AN ECONOMETRIC MODEL OF LAND PRICES IN ENGLAND

by

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Abstract

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A thesis presented on the land market in England between 1951 and 2001, determining an econometric VAR model of land prices that establishes a link between the price of agricultural land in England and variables that are under the influence of policy makers. The model makes use of the Johansen technique to determine the short run and long run effects of variables that control land prices.

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And to my family, to whom I shall always be indebted.

C h a p t e r   1

INTRODUCTION

The English agricultural land market as we know it today dates back to the 19th century. Although there have been many legislation changes since that time, the land market remains relatively similar in structure and at first glance, the market for agricultural land exists in the manner of a market for any good or service. However, it is substantially more complex than the markets for the majority of goods and services. Furthermore, it is far more significant. The agricultural land market reflects the current state of the whole agriculture sector, and changes in the sector over time are reflected in land prices movements. Furthermore, the land price has traditionally been used as a rather simplistic measure of the profitability of agriculture, which is not unreasonable, as an increase in the profitability of land would be expected to increase the demand for land and, given a fixed stock of land, lead to an increase in the price[1].

The research draws on the work of Harvey (1989), Lloyd (1991) and Just (1993) who have all made significant contributions to the field of agricultural economics and, in particular, land markets. The data utilised

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[1] Explored in more detail in Chapter II

over the sample period (1951-2001) was obtained from the Department of Environment, Food and Rural Affairs (DEFRA) and International Financial Statistics (IFS).

The basis for the research is twofold; the apparent inability of economic theory to account for the significant changes in the English agricultural land market (hereafter, referred to simply as ‘the land market’) over the last 50 years and the inability of previous land price models to allow an analysis of structural changes in agricultural support, especially since the early 1990s, when high support prices for output were partially replaced by payments in the form of direct subsidies.

A strong, congruent model of the land market that is also able to overcome these deficiencies is important as it enables policy makers to view the effect of changes in agricultural support, such as the MacSharry reforms, on agriculture as a whole.

A major assumption made throughout this research is that land is treated as a financial asset and this is not considered an unreasonable assumption as it provides year on year returns and arguably can be sold without being subject to depreciation. It has been commonly assumed that the land market can be represented by a present value model[2]. In this case, land prices and the returns to the land are directly related[3]:

$$1.1)\ PV = \frac{E_t[R_t]}{r}$$

where PV is the Present Value or current price of the land, $E_t[R_t]$ is the expected value of a constant stream of returns on the land and r represents the cost of capital by which future income should be discounted to determine its present value. From this we would expect that the current price and the returns to the land are directly related.

However, Figure 1.1 illustrates that in certain circumstances this is not be the case. Figure 1.1 presents the movement in land prices and land rents, a proxy for returns to the land[4], over the period 1951-2001. As with most macroeconomic data, land prices and land rents are trended upwards as a result of inflationary effects. As a consequence, both series of data are presented in real terms to remove the effects of inflation in both series.

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[2] The present value model is derived in Appendix 1, the appropriate nature of the PV model is explored in detail in Chapter 3

[3] Blake (2000)

[4] The variables used in the analysis are discussed further in Chapter 4

Figure 1.1 – Real Land Prices and Real Land Rent in England, 1951-2001

Even after deflating the variables, both land prices and land rents have increased over the sample period. However, we would expect a direct relationship between the two variables and this is not often the case. Furthermore, there are occasions when real land prices and real land rents appear to diverge. For instance, in 1973, when the UK joined the EEC (now EU), land prices reached their peak over the sample period at £11,428 per hectare (ha.), rising 135% in only two years. However, between 1971 and 1973, land rents fell marginally, from £121 ha. to £119 per ha. It is clear that there are other factors determining the change in land prices. In another example, towards the end of the sample period, between 1998 and 2001, there is an increase in land prices of 12%, from £6,426 to £7,224. However, simultaneously, there was a 13% decrease in land rents. There are other examples. This is not simply an effect of dynamic adjustment lags and, as a consequence, it appears that the present value model cannot deal explain these situations.

Various economists have attempted to overcome this by adhering to the present value model and exploring the possibilities that either there is growth in the rate of return or that the discount factor is not constant. Although previous research has not approached a general consensus over explaining the apparent discrepancies in the present value model, two models in particular are discussed further in Chapters 3 and 4. The model developed in this research argues that the variations in the land market can be explained using a model that takes account of factors not specified in the present value model. Real land prices are determined by the return to the land, the opportunity cost of the land and the inflation rate.

This, however, is preceded by a chapter that briefly looks major changes that have affected agriculture, in general, and so the land market, more specifically, since 1950, to give the reader a background to the area and to give a grounding for the research in later chapters.

Chapter 5 deals with the econometric analysis. The main point of the econometric analysis is to develop an empirical version of the theoretical model that can be used to test the hypothesis that an inflation inclusive present value model represents the land market well. However, it must be stressed that the econometric analysis is not simply in place to confirm or deny our hypothesis with respect to the present value model. The theoretical model alone does not give sufficient information on which variables are irrelevant or constant for the model, how the models operate differently in the short or long run and what the processes of adjustment within the model are.

While this research is not essentially, a study of econometrics, it does, however, make use of various econometric techniques such as VAR modelling, encompassing and impulse response modelling. Although brief explanations of these procedures are given, it is not within the remit of this research to describe, in depth, each technique. More detailed information can be found in such texts as Enders (95) and Harris (95).

The econometric testing confirms the hypothesis that the use of inflation and interest rates in a present value model can account for the variation in land prices and generally explain the apparent discrepancy between land prices and land rents.

This research not only deals with the determination of a land price model but also examines what the effects of the changes in financial aid given to agriculture on the land market are. The interest in this area lies in the reforms in the last decade that have altered the structure of agricultural support, involving a shift away from the high guaranteed support prices of the past towards direct subsidies per hectare of land. This would be expected to impact upon the land market as it alters the income that can be earned from the land. However, the change in support prices will have distinct and possibly different effects upon the returns to the land, and hence the land market, as compared to changes in subsidies. To analyse these effects it is necessary to determine a model of the measure of returns to agricultural land used in Equation 1.1, land rent. This is the concern of Chapter 6, which determines a model of land rents whereby land rental prices are a function of input prices in agriculture, output prices in agriculture and agricultural subsidies (net of taxes).

Chapter 7 determines, and looks at, the implications of the full land price model and how it explains the effects of the MacSharry reforms. The analysis suggests that, overall, the MacSharry reforms had a positive effect over land prices in England. However, the sharp increase in land prices from 1993 onwards was not purely as a consequence of the MacSharry reforms. In fact, less than half the rise in land prices over this period is attributable to the reforms in agricultural support.

In summary, this research determines a congruent model of land prices based upon economic theory that explains variations in land prices that previous models were unable to. In addition, the analysis is taken further and a link between land prices and the two main forms of support (price support and direct payments) is established, highlighting the importance of support policy in agriculture. With the inclusion of agriculture in WTO trade agreements, and the movement towards clearer and freer trade, the quantity of support, and division of support between price support and direct payments, would be expected to alter significantly agriculture and, as a result, land prices.

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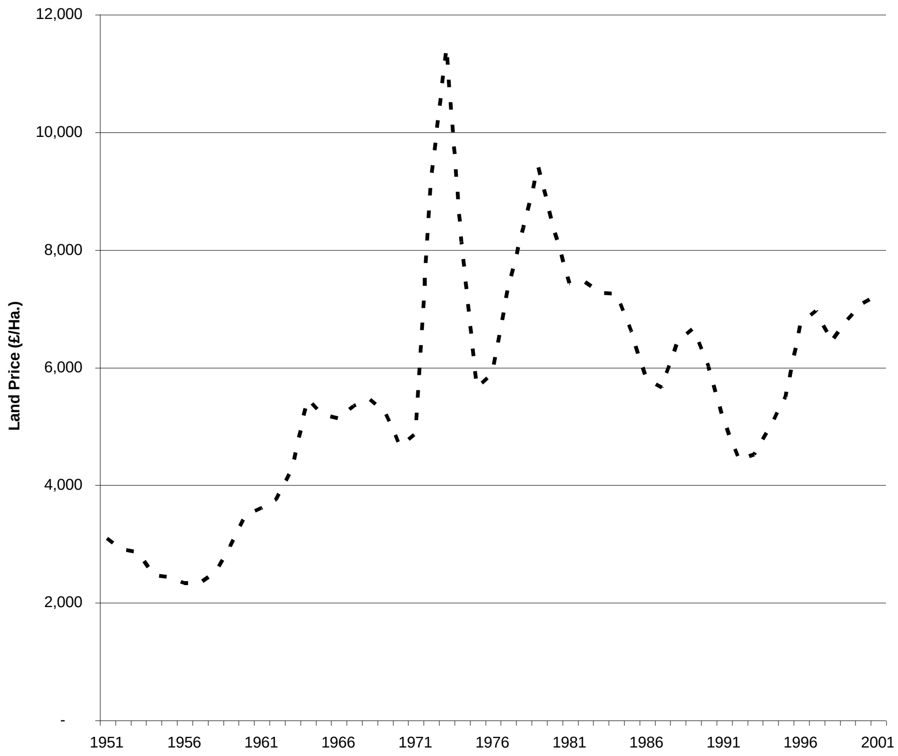
HISTORICAL PERSPECTIVE

Introduction

Although agriculture's influence on the whole economy has diminished over the last 50 years, currently accounting for only 2% of the workforce and only 1% of GDP, it still accounts for 70% of UK land use. As a result, the land market is of great importance and reflects the state, and changing nature, of agriculture. This is illustrated in Figure 2.1, which displays the real price of land in England between 1951 and 2001. Peaks and troughs in the land price series appearing to coincide with historical events that have affected the prosperity of agriculture generally. These events, many of which have been determined by agricultural policy, illustrate the type of influences that the land price model, determined in this research, would be expected to take account of.

This chapter offers a glimpse into those historical processes and events that have cumulatively helped to shape the land market over the last 50 years. This chapter highlights the state of agriculture throughout the sample period as a backdrop to the agricultural land market that is analysed later in the research.

Figure 2.1 – Real Land Prices in England, 1951-2001



While the agricultural land market has been subject to many influences since 1950, an emphasis is placed on the involvement of policy makers, who have been instrumental in a significant proportion of these changes.

A distinction between the use of the terms ‘policy makers’ and ‘government’ is made here and is not simply a point of semantics. In general, policy makers would simply cover economic agents in government. However, in this case, the use of the term ‘policy makers’ includes the European Parliament and European Council that determine agricultural policy for the EU as a whole, influenced by governments within the EU. Since 1973, the UK's policies for agriculture have been governed by the Common Agricultural Policy (CAP) within the EEC (now EU) and the CAP is briefly outlined.

The sample period is divided into three sections for the historical outline; 1951-1969, 1970-1979 and 1980-2001. These three sections denote time periods in which the general economic situation, agricultural policy and the motives behind these policies were markedly different.

1951-1969:

After the Second World War, agriculture was in a general period of uncertainty surrounding the continuation of support and as a result, the earliest part of the sample period was marked by an active encouragement of agriculture, following the Second World War.

Growth in Agriculture

The first objective during peacetime was to boost food supplies domestically as food rationing, which was not removed until 1953, became increasingly severe with each year, even after the war. However, the increase in food supplies could not be achieved by importing on a large scale as a consequence of the war eroding the country's reserves of foreign currency. In response to the demand, the government encouraged domestic agricultural production on an unprecedented scale through the 1947 Agriculture Act, which provided many of the incentives for the expansions in production seen in the 1950s. The act stated:

> *"The twin pillars upon which the Government's agricultural policy rests are stability and efficiency. The method of providing stability if through guaranteed prices and assured markets."*

These so-called twin pillars were achieved using a fixed price mechanism and deficiency payments. With the fixed price mechanism, the government set a price for each agricultural output above the actual market price; grains and sugar prices were set 18 months in advance and milk, eggs and fatstock prices were set between two and four years in advance. The difference between these artificially high agricultural prices and the actual market prices were paid by the government (and, hence, taxpayers) to the farmers. This provided the stability that was essential to the agricultural sector. Furthermore, it also provided, in part, the efficiency. The high guaranteed prices meant that farmers had the finance and the incentive to invest in capital, both replacement capital investment and new capital investment.

