ln y_{i,65} + \beta_2 SECSCH_{i,65} + \beta_3 \Delta \ln TTI_{it} + \beta_4 \Delta \ln POP_{it} + \beta_5 \left(\frac{INV}{GDP}\right)_{it} + \beta_6 LIB_{it} + \Delta\varepsilon_{it}, \quad (6.3)$$

where y_{it} is per capita GDP, $y_{i,65}$ is the 1965 level of per capita GDP, $SECSCH_{i,65}$ is the 1965 level of secondary school enrolment, *TTI* is the terms of trade index, *POP* is population, *INV/GDP* is the ratio of gross domestic investment to GDP, and *LIB* is a dummy variable capturing trade liberalisation. The liberalisation dummy is included in the ways discussed above, taking a value one in all years after and including liberalisation in one specification, and taking a value of one only in the year of liberalisation in another, but with lags also included. They argue that specifications such as this may be dynamically mis-specified, and specify a second estimating equation,

$$\Delta \ln y_{it} = \alpha \Delta \ln y_{i,t-1} + \beta_1 \ln y_{i,65} + \beta_2 SECSCH_{i,65} + \beta_3 \Delta \ln TTI_{it} + \beta_4 \Delta \ln POP_{it} + \beta_5 \left(\frac{INV}{GDP} \right)_{it} + \beta_6 LIB_{it} + \Delta \varepsilon_{it}, \qquad (6.4)$$

where $y_{i,t-1}$ are lags of per capita GDP. The main advantage of this equation over the previous one is that it models growth in a dynamic context, thereby allowing liberalisation to have both a short-run and long-run impact.

Introducing a lagged dependent variable as an explanatory variable creates a number of problems due to the fact that the lagged dependent variable and the error term are correlated rendering standard estimators of panel data biased[16]. The way they proceed to estimate the equation therefore is to follow the technique of Arellano and Bond (1991), which makes use of the fact that lags of the dependent variable two periods or more are valid instruments for the lagged dependent variable. Both of the above equations were estimated using annual data between 1975 and 1993, for up to 73 developed and developing countries, depending upon the definition of liberalisation employed. The results they obtained suggested the presence of a J-curve type effect, whereby growth initially falls but subsequently rises.

Alongside the variables employed by GMW we include a measure of openness. Equations (6.3) and (6.4) therefore are augmented with one of the measures of openness developed in Chapter Four to give the following two estimating equations,

[16] These and related problems of dynamic panel data are discussed in greater detail in the econometrics appendix at the end of the thesis.

$$\Delta \ln y_{it} = \beta_1 \ln y_{i,65} + \beta_2 SECSCH_{i,65} + \beta_3 \Delta \ln TTI_{it} + \beta_4 \Delta \ln POP_{it} + \beta_5 \left(\frac{INV}{GDP}\right)_{it} + \beta_6 LIB_{it} + \beta_7 open_{it} + \Delta\varepsilon_{it}, \tag{6.5}$$

and

$$\Delta \ln y_{it} = \alpha \Delta \ln y_{i,t-1} + \beta_1 \ln y_{i,65} + \beta_2 SECSCH_{i,65} + \beta_3 \Delta \ln TTI_{it} + \beta_4 \Delta \ln POP_{it} + \beta_5 \left(\frac{INV}{GDP}\right)_{it} + \beta_6 LIB_{it} + \beta_7 open_{it} + \Delta\varepsilon_{it}, \tag{6.6}$$

where *Open* is one of the two measures of openness developed in Chapter Four. In addition to this change, we include male and female initial schooling (*Syrm65* and *Syrf65*) separately[17]. Once again the liberalisation dummy is included in the two ways described above.

We have shown previously in this chapter that liberalisation has had a tendency to reduce imports and openness (to imports) at least in the short-run, and argued that a J-curve type relationship may exist between liberalisation and openness. Similarly we have also shown in Chapter Four that openness (to imports from the North) positively affects growth in our sample of countries. An interesting question to address therefore is whether the J-curve type relationship found between liberalisation and growth by GMW is caused by the short-run negative impact of liberalisation on openness, or whether liberalisation has an impact upon growth through other channels, examples being both domestic and foreign investment.

[17] We included total schooling rather than male and female schooling separately and found the coefficient to be insignificant, a result in line with previous chapters.

Finding a positive and significant coefficient on openness would lead us to infer that liberalisation has a negative impact upon growth, at least in the short-run, through its impact on openness. If in addition, we find that the relationship between liberalisation (and the various lags) and growth found by GMW disappears when openness is included, we can infer that the J-curve type relationship they obtain arises because of the impact of liberalisation on openness. If however, we still find a relationship between the liberalisation dummy and growth, then we have to infer that liberalisation also has an impact on growth through factors other than openness.

6.5-2 Static Panel Results

We begin by reporting the results from the static panel model in tables 6.7 through 6.10 before considering the changes when the model is specified dynamically. For the dynamic panel model we lose one cross-section from first differencing and another three from the instrumentation process, implying that the estimation period runs from 1980 to 1990. In order to compare the results from the static and dynamic models we use the same sample for both models. The equations are estimated on our full sample of 52 developing countries giving a total of 572 observations.

Turning first of all to the results on the core variables in Table 6.7, most are of the expected sign and tend to be significant. Investment (*AnnInv*) is found to be positive and significant, while initial GDP (*GDP65*) is negative and significant. Initial male schooling (*SyrM65*) is positive and significant, while initial female schooling (*SyrF65*) is negative, but insignificant, a result found previously.

Population growth (*DPOP*) is negative and significant as expected, but the coefficient on the change in the terms of trade (*DTTI*) is not significant, although it is positive. These results generally confirm those of GMW, although they often find the terms of trade coefficient to be significant[18]. The size of the coefficients on many of the variables differ from GMW to some extent however. This is likely to reflect the fact that the more advanced countries in their sample have been excluded from our sample.

Table 6.7: Impact of Liberalisation on Growth

DGDPPC	*1*	*2*	*3*	*4*
GDP65	-0.014 (-4.98)*	-0.014 (-4.65)*	-0.014 (-4.8)*	-0.015 (-5.60)*
AnnInv	0.16 (3.69)*	0.16 (3.63)*	0.15 (3.75)*	0.15 (3.72)*
SyrF65	-0.009 (-0.53)	-0.009 (-0.50)	-0.011 (-0.67)	0.003 (0.2)
SyrM65	0.02 (1.83)***	0.02 (1.65)***	0.02 (1.93)***	0.01 (0.93)
DPOP	-0.98 (-1.76)***	-1.01 (-1.69)***	-1.01 (-1.84)***	-0.77 (-1.42)
DTTI	0.004 (0.15)	0.003 (0.11)	0.005 (0.18)	0.004 (0.14)
WB		0.004 (0.68)		
DEAN			0.01 (2.21)**	
SACHS				0.02 (6.54)*
Constant	0.08 (3.82)*	0.07 (3.56)*	0.07 (3.70)*	0.07 (4.05)*
Wald Stat	57.51*	56.97*	75.41*	158.02*
1st-order serial correlation	2.96*	2.89*	2.86*	2.69*
2nd order serial correlation	0.62	0.63	0.4	-0.09

Note: All models are estimated using Huber/White/Sandwich robust standard errors. Values in parentheses are t-statistics. *, **, *** indicate significance at the 1, 5 and 10 percent levels respectively.

[18] The other difference being that they include total schooling, rather than female and male

When we consider the liberalisation variables, the results also support those of GMW although the size of the coefficients differ somewhat. The results suggest that trade liberalisation results in significantly higher growth. The coefficient on the World Bank indicator suggests that liberalisation increases per capita growth by 0.4 percent, but this is not statistically significant. The coefficients on the Dean *et al* and Sachs and Warner variable are significant however and suggest that liberalisation increases per capita growth by 1.4 percent and 2.3 percent respectively.

Table 6.8 reports the same set of results, but now we include liberalisation as a dummy taking the value one in the year of liberalisation only, but including lags. The results on the core variables are similar to those reported above, while the results on the liberalisation variable and the various lags are similar to those of GMW. Using the World Bank indicator we obtain a negative / positive / positive arrangement of signs on the liberalisation variable. Growth falls in the year of liberalisation, but then recovers in the following year and remains positive in the second year after liberalisation, although none of the coefficients are significant. When we use the Sachs and Warner indicator a negative / positive / positive relationship is also found, although once again the coefficients are insignificant. The coefficients on the Dean *et al* variable however suggests that there is no initial drop in growth following liberalisation, with all the coefficients being positive[19], although only significant in the second year after liberalisation.

schooling separately, and find it to be significant.

Table 6.8: Short-Run Impact of Liberalisation on Growth

DGDPPC	*WB*	*DEAN*	*SACHS*
GDP65	-0.014 (-4.98)*	-0.014 (-4.79)*	-0.015 (-5.03)*
AnnInv	0.16 (3.67)*	0.16 (3.72)*	0.16 (3.58)*
SyrF65	-0.01 (-0.54)	-0.01 (-0.55)	-0.01 (-0.51)*
SyrM65	0.02 (1.85)***	0.02 (1.83)***	0.02 (1.77)***
DPOP	-0.99 (-1.76)***	-1.01 (-1.82)***	-0.97 (-1.74)***
DTTI	0.004 (0.13)	0.005 (0.19)	0.005 (0.17)
Lib0	-0.002 (-0.34)	0.004 (0.42)	-0.002 (-0.14)
Lib-1	0.006 (0.64)	0.01 (0.99)	0.016 (1.26)
Lib-2	0.004 (0.56)	0.02 (3.24)*	0.01 (0.85)
Constant	0.07 (3.90)*	0.07 (3.73)*	0.08 (3.87)*
Wald Stat	80.58*	111.34*	68.76*
1st order serial correlation	2.94*	2.92*	2.90*
2nd order serial correlation	0.56	0.43	0.50

Note: All models are estimated using Huber/White/Sandwich robust standard errors. Values in parentheses are t-statistics. *, **, *** indicate significance at the 1, 5 and 10 percent levels respectively.

[19] The results of GMW point to an initial drop in growth following liberalisation, although the coefficient is not significant.

Table 6.9: Augmenting Standard Regression with *open1*

DGDPPC	*WB*	*WB*	*DEAN*	*DEAN*	*SACHS*	*SACHS*
GDP65	-0.012 (-3.7)*	-0.012 (-3.88)*	-0.011 (-3.68)*	-0.011 (-3.71)*	-0.013 (-4.52)*	-0.012 (-3.85)*
AnnInv	0.14 (2.95)*	0.14 (2.98)*	0.14 (3.04)*	0.14 (3.03)*	0.13 (3.04)*	0.14 (2.95)*
SyrF65	-0.02 (-1.1)	-0.02 (-1.16)	-0.02 (-1.35)	-0.02 (-1.18)	-0.01 (-0.45)	-0.02 (-1.10)
SyrM65	0.02 (1.65)***	0.02 (1.86)***	0.02 (1.96)**	0.02 (1.84)***	0.01 (0.89)	0.02 (1.77)***
DPOP	-1.13 (-2.07)**	-1.11 (-2.16)*	-1.14 (-2.27)**	-1.13 (-2.24)**	-0.88 (-1.80)***	-1.09 (-2.13)**
DTTI	0.004 (0.15)	0.005 (0.18)	0.006 (0.23)	0.006 (0.23)	0.005 (0.18)	0.006 (0.21)
LIB	0.004 (0.64)		0.014 (2.26)**		0.022 (6.52)*	
LIBO		-0.002 (-0.32)		0.005 (0.46)		0.00003 (0.003)
LIB-1		0.006 (0.63)		0.009 (0.99)		0.016 (1.39)
LIB-2		0.005 (0.63)		0.022 (3.24)*		0.0099 (0.83)
open1	0.07 (2.16)**	0.07 (2.23)**	0.07 (2.32)**	0.07 (2.25)**	0.06 (2.13)**	0.07 (2.24)**
Constant	-0.003 (-0.064)	-0.002 (-0.04)	-0.006 (-0.15)	-0.003 (-0.07)	0.005 (0.12)	-0.0012 (-0.028)
Wald Stat	100.41*	116.05*	118.71*	224.12*	208.76*	100.97*
1st order serial correlation	2.94*	2.98*	2.88*	2.94*	2.72*	2.94*
2nd order serial correlation	0.64	0.56	0.36	0.40	-0.15	0.49

Note: All models are estimated using Huber/White/Sandwich robust standard errors. Values in parentheses are t-statistics. *, **, *** indicate significance at the 1, 5 and 10 percent levels respectively.