The 1947 Agriculture Act was a great success and boosted production. The agricultural sector met all targets that had been set by the government during the 1950s. However, this success also meant that there was a growing burden of agricultural support because of the high deficiency payments. As a result, there was a shift in agricultural policy towards the expansion of products that would replace imports as the UK continued to encounter problems with balance of payments deficits. While commodities that provided an import replacement role were still encouraged, other products had restrictions to prevent excessive expenditure on deficiency payments. These included reductions to guaranteed prices, limits on the quantity for which guaranteed prices were eligible and import controls. These restrictions, implemented in the 1950s and 1960s, attempted to restrict the support expenditure and additionally, assist the harmonisation of policies towards those operated in Europe as, in the late 60s, the UK attempted to enter the EU.

In addition, an emphasis was placed on increasing efficiency, with the adoption of machinery and amalgamation of farms, both encouraged. These were covered by the Agricultural Acts of 1957 and 1967, which offered grants to existing farmers for the purchase of land that was not considered commercially viable on its own but, allied to other land, it was commercially viable. The grant within the 1957 Agricultural Act offered

30% of the land purchase price. This was raised to 50% in the 1967 Agriculture Act. As additional land generally leads to a more efficient utilisation of fixed capital, farmers are generally prepared to pay a high price, in excess of its agricultural earning potential, to obtain the land as it may not be available for sale again for a long time. This would be expected to have led to an increase in the land price. However, although the rate of amalgamation was relatively high during this period, there is little evidence to suggest that there was a significant effect upon the land market from the amalgamation of farmland. This is illustrated by the relatively static land prices between 1965 and 1970, during which the grant had been increased to 50% of the land's purchase price.

Tenure Legislation

Figure 2.1 illustrates that, despite increases in the prosperity of agriculture after 1947, land prices did not begin to increase till 1958. It is likely that this is as a result of the tenure legislation operating at the time. If landlords and tenants could not agree upon an annual rent to be paid then, according to the Agriculture Act of 1948, the dispute would be taken to arbitration. The arbiters argued that a 'proper' rent be payable and although this is vague, it was generally acknowledged that arbitration favoured the tenant. As a consequence, landlords were generally cautious in rent negotiations and verged on the side of lower than could be expected rents, to avoid arbitration that was also costly and inconvenient. In addition, rents are generally fixed for a period of three years and due to both these factors, rents did not rise in the same way that output prices did. As the rental income for landowners did not rise significantly, the price of tenanted land did not rise significantly either. Furthermore, this established a differential between vacant possession, with no tenants, and owner-occupied land.

A premium was paid for vacant possession that represented the higher return on the land, given that with vacant possession, landowners could farm the land themselves or establish a new tenant, in both scenarios receiving a market value of rent. However, with a 'sitting' tenant, already farming the land, the landowners expected a rent significantly lower than the market value.

The 1958 Agricultural Holdings Act altered the arbitration system so that arbiters had to take account of the market value of rent when assessing cases that come to arbitration. Although only a small percentage of rent negotiations actually ended up in arbitration, the effect of this change was to shift the rent of tenanted land towards that of vacant possession. However, landowners were still willing to accept less rent to avoid arbitration and rents were still fixed for a period of three years.

Land Use Legislation

Legislation that controls the uses for which land may be used was first specified in 1932, in the Town and Country Planning Act. This was the first act to specify the particular uses for land; residential, agricultural and industrial. Planning permission was given to developers on the basis that the development conformed to the land specification. However, refusal for this permission meant that compensation was to be given to landowners for the inability to develop the land in the way they wished.

However, as urban areas widened, there was a public desire for stronger legislation, the result of which was the 1947 Town and Country Planning Act, the basis for land use currently operating. According to the act, the landowner had no option but to retain the land in its current use unless specific permission was granted for a change in the use. Furthermore, 6% of the total land area in England was designated as green belt land. As the act determined the particular uses for the land, but did not compensate landowners for no granting planning permission, it increased the differential between land sold for agricultural purposes and land that may be developed. Lloyd (1991) states that the changes of land use that necessitate the compulsory purchase of land for road building places the value of land for development at 5-10 times that of agricultural land.

This research only considers land that is sold for agricultural purposes.

Removing land sold for development from the data does means that around 15,000 ha of farmland per annum, on average, between 1951 and 2001 is removed from the data. If the land is sold for development at a premium, but the income from the sale is used to purchase agricultural land, then there may be an increase in the land price as a consequence.

However, land that has been granted permission for development has been excluded for two reasons. Firstly, land sold for development is taken out of the agricultural land market because it introduces an upward bias in the estimated price of agricultural land. The agricultural land price reflects the nature of the land, its characteristics, which include its inability to be developed as a result of legislation.

If the land has been granted planning permission, it is no longer the same good. Another option would be to use the agricultural land sold for non-agricultural purposes. However, this leads to the second problem. The second reason we exclude this land is purely from a data point of view. The data provided by Defra excludes all sales of land for development.

Capital Gains Tax

The introduction of Capital Gains Tax in 1962, and subsequently modified in 1965, altered the structure of the land market. It is charged on the sale of any asset that has appreciated by a rate greater than that of the general rate of inflation, measured by the retail price index. The gain is considered to be the selling price minus the initial cost, adjusted for inflation. However, if the land was purchased prior to 1965, then the value in 1965 is taken. For the majority of the sample period the tax was levied at a rate of 30%.

Capital gains tax would be expected to have a dampening effect upon land prices, as any gains from land ownership would be taxed. However, farmers were given various forms of relief that enabled them to effectively evade capital gains tax. Farmers are given 'roll over' relief whereby capital gains tax is deferred on the sale of land if income from selling the land is used to purchase similar farming assets. Furthermore, this was supplemented with retirement relief. Retirement relief meant that if the seller is over 65%, the capital gains tax liability is reduced, and the cost of farm improvements and construction of farm buildings could be added to the acquisition cost. This reduced the amount of capital gain liable for taxation, with the farmhouse itself, animals and moveable property exempt.

The various forms of relief meant that land became more valuable, relative to other income earning assets, and increased the demand for the land, when compared to shares and other income earning assets. Capital gains tax also increased the differential between owner-occupied and tenanted land. While farmers are eligible to receive ‘roll over’ relief, the same cannot be said for landowners who allow tenants, who pay rent, to farm the land. Hence, land that is in vacant possession would be higher valued than land that is tenanted and so, capital gains tax, or more specifically the lack of relief from capital gains tax for landowners, is cited as one of a number of reasons for the demise of tenanted farms in England. Data covering sales of land in England by tenure, from Defra, suggests that in the 1990s only 1% of agricultural land sales in England were for tenanted land. Tenanted sales constitute only 1% of land sales so all land sales are grouped together.

1970-1979:

The 1970s were meant to herald a new era of prosperity, security and stability for agriculture as the UK entered the European Economic Community (EEC). However, this was far from the case. Although real land prices increased by 16% between 1970 and 1975, this masks the dramatic increases, and subsequent falls, in land prices during the intervening period. The peak in land prices over the whole sample occurred in 1973 (see Figure 2.1), the year in which the UK was accepted into the EEC.

However, land prices had already doubled in 1972. The benefits of guaranteed commodity prices within the Common Agricultural Policy (CAP) of the EEC were anticipated prior to the EEC entry, especially given the difficulties involved in entering the EEC. These difficulties led to a lag between it being almost certain that the UK would enter the EEC and the UK actually entering the EEC). This was exacerbated by other factors on the world stage such as grain shortages in 1972 and 1973 and the oil crisis in 1973.

During 1972 and 1973, world grain prices increased threefold as a result of poor harvests and the expansion of trade links. A number of consecutive poor harvests around the world, especially in 1972 and 1973, the worst of which was seen in Russia, led to sharp falls in grain production and a threefold increase in the price. This was exacerbated by the Great Russian Grain Deal, which opened up the Russian domestic grain market and created a high demand for world grain that only served to increase the demand for land and push its price up further.

Common Agricultural Policy

The CAP was originally introduced in 1962 and driven by the strategic need for food security in Europe, which led to a deliberate increase in domestic food production and reduced dependence upon imports. Its main mechanisms were to manage markets to remove surpluses and protection for the domestic markets through import taxes and export subsidies. The key objectives of the CAP, enshrined in Article 33 (39) of the consolidated Treaty of Rome are to:

increase agricultural productivity and thus to ensure a fair standard of living for agricultural producers;

stabilise markets;

assure availability of supplies;

ensure reasonable prices to consumers.

The CAP used a different system of support to that which the UK had previously been used to. With the deficiency payments, the government set artificial prices above the world price and the government paid the difference between the two prices. However, these payments were scrapped once the UK joined the EU and replaced by a new system. Effectively, the CAP taxes imports of agricultural commodities from outside the EU. This raises the internal domestic price above that of the world market price and, therefore, rather than the government, it is the consumer that pays the difference between the domestic market price and the world price. Furthermore, the government actually *gains* from this method of support as the difference between the domestic market price and world market price for imported agricultural products, is paid *to* the government. This enables the government to provide export subsidies for domestically produced agricultural products. In terms of the prices that farmers receive for their output, the change from direct payments to the high prices does not theoretically alter the benefit. However, in practice the CAP was expected to, and indeed did, raise the level of support to agriculture.

Accession to the EEC

Although the UK's application to join the EEC was successful eventually successful, it had applied on two previous occasions and been rejected. The first of three applications to the EEC was submitted on 9th August 1961. Britain’s post-war agricultural policies were directed towards ensuring an ample supply of agricultural produce, stabilising agricultural product markets and increasing efficiency and this was seen as being broadly in line with the policies of the CAP. Britain was still engaged in trade with the USA, the Commonwealth and its established trading partners. However, General De Gaulle, the president of France, vetoed the application in 1963 and the UK's membership was not accepted.

The second British application to join the EEC was vetoed once again by De Gaulle in 1967. In 1969, De Gaulle resigned from the French Presidency and former Prime Minister George Pompidou was elected as the new President. Britain applied again in 1971 and although entry was only official in 1973, from 1971 onwards it was purely a matter of 'when' rather than 'if' the UK would join the EEC.

With the future guaranteed future prices provided by the CAP length of time taken to enter the EEC, combined with the determination of the UK's proposed entry, meant that many farmers were both willing to buy land on the demand side and reluctant to sell land on the supply side. However, although prices were expected to be higher under the CAP, the extent to which this was the case was unknown.

Lloyd (1991) argues that this was a case of a speculative bubble[5]. A speculative bubble occurs in land markets when the land price rises for reasons other than that of an increase in the land's value. In this case, it is as a result of continuous rises in the expected returns that were expected to occur in the longer term. This can only have been exacerbated by the poor harvests around the world in 1972 and 1973 led to 50% increases in world grain prices, and heightened expectations of the future benefits that farmers would receive.

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5 Described in more detail in Chapter IV

The UK's accession to the CAP was graduated, taking five years for full membership, and till all the benefits were realised. While land prices rose a staggering 145% between 1970 and 1973, output prices and subsidies given to farmers rose 22% over the same period, implying a discrepancy between the expected and actual benefits of land use.

By 1975, grain harvests around the world had returned to decade average levels and the expected gains from the CAP had been realised. Real output prices, including direct subsidies, rose 20% between 1970 and 1975. Land prices rose 21% between the same years.

Between 1975 and 1979, real land prices rose sharply once again, rising 66% in the four years.

When the UK joined the EEC, the CAP adopted an element of the UK's pre-accession Annual Review, the 'objective method' of determining farm prices, allowing agricultural representatives to incorporate rising production costs into the support given to agriculture. As a consequence, the rising costs, which arose from the world oil crisis and the resulting stagflation, were added into farm commodity prices.

In addition, as the UK's accession to the CAP was finalised, with full accession concluded in 1978, the benefits that came with it began to be fully realised. The rising commodity prices boosted the profitability of agriculture and this was reflected in the higher land prices (Figure 2.1).

The land market remained buoyant and land prices continued to increase through to 1979, with interest mainly in vacant land, demanded by farmers who wished to amalgamate their land to take advantage of economies of scale as a result of, and to take further advantage of, the support policies from CAP.

1980-2001:

While the state of agriculture generally, and the land market specifically, were determined by a combination of policy change and world events during the late 1970s, over the last 20 years the land market has been primarily influenced by a change in the direction of agricultural policy.

In the initial sample period (1950-1969), agricultural policy was directed towards boosting the supply of agricultural commodities by increasing production and more efficient production through support. More recently, however, policies have been to reduce support to agriculture and reduce production (and the oversupply) of agricultural commodities.

Interest Rates

As the UK's accession to the CAP, and the benefits that came with it, began to be fully realised, there was a belief that the high prices were policy driven and not determined by the market. In addition, the collapse of the Bretton Woods fixed exchange rate system, followed by low interest rates in the early 1970s and ever increasing inflation led to heavy borrowing (at low cost) and high investment (with low opportunity costs) by farmers and landowners alike. However, by 1980, Agricultural Mortgage Corporation loan rates had reached 19% and despite the profitability of farming, purchasing extra land was significantly more expensive and difficult, with other investments seemingly more attractive (as the opportunity cost had risen). The demand for land decreased significantly and the supply increased as landowners that had over-borrowed sought to liquidate assets in the short term.

Re-orientation of CAP Policy

The support policies provided by the CAP were largely successful. However, as with supporting measures in the UK in the late 1950s, the CAP placed a large burden on the UK's budget, as it was a donor EEC member, and led to the overproduction of agricultural products with large surpluses seen within the European Community (EC).

The re-orientation of policy towards a ‘prudent price policy’ led to a reduction in the rising price support. Rises in farm support prices during the 1970s often approached 20% and in response to this the European Commission recommended price increases of 3% in the early 1980s, attempts to restrain prices and threshold quantities for guaranteed prices for the major products.

Ministerial inertia prevented any changes to a significant extent. This was increasingly evident as the problems of oversupply, combined with the addition of three new EC members; Greece, Spain and Portugal, placed even greater demands upon the Community budget.

The introduction of milk quotas introduced a shock to the land market for dairy farms. The earning potential of the land became dependent upon the milk quota on the land. Land with a high quota maintained their land prices.

The value of dairy farmland with no quota fell by around 40% in one year alone. Furthermore, this was also seen as a sign of things to come for other areas of agriculture with quotas to be introduced for crops and cattle. The fear of this affected land prices for all agriculture, which fell 22% in the mid-80s.

In 1988, the EC launched ‘Budgetary Discipline’ in an attempt to reduce expenditure on support without the negative spillovers of the type of quotas seen in the milk sector. The main instruments used were maximum guaranteed quantities.

Producers could exceed the quotas but would be subject to a reduction in prices dependent upon the quantity exceeded. Farmers were also encouraged to take the option of early retirement with the land being left fallow for at least five years grants for the reduction of farm output by 20%, known as extensification, and a voluntary arable land set-aside scheme giving £150 per ha. leaving 20% of the area fallow.

Further changes in the CAP, over and above the ‘budgetary reform’, were necessary in the early 1990s for three main reasons:

Growing surpluses

The introduction of quotas into the EU milk sector restricted the production of milk and aided the reduction of milk surpluses substantially. However, this covers only one area of agricultural production and there were no such limits on other areas such as crop and livestock production. However, the imposition of such quotas on other areas of agriculture, such as crop and livestock production, would be more difficult. Quotas on the production would be nigh on impossible to manage and limits on the production area would simply mean that areas with no quota for crop production would be used for livestock, leading to surpluses in that animal farming sector.

Movement towards freer world trade

Many countries in the World Trade Organisation (WTO), such as the USA and Australia, were concerned about the levels of support and restrictive access provided within the EU. The General Agreement on Tariffs and Trade (GATT) meetings that had taken place since 1948 attempted to liberalise multilateral trade. However, prior to the Uruguay Round, initiated in 1986, many of the GATT rules on trade did not apply to agriculture. The Uruguay round, finally concluded in 1994, was the first round to include a specific Agreement on Agriculture (AoA). The AoA set out the commitments that countries had agreed to implement over the period 1995-2000;

> ***Reduce domestic support*** *– a 20% global reduction in domestic support for agriculture compared with the 1986-88 average;*

Improve Market Access *– a conversion of non-tariff barriers to tariff equivalents, a reduction of all tariffs and their equivalents by 36% from a 1986-88 average base line;*

Cut Export Subsidies *– a 21% reduction in the volume of a 36% reduction in the expenditure for subsidised exports by developed countries compared with the average level in 1986-90; reductions of 14% and 24% for developing countries.*

Expansion of EU

The expansion of the EU after the reunification of Germany led the problem of how the EU could afford to provide the former East Germany with the sort of price support that was afforded to the EU.

The major resource that the former East Germany had was land for agricultural production as its service and manufacturing industries were not as developed or as efficient as those in the rest of the EU. However, providing agricultural support, at the high EU rate was not financially viable.

MacSharry Reforms

Commissioner Ray MacSharry enacted reforms in CAP during 1992 that were implemented a year later, attempting to bring the EU's policy for agriculture closer to that of international competitors and the reforms permitted the Uruguay Round Agreement to be concluded. Essentially, the reforms replaced the traditional price support (that encouraged production) with fixed area payments and that those who claimed the area payments must qualify by adhering to set-aside restrictions.

For cereals there was a 30% reduction in intervention prices over three years, compensation for price cuts on a per hectare basis and compensation paid conditionally for set aside. This also has spillover effects into the livestock industry as cereals are used as a feedstock for farm animals and as a result, livestock support reflects the support for its feedstock.

For beef producers there was a 15% cut in intervention prices over three years, restrictions on the use of 'normal' intervention and existing direct payments were increased. For sheepmeat producers, the support provided through premiums paid per ewe and the total number of premiums was limited to those paid in 1991.

For dairy producers the quota system was extended until 2000, there were small reductions in intervention prices but otherwise no change.

The consequences of the MacSharry reforms were that they greatly increased the significance of direct payments in farm incomes while also considerably extending the role of supply management policies (set-aside, ceilings on premium numbers). Furthermore, they helped to improve internal market balance by boosting demand (especially for cereals) and cutting supply. Farmers were, in practice over-compensated for support price reductions, as market prices did not fall to the same extent. This was a timely boost for agriculture when its profitability had been decreasing, illustrated in Figure 2.1.

WTO and Agenda 2000

Over the past decade, agricultural policy has been characterised by the growing influence of the World Trade Organisation (WTO). Previously, agriculture had been granted exemption from WTO rules on account of being a ‘special case’. However, this changed with the conclusion of the 1994 Uruguay Round of the GATT. Agriculture was not granted exemption any longer and was subject to the binding rules of the WTO. The WTO rules emphasise the importance of freer trade and transparent support, common among countries. The WTO stated that non-tariff barriers be changed to tariff-based barriers. In addition, the tariff barriers in agriculture, and expenditure on export subsidies, were both to be reduced by 36% over a period of six years.

A response by the EU to the changing trade environment in agriculture was to enact the Agenda 2000 CAP reforms, adopted in 1999. These reforms furthered changes that had been initiated by the MacSharry reforms, and increasing direct payments to farmers for cereals and beef at the expense of price support.

Conclusions

This chapter illustrates the environment in which the agricultural land market operates and highlights the sort of factors that would ideally be incorporated in any land price model to be developed. In particular, a land price model would ideally be able to react to changes in the support to agriculture, both in quantity and in structure (direct vs. indirect support).

Chapter 3

LAND PRICES: THEORETICAL CONSIDERATIONS

Introduction

This chapter provides a microeconomic framework for the land price model determined later. Without sound a theoretical framework, it could be argued that the choice of explanatory variables would be *ad hoc*. The theoretical model provided in this chapter is based on simplifying assumptions and hence, by definition, is an abstract concept but is necessary as a basis to work from.

This chapter looks at the theoretical workings of the land market, arguing that there are, in fact, two markets in operation; a market for the total stock of land and a market for the flow of land transactions, utilising the work of Harvey (1974) and Lloyd (1991). Given the several basic assumptions within the model, a simple present value model should, theoretically, be able explain the variation in land prices using the returns to the land and a constant discount factor.

Chapter 1 has illustrated that this is not always the case. The theoretical model does, however, illustrate areas where advancements may be made in the present value model so that the apparent problems of the model may be overcome. A variety of attempts have been made in the past to explain the variation in land prices over time and the divergences between land prices and land rents, used as a proxy for the returns to the land. The majority of these studies were conducted in the US and have generally concentrated on relaxing of the assumptions in the basic model and 'adding on' variables to the present value model in an attempt to explain any discrepancies. However, an alternative way of looking the land market was developed Just (1988). This views the land market from the perspective of economic agents attempting to maximise their utility and accumulate wealth (dependant on the value of land among other variables. The derivation of the land price model is rather long and included in detail in Appendix – Deriving the Basic Present Value Model. The land price is found to be dependent upon, not only the returns to the land, an interest rate (representing the opportunity cost of investing in land), and also the rate of inflation, which reduces the returns on other investments, reduces the debt incurred on loans for purchasing land and reduces the capital gains tax payable relative to that paid on other investments. This chapter is divided into three parts. The first part looks at the land market as an investment asset market and how the market operates in a microeconomic context. The second part looks at how the model is apparently inadequate in explaining the land market. Finally, this chapter looks at the model from an alternative point of view, using the work of Just (1988), who provides a thorough theoretical model that may provide an insight into the workings of the land market. Although the model is complex, it is possible to simplify the model significantly and the result is a model much like the present value model that highlights the importance of interest rates and inflation as explanatory factors in land markets.

Land Stock and Flow Markets

Harvey Model (1974)

In the theoretical model of the land market developed by Harvey (1974), there is assumed a;

> *fixed stock of land, divided into homogenous units;*
>
> *perfectly competitive price mechanism, including all input, output and financial systems;*
>
> *full information for all economic agents.*

The price of land is determined, as with any good, by the demand and supply. However, in this *stock market*, the first basic assumption implies that the supply of land is perfectly inelastic. This is not an unreasonable assumption given that additions to, or depletions from, stocks of land are negligible[6] such that even over relatively long time periods the stock of land can be treated as though it were fixed. The supply does not refer to the quantity of land available at any given time but to the accumulated stock of land. The demand curve relates to all those economic agents in the market who wish to hold land, not only those wishing to buy land, and the demand for the stock of land refers to prospective purchasers and current owners of land.

Each individual forms a market value of a market value for a unit of land. This market value is based upon the expected returns to the land during the period that the land is owned. The expected returns are discounted using a relevant discount rate, which is then used to make decisions on sales and purchases of land. The demand curve represents the ranking, in descending order, of those agents according to their willingness to pay a particular price. Whether the economic agent owns land at the current time or is willing to purchase land is considered irrelevant.

The current owner is said to have a reservation price, which is the minimum amount that the agent would accept to sell the land. Alternatively, there is an offer price, which is the maximum price that

---

[6] with the exception of land sold for development purposes which is not included in the DEFRA land

economic agents wishing to purchase land would pay for a unit of land. The stock demand curve represents both the reservation and offer prices. Effectively, Harvey (1974) argues that the decision rule is that, if an economic agent's valuation of the land exceeds that of the current owner then, the land will undergo a transaction. Alternatively, if the economic agent's valuation of the land is less than that of the current owner then the land will not be sold. As in any market, an increase in the price of the land means that there would be fewer economic agents willing to purchase the land.

The valuations vary across economic agents despite the same information being available to them, otherwise no transactions would take place and this is intuitively obvious as different economic agents would be expected to have different formations of expectations and different discount rates used to determine the expected discounted returns for the land.

The land market that Harvey (1974) proposes is illustrated in Figure 3.1. The demand curve is represented by DD and the supply curve is represented by QS. The point at which the two curves cross is the equilibrium price ($\boldsymbol{P}^{e}$), with quantity being the fixed stock of land, the price at which economic agents collectively wish to hold the stock of land.