Table 6.10: Augmenting Standard Regression with *open2*

DGDPPC	*WB*	*WB*	*DEAN*	*DEAN*	*SACHS*	*SACHS*
GDP65	-0.013	-0.013	-0.012	-0.013	-0.014	-0.013
	(-3.97)*	(-4.12)*	(-3.92)*	(-3.96)*	(-4.84)*	(-4.12)*
AnnInv	0.15	0.15	0.15	0.15	0.14	0.15
	(3.32)*	(3.37)*	(3.41)*	(3.41)*	(3.45)*	(3.30)*
SyrF65	-0.02	-0.02	-0.02	-0.02	-0.01	-0.02
	(-0.94)	(-1.01)	(-1.24)	(-1.04)	(-0.24)	(-0.94)
SyrM65	0.02	0.03	0.02	0.02	0.01	0.03
	(1.82)***	(2.05)**	(2.16)**	(2.02)**	(1.08)	(1.95)***
DPOP	-1.06	-1.05	-1.08	-1.07	-0.82	-1.02
	(-1.87)***	(-1.96)**	(-2.08)**	(-2.04)**	(-1.59)	(-1.94)**
DTTI	0.004	0.004	0.006	0.006	0.004	0.005
	(0.13)	(0.15)	(0.2)	(0.21)	(0.15)	(0.19)
LIB	0.003		0.014		0.022	
	(0.51)		(2.38)**		(6.74)*	
LIBO		-0.002		0.005		-0.001
		(-0.27)		(0.52)		(-0.099)
LIB-1		0.007		0.01		0.015
		(0.71)		(1.05)		(1.3)
LIB-2		0.005		0.023		0.009
		(0.66)		(3.38)*		(0.79)
open2	0.04	0.04	0.04	0.04	0.03	0.04
	(1.32)	(1.52)	(1.65)***	(1.53)	(1.17)	(1.43)
Constant	0.03	0.03	0.03	0.03	0.04	0.04
	(0.93)	(0.93)	(0.72)	(0.84)	(1.21)	(0.95)
Wald Stat	83.77*	98.80*	98.98*	171.96*	180.96*	85.18*
1st order serial correlation	2.95*	2.98*	2.89*	2.95*	2.73*	2.95*
2nd order serial correlation	0.66	0.59	0.39	0.43	-0.09	0.52

Note: All models are estimated using Huber/White/Sandwich robust standard errors. Values in parentheses are t-statistics. *, **, *** indicate significance at the 1, 5 and 10 percent levels respectively.

Tables 6.9 and 6.10 report the results after augmenting the model with our measures of openness. Including openness has little impact on the sign and significance of the core variables in the model. Moreover the liberalisation variable (*LIB*) is still found to be positive and significant using the Dean *et al* and the Sachs and Warner indicator. The results concerning the short-run impact of liberalisation are similar to those reported above, although the coefficient on the liberalisation variable in the year of liberalisation is now positive for the

Sachs and Warner indicator. The coefficients on openness however are always positive, and for *open1* at least, tend to be significant[20]. The results suggest that there is a role for openness in the model, in addition to trade liberalisation.

The results from the static model suggest that liberalisation has a positive and significant impact upon growth. This is true for all of the liberalisation indicators employed, except the World Bank indicator, which is positive but insignificant. It is difficult to reach any strong conclusions concerning the short-run impact of liberalisation on growth. The World Bank and the Sachs and Warner indicator tend to suggest the presence of a J-curve relationship between liberalisation and growth, although the coefficients are not significant, while the Dean *et al* indicator suggests there is no initial drop in growth, with a positive and significant impact of liberalisation found two years after liberalisation.

The results of including openness in the model are mixed, but for *open1* at least suggest that growth is positively and significantly related to openness. This implies that the level of openness is important for growth, in addition to the impact of liberalisation. We showed in the previous section that liberalisation reduces openness, at least in the short-run. Given that openness positively affects growth, we can infer that liberalisation has a negative indirect impact upon growth (at least in the short-run) through its impact upon openness. Introducing openness into the model does not change the sign or significance of

[20] In general the results on the openness measure are not as strong as those reported in Chapter Four. As mentioned in Chapter Four the model of imports was better at explaining the cross-section variation in imports compared to the time-series variation. This chapter uses annual data and thus increases the time-series component of the data when compared with Chapter Four, which used three five-year averages. Given that the measure of openness is not as good as

the coefficients on liberalisation however. The coefficients on the Dean *et al* and Sachs and Warner indicators suggest that liberalisation significantly increases growth, both when openness is included and excluded from the model. This leads us to conclude that although liberalisation affects growth through openness, it is also affecting growth positively through other channels.

6.5-3 Dynamic Panel Results

The dynamic model is estimated using the Generalised Methods of Moments estimator of Arellano and Bond (1991). Details of this technique are provided in the econometrics appendix. Essentially it involves utilising lags of the dependent variable of period two years or further as instruments for the dependent variable. The consistency of this estimator requires the lack of second order serial correlation and the validity of the instrument set. These are tested for using a robust test for second order serial correlation and the Sargan test of the validity of the instruments. The results from the dynamic model are reported in Tables 6.11 through 6.13. The results reported are the two-stage estimates, with the number of lags of the dependent variable included being the number that it takes to eliminate second order serial correlation.

accounting for the time-series variation in openness we might expect less significant coefficients using annual data than five-year averages.

Table 6.11: Short-Run Impact of Liberalisation in the Dynamic Model

DGDPPC	*WB*	*DEAN*	*SACHS*
GDP-1	0.24	0.20	0.26
	(3.31)*	(2.69)*	(4.29)*
GDP-2	-0.07	-0.03	-0.05
	(-2.24)**	(-1.13)	(-2.11)**
GDP-3	-0.01		-0.04
	(-0.56)		(-1.69)***
GDP65	0.0009	0.004	-0.001
	(0.27)	(0.80)	(-0.31)
AnnInv	0.04	0.07	0.11
	(0.74)	(1.29)	(1.77)***
SyrF65	-0.11	-0.01	-0.09
	(-3.70)*	(-3.12)*	(-2.77)*
SyrM65	0.11	0.09	0.1
	(4.60)*	(3.52)*	(4.16)*
DPOP	0.13	-0.24	0.45
	(0.29)	(-0.42)	(1.03)
DTTI	0.07	0.08	0.09
	(3.47)*	(3.95)*	(3.86)*
LIBO	-0.03	-0.02	-0.01
	(-1.32)	(-0.87)	(-0.46)
LIB-1	0.01	0.02	0.04
	(1.01)	(1.37)	(2.34)**
LIB-2	0.05	0.05	0.05
	(3.14)*	(3.24)*	(2.45)**
Constant	-0.04	-0.05	-0.04
	(-2.45)*	(-2.13)**	(-1.92)***
Wald Stat	117.74*	139.58*	225.72*
Sargan Test	36.70	34.51	36.58
1st order serial correlation	1.63	1.49	1.16
2nd order serial correlation	1.60	1.17	1.44

Note: All models are estimated using Huber/White/Sandwich robust standard errors. Values in parentheses are t-statistics. *, **, *** indicate significance at the 1, 5 and 10 percent levels respectively.

In Table 6.11, we see that modelling growth dynamically has a number of effects on the core variables in our model. Firstly, initial GDP and population growth are insignificant and often not of the *a-priori* expected sign[21]. Similarly,

[21] This goes against the results of GMW who find all variables to be significant. The difference may simply reflect the fact that we have excluded a number of the more advanced countries from our sample.

in two of the three cases investment becomes insignificant. The terms of trade index now becomes positive and significant as expected however, and the female schooling rate, which was previously insignificant is now negative and significant. Turning to the liberalisation variables, we see that for all three indicators there is consistently the presence of J-curve type effects. Growth falls in the year of liberalisation, although the coefficient is not significant, but then rises in the year after liberalisation and rises further still in the second year after liberalisation, with the coefficient always being significant two years after liberalisation.

In Tables 6.12 and 6.13 we include openness. There are few changes to the core variables and to the coefficients on liberalisation. In particular, the J-curve relationship between growth and the three liberalisation indicators remains. Concentrating on the openness indicators themselves, we find a consistent story, which is that the coefficient on openness is generally positive, but never significant. The reasons for the lack of significance when the model is dynamically specified are not clear, but the correlation between the lags of GDP and the openness measures are not that high (see Table A1.5 in the Data Appendix), suggesting that it is not a problem of multicollinearity. Moreover, the fact that openness is not significant even when liberalisation is excluded from the model (*NO LIB*) implies that it is not the liberalisation indicators themselves that are making the openness variable insignificant.

Table 6.12: Including *open1* in the Dynamic Model

DGDPPC	*NO LIB*	*WB*	*DEAN*	*SACHS*
GDP-1	0.23 (3.89)*	0.18 (2.28)**	0.19 (2.63)*	0.25 (4.24)*
GDP-2	-0.04 (-1.56)	-0.08 (-2.47)**	-0.03 (-1.09)	-0.06 (-2.16)**
GDP-3		-0.03 (-1.03)		-0.04 (-1.69)***
GDP65	0.003 (0.66)	0.002 (0.45)	0.003 (0.49)	-0.001 (-0.19)
AnnInv	0.09 (1.71)***	0.01 (1.9)***	0.08 (1.34)	0.10 (1.68)***
SyrF65	-0.1 (-3.18)*	-0.1 (-3.89)*	-0.01 (-2.72)*	-0.1 (-2.75)*
SyrM65	0.09 (3.98)*	0.1 (4.30)*	0.09 (3.45)*	0.1 (4.10)*
DPOP	-0.1 (-0.23)	-0.3 (-0.55)	-0.2 (-0.31)	0.5 (1.12)
DTTI	0.07 (3.48)*	0.06 (2.57)*	0.08 (3.91)*	0.09 (3.78)*
LIB0		-0.02 (-1.24)	-0.02 (-0.99)	-0.01 (-0.43)
LIB-1		0.02 (1.78)***	0.02 (1.39)	0.04 (2.16)**
LIB-2		0.05 (2.68)*	0.05 (3.26)*	0.05 (2.48)**
open1	0.05 (0.79)	0.06 (0.94)	-0.02 (-0.22)	0.03 (0.42)
Constant	-0.09 (-1.28)	-0.10 (-1.34)	-0.03 (-0.40)	-0.07 (-1.01)
Wald Stat	251.94*	158.76*	133.47*	227.85*
Sargan Test	39.65	38.22	34.54	36.31
1st order serial correlation	1.32	1.28	1.50	1.22
2nd order serial correlation	1.27	1.01	1.08	1.53

Note: All models are estimated using Huber/White/Sandwich robust standard errors. Values in parentheses are t-statistics. *, **, *** indicate significance at the 1, 5 and 10 percent levels respectively.

Table 6.13: Including *open2* in the Dynamic Model

DGDPPC	*NO LIB*	*WB*	*DEAN*	*SACHS*
GDP-1	0.24 (4.09)*	0.18 (2.40)**	0.18 (2.38)**	0.25 (4.24)*
GDP-2	-0.04 (-1.75)***	-0.08 (-2.36)**	-0.03 (-0.96)	-0.06 (-2.16)**
GDP-3		-0.04 (-1.32)		-0.04 (-1.68)***
GDP65	0.002 (0.43)	0.0001 (0.036)	0.005 (0.96)	-0.001 (-0.18)
AnnInv	0.1 (2.06)**	0.11 (2.09)**	0.07 (1.16)	0.1 (1.65)***
SyrF65	-0.1 (-3.55)*	-0.11 (-4.04)*	-0.1 (-3.15)*	-0.1 (-2.79)*
SyrM65	0.08 (4.09)*	0.1 (4.16)*	0.09 (3.47)*	0.1 (4.19)*
DPOP	-0.18 (-0.39)	-0.37 (-0.72)	-0.28 (-0.48)	0.40 (0.90)
DTTI	0.06 (3.25)*	0.06 (2.55)*	0.08 (3.98)*	0.08 (3.39)*
LIB0		-0.02 (-1.78)***	-0.02 (-0.83)	-0.01 (-0.49)
LIB-1		0.02 (1.51)	0.02 (1.28)	0.03 (1.91)***
LIB-2		0.06 (2.88)*	0.05 (3.30)*	0.05 (2.46)**
open2	0.04 (0.80)	0.05 (1.02)	0.04 (0.64)	0.03 (0.57)
Constant	-0.08 (-1.40)	-0.08 (-1.47)	-0.09 (-1.40)	-0.08 (-1.21)
Wald Stat	253.88*	172.99*	139.69*	226.07*
Sargan Test	40.07	38.47	34.08	36.26
1st order serial correlation	1.04	1.21	1.52	1.15
2nd order serial correlation	1.08	0.73	1.06	1.47

Note: All models are estimated using Huber/White/Sandwich robust standard errors. Values in parentheses are t-statistics. *, **, *** indicate significance at the 1, 5 and 10 percent levels respectively.

The implication of this set of results is that liberalisation has an impact on growth, with the presence of a J-curve relationship confirmed using the three indicators of liberalisation employed by GMW. The results suggest that immediately following liberalisation growth falls, but then recovers and is significantly higher than pre-reform levels either one or two years after liberalisation. Using the results from Tables 6.9, 6.10 and 6.11 it is possible to estimate the long-run contribution of liberalisation to GDP per capita, using the formula $\sum \beta_i /(1-\sum \alpha_i)$, where β_i are the coefficients on the reform variables and α_i are the coefficients on the lagged dependent variables. The estimated long-run impact of liberalisation for the various liberalisation indicators is reported in Table 6.14 below.