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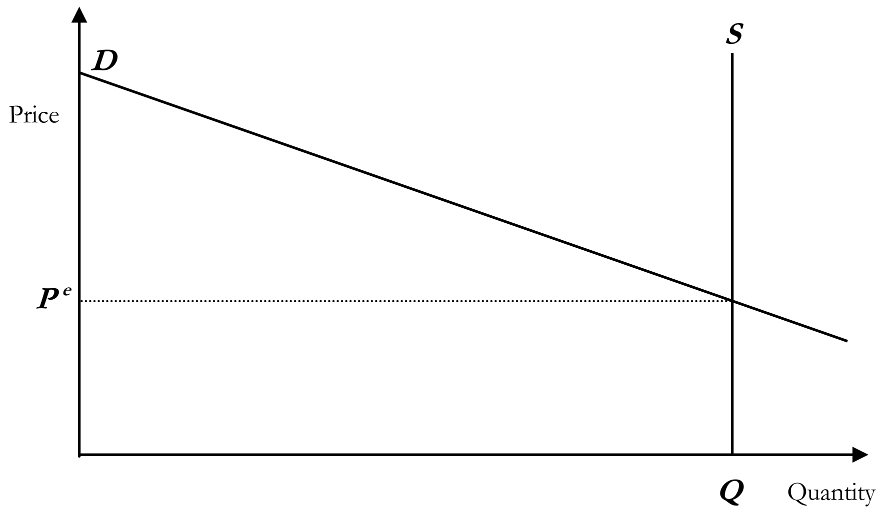
price data, and hence, in this analysis.

Figure 3.1 – The Stock Land Market



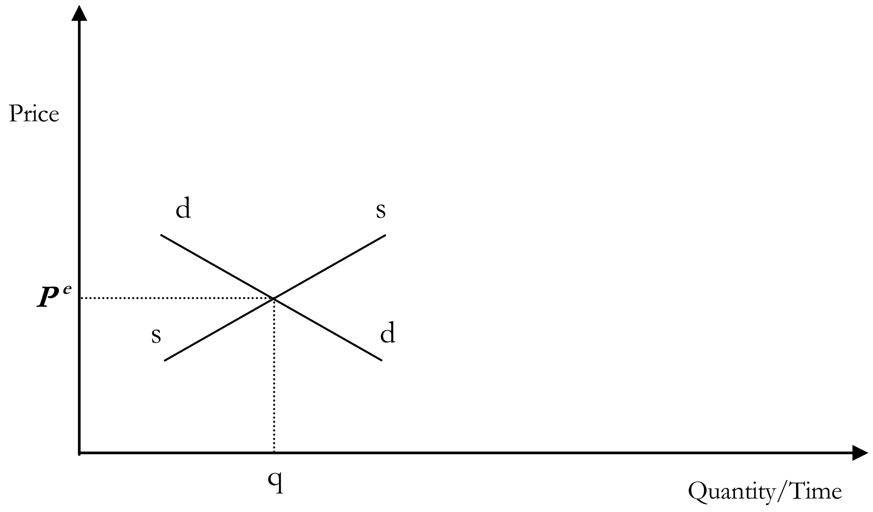
Over time, the expectations of future income and the discount rates would be expected to change such that this equilibrium only exists for this given point in time. The changes in expectations would be expected to shift the demand curve. The equilibrium establishes the market for the stock of land as a whole with all the economic agents acting collectively as a unit and this is reflected in the price. However, this states nothing about the distribution of the land amongst individual economic agents. As the equilibrium price only refers to a position where the population of economic agents wishes to hold the stock of land (and where distribution is not accounted for), it is possible that at equilibrium there are individuals who are not in equilibrium. At this position there may be individual economic agents who wish to sell units of land at the equilibrium price and individual economic agents who wish to buy units of land at the equilibrium price and, as a result, transactions occur at the stock equilibrium.

Blake (2000) argues that this can be explained by the fact that within the market for agricultural land there are two markets operating; a market for the total stock of land and a market for the flow of land sales/purchases in a given time period.

As the equilibrium price only refers to a position where the population of economic agents wishes to hold the stock of land (and where distribution is not accounted for), it is possible that at equilibrium there are individuals who are not in equilibrium. At this position there may be individual economic agents who wish to sell units of land at the equilibrium price and individual economic agents who wish to buy units of land at the equilibrium price.

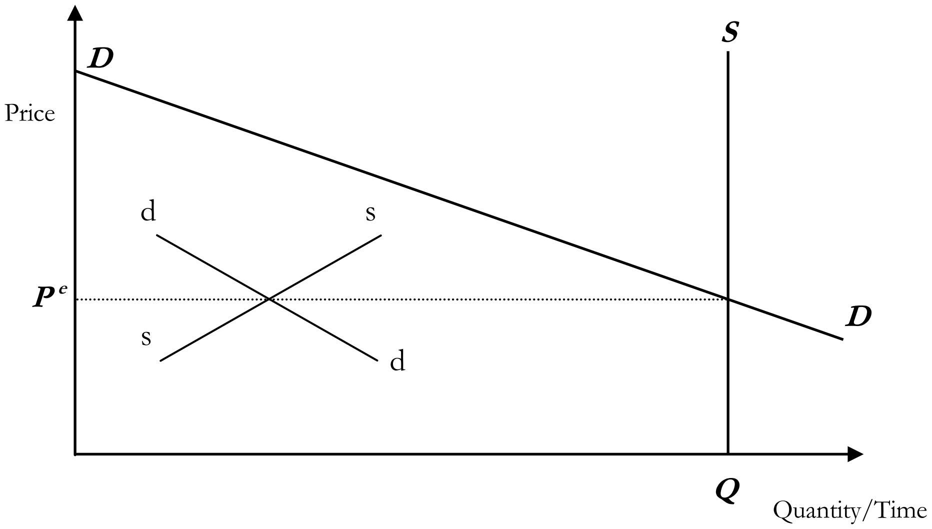
Hence, transactions with respect to land take may place even during equilibrium in what Lloyd (1991) describes as intra-market disequilibrium. These transactions can be illustrated by their own supply and demand schedules in which the supply schedule now represents the number of units of land that individual economic agents wish to sell in a given time period which will depend upon the distribution of the units of land. The supply schedule is therefore a graphical representation of the reservation prices of individual economic agents in the land market shown in Fig. 3.2. By the definition of reservation prices the supply schedule will slope upwards as increasing prices, *ceteris paribus*, lead to an increase in the number of economic agents who wish to sell their land.

Figure 3.2 – Land Flow Market



Likewise, the demand schedule represents the number of units of land that individual economic agents wish to buy in a given time period which will also depend upon the distribution of the units of land. The demand schedule is, therefore, a graphical representation of the offer prices of individual economic agents in the land market. By the definition of offer prices, the demand schedule slopes downwards as increasing prices, *ceteris paribus*, lead to a decrease in the number of economic agents who wish to buy other economic agent's land. Clower (1954) uses the concepts of temporary and stationary equilibrium to describe the difference between the stock of land and the individual land markets. In the stock of land market where the supply and demand curves intersect can be considered an equilibrium as the supply of the stock of land is equal to that which is demanded by the total number of economic agents acting as group. Within this group, however, there may be many individuals who may be wishing to sell their units of land or purchase land and. For those wishing to sell their land, their valuation of the land is below that of the market and for those wishing to purchase more land the market valuation is below that of the individual wishing to purchase the land. In this case the land market as a whole is in equilibrium. However, trade of land may still occur due to the differences in individuals. On an individual basis land will be traded until there is equilibrium in the individual land market. For there to be a full equilibrium, where both the stock and transactions markets are in equilibrium, the quantity of the stock demanded must equal the fixed supply and simultaneously there must be no trade between individuals who are all holding the quantities of land they wish to at the given price. The temporary equilibrium situation where the stock of land market is in equilibrium is shown in Figure 3.3.

Figure 3.3 – Stock and Flow Land Market Temporary Equilibrium



QS represents the stock of land which is constant at any given point in time. The demand curve DD represents the total demand for land at any point in time and consists of all the individuals in the market whether they are owners of land or those who wish to own land. For those economic agents who currently own land the valuation represents the reservation price, which is the minimum price that the agent would sell the land for.

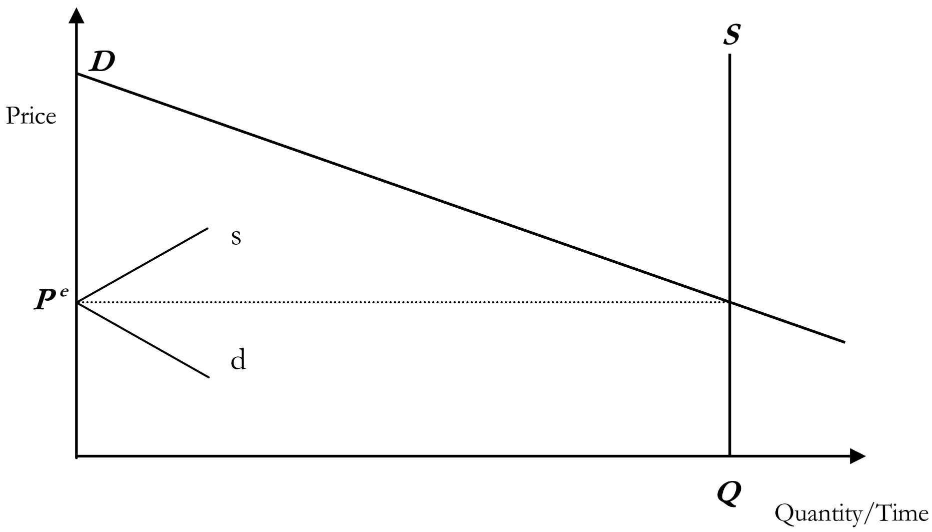
Alternatively each agent who wishes to own land has an offer price that is the maximum price that the individual is willing to pay for a unit of land. These two different valuations lead to the demand (dd) and supply (ss) curves. The demand curve (dd) orders the individuals in ascending order those who are willing to pay greater amounts for a unit of land. The supply curve (ss) orders the agents in ascending order those who are willing to accept greater amounts for a unit of land. If it is assumed in the land market that there are no transactions costs and location is irrelevant then the valuation is irrespective of whether the agent holds the land or not each offer price is simply a matter of time as the offer price becomes the reservation price as soon as the land is purchased. The opposite is intuitively true, as a reservation price becomes an offer price as soon as the land is sold. Equilibrium, *ceteris paribus*, is at P^e where supply and demand will continue to converge to this equilibrium where no transactions take place as those wishing to own land at the given price do so. Above this equilibrium offer prices are above reservation prices and hence there will be sales of land. At the market equilibrium price there is, however, disequilibrium in terms of the disallocation of land. The extent of the misallocation of land is given by q, the number of transactions in each period. This misallocation occurs as there are still offer prices[7] greater than the market prices implying that there are still economic agents who wish to buy land and there are still reservation prices (minimum prices which an economic agent wishing to sell land is willing to sell for) greater than the market prices implying that there are still economic agents who wish to buy sell.

To achieve a full, what Clower (1954) terms as a stable, equilibrium then under the temporary equilibrium there will still be transactions, sales and

[7] Maximum price an economic agent wishing to purchase land is willing to pay

purchases of land such that stable equilibrium all those wishing to hold land at the given equilibrium price do so such that no transactions take place. As these transactions take place there is a movement in the demand curve (dd) and the supply curve (ss) horizontally such that all reservation prices are equal to or above offer prices. This is presented in Figure 3.4. It represents a stable equilibrium as the stock of land supplied (***S***) is equal to that which is demanded (***D***) while simultaneously, on an individual basis (s, d), there are no transactions as every economic agent who wishes to hold land at the given equilibrium price does so and *ceteris paribus* there will be no change away from the situation.

Figure 3.4 – Stock and Flow Markets in Full Equilibrium



The main difference between the market for land and the market for any other good is that the number of transactions is not dependent on the price *per se* but on the misallocation at that equilibrium price. At an aggregate level there is no discernible difference but at the microeconomic level transactions are purely a method by which a redistribution of land takes place. Traill (1979) utilises the curves *d* and *s* to determine a model of land prices. Furthermore, he assumes that, in forming the curves *d* and *s*, economic agents determine their own valuation of land. These valuations are assumed to be determined by viewing land as analogous to an investment asset, such as a share.

Owning the land is assumed to earn a return each year, either by the landowner farming the land his or her self, or by tenants farming the land and paying rent. In the initial case, it is assumed that the investor in the land wishes to purchase the land, own it for one year and sell it at the end of the year. He or she expects to earn one year's return on the income from the land and the price the land is sold for at the end of the year. In perfectly competitive markets, the price will be equal to the expected income over that time;

$$3.1)\ P_0 = \frac{E[R_1]}{1+r} + \frac{E[P_1]}{1+r}$$

P_0 represents the price of the land. $E(d_1)$ represents the net return to land ownership at the end of the year. P_1 represents the value of the land is sold at the end of the year. r is market-determined rate of discount of the cost of capital. The return on the land comprises of two elements; income and capital gain. d_t represents the income element and P_1-P_0 represents the capital gain of the land.

However, it is unlikely that anyone would purchase the land for only one year. It is more likely that the land would be held for a number of periods, based on an expected present value of the future stream of returns to the land. In this case, the expected net return to land is represented by[8]:

3.2) $$E_t[P_t] = \sum_{t=1}^{T-1} \frac{E_t[R_t]}{(1+r)^t} + \frac{E_t[P_T]}{(1+r)^{T-1}}$$

E_t represents the expectations based upon the information that is available at time $t = 0$. R_t represents the net returns to land ownership in the time period t which available at the point where t ends. P_t represents the value of the land is sold at the end of time period T. P_T represents the value of the land is sold at the beginning of time period T. r is said to represent the rate at which the returns to land are discounted.

If there is no intention at time 0 to sell the land at time T then the right hand term falls to zero, as $T \rightarrow \infty$, which occurs if $E(P_\infty)$if finite, then;

[8] For a full derivation of this, see Appendix – Deriving the Basic Present Value Model

3.3) $E_t[P_t] = \sum_{t=1}^{\infty} \frac{E_t[R_t]}{(1+r)^t}$

The expected net present value, effectively price, of a unit of land equal to the sum of returns from time period T to ∞.

The Traill (1979) model is based upon determining the curves *d* and *s*, in effect the quantities of land that are demanded and supplied at any given price. However, this is clearly unobservable data. In an attempt to overcome this problem, Traill (1979) uses the observed prices in the land market as equilibrium prices in the model. This is where the supply of land is met by the demand for the land. The rest of the demand and supply curves, *d* and *s*, are determined by the rate of transactions at the equilibrium prices which are observable. The rate of transactions at these prices is also observable. However, this introduces another problem.

In the model developed by Harvey (1974) earlier, a pre-cursor to the Traill (1979) model, it was seen that the level of transactions in any given period is independent of the price. A given number of transactions simply represents the mechanism where land is reallocated amongst economic agents who have a demand for the land at the market price from those economic agents holding land who have a supply for the land at the market price. The transactions, whether high or low, do not alter the price. The degree of misallocation depends upon the extent to which the land valuations of those who wish to purchase land, prospective purchasers, exceeds the valuations of land by those who currently hold land at the current equilibrium price. It does not depend upon the price itself. Lloyd (1991) suggests that in periods where there are major changes regarding the profitability of agriculture, such as changes in the CAP, land sales may stall as landowner farmers await a policy decision. In this case, transactions of agricultural land sold for non-agricultural purposes, which generally only accounts for less than 10% of land purchases, plays a more significant role in land price determination and may bias the price upwards. However, Lloyd (1991) provides no evidence for this and it is not confirmed by an analysis of land prices and land sales data over the last 30 years. A time series regression[9] implies that there is no relationship between land prices and transactions in England[10]. In addition, statistical evidence presented by Wollmer (1992) implies that the area of land is independent of the land price in England and Wales. As a consequence, it is likely that Traill's findings of a negative correlation between land prices and transactions are most likely spurious, a statistical anomaly. Traill (1979), however, accepts the specification of a model with transactions as a proxy. He uses a plot of nominal land prices and the level of transactions between 1945 and 1977, which presents a negative relationship between land prices and the level of

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[9] See Appendix – Land Prices and Transactions

[10] Land Prices and Land Sales data between 1975 and 2001 provided by DEFRA, representing the data for all sales of agricultural land

transactions, as evidence for his model, arguing that this negative relationship represents a demand curve in some sense. Furthermore, he goes on to argue that the discrepancy between theoretical results and the land prices illustrated in Chapter 1 may be explained if two assumptions are made with respect to the nature of the demand and supply curves. The assumptions necessary are;

a stable demand curve;

exogenous supply curve.

The demand curve will be stable if the sales of land in one period do not significantly affect transactions in the next period, in which case the demand curve cannot move in a horizontal manner towards the y axis (price) as a result of transactions, a movement described from Figures 3.3-3.4.

This requires that one of two conditions be met;

Offer prices in one period must be replaced in the next period by equivalent offer prices of new prospective purchases, or;

The change of prospective purchasers to holders of land, and withdrawal from the land market, has no significant effect upon the land market.

These conditions are not testable without *a priori* knowledge of the economic agents demanding land at a particular point in time, although, neither condition appears unreasonable.

The specification of a perfectly inelastic supply curve is substantially more problematic. It means that the quantity of land sold in any period is unaffected by the past, contemporaneous and future price of land. It is possible that a number of sales may be involuntary through death or bankruptcy but intuitively, the price of land is a consideration in, if not the fundamental cause of, the vast majority of sales of land.

It is difficult to determine whether Traill (1979) has determined a model that reflects the land market or imposed strict, binding restrictions in which a model is determined that reflects his data set in particular[11]. Lloyd (1991) states that:

---

[11] examined in the empirical analysis

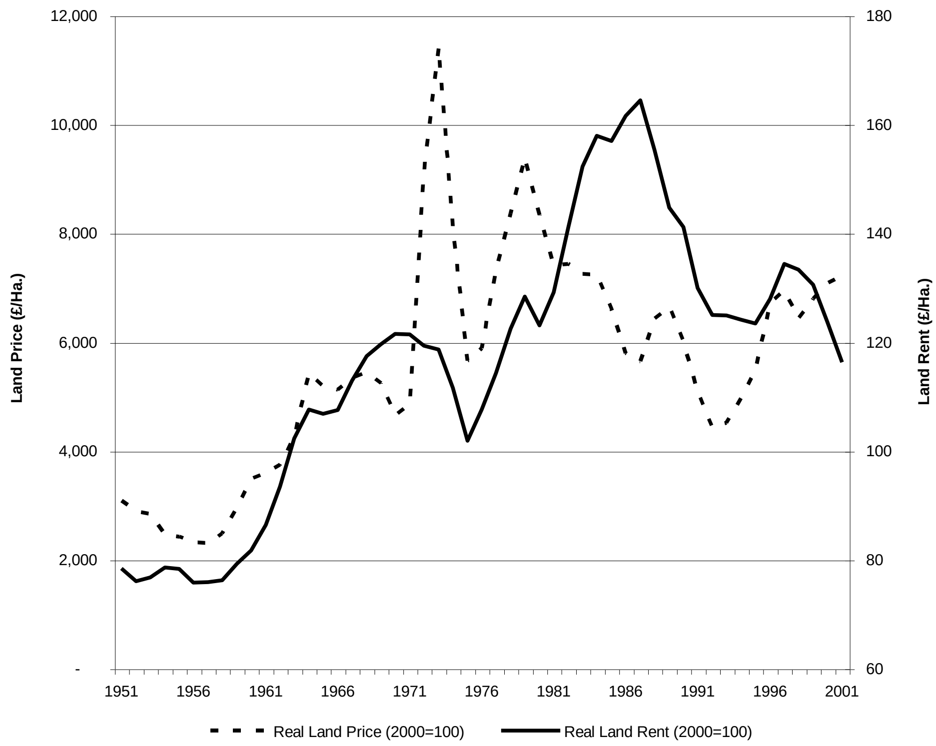
Having considered these assumptions one may reasonably surmise that far from explaining the discrepancy between empirical observation and theory, the restrictions imposed establish conditions under which such a discrepancy is possible.

Apparent Discrepancies in the Theoretical Model

The implication from the Traill (1979) model is that land prices and returns to land would be expected to be directly related and a simple plot of these two time series illustrates that this is not always the case. Figure 3.4 displays the movement in real land prices and real land rents, a proxy for returns to the land[12], over the period 1951-2001.

Even after deflating the variables, both land prices and land rents have increased over the sample period, illustrating the increasing value of land between 1951 and 2001. It would be expected that changes in the return to land would be reflected in the price of the land. For example, an increase in the return to the land would be expected to be reflected in an increase in the land price. And, in general, this is the case.

Figure 3.4 – Real Land Prices and Real Land Rent in England, 1951-2001



However, we would expect a direct relationship between the two variables throughout the sample period and this is not often the case. Furthermore, there are occasions when real land prices and real land rents appear to diverge. The early 1970s are notable for being a period in which land rents were relatively static whereas land prices increased significantly. In 1973, when the UK joined the EEC (now EU), land prices reached their peak over the sample period at £11,400 per hectare, rising 135% in only two

[12] The variables used in the analysis are discussed further in Chapter 5

years, between 1971 and 1973. However, over the same period, land rents remained relatively static, falling only £2 per ha., from £121 to £119.

During the early and mid 1980s, the divergence was even more significant. Between 1980 and 1987, land rents rose 34%, rising from £123 per ha. to £164 per ha, and although it would be expected that this is reflected in land prices, over the same seven year period, land prices fell by 32%, from £8,300 per ha. to £5,700 per ha.

Between 1998 and 2001, there is an increase in land prices of 12%, from £6,400 to £7,200. However, simultaneously, there was a 13% decrease in land rents.

The basic present value model cannot account for these instances. These are not simply anomalies, and occur over a total of 12 years from the sample of 50 years. It is clear that, either there are other factors at work in the model, in which case the theoretical model must be altered, or the variables that are used in the empirical model do not represent the variables in the theoretical model well. The latter is dealt with in the next chapter.

This research postulates that the basic present model is limited in its explanatory value. However, this can be overcome, once the effects of inflation are taken account of. This can be done by utilising a model developed by Just (1988).

Explaining Apparent Differences using a Theoretical Model

The Just (1988) model approaches the land market from a different point of view. Essentially, Just (1988) argues that the equilibrium land price can be derived by looking at an individual farmer's utility maximisation problem.

An individual farmer, said to also own the land, is assumed to have a utility function dependent upon consumption and wealth, which, in turn, is dependant upon, among other things, the equilibrium land price. The farmer maximises this utility function subject to a series of constraints. Just (1988) argues that this can be aggregated for the market as a whole and solved to determine a land price function. This land price function, derived in this section, states that the price of land is dependant upon the returns to the land, the opportunity cost of wealth that is tied up in land ownership, the opportunity cost of investment tied up in land ownership, and various forms of taxation. Just's model highlights the importance of inflation within the model, taxation and differing opportunity costs for investment and wealth.

Just Model – Specifying a Wealth Function

In the Just (1988) model, the driving force in farmland markets is wealth accumulation.

Wealth is defined as:

3.4) $W_t = (1-\rho)A_t P_t + S_t - D_t - T_t^*$

$W_t = real\ wealth\ at\ the\ end\ of\ period$
$\rho_t = rate\ of\ sales\ commision\ and\ transactions\ costs\ on\ selling\ land$
$A_t = total\ acreage\ of\ land\ held\ after\ current\ transactions$
$P_t = real\ price\ of\ land\ at\ the\ end\ of\ period\ t$
$S_t = real\ savings\ (and\ other\ investments)\ at\ the\ end\ of\ period\ t$
$D_t = real\ debt\ at\ the\ end\ of\ period\ t$
$T_t^* = tax\ that\ would\ be\ incurred\ on\ the\ sale\ of\ all\ land$

The wealth function states that a farmer's wealth is dependent upon the variables that directly affect land prices. i.e. savings, debt and transactions costs. In addition, within this wealth function there are functions to represent savings, debt and taxes (*S*, *D* and *T* respectively) and inflation has separate and distinct effects within savings, debt and taxes in the relationship.

The debt function is given in Equation 3.5:

$$3.5)\ D_t = \frac{1}{f_t}\left[(1-\pi_t)D_{t-1} + d_t\right]$$

$f_t = 1$ *plus the current inflation rate*
$\pi_t =$ *current rate of principal repayment on debt*
$d_t =$ *net current real borrowing (at the beginning of period t)*

Inflation and debt are inversely related. Just (1988) argues that this reflects the fact that farmers expect high inflation to reduce the total amount of debt, in real terms, which must be repaid. This is because large increases in inflation, with no change in the nominal interest rate, lead to a fall in the real interest rate[13]. However, the debt-reducing effect of holding land is non-existent in a period of low inflation and Just argues that a model of the farmland market must take account of this:

> *"...a model of land prices must reflect the way in which inflation affects this return to holding land in addition to the conventional value of land reflected by the discounted value of returns."*

The justification for this argument is somewhat questionable. Basic macroeconomics would suggest that this is not the case. The Fisher Effect states that a one percent increase in the inflation rate leads to a one percent increase in the nominal rate of interest, thus leaving the real rate of interest static. The Fisher Effect can, and will, be tested in the Chapter V.