Table 6.14: Estimated Long-Run Impact of Liberalisation on per capita GDP growth

	WB	*DEAN*	*SACHS*
Without Openness	0.018	0.07	0.09
open1	0.06	0.07	0.09
open2	0.06	0.07	0.08

Table 6.14 shows that liberalisation according to the three indicators of liberalisation employed by GMW would lead to a long-run increase in the growth of GDP per capita of between 2 percent (for the World Bank indicator when openness is excluded) and 9 percent (for the Sachs and Warner indicator when openness is excluded)[22]. The impact is biggest for the Sachs and Warner indicator, which is also the case for the GMW results, although the value is much lower here than in their results. The reason for the relatively large value on the Sachs and Warner indicator according to GMW is that it is more a measure of openness than liberalisation.

[22] Caution should be used when interpreting these figures given that we are only using data for three years to estimate the impact of liberalisation on growth in the long-run. We would maybe

The results from the dynamic model suggest that liberalisation has an impact upon growth through various channels. They also suggest however that openness is not significantly related to growth. This has the further implication that liberalisation doesn't impact on growth through its impact on openness. The results are in contrast to the results from the static model, which showed that openness does affect growth, and that liberalisation therefore has an indirect impact upon growth through its impact on openness. The results from this section therefore do not support the view that there exists a separate role for openness alongside liberalisation in our model.

6.6 Concluding Remarks

In this chapter we have addressed two important issues regarding the role of trade liberalisation. Firstly, the impact that liberalisation has upon openness, and secondly its impact on growth. While the second of these questions has been widely addressed elsewhere, this is not the case for the first. We began the chapter by discussing the possible benefits that liberalisation can have upon openness and growth, as well as highlighting some of the problems that may reduce its impact.

We proceeded to examine the impact of trade reforms on our measure of openness. Initially, this was achieved simply by examining the change in openness before and after liberalisation. A more formal approach followed, whereby we included indicators of liberalisation in an econometric model designed to predict imports from the North. The results from the simple

expect that the figures reported are better at predicting growth for the next 5 to 10 years rather comparison seemed to suggest that openness tended to be higher immediately following liberalisation and tended to increase further over time. This was the case for all of the indicators of liberalisation except for that of the World Bank. The results from the econometric model were unambiguous and suggested the opposite. They suggested that openness was significantly lower following reform than prior to it, this was the case even after including a variable that was intended to capture other policies implemented at the same time as liberalisation. There was evidence however to suggest that this may only be a short-term phenomenon, with openness falling significantly immediately following reform, but then recovering somewhat. It may be that in the long-run openness does indeed increase, but with the limited span of our data this could not be shown.

The second half of the chapter examined the impact of trade liberalisation on economic growth, building upon work by Greenaway, Morgan and Wright (1998), who had previously found evidence of a J-curve relationship between trade reform and growth. The main hypothesis we tested was whether this J-curve relationship simply reflected the short-run negative impact of liberalisation on openness that we had found, or whether there were other forces at work driving this relationship. To achieve this we estimated a standard growth equation, including our measure of openness alongside indicators of trade liberalisation. The equation was estimated using both static and dynamic panel data techniques. The static results suggested that openness was important for growth, and that as such liberalisation had a short-run negative impact

than the next 30 or 40 years.

through its impact on openness. It was also the case however, that the J-curve relationship found by GMW often remained, implying that liberalisation also has an impact on growth through other channels.

When the model was estimated dynamically, the results were less supportive of a relationship between openness and growth, with positive but insignificant coefficients found on the openness variable. In contrast to the static results, this suggested that openness wasn't important for growth and also that liberalisation didn't affect growth through its impact on openness. We were still able to show however that a J-curve relationship between liberalisation and growth remained, implying that trade liberalisation in the long-run is good for growth. We were able to compute that liberalisation could lead to a long-run increase in GDP per capita of between 2 and 9 percent depending upon the liberalisation indicator employed. An issue that arises from these latter results is, how does liberalisation affect growth? The dynamic results suggest that it is not through increased openness (to imports from the North), but through other channels. An interesting avenue for future research therefore, is in understanding the channels through which liberalisation affects growth, likely candidates include aid and FDI, but possibly also the reallocation of resources and other forms of openness.

Appendix 6A: Liberalisers According to the Three Measures of Liberalisation

Table 6.15: Countries Liberalising According to the World Bank Liberalisation Measure

Pre-1976	1976-1980	1981-1985	1986-1990	Post-1990
	Kenya	Ghana	Algeria	El Salvador
	Sierra Leone	Malawi	Cameroon	India
	South Africa	Mauritius	Central African Republic	
	Sudan	Senegal	Niger	
	Zimbabwe	Togo	Tunisia	
	Dominican Republic	Zambia	Zaire	
	Guatemala	Costa Rica	Honduras	
	Haiti	Jamaica	Mexico	
	Bolivia	Panama	Trinidad and Tobago	
	Ecuador	Brazil	Argentina	
	Nicaragua	Chile	Uruguay	
	Paraguay	Colombia	Venezuela	
	Peru	Guyana	Bangladesh	
	Myanmar	Korea	Indonesia	
	Israel	Pakistan		
	Kuwait	Thailand		
	Malaysia			
	Philippines			
	Sri Lanka			
	Malta			

Table 6.16: Countries Liberalising According to the Dean *et al* Liberalisation Measure[23]

Pre-1976	1976-1980	1981-1985	1986-1990	Post-1990
		Costa Rica	Cameroon	
		Mexico	Ghana	
		Chile	Kenya	
		Colombia	Malawi	
			Senegal	
			South Africa	
			Argentina	
			Brazil	
			Peru	
			Venezuela	
			Indonesia	
			Korea	
			Malaysia	
			Pakistan	
			Philippines	
			Sri Lanka	
			Thailand	

Table 6.17: Countries Liberalising According to the Sachs and Warner Liberalisation Measure

Pre-1976	1976-1980	1981-1985	1986-1990	Post-1990
Mauritius	Chile	Ghana	Tunisia	South Africa
Indonesia		Bolivia	Uganda	Honduras
Korea		Israel	Costa Rica	Nicaragua
Malaysia			El Salvador	Argentina
Thailand			Jamaica	Brazil
			Mexico	Peru
			Guyana	Uruguay
			Paraguay	Sri Lanka
			Venezuela	
			Colombia	
			Israel	
			Philippines	

[23] This is likely to be the most troubling measure of liberalisation since it only considers liberalisation for 32 countries since the mid-eighties. The fact that the results in this chapter are similar regardless of the measure used suggests however that the problem of different samples is not likely to be large.

Chapter Seven

Summary and Conclusions

Chapter Seven

SUMMARY AND CONCLUSIONS

7.1 Introduction

In this final chapter we provide an overview of the thesis and a summary of the results obtained. From these results various conclusions concerning the role of trade and trade liberalisation in the growth process of developing countries are drawn. The chapter concludes by highlighting a number of avenues for future research.

The aim of this thesis was to examine the impact of trade and trade liberalisation on economic growth in a sample of developing economies. The research is intended to identify channels through which the potential benefits of trade occur. This is addressed by examining and testing the implications of the new or endogenous theories of growth, which highlight a number of sources of growth. Trade by impacting upon these sources would be expected to affect growth. The thesis concentrates on North-South trade, since it is expected that it is through trade with more developed countries that developing countries gain access to advanced knowledge, technologies and products, which can then influence economic growth.

The importance of international trade to countries in both the developed and developing world has been increasing steadily since the end of the Second World War. This in itself provides a rationale for examining the impact of trade in developing countries, who have tended to be less willing to liberalise their trade regimes than developed countries. There are however a number of trade-related issues of potential interest. For example, the impact of trade on poverty, the environment, and interactions between technology and trade. There remain however many reasons for focusing on trade and growth. Firstly, much of the existing empirical evidence precedes the new growth theories. Secondly, the measures of openness used in this literature, of which there are many, often do not relate to the channels through which trade should benefit countries in terms of improved growth.

The remainder of this chapter is organised as follows. In section 7.2 we provide an overview of the thesis, the methods employed and results obtained. Using this we provide some concluding remarks concerning the role of trade in the growth process in section 7.3. This section also provides a number of caveats to and shortcomings of the research. Finally, in section 7.4 we outline a number of avenues for possible further research.

7.2 Overview

In Chapter One we argued that despite the vast theoretical and empirical literature built up over many years, there still exists considerable controversy over the role of trade in the growth process. This was achieved by considering the various theories used to link trade to growth through time and by briefly examining the empirical literature on the openness-growth debate.

The chapter began with a brief overview of the traditional arguments in favour of trade, predicated on the concept of comparative advantage. However, while trade according to these arguments should raise the level of income they provide no role for trade in the growth process. By contrast endogenous theories of growth, which future chapters addressed more fully, suggest that trade can be beneficial to growth by allowing the importation of capital and intermediate goods and through the diffusion of knowledge across borders. The models do not create the certainty however that a more open trade regime will always result in higher growth; examples exist whereby countries could have lower growth rates following trade liberalisation. Trade is likely to be detrimental to a country's growth rate if knowledge does not flow freely across borders, or if trade leads to specialisation in technologically backward sectors, a result that may have important implications for developing countries. A brief discussion of the empirical evidence noted that the evidence that had amassed concerning the trade-growth relationship in general supported the notion that openness to trade boosts growth. It was also noted however that a number of problems with the empirical evidence have been highlighted, relating to the statistical techniques used and the measures of openness employed.

In Chapter Two, the existing theoretical literature linking trade to growth was examined. It began by examining the neoclassical model of growth, in which trade and trade reform did not affect the long-run growth rate. The model did however provide a foundation for examining the new theories of growth. These emphasise a number of determinants of growth; capital accumulation, human capital accumulation through both education and learning by doing, and technological progress through innovation. In these models an externality associated with one of these activities provides the source of long-run growth. The implication is that long-run growth can be affected by policy, with trade policy being one such policy.

When trade was introduced into the new growth models it was shown that a diversity of results could be obtained; trade liberalisation may increase, retard or leave growth unaffected. The impact of trade on growth in these models depends upon a number of factors. These include the assumptions made about the country, for example, its resource endowments, the extent to which knowledge flows across countries and upon the source of growth that the model assumes. Trade for example, would be expected to increase growth if spillovers occur across countries and if a country is well endowed with resources that are used intensively in the sectors in which spillovers occur. The results of the theory however do not support the view that trade liberalisation is a panacea, other conditions need to be in place for countries to benefit from trade in terms of higher growth. In particular, factors that can affect a country's resource endowments will be important, with investment and human capital accumulation helping countries benefit from trade.

Chapter Three summarised the results of the empirical literature that has built up examining the relationship between trade, trade liberalisation and growth. Initially this involved describing the numerous measures of openness and trade liberalisation that have been developed, partly in response to the difficulty in identifying trade liberalisation episodes and in defining what is actually meant by openness. Measures of openness based on average tariffs and the coverage of non-tariff barriers, the volume of trade, structural adjusted trade measures and various measures of distortions in exchange rates and relative prices were discussed. It was noted that the fact that these different measures tend not to be highly correlated is one of the main reasons why there is still a great deal of controversy over the empirical evidence.

The chapter also described the results of a number of studies that use these measures to examine the relationship between openness and growth. We noted that in general, cross-country studies of the trade-growth relationship tend to find evidence that countries that are more open to trade have higher growth. Such evidence is not always found in time-series data however. A number of studies using time-series data, often using export growth as a measure of openness, find little evidence for a positive relationship between trade and growth. Where evidence of a statistical relationship between trade and growth is found, it is often the case that growth causes trade, rather than trade causing growth. Panel data studies have found that a number of openness measures impact significantly on growth, but others however are found not to. Other studies consider the impact of trade liberalisation on growth, often looking at time-series data for a small number of countries. The results of these studies tend to be mixed. This may not be such a surprising result since the theoretical literature suggests that not all countries will benefit from liberalisation. The emerging panel data evidence on the relationship between trade liberalisation and growth has suggested the possibility of a J-curve relationship, with growth initially falling following liberalisation, but then rising above the pre-liberalisation rate.

Chapter Four examined the role of trade, and in particular the role of North-South trade in manufactured goods. Many existing measures of openness predate the new growth theories and are often not directly related to the channels through which theory would suggest openness could affect growth. New growth theories highlight imports of capital and intermediates and the diffusion of technology across borders as key channels. Thus, it could be expected that trade with the North would benefit countries in the South, since Northern countries have historically produced the majority of capital and intermediate goods, and who through their R&D expenditures are the major producers of new knowledge.

To examine the role of North-South trade in goods we constructed a measure of openness to imports of manufactures from the North for our sample of countries in the South. The overall aim was to examine whether those countries that are more open to imports from the North benefit in terms of higher growth. Openness was measured as the ratio of the observed level of imports from the North to the predicted level of imports. The latter was obtained from an empirical model. This model assumed that imports from the North to the South could be largely explained by the resource endowments of countries in the South and various geographical or gravity determinants.

This measure of openness was included in an empirical growth model. The coefficient on openness was found to be quite large, positive and significant, suggesting that those countries that are more open to imports from the North benefit in terms of higher growth. This result tended to be robust to the inclusion of a large number of variables and to the removal of outliers from our sample. The estimated coefficients suggested that an increase in openness by one standard deviation could increase growth by between 0.4 and 0.8 percent, depending upon the model estimated.