The debt reducing power of inflation is only possible if there are different inflation and/or interest rates in the capital and farm markets. While it is unlikely that there are differing inflation rates[14], it is possible, and even likely, that there are differing rates of interest in each of the markets.

As result, higher rates of inflation lower the cost of borrowing money that could be used to purchase land, increase the profitability of purchasing land on borrowed money and increase the demand for it.

Inflation also has an effect on savings:

3.6) $S_t = \frac{1+\gamma_t}{f_t} s_t + F_t$

where

---

[13] The debt relationship makes an important distinction between debt and borrowing, the former D_t representing the total quantity of liability which is a stock variable, as opposed to borrowing, which represents the change in liability and is a flow variable.

[14] That could be determined practically

$$s_t = S_{t-1} - a_t p_t + D_t - \pi_t - \lambda_t$$

$\gamma_t = real\ rate\ of\ return\ on\ savings$
$a_t = net\ purchases\ of\ land\ at\ the\ beginning\ of\ period\ t$
$p_t = real\ price\ of\ land\ at\ the\ end\ of\ period\ t$
$\lambda_t = costs\ associated\ with\ debt\ and\ land\ transactions$
$F_t = real\ cash\ flow\ per\ acre\ from\ farming\ (net\ returns$
$including\ government\ payments\ less\ interest\ payments,$
$consumption\ and\ taxes$

The implication of Equation 3.6 is that inflation adds to the debt reducing effect of inflation by reducing the real value of savings. High and increasing inflation tends to reduce savings, making holdings of land favourable assets relative to that of savings. A model of land prices must reflect the debt reducing effect of inflation and savings erosion. Moreover as wealth is the driving force of land markets, these two must carry equal weight assuming that the original wealth relationship holds.

A variable that Just argues must be included but that many researchers neglect is tax law, from which the tax liability on sale of land can be represented as:

3.7) $T_t^* = \tau_t \nu_t \psi_g p_t A_t$

$$\tau_t = current\ tax\ rate\ on\ income$$
$$\nu_t = proportion\ of\ capital\ gains\ (losses)\ applied\ to\ taxable\ income$$
$$\psi_g = proportion\ of\ current\ land\ value\ attributable\ to\ capital\ gain$$

According to US tax law only 40% of capital gains on farmland were taxable until 1987 and as a result, in a situation when general asset prices are increasing, holding land becomes an attractive wealth accumulator as it received a 60% tax break in comparison to other investment assets. An increase in the tax break on capital gains would make land a more attractive asset to hold and, alternatively, a decrease in the tax break on capital gains would make land a less attractive asset to hold. However, Burt (1985) argues that changes in tax rates, especially effective rates, occur relatively infrequently and, as a result, are generally evolutionary with new tax loopholes being discovered to the extent that there is little change overall. This is certainly born out over the recent past in both the US and UK where tax legislation on capital gains has changed remained relatively unchanged.

Just points out that the effect of capital gains tax is still valid as a result of the inflationary effect. There is no additional demand for land as a result of the capital gains break in times when there is no inflation. However, while many assets suffer when there are high rates of inflation, the land market is left unchanged, in real terms, and Just argues ‘traditional *ad hoc* models’ do not take account of this capital gains tax break affect and that this is a major failing of previous models:

> *"The typical* ad hoc *approach in estimating land price models does not take these considerations into account and thus cannot use estimates from inflationary periods to analyse or project land prices in deflationary periods or to estimate the effects of eliminating the capital gains tax break."*

The implication, Just argues, of this is that the previous work, that does not include the effects of taxation, is effectively 'spurious' in nature. However, as tax changes occur relatively rarely, the cause of changes in the tax variable is inflation, rather than taxation, and it could be argued that the model should only include inflation. This certainly appears to concur with a simple time series plot of land prices in the previous chapter. In England, the legislation on capital gains was changed in 1962 (and subsequently revised further in 1965) to give landowners the type of tax incentives that Just argues must be taken account of.

However, over this period, land prices remained relatively static and as a result, it is difficult to argue that changes in the tax legislation had a significant effect upon the land market and advocate the inclusion of taxation in the model. However, it appears likely that the inflation hedge benefit that the tax break afforded to landowners was relatively low as a result of low inflation rates.

Furthermore, although Burt (1985) states that taxes have an 'obvious' influence on land prices, he goes on to state that there is little justification for utilising taxes as an explanatory variable in a time series regression for land prices. Burt (1985) argues being that there are many devices available for delaying the inevitable payment of capital gains taxes,

> *'...even to the next generation, and the opportunity to amortise the payment by selling on the contract make any constructed variable for a time series regression most tenuous.'*
>
> *Burt (1985)*

Just also attempts to take account of credit market imperfections by arguing that lenders to agricultural investors only allow lending only up to a certain point, that there is a maximum ratio of debt to assets:

3.8) $D_t \leq \mu p_t A_t$

where μ is the maximum debt ratio that may or may not be binding. Just argues that the proportion of farmers in each category, those for which the constraint is binding and those for which it is not, is:

> *"crucial in determining how land prices behave"*

Whether it is, as Just argues, crucial is difficult to determine but it is not an unreasonable assumption to make. Just argues that in an inflationary market the debt constraint relaxes due to the appreciated values of currently owned land that provides further collateral for further borrowing. In other words, an inflationary market increases the nominal values of land price; land currently held is more valuable and provides more wealth against which financial intermediaries are more willing to lend money. The opposite occurs in a deflationary market.

However, this does not take account of two important points. Firstly, in an inflationary market, expectations of future land prices would rise with inflation, leading to a rise in the number of land transactions and, in turn, a fall in the debt constraint. Furthermore, in an inflationary market if the currently owned land increases in price then so must land wished to be purchased and so the constraint has no real effect.

Just’s model utilises several assumptions attempting to make the model less restrictive;

The utility level of farmers depends upon consumption and wealth

(evaluated on a ‘cash-out’ basis), is strongly separable in each category and follows constant absolute risk aversion in each.

Production follows constant returns to scale;

Capital markets are assumed to be imperfect;

in that the savings interest rate is less than that for borrowing, finance charges are incurred in obtaining new loans and debt limits can be encountered.

Transaction costs are incurred for the sale of land;

Building sales are tied to land sales.

It should be noted that Just argues that farming is risky both in terms of operating income and wealth as both farm income and land price variation are dependent upon government policies, which are subject to unpredictable changes over long horizons. As a result, farmers cannot make decisions in the long run with certainty as production plans and investment portfolios may be altered due to unexpected events. Hence, the farmer's assumed objective is on a short-run basis with decisions altered on a frequent basis to meet the short run goals with changing economic conditions.

However, this makes little sense intuitively. The previous chapter has illustrated how, contrary to Just's belief, government policy makes price changes for farmers less volatile in the long run, especially since the adoption of the CAP in 1973. In this case, farmers are able to make decisions in the longer term and intuitively, this appears more sensible.

By the nature of farming, investment in land is a relatively expensive cost and for the stream of returns from farming to be profitable takes a long time in itself. Hence, the purchase of land is a long-term decision. Land is not purchased for farming purposes for one year only and sold again.

Just Model – Maximising a Utility Function

The utility function that Just attempts to maximise is:

3.9) $\max\ E\left(U^{*}\right) = E\left(W_{t}\right) - \frac{\beta_{2}}{2} Var\left(W_{t}\right)$

where $E\left(U^{*}\right)$ is the average utility.

It is assumed that returns from farming and land prices are viewed as normally distributed.

The maximisation of the utility function is a 2 stage utility problem using an open loop stochastic optimal control approach with a one period planning horizon decision rule deriving from the work of Rausser and Howitt (1985) to determine consumption from the maximised wealth.

The first order constraint of the average utility is given as:

3.10) $\frac{\partial E\left(U^{*}\right)}{\partial a_{t}} = \phi\left(b_{1} + b_{2}\overline{R}_{t} - \frac{\beta\phi^{2}}{2}\right)c_{1} - \beta\phi^{2}c_{2}a_{t} = 0$

which can be aggregated for the land market as a whole:

3.11) $b_{1} + b_{2}\overline{R}_{t} - \beta\phi^{2}c_{1} - \beta\phi^{2}c_{2}A_{t} = 0$

Given the possible set of solutions derived from the binding constraints:

sell out $\left(a_t = -A_t\right)$

debt free ownership $\left(D_t = 0, A_t > 0\right)$

no savings or debt i.e. constraints not binding $\left(s_t = 0\right)$

then;

3.12) $b_1^{'} + b_2^{'}\overline{R}_t - \beta\phi^2 c_1 - \beta\phi^2 c_2 A_t = 0$

where;

$$b_1^{'} = \overline{b}_2 \overline{P}_t - b_1^{*} p_t$$

$$b_2^{'} = \left(1-\gamma\right) + \Phi_3 \frac{\theta}{r_t + \pi}\left[\left(\gamma_t - r_t\right)\left(1-\tau\right) - \left(1+\gamma_t\right)\left(1-\tau\right)\right]\Delta\psi_d$$

$$c_2 = \overline{b}_1^2\omega + \left(1-\tau\right)^2\sigma + 2\overline{b}_1\left(1-\tau\right)\varepsilon$$

Aggregating over all land by multiplying by A_t, the summation over all individuals and dividing by aggregated land gives where $\overline{R}_t^{*}$ and $\overline{A}_t$ are weighted averages, and $b_1^{'} = \bar{b}_2 \bar{P}_t^* - b_1^* \bar{p}_t$ where $\bar{P}_t^*$ and $\bar{p}_t$ are weighted averages such that:

$$3.13)\ b_1^{'} \bar{P}_t + b_1^{*'} \bar{p}_t^* + b_2^{*'} \bar{R}_t^* - \beta\phi^2 c_2 \bar{A}_t = 0$$

and hence this can be solved for the land price:

$$3.14)\ \bar{P}_t = \frac{1}{b_1^{*'}} \left(\tilde{b}_1 \bar{P}_t^* + b_2^{''} \bar{R}_t^* - \beta\phi^2 c_2 \bar{A}_t \right)$$

where $\bar{P}_t$ is the average real land price at the end of period *t*. If the terms excluding the debt constraints are removed then:

$$3.15)\ \bar{p}_t = f_t \frac{\rho(1-\tau_t \nu_t \psi_t)\bar{P}^* + (1-\tau_t)\bar{R}_t^* - \beta\phi^2 A \Sigma_t}{1-\tau_t \nu_t \psi_t + \gamma_t(1-\tau_t) + \Psi_s Z_t + \psi_t - \Psi_t f_t (1-\Delta) Z_t}$$

where $\bar{p}_t$ is the average land price at the beginning of period *t*.

This is the land price model that Just (1988) attempts to estimate. In Equation 3.14, the numerator represents the value of holding an acre of land. The denominator represents the opportunity cost of utilising a unit of money's worth of wealth in land, not dissimilar to the previous models developed in essence and although the whole equation looks daunting, it can be broken down into eight distinct identities:

The first identity in the numerator is the expected value of land, after the change in its value, over the time period.

The second identity is the value of holding land attributable to farming including government payments.

The third identity is the opportunity cost of utilising a unit of money used for investment.

The first identity in the denominator is the tax break available for those who hold land and so do not pay tax until the land is sold.

The second denominator term reflects the rate of income tax on savings.

The third denominator term represents the higher costs incurred by those who must borrow to fund land purchasing.

The fourth denominator is the property tax on a unit of money invested in land.

The fifth term in the denominator reflects the credit constraints on the opportunity cost of money invested in land.

The Just (1988) model highlights the importance of inflation, taxation and the opportunity costs in the determination of land prices.

The land price is positively related to the expected change in the land price over time, the return to the land, the tax break on continuous land ownership and the constraints on opportunity costs of land ownership.

The land prices is also negatively related to the opportunity costs of investing money in land, the rate of income tax, the additional costs of borrowing to invest in land and the property tax.

Conclusions

To determine which model is to the basis for the model in this research, the empirical results of the Traill and Just models must be briefly explored in the next chapter. The theoretical analysis advocates the use of the Just (1988) model as the basis for a model of the land market. However, it is clear from Equation 3.15 that the model is highly data intensive and difficult to estimate with eight explanatory variables and that the use of Just's model in this form provides various problems highlighted in this chapter. The next chapter aims to determine the land price model to be used in this research using the research in this chapter and the empirical results of these models in the next chapter.

The Just (1988) model does, however, illustrate the importance of inflation in a land price model. According to the model, increases in the rate of inflation will necessarily lead to increases in the land price. The reason for this, as Equations 3.5 and 4.6 demonstrate, is that the increases in the rate of inflation lead to a decrease in the debt, in real terms, which must be paid when loans are taken out to finance purchases of land. This leads to a decrease in the return on savings and other investments that do not have the capital gains tax advantage that accrues to land, as an asset. As a result, although the Equation 3.15 may not be possible to estimate, any model of land prices must include inflation as an explanatory variable.

Chapter 4

LAND PRICES: EMPIRICAL CONSIDERATIONS

Introduction

The previous chapter focused on theoretical models that represent the market for agricultural land. Models such as the Harvey (1974) model provide the basis for research into the land market in more recent times. While the present value model in its most basic form appears to be insufficient to explain the variations in land prices and the divergences between land prices and land rents, it has, however, provided the basis for the main body of research into land prices.

A number of reasons for the discrepancies, inherent in the present value model, have been put forward by a range of authors; speculation, credit constraints or lack of, taxation, inflation, the non-agricultural demand for land, expectations, government policy and many others. This research has generally focused on arbitrarily choosing one of the assumptions made in the basic model that intuitively *appears* to have an effect, and relaxing this assumption.

There is little in the way of general consensus with respect to explaining the discrepancies highlighted in the present value model and the models provide little insight. However, a brief illustration of the lack of the contradictory nature of previous research is provided in the first section of this chapter. The second section looks at a re-estimation of Traill's land price model, highlighting the unsatisfactory nature of the model in empirical terms. The third section looks briefly at the results of Just (1988) model.

Previous Research

The majority of previous research into land markets derives from a period in the 1970s during which there was a significant divergence between land prices and returns to land. Since the divergence between land prices and land rents was initially apparent, there have been a variety of attempts to account for this divergence.

The majority of these studies, generally in the US (where the sharp increases in land prices in the 1970s were also seen), have focused on the present value model with an *ad hoc* specification of an additional variable that intuitively appears to have an effect on the land market.

As noted in the previous chapter, in the theoretical model of the land market developed by Harvey (1974), there is assumed to be a;

fixed stock of land, divided into homogenous units;

perfectly competitive price mechanism, including all input, output and financial systems;

full information for all economic agents.

The majority of previous research argued that, if the present value model is a valid representation of the land market, then it is one of these three assumptions that must be relaxed to explain sharp increases in the land price, without similar increases in the returns to land, such as those seen in the 1970s. However, the explanations for this increase are often contradictory.

Speculation

Lloyd (1991) argues that the increases in land prices seen in the early 1970s resulted from a speculative bubble. Speculative bubbles exist when prices deviate from their value in a non-stationary manner due to self-fulfilling beliefs that the price is dependent upon variables that may be irrelevant with respect to the asset's value. In other words, economic agents mistakenly expect that the price of land will rise even though there may be no increase in the returns to land.

Malkiel (1996) argues that there have been many examples of speculative bubbles throughout history, although the majority of these occurred in stocks markets. The reason given for this is the 'Greater Fool Theory'. According to the 'Greater Fool Theory', asset prices rise, initially, as a result of increases in the returns. However, once returns fail to rise further, investors still demand these assets. This is because they believe that they can still sell the assets at a large profit to other investors (or greater fools in Malkiel's terminology), despite the fact that the assets are vastly overvalued. At some point, and for no apparent reason, the bubble bursts as there are no more 'fools' willing to buy. At this point, there is mass panic, and investors attempt to sell all their assets until asset values are in line with the returns once again.

Lloyd (1991) states that this occurred in the UK market for land during the early 1970s, stating that the volatility of this period "had all the hallmarks" of a speculative bubble. Land prices rose 135% in only two years, between 1971 and 1973. This was subsequently followed by a 102% fall in the land price, between 1973 and 1975. Intuitively, the gains from joining the EEC, which by the early 1970s was considered inevitable, in addition to the sharp rise in world grain prices, led to this speculative bubble. The change in the returns to land, although expected to be positive, was unknown and it is possible that a problem of asymmetric information sets developed so those prices were bid higher than the returns that were actually earned by the land.

However, there is little evidence to advocate the suggestion of a speculative bubble in the land market. Rather, Falk (1991), in determining a present value model of land prices, analysed the existence of speculative bubbles and concluded that, not only do speculative bubbles not exist in stock markets, they do not exist in land markets either.

If speculative bubbles do, however, exist in land markets, however, then this provides a serious problem in that the basic present value model;

4.1) $E_t[P_t] = \sum_{t=1}^{\infty} \frac{E_t[R_t]}{(1+r)^t}$

developed in the previous chapter, is not valid. This representation of the present value model is only valid if, as $T \rightarrow \infty$, $E(P_{\infty})$ is finite. However, this is not the case when there are speculative bubbles. Where there are speculative bubbles, the expected net return to land is represented by:

4.2) $$E_t[P_t] = \sum_{t=1}^{T-1} \frac{E_t[R_t]}{(1+r)^t} + \frac{E_t[P_T]}{(1+r)^{T-1}}$$

and although Traill (1979) does not state explicitly that this is the reason for including the capital gain in his model[15], it is possible that this may provide a theoretical basis for his inclusion of capital gain.

Non-agricultural Demand

Another explanation is that the non-agricultural demand for land played a significant part of the early 1970s' increases in land prices. Financial institutions, which generally account for the minority of land transactions, increased their land holdings by more than 500% and that the majority of other transactions were between private individuals who acquired vacant possession land with the intention of selling the land for development.

[15] Described later in this chapter

It is possible that while there was a stalling of farming investors in land, there was simultaneously a sudden emergence of institutional investors that shifted the thin land market temporarily into an unstable state. Effectively, the non-agricultural demand for land and institutional demand for land became temporarily accounted for a significant proportion of land transactions. The payoff from the land for non-agricultural usage and the relative payoff for institutional investors, *vis-à-vis* other investments, is greater than that from agricultural sources and, as a result, the price that each of these is willing to pay for land is greater than that from individual farmers. The consequence of this is that, in a land market where the number of transactions does not appear to be significantly higher, as transactions between farming landowners are replaced by institutional and other non-agricultural investors (using the land for development), land prices may increase substantially.

The assumption that the land market is a thin market is not unreasonable, given that land transactions occur far less frequently than transactions for other investment assets. However, this does provide a problem for empirically modelling as data on the non-agricultural demand for agricultural land is not readily available. However, as it appears, from the data, that this is the only period where it appears to have occurred, it may be overcome with the use of a dummy variable.

Other Conflicting Evidence

Reinsel and Reinsel (1979) argued that a lack of constraints in credit markets were responsible for the land price boom in the 1970s. Loose credit markets allow large borrowing that makes it easier to purchase land. However, this is in direct contradiction to Shalitz and Schmidt (1982), who argued that credit market constraints were actually the cause of steep changes in land prices, dependant upon the land collateral value of assets. As the collateral value of assets increases, with credit market constraints, the land price falls. Likewise, if the collateral value of assets decreases, with credit market constraints, the land price falls.

Hoover (1961) argued that inflation caused real growth in land prices. The logic behind inflation causing real growth in land prices is the perception that land is a real asset that is capable of holding its value during inflationary periods. Feldstein (1980) suggested a more plausible method by which inflation could cause real land price growth. In this model there is a specific theoretical mechanism by which inflation changes real land prices as a consequence of a tax system that gives 60 % of capital gains exemption from taxation. However, as noted in the previous chapter, although Burt (1985) argues that taxes have an ‘obvious’ influence on land prices he goes on to state that there is little justification for utilising taxes as an explanatory variable in a time series regression for land prices, as changes in tax rates, especially effective rates, occur relatively infrequently and as such are generally evolutionary with new tax loopholes discovered almost simultaneously. In this case there is little change overall.

However, Alston (1986) analysed the question of whether inflation or real growth in net rental income could have had an important impact on land prices during the 1970's by formulating a model to test the Feldstein hypothesis that there is a positive effect of inflation on real land prices against an alternative hypothesis with the opposite effect.

The result showed inflation to be theoretically ambiguous and suggests that most of land price growth can be explained by real growth in net rental income to land yet the model supported a negative effect for the level of expected inflation on real land prices although the effect of inflation was relatively small and directly contradicts the findings of Hoover (1961).

In recent years there have been attempts have been made by various authors, in the US and Canada, such as Weisensel et al (1987), Romain et al. (1995) and Clark et al. (1993), to quantify the effects of government policy on land markets. These models have tended to focus purely on the subsidies provided to farming, excluding price support. The methodology tends to be somewhat *ad hoc*, with disappointing results and the research suffers from data problems.

Expectations

Prior to analysing the price models of Traill (1979) and Just (1988), it is important to note the role of expectations, the forecasts or views of decision makers about future prices, in the land price model. According to the present value model, as previously noted, the land price is dependent upon the expected stream of future returns. As a consequence, how the expectations are formed, influences the empirical model significantly.

The most simplistic form of expectations is naïve expectations. If economic agents are assumed to have naïve expectations of the future returns at any given time, then a prospective land purchasing economic agent expects to receive any increase in the return to the land each and every year. Naïve expectations are formed simply by using lagged values of the returns to land. Adaptive expectations, also uses lagged values of the returns to land. However, in the case of adaptive expectations, each lagged value is weighted and these weights decline exponentially.

A more complex method of expectations theory is to use rational expectations, an equilibrium concept and is dependent upon land rent being subject to a stochastic process, implying that the method of forecasting land rents is independent of the land priced model.

In rational expectations, the optimal choice of forecasting land rents in the future for one economic agent is dependent upon the conditional on the choices of other economic agents.

The majority of previous research in land markets has either, used naïve expectations as in the case of Traill (1979) and Lloyd (1991), or has utilised adaptive or rational expectations and achieved unsatisfactory results. Tegene and Kuchler (1994) tested the present value model over three agricultural regions in the US with the result that:

> *"regardless of the discount rates used the present value model under rational expectations is rejected"*

In addition, Just (1988) tests the differing types of expectations and finds the best results are achieved using naïve expectations. No implicit assumption is made with respect to expectations within the research. However, the determination of lags necessary for a robust VAR model determines the extent to which previous values of land prices are utilised to determine expectations.

In the next sections, the empirical results of the Traill (1979) and Just (1988) models are explored to determine the basis for a land price model.

The Traill (1979) Model

The research in the last chapter has examined different models and approaches to resolve the best method of determining a model of the land market. The Harvey (1974) model provides a good theoretical microeconomic framework which was extended by the Traill (1979) model and this is seen as a good basis to start from, working as it does with the present value model. The problems of the Traill (1979) model are noted. With the assumption of a perfectly elastic supply Traill has effectively stated a demand-determined relationship between average price and the total area of land traded to represent the land market. Traill (1979) states three variables and a dummy that determine the price of land;

- Current and expected profitability of farming[16]
- The opportunity cost of capital[17]
- The expected capital gains from land purchase[18]
- Dummy for EEC entry

In effect:

4.3) $P_t = f\left[T_t, PV_t, CAPGAIN_t, D_t\right]$

---

[16] Proxied by net farming income and growth of net farm income respectively

[17] Proxied by the Agricultural Mortgage Company's loan rate

where;

P_t = The price of land at time t

T_t = The number of transactions at time t

PV_t = Expected farming income in the time period t

$CAPGAIN_t$ = Expected capital gains in the time period t

D_t = The dummy variable for entry to the EEC (now EU)

and all the data is in nominal terms where applicable.