The role of openness to North-South trade and its impact on growth was again the subject of Chapter Five. In this chapter however, we shifted our focus to the impact that knowledge produced in the North had upon growth in the South, and the role of goods trade in this relationship. It has long been thought that developing countries can catch up with more advanced countries through importing advanced technologies. Indeed, this is the explanation often used for the inclusion of a catch-up term in growth regressions, a variable that tends to be significant in such regressions. Moreover, the role of knowledge in the growth process is one of the central features of the new growth theories. In one strand of this literature growth occurs through R&D expenditure. R&D provides an economy with either a wider variety of products or with improvements in the quality of products. In addition, it enhances the stock of available knowledge used in R&D, which raises the productivity of future innovation. In an international context, trade is likely to embody knowledge produced abroad and can increase the rate of domestic innovation and enhance growth. In addition, imports of foreign knowledge may also encourage imitation, which may enhance growth.

An empirical literature has begun to emerge examining the role of knowledge spillovers in the growth process. We follow this literature and construct knowledge stocks for a number of the more advanced economies using cumulative past R&D expenditures. The access of developing countries to the knowledge stocks of these advanced economies is assumed to depend upon the extent of trade between the developing and the developed economies. The constructed knowledge stocks are weighted by various measures of either the level of trade or the level of openness between the developed and developing economies in our sample to take account of this assumption.

We proceeded to construct a number of different specifications for the trade-weighted foreign knowledge stocks to test the robustness of the results and examine various hypotheses. We included these foreign knowledge variables in a model of growth for our sample of countries and found that the results in favour of significant growth promoting foreign knowledge spillovers were not strong. Although evidence in favour of such spillovers was found in a number of cases, the results tend not to be robust, particularly to the inclusion of regional dummy variables, which suggests the possibility of a regional dimension to knowledge spillovers. We found evidence in favour of foreign knowledge spillovers both when the knowledge stocks were weighted by measures of the level of trade and the level of openness. The only time we were not able to find evidence of foreign knowledge spillovers was when the knowledge stock was weighted by a measure of the distribution of trade. We also found some limited evidence to show that there may exist a non-linear relationship between the knowledge stock weighted by the level of openness and the extent of foreign knowledge spillovers. These results suggested that low levels of openness result in positive foreign knowledge spillovers, but that an increase in openness from initially a relatively high level doesn't result in increased spillovers. It has been suggested that education should be an important factor in allowing countries to be better able to make use of imported knowledge. The results we obtained however were not supportive of a role for education in facilitating knowledge spillovers, although this may reflect the high correlation between the education weighted knowledge spillover term and other measures of schooling in the model. Indeed, the coefficients on the schooling variables were jointly significant, suggesting that education is important for growth.

Chapter Six moved away from examining the impact of openness that had been the concern of the previous two chapters and considered the impact of trade liberalisation. Although previous chapters found some support for the notion that countries that are more open to international trade benefit in terms of higher growth there are a number of reasons why countries that undergo trade liberalisation may not enjoy the benefits suggested by the relationship found between openness and growth. These include a lack of credibility, the inappropriate timing and sequencing, and the weak implementation of reforms.

As a first step we examined the impact that liberalisation has had upon the measure of openness we constructed in Chapter Four, and upon imports from the North, employing the model we used to predict imports. We employed three previously used measures of liberalisation. A simple examination of the change in our measure of openness suggested that openness tended to be higher following liberalisation, and tended to increase over time. The results of including the liberalisation measures in the empirical model of imports however, suggested that openness was significantly lower following liberalisation than prior to reform. This was true even after attempting to control for other policies undertaken alongside liberalisation that may affect the level of imports. The results indicated that this might only be a temporary reduction however, suggesting the possibility of a J-curve relationship between liberalisation and openness. The short time span between the dates of liberalisation and the end of the sample period precluded us from examining whether in the long-run liberalisation did increase openness to goods from the North.

We then moved on to examine the impact of liberalisation on growth by extending the work of Greenaway, Morgan and Wright (1998). These authors had previously found the possibility of a J-curve relationship between liberalisation and growth, with growth initially falling following reform, but then increasing. We followed their methodology including sequentially a number of measures of liberalisation in a model of growth, and estimating the model using both static and dynamic panel data techniques. In addition to the variables included by GMW, we included a measure of openness alongside the liberalisation measure, to investigate whether the J-curve relationship found by them was being driven by the J-curve relationship that we had found between liberalisation and openness, or whether liberalisation was impacting upon growth through channels other than openness.

The results we obtained were mixed, depending upon whether the model was estimated dynamically or statically. Both the static and dynamic results suggested the presence of a J-curve relationship between liberalisation and growth, whether openness was included in the model or not, suggesting that liberalisation was impacting upon growth through other channels, in addition to any impact it was having through openness. The results on openness differed depending upon how the model was specified. The results from the static model generally suggested that openness is positively related to growth, suggesting that liberalisation has an indirect negative impact through openness, at least in the short-run. The results from the dynamic model however suggested that openness does not affect growth, leaving us with the result that liberalisation doesn't affect growth through its impact on openness, but through other channels. The results on openness tended to be less significant in this chapter when compared with Chapter Four. This it was argued was because of the use of annual data in this chapter as opposed to three five-year averages in Chapter Four. Given that the model of openness is not as good as measuring the time-series as compared with the cross-section variation, we would that the coefficients wouldn't be as significant when the time-series component of the data increases by a multiple of five.

7.3 Conclusions

This thesis aimed to improve upon many existing studies of openness, liberalisation and growth. There are at least two major differences in this study when compared with the majority of others. Firstly, it concentrates on imports as opposed to exports, total trade or some other measure of openness. This emphasis is driven by the new theories of growth that emphasise knowledge accumulation. Imports by providing access to the knowledge and technology of other countries should be expected to enhance growth. This is likely to be particularly important for developing countries that tend not to produce new knowledge or technology themselves. Secondly, the thesis concentrates on North-South trade, that is imports from the North to the South. Such imports should involve inflows of more technologically advanced goods than would trade between developing countries, particularly technologically advanced capital and intermediate goods, than from trade with other developing countries.

One contribution the thesis makes is to develop a new measure of openness. Inevitably this has some shortcomings. One is the possibility of omitted variables from the model predicting trade. Leamer in his study measuring openness for 185 different commodities noted that the impact of tastes and history, both missing from his model and ours, may explain much of the observed openness for individual products. The exclusion of tastes in our model may not be such a large problem, since we are looking at aggregated data, whereas Leamer considered much more disaggregated data. Leamer used net exports in order to measure openness; history can play a role here where an industry develops in a country that it wouldn't be expected to according to the country's measured resource endowments. In this case such a country would be classed as much more open in this industry than would be expected from considering resource endowments alone. A further role of history may also be important however, where countries in the South import a lot from particular countries in the North, due to such things as past colonial links. In this case such a country would be classed as far more open to goods from its old colonial power than would be expected given resource endowments and geographic factors. This is not likely to be an important omitted variable because the inclusion of the common language dummy is likely to capture this, since many colonial powers passed their language on to their colonies.

A further omitted variable that may be important is internal transport costs. External transport costs were accounted for to a large extent through the inclusion of the various gravity determinants, but there was nothing in our model that accounted for differences in infrastructure within countries, largely due to a lack of data on for example length of paved roads, length of railways and extent of telecommunications. The importance of not including a measure of internal infrastructure arises because it has been shown elsewhere (for example Bougheas *et al*, 1999) that a poor internal infrastructure can hinder a country's trade. If this is an important omitted variable then we would expect that countries that have relatively good internal infrastructure would be classed as more open according to our model, since they would trade more than would be expected. It could be argued that such countries that have invested in internal infrastructure are indeed more open to trade. This would imply however that the measure of openness developed is not a measure of trade policy *per se*, but an indicator of how a countries policies (past and present) in general impact upon trade.

For our sample of countries, we found evidence in favour of foreign knowledge spillovers, the results tend not to bė robust however. A lack of robustness need not be an important issue in this context. We expect the extent of foreign knowledge spillovers to be dependent upon a large number of factors, finding out that the spillover variable becomes insignificant when other variables are included can provide insights in to the factors that facilitate spillovers. In the models estimated however, we often found that the spillover variables were becoming insignificant when regional dummies were included, implying that spillovers have a regional component. Such dummies are included in models to take account of factors that are specific to individual regions, but little is known about what these factors are. Research in to understanding what these variables are capturing may well provide insights in to the factors that facilitate foreign knowledge spillovers.

A number of hypotheses were tested relating to the importance of the level of trade, to whether the relationship between spillovers and growth was linear or non-linear and to the role of education in facilitating knowledge spillovers. The results did not provide strong answers to many of these questions. We noted in Chapter Five that theory suggests that a movement from autarky to openness should result in positive knowledge spillovers, with the level of trade being unimportant. We also discussed reasons why the level of trade may well be important in facilitating spillovers however. We constructed specifications of the foreign knowledge variable that depend upon the distribution of trade, the level of trade and the degree of openness. We found evidence to suggest that both the level of trade and the degree of openness are important in facilitating spillovers, but that the distribution isn't. Given that this last specification doesn't depend upon the level of trade and given the high correlation between openness and the level of trade, it is reasonable to conclude that the level of trade is important in facilitating knowledge spillovers. The results we obtained also supported the possibility of a non-linear relationship between growth and the foreign knowledge spillover variables that were weighted by measures of openness. These results suggested that there were positive and significant growth promoting spillovers at low levels of openness, but not at higher levels. It was argued that a possible explanation for this is that an increase in openness at low levels of openness results in a large increase in imports and therefore spillovers, but that an increase in openness from an initially high level may not result in significantly higher levels of imports.

The results we obtained didn't provide evidence to suggest that education is important in facilitating knowledge spillovers (a result similar to that of Coe, Helpman and Hoffmaister, 1997). This may simply reflect the fact that there is a high correlation between the education weighted foreign knowledge stock and the education terms and the trade weighted knowledge stocks. Indeed removing the education terms did result in education being important in facilitating spillovers. The results however still do not provide strong support for the importance of education in facilitating spillovers. One rationale for this may be that the benefits from foreign knowledge are dependent upon a large number of factors, with education being just one of these. In which case we may not expect a variable that assumes that education is the only important factor to be significant.

The primary aim of foreign knowledge studies, such as that in Chapter Five is to test for knowledge spillovers, that is, the extent to which the foreign R&D stock spills over to the domestic economy, enlarging the total stock of knowledge used as a public input into domestic manufacturing and thereby raising productivity and growth. There is nothing inherent in the estimation that captures an essential property of this process however, namely the use and take-up of foreign knowledge by domestic manufactures and innovators. Without this it seems impossible to rule out a range of alternative interpretations of the results. For example, they may be driven by a higher foreign knowledge stock boosting foreign growth, yielding growth in demand for exports from developing countries and a consequent rise in the growth rate of GDP per capita. Alternative examples include technology imitation, technology transfer via foreign investment, and institutional reform and cultural change.

The fact that the results suggest that openness to the North is significantly and robustly related to growth, but that spillovers of foreign knowledge are not strongly associated with higher growth may seem troubling. It is quite plausible however that openness is good for growth, but that knowledge spillovers have only a limited impact upon growth. Using a piece of machinery imported from the North, even if it is new and innovative is easier than implementing and using the results of another firms R&D in ones innovation process. If this is the case we may expect that North-South trade would be beneficial by allowing the importation of machinery and intermediates for developing countries, but that imports of knowledge may be less so, unless the country has the relevant policies and infrastructure in place to take advantage of such spillovers.

The final part of the thesis addressed the role of trade liberalisation in promoting both growth and openness to goods from the North. This is important for a number of reasons, not least because of the increasing prevalence of liberalisation, often in response to pressure from international financial institutions. Moreover, it is important to examine whether trade liberalisation has brought about the benefits in terms of growth that we would expect given the results obtained concerning the impact of openness on growth. If liberalisation hasn't delivered such benefits, could it be because imports haven't responded to reforms?

The results consistently show that no matter how liberalisation is measured, growth is higher following liberalisation than prior to it, although the difference is not always statistically significant. The results also show however that in the short-run growth may well be lower than prior to reform. These short-run costs in terms of growth, when combined with other short-term costs such as unemployment may have important implications for the sustainability of reforms.

Although we can show that liberalisation has a positive impact on growth, at least in the long-run, we cannot show the same for its impact on openness to imports from the North. In general, the results suggest that imports from the North and openness are significantly lower following liberalisation than prior to it, although some of this is likely to reflect policies other than liberalisation, such as macroeconomic stabilisation. We are again able to show however, that this decline may to some extent only be a short-run phenomenon, with the evidence showing that imports and openness begin to rise towards their pre-reform level after some years. Combining this result with those from earlier chapters suggest that liberalisation may have an additional impact on growth, at least in the short-run, through its negative impact on openness.

The role of openness found in previous chapters was challenged by results from our dynamic model of growth. In the static models we were able to show that openness to imports from the North was significantly related to growth. Such results suggested two things; firstly, that openness to imports from the North is good for growth in the South and secondly that liberalisation may have a negative impact in the short-run, through its negative impact upon openness. In the dynamic model however, no significant relationship between openness and growth was found, implying that openness did not affect growth, and indeed that liberalisation, although affecting growth through other channels, did not have an impact upon growth through its impact on openness.

The results concerning the impact of liberalisation on both openness and growth that were found suffer from the problem that at the same time as liberalisation is undertaken, so too are other policies. This implies that the results concerning the changes in openness and growth that are found to occur at the time of liberalisation cannot be linked solely to trade liberalisation with certainty. Although we do try to control for other policies, in particular macroeconomic stabilisation policies, when we estimate the impact of liberalisation on openness, it is not clear whether all such policies are being accounted for.

A further issue relates to the identification of trade liberalisation. It was noted throughout the thesis that measuring liberalisation and openness is by no means an easy task. Since, the correlation between the three different liberalisation measures is not high this could lead one to question which is a good measure of liberalisation. The fact however, that the results on both openness and growth appear to be similar regardless of the measure of liberalisation used may imply that this is not too great a problem.

The results concerning the impact of openness on growth in the static and dynamic models are also interesting. Why, in general, do we find evidence of a positive impact of openness on growth in the static, but not in the dynamic model? This is unlikely to reflect problems of multicollinearity between openness and the lags of GDP per capita, since the correlation between the two is not high. Moreover, it is not because the impact of openness on growth is being captured by the liberalisation variable, since the openness variable is found to be insignificant when the liberalisation variable is excluded. In addition, the fact that the liberalisation dummy variables are significant, suggesting a positive long-run impact of liberalisation on growth and a deterioration in the short-run may not be that helpful. Ideally, we would like to know through which channels liberalisation impacts upon economic growth. For example, we were not able to show that the poor growth performance immediately following liberalisation was caused by the reduction in openness (at least in the dynamic model). This leaves us with the question of what causes growth to decline in the short-run.

Overall, what do the results from the thesis tell us about the relationship between North-South trade and growth? Firstly, they suggest that developing countries that are more open to trade with the North enjoy higher growth rates than those that are relatively closed. This has the implication therefore that developing countries should benefit (at least in terms of growth) if they liberalise their trade regimes. Openness to trade with the North provides benefits through the importation of more advanced capital and intermediate goods and through the diffusion of technology.

The results also suggest that knowledge spillovers are important for growth, with the level of trade being important in facilitating such spillovers. The results also point to other factors however, that facilitate knowledge spillovers. The results of Chapter Five do not provide any firm conclusions as to what these other factors are and more research is needed to identify them. It is likely though that investment in education, social capability and infrastructure are important. Education for example, enables people to better take advantage of imported technology and will also shift a country's comparative advantage towards goods in which technological advance takes place.

Trade liberalisation was shown to provide long-term benefits, but also short-term costs, which may have implications for the sustainability of reforms. In the short-run, both openness and growth were lower following liberalisation. Such results allow for the possibility that opposition to reforms in the early stages of liberalisation may be strong, which can lead to reforms being reversed. To the extent that openness to imports from the North is an important source of growth, we would expect that such a decline in openness following liberalisation would be bad for growth. Moreover, the initial reduction in growth following reform and the likely consequences of higher unemployment may undermine the long-run success of reforms and lead to them being reversed. This may lead to a justification for foreign assistance (e.g. from the IMF and World Bank) at least in the short-run, which can help alleviate some of the problems associated with lower growth and help fill the gap in imports from the North that facilitate growth.

7.4 Suggestions for Future Research

In this section we provide a number of avenues for future research that may be worthwhile. Obviously the area of trade and growth is huge and we could list numerous possible avenues for future research. We try to limit our suggestions, drawing upon the various results of the thesis that we consider to be potentially fruitful avenues for future research.

The measure of openness developed in Chapter Four can be considered an advance over some previous measures since it emphasises the role of imports and also the role of what we expect to be imports of more advanced goods and technologies. A number of problems with the measure developed have been identified however. The most important of these is the possibility of omitted variables in our model predicting trade flows. One possible avenue for future research then is to see if different measures of openness that emphasise the same channels as ours result in similar results to ours. One possibility is to look at tariffs on imports of particular goods that may be considered to embody advanced technology. Research by Lee (1993, 1995) is along these lines, but there is scope for further research here.

A further extension of Chapter Four would be to use more disaggregated trade data, in the hope of finding out what kind of imports generate growth. In Chapter Four we estimate openness to imports of Northern manufactures. It would be possible to estimate openness to imports of goods at the two-digit level for example, or openness at some other level of aggregation, such as primary products, intermediate and capital goods.

The importance of services in international trade has also increased a great deal. We excluded services from our analysis, taking a strict interpretation of the new growth theories and concentrating on manufactures that are more likely to represent imports of capital, intermediates and advanced technology. Given the increased prevalence of service trade however, it may be worthwhile examining the importance that service trade has upon growth and the effect that service trade has had upon the impact of manufactured trade on growth.

Similarly, Rodriguez and Rodrik (1999) suggest that it may be important to look at the impact of openness on growth for different samples of countries. For example, they suggest differentiating between high income and low income countries, small and large countries, and countries with a comparative advantage in primary products and those with an advantage in manufacturing goods, and examining the impact of openness on growth in these sub-samples. This is a further possibility in extending the use of the measure of openness developed in Chapter Four.

It has been suggested that factors other than trade are important in facilitating foreign knowledge spillovers. This is the argument put forward to explain the different results concerning the importance of foreign knowledge spillovers often found in cross-section and panel data studies. The argument being that country dummies included in panel data studies are picking up factors that help facilitate knowledge spillovers. One avenue for future research therefore, is in understanding the factors that facilitate knowledge spillovers. We suggested a number of possible factors facilitating these; social capability, the level and composition of trade, FDI, the presence of a domestic R&D sector and the presence or absence of a system of legally sanctioned property rights. In Chapter Five we concentrated on the role of trade in facilitating knowledge spillovers, it would be possible however to examine other factors that may be important in facilitating spillovers.

One way for research to proceed therefore is to go beyond aggregate studies of knowledge spillovers. More conclusive results may be found by looking at more disaggregated data, such as sectoral and firm-level data. A greater understanding of the mechanisms through which spillovers occur is likely to be aided by such studies. Some already look at sectoral data, such as that by Keller (2000), but there remains scope for further research in this area.

Alternatively, it may be worth considering some properties of the recipient country. For example, it may be that the production specialisation of some small countries is less suited to the absorption of technology. If a recipient country is either producing goods that use high-tech inputs or has its own R&D sector then spillovers may be more likely than for an economy that is primarily agricultural. A simple test of this hypothesis would be to look for differences between countries that have a primarily agricultural production base and those with a strong manufacturing base. Since R&D tends to be concentrated in manufacturing it may be expected that spillovers are less effective in those countries with little manufacturing. An alternative approach that side steps the difficulties in interpreting econometric results with such aggregated data would be a case study approach. In principle for example, it would be possible to examine the impact of knowledge spillovers due to the opening of trade in some well-defined region such as China's coastal provinces, possibly using firm level data.

There is also a lack of research on other forms of knowledge diffusion, many of which could affect or be affected by the role of trade. The 1999 World Development Report identifies a number of possible channels for knowledge diffusion. These include trade, FDI, migration and technology licensing, but also such things as electronic interchange. Evidence has begun to emerge suggesting that spillovers of knowledge through FDI may provide important benefits for developing countries (see for example Xu and Wang, 2000), but there is no such evidence for other channels of diffusion. One channel that is becoming increasingly important is electronic interchange; research identifying the impacts of such interchange on knowledge diffusion would be particularly worthwhile. A related line of research may look at the impact this has had on the role of trade as a conduit for knowledge diffusion; with the increasing importance of electronic interchange, has the role of trade as a conduit diminished?

As a first extension of Chapter Six and when the data becomes readily available it would be useful to extend the dataset beyond 1990. Many of the countries in the sample liberalised in the mid to late eighties. Extending the dataset would allow us to test whether openness is indeed negatively affected by liberalisation in the long-run, or if over time imports and openness respond positively to liberalisation.

We examined whether liberalisation affected growth through its impact on openness to imports from the North. Although we found some limited evidence to suggest that it may, liberalisation was still having a significant effect through other channels. A further extension therefore would be to examine the other channels through which liberalisation affects growth. The most promising candidate is likely to be investment, which has also been shown in many of the cross-country studies of liberalisation to suffer a slump following liberalisation.

One way to proceed therefore would be to model investment and then examine the importance of liberalisation on this variable.

It was suggested above that although openness is found to be positively related to growth, the benefits may not be fully appropriable without the existence of other supporting policies. Recently this argument has become quite widely accepted, yet there is very little evidence trying to identify what these supporting policies should be. It is often suggested that such things as investment in infrastructure and human capital, the maintenance of the rule of law, domestic competition policy and macroeconomic stability are all important supporting policies that should be in place to benefit fully from openness, but there is no evidence identifying which of these policies are most important. There is therefore a fertile area for research in identifying the supporting policies that may help countries get the most from openness.

Data Appendix

DATA APPENDIX

A1.1 Introduction

This appendix provides details on the sample of developing countries and the data used in the thesis, including information regarding the construction of the variables and the sources of the data. Section A1.2 lists the sample of countries, while section A1.3 lists the variable names used throughout the thesis and provides details on their construction and data sources. Finally, tables showing the correlations between the various variables are provided.

A1.2 Country Sample

Table A1.1 below classifies the country sample according to income level and regional location. This table is followed by a list of the countries used in the sample.

Table A1.1: Classification of Countries by Location and Income Level

	Low Income	Lower-Middle Income	Upper-Middle Income	High Income	**Total**
East Asia	1	3	1	0	**5**
Latin America	2	16	4	0	**22**
Sub-Saharan Africa	10	4	1	0	**15**
Other	5	1	2	2	**10**
Total	**18**	**24**	**8**	**2**	**52**

Notes: The classification according to income was based on the 1990 World Development Report; the last year in our sample.
The two high-income countries in the sample are Israel and Kuwait.
The ten 'Other' countries are located as follows; 2 in North Africa, 1 in Europe and 7 in Asia.

The sample of 52 developing countries used throughout the thesis is the following,

1. Algeria
2. Cameroon
3. Central African Republic
4. Ghana
5. Kenya
6. Malawi
7. Mauritius
8. Niger
9. Senegal
10. Sierra Leone
11. South Africa
12. Sudan
13. Togo
14. Tunisia
15. Zaire
16. Zambia
17. Zimbabwe
18. Costa Rica
19. Dominican Republic
20. El Salvador
21. Guatemala
22. Haiti
23. Honduras
24. Jamaica
25. Mexico
26. Nicaragua
27. Panama
28. Trinidad and Tobago
29. Argentina
30. Bolivia
31. Brazil
32. Chile
33. Colombia
34. Ecuador
35. Guyana
36. Paraguay
37. Peru
38. Uruguay
39. Venezuela
40. Bangladesh
41. Myanmar
42. India
43. Indonesia
44. Israel
45. Korea
46. Kuwait
47. Malaysia
48. Pakistan
49. Philippines
50. Sri Lanka
51. Thailand
52. Malta

The choice of countries for our sample of developing countries was largely dictated to us by data availability. In Chapter Six for example we looked to replicate the results of Greenaway, Morgan and Wright (1998). As such we were restricted to the developing countries in their sample. Despite this the sample of countries seems to be a representative sample with countries from all regions of the world, both countries that have liberalised and those that have not, both large and small countries (in terms of population and area), and both rich and poor countries. At the same time however, it must be noted that certain interesting cases have been omitted, examples being China, Tanzania and Turkey.

A1.3 Variable Names, Definitions and Sources

Variable Name	*Description*	*Source*
AnnInv	Annual ratio of Investment to GDP (logged value)	*GMW 1998*
Area	Area of importer in square miles (logged value)	*BL 1994a and CIA 1998*
Avgrow	Five-year average of GDP per capita	*SH*
Capital	Real value of the capital stock (in logs). Constructed assuming a 15-year average life of assets	*GMW 1998*
Civlib	Measure of civil liberties. Index between 1 and 7 (1 greatest political rights)	*BL 1994a*
ComLang	Dummy variable taking the value 1 if the importer and exporter share a common language	*Haveman*
Dean et al (DEAN)	Dummy variable taking the value 1 in all the years after and including the year of liberalisation according to Dean *et al* (1994)	*GMW 1998*
DEAS	Dummy variable taking the value 1 if the country is in East Asia	*BL 1994*
Dist	Great circle distance between capital cities in Miles (logged value)	*Haveman*
DLAT	Dummy variable taking the value 1 if the country is in Latin America	*BL 1994*
DSSA	Dummy variable taking the value 1 if the country is in Sub-Saharan Africa	*BL 1994*
DGDPPC	Logged change in the annual level of GDP per capita	*GMW 1998*
DPOP	Log of the annual change in population	*GMW 1998*
DTTI	Change in the Terms of Trade of the Importing Country	*GMW 1998*

GDPIN	Real GDP of the importer and exporter interacted (logged value)	*SH*
GDPPC	Real per capita GDP of the importer and exporter interacted (logged value)	*SH*
GDP65	Real value of GDP per capita in 1965 (logged value)	*GMW 1998*
Gov't	Real Government share of GDP (%)	*SH*
Import Share	Share of manufacturing imports from each Northern country in GDP (logged value)	*OECD and SH*
Import Volume	Real value of total manufacturing imports from each Northern country (logged value)	*OECD*
Inflation	Annual rate of price increase	*SH*
InitGDP	Real value of GDP per capita in 1976 (logged value)	*SH*
Inv	Five-year average of investment in constant dollars (logged value)	*GMW 1998*
K/Worker	Value of capital per worker (logged value)	*Own Calculations*
Land/Worker	Ratio of area to the labour force	*Own Calculations*
LockM	Dummy variable taking the value 1 if the importer is landlocked	*Haveman*
LockX	Dummy variable taking the value 1 if the exporter is landlocked	*Haveman*
Labour	Number of people in the workforce of the importing country (logged value)	*GMW 1998*
Polrit	Measure of political rights. Index between 1 and 7 (1 greatest political rights)	*BL 1994a*
PopGrow	Annual rate of population growth	*BL 1994a*
Prix	Real value of primary exports of the importing country	*WB*

Prix/GDP	The share of primary exports in GDP	*Own Calculations*
PyrF	Average years of primary schooling in the female population	*BL 2000*
PyrM	Average years of primary schooling in the male population	*BL 2000*
Sachs and Warner (SACHS)	Dummy variable taking the value 1 in all the years after and including the year of liberalisation according to Sachs and Warner (1995)	*GMW 1998*
Skilled	Proxy for the stock of skilled labour (logged value). Percentage of people over 25 with higher education multiplied by the labour force	*BL 1994a and GMW 1998*
Skill/Unskill	Ratio of skilled to unskilled labour	*Own Calculations*
SyrF	Average years of secondary schooling in the female population	*BL 2000*
SyrF65	Average years of secondary schooling in the female population in 1965	*BL 2000*
SyrM	Average years of secondary schooling in the male population	*BL 2000*
SyrM65	Average years of secondary schooling in the male population in 1965	*BL 2000*
Unskilled	Proxy for unskilled labour (logged value). Equal to *Labour* minus *Skilled*	*Own Calculations*
World Bank (WB)	Dummy variable taking the value 1 in all the years after and including the year of liberalisation according to World Bank (1993)	*GMW 1998*

Notes

The codes used in Column Three of the above list refer to the following sources; *BL 1994* and *BL 2000* refer to the Barro and Lee datasets published in 1994 and 2000 respectively. *CIA 1998* refers to the *Central Intelligence Agency (CIA) World Factbook 1998*, while *GMW 1998* refers to the data used in the paper by Greenaway, Morgan and Wright (1998). The source of the import data was the OECD publication *International Trade by Commodity Statistics, 1961 – 1990.* The trade data is taken as exports from the Northern country to the Southern country rather than as imports in to the South from the North, due to problems of inadequate import data for many of the developing countries[1]. The data used is total imports of manufactured goods. *SH* refers to the Summers and Heston database (1991), while *WB* refers to the *World Bank Indicators Database* (1994). Finally, *Haveman* refers to a website maintained by Jon Haveman, which contains a large amount of trade and trade-related data.

The following four Tables report the correlations between the variables used in the various models estimated throughout the thesis. Table A1.2 reports the correlations for the model that looked to predict import volumes, while Table A1.3 does the same for the model predicting import shares. Finally, Tables A1.4 and A1.5 report the correlations of the growth models estimated in Chapters Five and Six. Table A1.4 reports the correlations of the data on five-year averages, while Table A1.5 does the same for the data on annual observations.

[1] The two figures should be equivalent except for trans-shipments however. Trans-shipments are not likely to be large for the majority of the countries in the sample, with the possible exception of Panama.

Table A1.2: Correlations Between Variables used in Estimating Import Volumes

	Import Volume	*Dist*	*GDPIN*	*GDPPC*	*LockM*	*LockX*	*ComLang*	*Area*	*Labour*	*Capital*	*Skilled*	*Unskilled*	*TOT*	*PriX*	*WB*	*Dean*	*Sachs*
Import Volume	1																
Dist	-0.19	1															
GDPIN	0.76	0.05	1														
GDPPC	0.38	-0.04	0.37	1													
ComLang	0.02	0.08	-0.08	-0.08	1												
LockM	-0.27	0.04	-0.26	-0.26	0.04	1											
LockX	-0.03	-0.07	-0.07	0.12	-0.11	0.00	1										
Area	0.16	0.15	0.4	-0.22	-0.11	0.16	0.00	1									
Labour	0.32	0.14	0.57	-0.28	-0.08	-0.16	0.00	0.71	1								
Capital	0.51	0.08	0.72	0.38	-0.1	-0.36	0.00	0.48	0.68	1							
Skilled	0.43	0.21	0.67	0.17	-0.13	-0.34	0.00	0.48	0.78	0.86	1						
Unskilled	0.31	0.14	0.56	-0.3	-0.08	-0.15	0.00	0.71	0.99	0.67	0.76	1					
TOT	0.03	0.01	-0.02	-0.02	-0.05	-0.03	0.00	0.11	-0.02	-0.01	-0.07	-0.02	1				
PriX	0.46	0.15	0.62	0.37	-0.09	-0.27	0.00	0.52	0.55	0.83	0.67	0.54	0.17	1			
WB	-0.06	0.02	-0.03	0.08	0.00	-0.05	0.00	-0.13	-0.1	-0.05	0.02	-0.11	-0.21	-0.16	1		
Dean	0.1	0.08	0.19	0.06	-0.02	-0.08	0.00	0.13	0.22	0.2	0.27	0.22	-0.19	0.2	0.26	1	
Sachs	0.12	0.16	0.16	0.14	-0.04	-0.08	0.00	-0.05	0.13	0.2	0.23	0.12	-0.16	0.26	0.1	0.28	1

Table A1.3: Correlations Between Variables used in Estimating Import Shares

	Import Share	*Dist*	*GDPIN*	*GDPPC*	*ComLang*	*LockM*	*LockX*	*K/Worker*	*Skill/Unskill*	*Land/Worker*	*TOT*	*Priv/GDP*	*WB*	*Dean*	*Sachs*
Import Share	1														
Dist	-0.23	1													
GDPIN	0.64	0.05	1												
GDPPC	0.33	-0.04	0.37	1											
ComLang	0.06	0.08	-0.08	-0.08	1										
LockM	-0.22	0.04	-0.26	-0.25	0.04	1									
LockX	-0.03	-0.07	-0.07	0.12	-0.11	0.00	1								
K/Worker	0.24	-0.06	0.31	0.83	-0.05	-0.3	0.00	1							
Skill/Unskill	0.15	0.05	0.27	0.51	-0.09	-0.17	0.00	0.5	1						
Land/Worker	-0.16	-0.04	-0.13	-0.03	-0.04	0.53	0.00	-0.02	-0.15	1					
TOT	0.03	0.01	-0.02	-0.02	-0.05	-0.03	0.00	0.02	-0.12	0.12	1				
Priv/GDP	0.26	0.17	0.5	0.33	-0.06	-0.21	0.00	0.46	0.18	0.03	0.23	1			
WB	-0.04	0.02	-0.03	0.08	0.00	-0.05	0.00	0.05	0.2	-0.11	-0.21	-0.19	1		
Dean	0.05	0.08	0.19	0.06	-0.02	-0.08	0.00	0.01	0.16	-0.13	-0.19	0.16	0.26	1	
Sachs	0.08	0.16	0.16	0.14	-0.04	-0.08	0.00	0.12	0.19	-0.15	-0.16	0.25	0.1	0.28	1

Table A1.4: Correlations Between Variables used in the Growth Regression (Five-Year Averages)

	Avgrow	*InitGDP*	*Inv*	*PopGrow*	*SyrF*	*SyrM*	*PyrF*	*PyrM*	*Polrit*	*Civlib*	*Gov't*	*Inflation*	*DEAS*	*DLAT*	*DSSA*	*Open1*	*Open2*	*KS1*	*KS2*	*KS3*	*KS4*	*KS5*	*SMKS*
Avgrow	1																						
InitGDP	-0.14	1																					
Inv	0.27	0.39	1																				
PopGrow	-0.21	-0.15	-0.1	1																			
SyrF	-0.06	0.75	0.41	-0.29	1																		
SyrM	0.11	0.59	0.39	-0.24	0.87	1																	
PyrF	0.05	0.65	0.51	-0.51	0.75	0.6	1																
PyrM	0.14	0.52	0.52	-0.45	0.63	0.61	0.92	1															
Polrit	-0.08	-0.47	-0.23	0.29	-0.42	-0.37	-0.52	-0.5	1														
Civlib	-0.05	-0.5	-0.19	0.19	-0.4	-0.29	-0.47	-0.41	0.84	1													
Gov't	-0.25	-0.23	-0.35	0.07	-0.19	-0.19	-0.16	-0.12	0.2	0.16	1												
Inflation	-0.01	0.07	0.05	-0.05	0.03	0.01	0.07	0.03	0.03	0.06	0.18	1											
DEAS	0.37	-0.06	0.31	-0.12	0.08	0.26	0.18	0.29	-0.02	0.09	-0.21	0.04	1										
DLAT	-0.22	0.47	0.22	-0.24	0.33	0.07	0.42	0.23	-0.26	-0.35	-0.29	0.08	-0.28	1									
DSSA	-0.18	-0.48	-0.46	0.3	-0.49	-0.45	-0.47	-0.37	0.36	0.38	0.35	-0.02	-0.21	-0.55	1								
Open1	0.22	0.12	0.21	-0.07	0.28	0.32	0.32	0.39	-0.16	-0.13	0.12	0.02	0.22	0.11	-0.27	1							
Open2	0.15	0.15	0.09	-0.11	0.32	0.29	0.36	0.4	-0.2	-0.21	0.22	0.01	0.11	0.07	-0.13	0.83	1						
KS1	-0.17	0.46	0.19	-0.22	0.4	0.29	0.47	0.37	-0.47	-0.45	-0.26	-0.03	-0.03	0.74	-0.55	0.15	0.13	1					
KS2	0.24	0.51	0.53	-0.05	0.43	0.49	0.39	0.4	-0.38	-0.32	-0.44	-0.06	0.37	0.22	-0.55	0.38	0.11	0.47	1				
KS3	0.28	0.45	0.53	0	0.37	0.46	0.32	0.36	-0.33	-0.26	-0.39	-0.08	0.38	0.03	-0.42	0.36	0.08	0.28	0.97	1			
KS4	-0.23	-0.03	-0.04	-0.12	0.25	0.28	0.2	0.24	-0.1	0.01	0.17	-0.29	0.08	0.03	-0.06	0.28	0.44	0.17	0.04	0.04	1		
KS5	-0.25	-0.03	-0.13	-0.14	0.26	0.26	0.23	0.25	-0.1	-0.03	0.27	-0.26	0.01	0.02	0.02	0.28	0.44	0.14	-0.2	-0.2	0.92	1	
SMKS	0.04	0.56	0.36	-0.24	0.86	0.98	0.58	0.6	-0.36	-0.27	-0.18	-0.04	0.26	0.07	-0.42	0.28	0.26	0.29	0.46	0.44	0.41	0.37	1

Table A1.5: Correlations Between Variables used in the Growth Regression (Annual Data)

	DGDPPC	*GDP-1*	*GDP-2*	*GDP65*	*INV*	*SYRF65*	*SYRM65*	*DPOP*	*DTTI*	*WB*	*DEAN*	*SACHS*	*Open1*	*Open2*	*Dopen1*	*Dopen2*
DGDPPC	1															
GDP-1	0.38	1														
GDP-2	0.16	0.38	1													
GDP65	-0.17	-0.16	-0.16	1												
INV	0.23	0.26	0.22	0.07	1											
SYRF65	0.03	0.03	0.03	0.58	0.00	1										
SYRM65	0.13	0.13	0.13	0.37	0.05	0.86	1									
DPOP	-0.20	-0.16	-0.16	0.01	-0.12	-0.33	-0.37	1								
DTTI	0.05	0.00	0.00	0.01	0.16	0.01	0.02	-0.01	1							
WB	-0.03	-0.03	-0.08	0.00	-0.15	0.11	0.17	0.05	0.04	1						
DEAN	0.07	0.06	0.06	-0.04	-0.04	0.08	0.10	-0.02	-0.02	0.26	1					
SACHS	0.24	0.23	0.21	0.02	0.10	0.14	0.28	-0.27	0.01	0.11	0.29	1				
Open1	0.19	0.21	0.19	-0.07	0.18	0.32	0.36	-0.08	-0.01	0.01	0.04	0.11	1			
Open2	0.14	0.15	0.13	0.00	0.11	0.32	0.30	-0.08	-0.01	0.08	-0.02	0.11	0.85	1		
Dopen1	0.10	0.05	-0.06	-0.01	0.06	-0.04	-0.04	0.01	-0.14	0.02	0.03	0.05	0.10	0.09	1	
Dopen2	0.09	0.04	-0.07	0.02	0.05	0.00	0.00	0.01	-0.16	0.04	0.04	0.05	0.12	0.10	0.98	1

Econometric Appendix

ECONOMETRIC APPENDIX

A2.1 Introduction

Throughout the thesis we employ panel data techniques to estimate our various models. Panel data combines elements of cross-section and time-series data, and its use has many advantages over either cross-section or time-series data. One advantage of panel data over cross-section data is that if the explanatory variables in a cross-section regression are correlated with other unobservable variables, then the least squares coefficient estimators are biased. With multiple observations of the cross-section units however, the effect of the unobserved variables may be eliminated by looking at either first differences or deviations from the means of the cross-section units at a particular point in time (See Hsiao, 1986, p. 4). In addition, this method also allows for the intercept term to vary as a way of representing missing individual and/or time effects. Hsiao (1986) identifies the increased number of observations available that increases degrees of freedom and reduces the collinearity among explanatory variables as additional important advantages of panel data techniques over cross-section and time-series techniques.

Chapters 4 and 5 make use of conventional panel data techniques, while chapter 6 uses dynamic panel data methods. In this appendix we discuss in greater detail the econometric techniques used throughout the thesis[1]. We begin in section A2.2 by describing a basic model of panel data. In section A2.3 we consider a model in which we allow the intercept term to vary across individuals, before examining fixed effects models and random effects models to estimate this general model in sections A2.3-1 and A2.3-2 respectively. In section A2.4 we briefly discuss a model in which the intercept term is allowed to vary over time, as well as across individuals. Section A2.5 discusses the various arguments for employing either a fixed effects or a random effects model. Finally, in section A2.6 we discuss dynamic panel data techniques that are employed in chapter 6.

A2.2 A Basic Model

The basic problem is to specify a model that adequately allows for differences in behaviour over cross-section units, but also for any difference in behaviour over time for a given cross-sectional unit. A general model for panel data estimation can be written as

$$y_{it} = \alpha_{it} + \beta'_{it} X_{it} + \varepsilon_{it}, \qquad \textbf{(A2.1)}$$

where $i = 1, 2, \ldots, N$ refers to a cross-sectional unit and $t = 1, 2, \ldots, T$ refers to a given time period, y_{it} is the value of the dependent variable for individual i at time t and X_{it} is a vector of $k\text{-}1$ explanatory variables. The error term, ε_{it}, is assumed to have a zero mean and a constant variance ($\varepsilon_{it} \sim IID(0,\sigma_\varepsilon^2)$). In the above equation, the α_{it} (i.e. the constant term) and the β_{it} (i.e. the slope coefficients) are parameters to be estimated. In general, these estimated parameters could be different for different individuals and in different time periods. It is often the case however that more restrictive assumptions are made concerning the estimated parameters. In this appendix we examine two of these. The first assumes that the slope coefficients are constant, but that the intercept term can vary over individuals (section A2.3), while the second assumes that the slope coefficients are again constant, but that the intercept can vary over individuals and also time (section A2.4).

[1] See Greene (1993), Hsiao (1986) and Baltagi (1995) for a more detailed discussion of panel data techniques.

In addition to the assumptions made about how the slope and intercept parameters can vary across individuals and time, assumptions also need to be made about whether any variable coefficients are assumed to be random or fixed. In fixed effects models, the variable coefficients are assumed to be fixed parameters, and the model is estimated including dummy variables to take account of the variable's individual and time effects. Alternatively, in random effects models the individual and time effects are assumed to be random variables with mean zero and constant variance.

A2.3 Models in which the Intercept Varies Across Individuals

If the various slope coefficients are assumed to be fixed across individuals and time, but the intercept term can vary to capture differences in behaviour across individuals, equation (A2.1) becomes,

$$y_{it} = \alpha_i + \beta' X_{it} + \varepsilon_{it}. \qquad \textbf{(A2.2)}$$

Note that the constant term no longer contains a subscript t, since the intercept is assumed constant across time periods, and the slope coefficients no longer contain subscripts i or t, since these are assumed constant across both individuals and time. In this example a varying intercept is assumed to capture differences across individuals and may be thought of as capturing the effect of unobservable time invariant effects. The error term for this model can be written as,

$$\varepsilon_{it} = \mu_i + u_{it}, \qquad \textbf{(A2.3)}$$

where μ_i represents the unobservable individual effects and u_{it} denotes the remaining error term. μ_i is time invariant and accounts for any individual specific effects that are not included in the model. Given this, equation (A2.2) can be rewritten as,

$$y_{it} = (\alpha + \mu_i) + \beta' X_{it} + u_{it}, \qquad \textbf{(A2.4)}$$

where $\alpha_i = \alpha + \mu_i$ is the intercept for the *i*th individual, with α being the "mean intercept" and μ_i representing the difference from this mean for the *i*th individual. The choice that has to be made now is whether to assume that the μ_i are fixed or random.

A2.3-1 Fixed Effects Models

In fixed effects models the unobservable μ_i is assumed to be non-stochastic with the remaining error assumed to have zero mean and constant variance ($u_{it} \sim IID(0,\sigma_u^2)$). The intercept for each individual is a fixed parameter to be estimated along with the slope coefficients. To estimate equation (A2.4) using a fixed effects model, dummy variables for each individual, *i*, are included in the regression and the model is estimated without a constant term using OLS. This is known as the Least Squares Dummy Variable (LSDV) model and can be written as,

$$y_{it} = \mu_j D_{jt} + \beta' X_{it} + u_{it}, \qquad \text{(A2.5)}$$

where D_{jt} are dummy variables that take the value 1 if $j = i$ and 0 otherwise. There is therefore a dummy variable corresponding to each individual in the sample. The coefficient on the dummy variable for individual *i* gives an estimate of the intercept term for this individual.

A practical problem that may arise when estimating this model is that many statistical packages automatically include a constant term, in which case there is perfect collinearity between the intercept term and the full set of individual dummy variables. An alternative method of estimating the model is to include alongside the intercept term, *N-1* dummy variables. Once again the model can be estimated using OLS, the only difference being in the interpretation of the coefficients on the dummy variables. In this latter case the coefficient of the dummy variable for individual *i* gives an estimate of the difference between the intercept for individual *i* and that for the individual for which no dummy variable is included.

A further problem that may arise when estimating the LSDV model is a numerical one; if *N* is very large, equation (A2.5) will include too many individual dummies and may aggravate the problem of multicollinearity amongst the explanatory variables. In this situation, it is convenient to express each variable in terms of deviations from individual means and perform OLS on the transformed variables to obtain parameter estimates. This approach eliminates the individual effects and the resulting model takes the form,

$$y_{it} - \bar{y}_i = \beta(x_{it} - \bar{x}_i) + (u_{it} - \bar{u}_i), \qquad \textbf{(A2.6)}$$

where $\bar{y}_i$, $\bar{x}_i$ and $\bar{u}_i$ are the individual means of the variables. Since equation (A2.6) utilises the variation of the variables within each individual, it is often referred to as the within-group regression.

Once a model has been estimated using the LSDV approach an important question to ask is whether different individuals have different intercepts, or whether it is adequate to assume that all the intercepts are identical. If the latter were true, then there are no individual fixed effects and no basis for differentiating the time-series / cross-sectional nature of the data, and for estimation purposes the data can be treated as a single sample with *NT* observations. A standard *F*-test comparing the restricted and unrestricted sum of squares can be used to test for the presence of individual fixed effects. Under the null hypothesis, the intercepts are assumed equal for all individuals (i.e. there are no individual fixed effects), as opposed to the alternative hypothesis that the intercepts are not all equal. The test statistic of this hypothesis is given by,

$$F = \frac{(RSS_R - RSS_U)/(N-1)}{RSS_U/(NT - N - K)}, \qquad \textbf{(A2.7)}$$

where *RSS* is the residual sum of squares, *R* refers to the restricted model (i.e. with a single overall constant) and *U* refers to the unrestricted model (i.e. with individual specific intercepts). The number of degrees of freedom in the unrestricted model is given by *(NT-N-K)* and *(N-1)* is the number of linear restrictions. Under the null hypothesis, the test statistic has an *F* distribution with *[(N-1),(NT-N-K)]* degrees of freedom. Rejection of the null hypothesis confirms the existence of individual fixed effects.

A2.3-2 Random Effects Models

The random effects model assumes that the individual effects are random variables with mean zero and constant variance ($\mu_i \sim IID(0,\sigma_\mu^2)$). Additional assumptions required for random effects models are that the individual effects are uncorrelated with u_{it} and that the explanatory variables are uncorrelated with both μ_i and u_{it}.

We can write equation (A2.4) as

$$y_{it} = \alpha + \beta' X_{it} + (\mu_i + u_{it}), \qquad \textbf{(A2.8)}$$

where (μ_i + u_{it}) can be regarded as a composite error term, where the first term is an individual specific error term and the second is the standard error term. In the random effects model, this error term no longer satisfies the assumption of serial independence as there is within individual correlation through time. The structure of this covariance matrix is such that, for a given individual, the correlation between any two error terms in different time periods is the same. Moreover, the correlation is not only constant over time, it is also identical for all individuals. Since the error term is correlated, OLS is not appropriate for estimation purposes and Generalised Least Squares (GLS) is the best linear unbiased estimator (BLUE)[2].

A2.3 Allowing the Intercept to Vary across Individuals and Time

In this section we will briefly discuss the case where the intercept can vary to capture differences across time, as well as differences in individuals. Once again we retain the assumption that the slope coefficients are assumed constant. In this case equation (A2.2) becomes,

$$y_{it} = \alpha_{it} + \beta' X_{it} + \varepsilon_{it}. \qquad \textbf{(A2.9)}$$

The slope coefficients do not contain any subscripts because they are assumed constant across time and across individuals, but now the intercept term contains a time subscript, in addition to an individual subscript. The error term for this model now becomes,

$$\varepsilon_{it} = \mu_i + \lambda_t + u_{it}, \qquad \textbf{(A2.10)}$$

where λ_t represents the unobserved time, which implies that equation (A2.4) now becomes

$$y_{it} = (\alpha + \mu_i + \lambda_t) + \beta' X_{it} + u_{it}, \qquad \textbf{(A2.11)}$$

with intercept $\alpha_{it} = \alpha + \mu_i + \lambda_t$ and where in a given time period the time effects, λ_t, represent the influence of factors that are common to all individuals in the sample. Again it is necessary to make a choice between a fixed effects and a random effects estimation, and then proceed along the same lines as those discussed in sections A2.3-1 and A2.3-2.

There are a number of minor differences that need to be taken into account when we allow the intercept to vary across both individual and time. In the fixed effects model,

[2] See Greene (1993).

one of the μ_i and one of the λ_t are redundant, and other restrictions such as $\sum_i \mu_i = 0$ and $\sum_t \lambda_t = 0$ need to be imposed. Once these are incorporated however, the model can be estimated using OLS. In the random effects model we have to assume that the individual and time effects are both random variables with mean zero and constant variance. In addition we have to make the assumption that the μ_i, λ_t and u_{it} are all uncorrelated for all *i* and *t*. After making these assumptions GLS is again found to be BLUE.

A2.5 Fixed versus Random Effects

Given the distinction between fixed and random effects models, it is important to understand which specification should be used in particular circumstances. This is not as straightforward as it sounds, as no hard and fast rules for determining which specification to employ exist. A random effects model is the method suggested by Hsiao (1986) "when inferences will be made about a population of effects from which those in the data are considered to be a random sample" (p. 43), while a fixed effects model would be more appropriate if the focus was on a specific set of individuals, with inferences being restricted to the behaviour of these individuals. This approach however may not always give clear guidance as to the best approach, for example, a sample of 15 countries may be considered to be a small sample of the total population of countries and would suggest the use of a random effects model, yet if these 15 were the European Union (EU) countries it could be argued that the sample constitutes the whole population of EU countries, with a fixed effects model being more appropriate.

A further consideration when making the choice between fixed and random effects is that fixed effects models result in the loss of degrees of freedom by incorporating dummy variables for each i and/or t. This can have an important impact on the quality of the estimates obtained. Fixed effects models do have one important advantage over random effects models however, in that there is no need to assume that the individual and time effects are uncorrelated with the explanatory variables in fixed effects models, a necessary assumption in random effects models. If the individual and time effects are correlated with the explanatory variables the random effects estimator may lead to omitted variable bias, while those from the fixed effects model will be consistent, and the fixed effects estimator will be best linear unbiased.

It is of course possible to follow a mixed strategy whereby the time effects (for example) are assumed fixed and the individual effects are assumed random; this is a method often used in the thesis and is likely to be particularly useful if T is small. If in this example, the time dummy variables are included within the explanatory variables, X, then the model becomes one with individual effects only.

A number of tests have also been developed that may provide further guidance as to which specification to use. One is that proposed by Hausman (1978), which tests the basic assumption of the random effects model that the individual and/or time effects are uncorrelated with the explanatory variables. If there is correlation between these and the explanatory variables, then GLS is not valid. The following statistic can be used to test the null hypothesis of zero correlation between the effects and the explanatory variables,

$$W = (\hat{b} - \hat{\beta})' \left[\text{var}(\hat{b} - \hat{\beta})\right]^{-1} (\hat{b} - \hat{\beta}), \qquad \textbf{(A2.12)}$$

where $\hat{b}$ is the GLS estimate and $\hat{\beta}$ is the LSDV estimate. Under the null hypothesis W is asymptotically distributed as chi-squared with K degrees of freedom. Under the null hypothesis, both OLS in the fixed effects model and GLS are consistent, although OLS is inefficient. In this case the coefficient estimates from the two models should not differ systematically. Under the alternative hypothesis where the effects and the explanatory variables are correlated however, OLS estimates are consistent but GLS estimates are not. The Hausman test therefore proceeds by comparing the OLS coefficient estimates with those from GLS to test for correlation between the effects and the explanatory variables. Rejection of the null hypotheses suggests that the fixed effects model is the most appropriate one.

A further test that can be used to provide guidance as to which model to use is one developed by Breusch and Pagan (1980). If all the individual and time effects equal zero then the random effects do not exist and the least squares estimator in the fixed effects settings is best linear unbiased. Breusch and Pagan derived a Lagrange Multiplier (LM) test for this hypothesis based only on the restricted residual sum of squares. The test statistic when only individual effects are included is,

$$\lambda = \frac{NT}{2(T-1)}\left[\frac{\sum_i\left(\sum_t \hat{u}_{it}\right)^2}{\sum_i\sum_t \hat{u}_{it}^2} - 1\right]^2 \qquad \textbf{(A2.13)}$$

while the statistic when both individual and time effects are included is,

$$\lambda = \frac{NT}{2}\left\{\frac{1}{T-1}\left[\frac{\sum_i\left(\sum_t \hat{u}_{it}\right)^2}{\sum_i\sum_t \hat{u}_{it}^2}\right]^2 + \frac{1}{N-1}\left[\frac{\sum_t\left(\sum_i \hat{u}_{it}\right)^2}{\sum_i\sum_t \hat{u}_{it}^2}\right]^2\right\}. \qquad \textbf{(A2.14)}$$

Under the null hypothesis of no random effects, λ is asymptotically distributed as a chi-squared with one and two degrees of freedom for equations A2.13 and A2.14 respectively. Rejection of the null hypothesis is evidence in favour of the random effects model. Throughout the thesis we report both the Hausman and the Breusch-Pagan test statistics with our results, and where possible we use these tests as one factor when determining whether to employ a fixed effects or a random effects model, except where we have an *a-priori* justification for choosing either a fixed effects or a random effects model. A difficulty that arises when reporting these two statistics and when using them as a justification for either specification is that in a number of cases one test would support a fixed effects specification, while the other test would support a random effects specification.

A2.6 Dynamic Panel Data Models

In chapter 6 we employ dynamic panel techniques, where lagged values of the dependent variable appear as explanatory variables in the model, to estimate the impact of openness and trade liberalisation on economic growth. In this context it is reasonable to assume that a country's past performance will be a significant determinant of its present performance, and should therefore be included in a model which analyses the consequences of trade reform on economic performance. An obvious advantage of dynamic over cross-section methods is that dynamic models explicitly consider the behaviour of a variable over time whereas cross-section techniques generally analyse a static or equilibrium relationship. The dynamic approach therefore is more suitable for many economic situations, in particular the impact of trade liberalisation, since it may be expected that responses to change, such as liberalisation, will not be immediate. Dynamic models also have advantages over time-series analysis, since dynamic models allow for an improved understanding of the dynamics of the adjustment process and can be used when the number of time periods is short. Dynamic panel models are characterised by the presence of a lagged dependent variable among the explanatory variables. We can write a general expression for a dynamic panel model therefore as,

$$y_{it} = \delta y_{i,t-1} + \beta' X_{it} + \varepsilon_{it}, \qquad \textbf{(A2.15)}$$

where $i = 1, 2,\ldots\ldots,N$ and $t = 1, 2,\ldots\ldots,T$, y_{it} is the dependent variable, $y_{i,\,t-1}$ is a lagged dependent variable, δ and β are parameter estimates, X_{it} is a vector of k-1 explanatory variables and ε_{it} is the error term. For ease of exposition we assume that the error term follows the structure of the one-way error components model (i.e. we allow the intercept to vary across individuals, but not over time). This implies that the error term follows the structure given by,

$$\varepsilon_{it} = \mu_i + u_{it}, \qquad \textbf{(A2.16)}$$

where both μ_i and u_{it} have zero mean and constant variance (i.e. $\mu_i \sim IID(0,\sigma_\mu^2)$ and $u_{it} \sim IID(0,\sigma_u^2)$), and are independent of each other and among themselves.

The major problem that arises when introducing a lagged dependent variable as an explanatory variable is that the error term and the lagged dependent variable are correlated, which implies that OLS and GLS are biased. Given that y_{it} is a function of μ_i, and given that μ_i is not dependent on time, it must be the case that $y_{i,\,t-1}$ is also dependent on μ_i, in which case the lagged dependent variable is correlated with the error term and OLS and GLS estimates are biased, even if u_{it} are not serially correlated. As such an alternative method of estimating such models is required.

One solution proposed that removes the individual specific effect is to first difference equation (A2.15), which gives,

$$\Delta y_{it} = \delta \Delta y_{i,t-1} + \beta \Delta X_{it} + \Delta u_{it}, \qquad \textbf{(A2.17)}$$

where $\Delta y_{it} = (y_{it} - y_{i,t-1})$, $\Delta y_{i,\,t-1} = (y_{i,t-1} - y_{i,t-2})$, $\Delta X_{it} = (X_{it} - X_{i,t-1})$ and $\Delta u_{it} = (u_{it} - u_{i,t-1})$. By first differencing equation (A2.15) we eliminate the individual effect, since (μ_i - μ_i) drops from the equation. The error term in equation (A2.17), Δu_{it}, is a moving average process of order one, with unit roots. Although the correlation between the lagged dependent variable and the error term from equation (A2.15) is removed by first differencing (i.e. by removing μ_i), the transformed error term and Δy_{it} are now correlated (see Nickell, 1981). A solution to this problem however is to use instrumental variable (IV) techniques.

Anderson and Hsiao (1981) for example suggest first differencing the model to remove the μ_i, and then using $\Delta y_{i,t-2} = (y_{i,t-2} - y_{i,t-3})$ or $y_{i,t-2}$ as instruments for $\Delta y_{i,t-1}$. These instruments are correlated to $\Delta y_{i,t-1}$, but will not be correlated with $\Delta u_{it} = (u_{it} - u_{i,t-1})$, as long as the u_{it} are not serially correlated. This IV technique will lead to consistent but not necessarily efficient estimates of the parameters in the model because it does not make use of all the available moment conditions[3] (see Ahn and Schmidt, 1995). The estimator that uses the lagged level as an instrument, $y_{i,t-2}$, rather than the lagged difference, $\Delta y_{i,t-2}$, is recommended by Arellano (1989) who finds it to be more efficient. Moreover, instrumenting with the lagged level has the advantage over using the lagged difference, that only two time periods are required rather than at least three.

Arellano and Bond[4] (1991) propose an extension of Anderson and Hsiao (1981), which utilises the General Methods of Moments (GMM) procedure to accommodate the inclusion of further lagged variables as additional instruments. Additional instruments can be obtained by utilising the available orthogonality conditions that exist between the lagged values of the dependent variable and the errors. Thus the further advanced the panel, the greater the number of instruments available. The advantage of this procedure

[3] Moment conditions are conditions on the covariances between regressors and the error term. Regressors may be orthogonal to the error term, in which case we can use orthogonality conditions, that the covariance between the regressors and the error term is zero.
[4] Others such as Arellano and Bover (1995), Ahn and Schmidt (1995) and Keane and Runkle (1992) have suggested other instruments. See Baltagi (1995) for more detail on these estimators.

is that it allows both the cross-section and the time-series elements of the data to be exploited when constructing valid instruments.

This approach can be illustrated using the following dynamic panel model with no additional explanatory variables,

$$y_{it} = \delta y_{i,t-1} + \varepsilon_{it}. \tag{A2.18}$$

The model is first differenced to remove the individual effects,

$$(y_{it} - y_{i,t-1}) = \delta(y_{i,t-1} - y_{i,t-2}) + (u_{it} - u_{i,t-1}). \tag{A2.19}$$

Due to the presence of a lag in the data and due to first differencing the data we lose two periods, meaning that the first period that the relationship is observed will be $t = 3$. At $t = 3$ the equation to be estimated is given by,

$$(y_{i3} - y_{i2}) = \delta(y_{i2} - y_{i1}) + (u_{i3} - u_{i2}). \tag{A2.20}$$

A valid instrument for the lagged dependent variable in this case would be y_{i1} since it is highly correlated with $(y_{i2} - y_{i1})$, but uncorrelated with the residuals as long as u_{it} is not serially correlated. In the second period for which the relationship is observed however (i.e. $t = 4$) we have,

$$(y_{i4} - y_{i3}) = \delta(y_{i3} - y_{i2}) + (u_{i4} - u_{i3}). \tag{A2.21}$$

In this case, both y_{i1} and y_{i2} are valid instruments, since both are correlated with the lagged dependent variable, but uncorrelated with $u_{i4} - u_{i3}$. By adding an extra instrument with each observed period, the set of valid instruments becomes $(y_{i1}, y_{i2}, \ldots, y_{i,t-2})$. Denoting the matrix of instruments for each i as Z_i, the orthogonality conditions can be expressed as $E[Z'_i \Delta v_{it}] = 0$. The preliminary one-step consistent estimator of δ proposed by Arellano and Bond (1991) can be obtained by pre-multiplying the differenced equation (A2.19) by Z',

$$Z'\Delta y_{it} = Z'(\Delta y_{i,t-1})\delta + Z'\Delta u_{it}, \tag{A2.22}$$

and performing GLS. The optimal weighting matrix W for the GMM estimator for a fixed T and $N \rightarrow \infty$ is[5],

$$W = [Z'_i(\text{var}(\Delta u_{it}))Z_i] \qquad \textbf{(A2.23)}$$

which is unknown. It can however be obtained via the one-step estimator by setting W as,

$$W = [Z'_i GZ_i] \qquad \textbf{(A2.24)}$$

where G is the covariance matrix (i.e. $G=(\Delta u_{it})(\Delta u_{it})$). To operationalise the optimal GMM estimator, Δv_{it} is replaced by the differenced residuals obtained from the one-step estimation procedure. The resulting estimator is the two-step Arellano and Bond (1991) GMM estimator. The one-step and two-step estimators are asymptotically equivalent if the u_{it} have zero mean and constant variance.

If there are additional strictly exogenous explanatory variables, X_{it}, as in equation (A2.15), where these explanatory variables are independent of u_{it}, and where all the X_{it} are correlated with μ_i, then all the X_{it} are valid instruments for the first differenced equation of (A2.15). Therefore, X_{it} should be added to Z_i and equation (A2.22) becomes,

$$Z'\Delta y_{it} = Z'(\Delta y_{i,t-1})\delta + Z'(\Delta X_{it})\beta + Z'\Delta u_{it}, \qquad \textbf{(A2.25)}$$

and estimation proceeds along the lines outlined above. If however, X_{it} are predetermined rather than strictly exogenous, with X_{it} correlated with u_{it} for $s < t$, but zero otherwise, then only $X_{i,s-1}$ are valid instruments for the differenced equation at period s. The reduction in available instruments results in an adjustment to Z_i used in equation (A2.25), but otherwise estimation proceeds as above.

[5] See Hansen (1982).

The legitimacy of the above approach depends upon two factors, the validity of the instrument set, and the lack of second order serial correlation. Arellano and Bond (1991) suggest the use of a Sargan test[6] to test the validity of the instrument set. The null hypothesis of the Sargan test is of exogeneity of the instrument set, and the test statistic is calculated as follows,

$$J = \Delta\hat{v}'Z\left[\sum_{i=1}^{N} Z_i'(\Delta\hat{v}_i)(\Delta\hat{v}_i)'Z_i\right]^{-1} Z'(\Delta\hat{v}), \qquad \textbf{(A2.26)}$$

Where $\Delta\hat{v}$ are the residuals of the two-step estimation and Z is the matrix of instruments. The J-statistic follows a chi-squared distribution with $(p\text{-}k\text{-}1)$ degrees of freedom, where p refers to the number of columns of Z and k is the number of explanatory variables.

Arellano and Bond (1991) also propose a test for the hypothesis of no second order serial correlation for the error term of the first differenced equation. The assumption of a lack of second order correlation is essential to the consistency of the estimates. This can be tested by utilising a robust N(0,1) test for the presence of second order serial correlation. The test statistic for this test is given by,

$$m = \frac{\hat{u}'_{t-2}\,\hat{u}}{\sqrt{\hat{u}}}, \qquad \textbf{(A2.27)}$$

where $\hat{u}$ are the differenced residuals. The null hypothesis of this test is that $E\left[\Delta u_{it}\Delta u_{i,t-2}\right]=0$ (i.e. no second order serial correlation). m is only defined for $T \geq 5$, since it involves differenced residuals two periods apart.

[6] Following Sargan (1958).

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