In Traill's analysis the model developed includes an additional term $CAPGAIN_t$ This variable is included to take account of any capital gains accruing during the time of ownership. This is not included in the theoretical model and is only justified on the basis that, as Traill (1979) argues, economic agents may have a different expectation of land price growth to that of farm income growth and that the variable $CAPGAIN_t$ takes account of that. It appears that Traill is taking account of speculation (and speculative bubbles), meaning that the representative present value model is Equation 4.2), not Equation 4.1).

[18] Proxied by land price changes in previous years

Traill (1979) defines $CAPGAIN_t$ as a three year moving average before 1972 but as a one period change after 1972 that reflects the volatile nature of land prices in the latter period of the sample. In Traill's original model there are various other factors that are included. These include attitudes to risk, technological change and capital taxation but these are not included in the estimated model due to limitations in the data or because they provided statistically spurious results.

Lloyd (1991) argues that there are concerns over the use of net farming income as a measure of the return to land ownership. Under a purely landlord-tenant system of tenure the net return to land ownership would effectively be net rent. In England, however, there is a prevalence of owner-occupation such that Traill (1979) disregarded rent figures. The figures for farming income are unsatisfactory as they represent the return to labour and capital, not the land itself. Net Farm Income is defined as:

> *The return to the principal farmer and spouse for their manual and managerial labour and on the tenant-type capital of the business. Tenant-type assets…include crops, machinery and livestock.*[19]

[19] Defra Website 2002

Farming income excludes the return to land that is paid in the form of rent such that farming income only affects prices to the extent that it affects rents.

It is the distinction between the profitability of land and the profitability of farming that Lloyd (1991) considers important as his re-estimation of the model over a longer sample finds, contrary to expectations, a weak negative correlation between farming income and land prices.

Despite this the re-estimation of the Traill (1979) model finds that PV_t is highly significant which Lloyd (1991) postulates is due to the fact that the variables are in nominal terms such that there is a trending effect from inflation. This is confirmed by the re-estimation of the Traill (1979) model using deflated variables that finds that PV_t is not significant at the 5% level.

Lloyd (1991) also argues that because the variables are all in nominal terms there is an increase in the explanatory power of the regression as a whole (as inflation trends all the variables together) and also causes problems of multicollinearity between PV_t and $CAPGAIN_t$ and this is confirmed by re-estimation of the Traill model in real terms.

Equation 4.4 and Table 4.1) present the Lloyd (1991) re-estimation of the Traill (1979) model with the use of deflated variables.

4.4) $LP = 130.39 + 3.19PV_t + 0.4CAPGAIN_t - 0.15T_t + 39.67D_t$

Table 4.1 – Re-estimation of Traill Model

	Land Price 1945-1977	
Constant	130.39	(6.98)
PV_t	3.19	(1.41)
$CAPGAIN_t$	0.40	(2.37)
T_t	-0.15	(-7.98)
D_t	39.67	(2.35)
R^2	0.82	*t* stats. in parentheses

According to the standard diagnostic testing procedure, there are no econometric problems once deflated variables are utilised in the model. However, the correlation coefficient has decreased from 97% (see Lloyd 1991)) to 82%. Expected farming income in the time period is positively related to the land price however it is found not to be significant at the 5%

level. As would be expected the variable $CAPGAIN_t$ is positively related to the land price and is significant at the 5% level. T_t, the number of transactions, is negatively related to the land price and significant at the 5% level as would be expected.

Traill (1979) states other factors that may be useful in determining a complete model of land prices but these are neglected in the final model, either because the data was unavailable or because the variables were found to be statistically insignificant. However, the importance of this point should not be overlooked. The omission of relevant variables constitutes a specification error and may bias the estimation (lead to over estimating or underestimation) of the remaining variables.

Farming income is, empirically, not relevant in the model of land prices[20] and given the spurious nature of the model, it is considered unsatisfactory and the Just model is now examined.

The Just (1988) Model

Of the literature on land market research, the most detailed theoretical model was developed by Just (1988) alongside his work with Miranowski

[20] i.e. not significant at the 5% level

(Just and Miranowski, 1993). However, the model is questionable from an econometric point of view. The model suffers from two points of view. Firstly, the model full results of the model are not published and, as a result, it is difficult to give a full assessment of the empirical model. Secondly, the lack of econometric testing and the large number of similar variables gives rise to problems of multicollinearity.

Just (1988) argues that empirically it is possible to explain the divergence between land prices and land rents, such as that seen in the 1970's, utilising simply returns to the land (Alston, 1986 and Burt, 1986). However, these re-estimated models of Alston and Burt by Just employ *ad hoc* lag specifications with a weighting system whereby there is a greater weight upon longer lags than on shorter lags, which intuitively is unlikely. These models are further undermined by the fact that they do not take account of discount factors and hence are based purely on correlation such that the models are *ad hoc*. It is not possible to level this same criticism of an *ad hoc* model at Just as there is a theoretical framework outlined.

The Just (1988) model is given in 4.5):

$$4.5)\quad \overline{p}_t = f_t \frac{\rho(1-\tau_t\nu_t\psi_t)\overline{P}^* + (1-\tau_t)\overline{R}_t^* - \beta\phi^2 A\Sigma_t}{1-\tau_t\nu_t\psi_t + \gamma_t(1-\tau_t) + \Psi_s Z_t + \psi_t - \Psi_t f_t (1-\Delta) Z_t}$$

where $\bar{p}_t$ is the average land price at the beginning of period t.

In relationship 4.5) the numerator represents the value of holding an acre of land and the denominator represents the opportunity cost of utilising a unit of money's worth of wealth in land. The first numerator is the expected value of land after appreciation and the second is the value of holding land attributable to farming including government payments. The first denominator is the opportunity cost of utilising a unit of money used for investment. The second denominator represents the tax break available for those who hold land and hence do not pay tax until the land is sold. The third denominator term reflects the rate of income tax on savings while the fourth denominator represents the higher costs incurred by those who must borrow to fund land purchasing. The fifth denominator is the property tax on a unit of money invested in land and the sixth denominator reflects the credit constraints on the opportunity cost of money invested in land.

Just finds that land price expectations are the most important explanatory variable but that this is due to a change in other variables such as the changes in previous prices. However, the extraordinary finding in Just's research is that inflation and the opportunity cost of capital are approximately as important as returns in explaining variations in land price with the increase in inflation accounting for 23% of the 1973 increase and 18% of the increase in 1974. Furthermore, this was essentially due to the reduction in real capital with a reduction in the opportunity cost of a unit of money invested in a given activity and also a decrease in the real return on savings such that investment in land became relatively attractive. Just argues that the increase through to 1978 is merely the effect of the initial change from 1973-1974 but that this took time to work through the system although a justification for this is not given but correlates well with the oil crisis and its macroeconomic effects. Government payments are not relatively important in explaining variations in land prices. Although they may account for roughly 15-25% of the capitalised value of land, Just argues that because of their stabilising tendency they may account for only a small part of fluctuation in land prices. Credit availability has little effect on land prices as well and the basis for this is that debt is relatively low compared to land value such that it is unlikely that credit constraints have an effect due to the collateral available. Returns are also relatively unimportant. Due to high inflation real returns were in decline following 1973 and Just argues that the supporting empirical evidence provided by Alston (1985), estimating 'peculiar' lag distributions giving more weight to longer lags than shorter lags, utilises '*ad hoc*' empirical specification. As a consequence of the detailed specification of the model the variables specified in the relationship are not available however Just argues that:

> *“...data for the indicator variables are not directly available in some cases but reasonable proxy variables are available.”*

and Just gives three examples.

Firstly, the proportion of farmland financed by debt is approximated by the ratio of total debt to the value of all farmland. Secondly, the proportion of farmland with no or minimal savings is roughly the same as the proportion of farmland of farm that uses debt farming, approximated by the ratio of total debt: total debt capacity, $\Psi_s = D_t / \mu p_t A_t$. The proportion of current land value to land value attributable to capital gain is the ratio of current land value to land value at the time of last purchase that is unobservable but approximated by the ratio of current land value to the lagged land value in nominal terms.

Just (1988) goes on to develop a model that includes government payments and finds that these payments are only a minor factor in explaining the variations in land prices on a 'year to year' basis. The argument he uses for this is that payments generally do not change very often and when they do change it is generally to offset a change in the returns to farming, the main example being deficiency payments. However, Just does argue that government payments may be an important factor in determining the absolute level of land prices and while, on Just's argument, it would not be expected that government payments would be included in a short run model of land prices, they may be important in determining a long run model;

> *"Government payments may account for roughly 15-25% of the capitalised value of land; but because of their stabilising tendency, (for example compensation payments) they account for only a small part of fluctuations in land prices."*

Furthermore, Just determines a model that attempts to take account of credit availability and its possible effects on the variation in land prices. Just finds that there is only a minor effect and argues that this is due to the fact that debt is small relative to land value. In this case it is considered unlikely that a large proportion of land holdings are limited by any constraints upon lending. Additionally, Just finds that sharp declines in land prices tend to lead to a decline in debt. The estimated model utilises four forms of expectations; Rational Expectations (developed by regressing actual prices and returns on available explanatory data and using the predictive values), Adaptive Expectations (utilising a geometric lag structure), Extrapolative expectations (formed by extending a four year trend) and naïve expectations were developed by using lagged values.

Data from the period 1963-1986 was utilised for the model estimated by the Seemingly Unrelated Regression method. Preliminary estimation by Just led to poor precision of the parameters on transactions costs Δ and ρ such that values of 0.02 and 0.94 respectively are imposed. The justifications of these restrictions are not given and somewhat arbitrary, if not questionable. Comparison with the study by Alston (1985) over the same estimation period seemingly provides Just with favourable results. For instance Just finds an R^2 of 98% compared to Alston's estimation of 95%. However, R^2 is a statistic which is non-decreasing with increasing numbers of regressors the addition of greater numbers of variables can only increase the R^2 value, whether the variables are statistically significant or not, and the standard errors of each of the variables is not given so it is difficult to determine which, if any, of the variables are statistically significant. The number of variables also highlights another problem. Many of the variables follow a similar trend and although this points to a high degree of correlation also indicates that there may be severe econometric problems such as multicollinearity which cannot be confirmed as a result of the lack of econometric testing in the Just model. Yet, it is likely that if the model includes a variable to take account of the tax break that land has, on capital gains, which is primarily determined by inflation[21] and also includes inflation as another variable, then there is a clear conflict.

[21] as Burt (1985) argues that tax changes occur relatively infrequently it is inflation that has the major impact upon his tax break variable.

Conclusions

The Just (1988) model is a rather complex derivation and suffers from various empirical problems highlighted in this chapter and theoretical problems noted in the previous chapter; the large number of variables, many of which are trended together, and the inclusion of taxation. As a consequence, this research does not attempt to reproduce this version of the Just model (1988) for empirical reasons. However, the model does highlight the necessity for a land model that includes inflation as an explanatory variable. In addition, the model highlights the need for an interest rate that reflects the opportunity cost of investing in land and by making several assumptions;

credit market imperfections $\left(\gamma_t = r_t\right)$,

transactions costs $\left(\Delta = 0, \rho = 1\right)$

risk aversion $\left(\beta = 0\right)$

all of which are standard simplifying assumptions made in earlier research by authors such as Harvey (1974), and by excluding taxation[22] in the model, then the model may be simplified into a basic present value model where inflation also plays an important explanatory role:

$$4.6)\ \bar{p}_t = f_t \frac{\bar{P}_t^* + \bar{R}_t^*}{1 + r_t}$$

The land price is dependent upon the return to land, the real rate of return and the inflation rate. It is analogous to the basic present value model, assuming no speculation. However, it is significantly different in two respects. Firstly, the inclusion of $\bar{P}_t^*$ takes account of the various effects of inflation that Just argues affect land markets. Secondly, r_t is a non-constant rate of return. The rate of return represents the opportunity cost of investing in land, in that money used to purchase land could be invested and earn a rate of return r_t. The land price, as defined in Equation 4.6 would be expected to be positively related to the inflation rate and the return to land, and negatively related to the rate of return.

Whereas in the Just (1988) model, the rate of interest used is the real rate, this research uses the nominal rate. This is for two reasons. Firstly, Blake (2000) argues that in assessing the rates of returns on assets, the nominal

[22] to avoid problems of multicollinearity and in line with the findings of Falk (1991)

rate of interest should be utilised. In addition, the next chapter illustrates that the nominal rate of return and inflation rate are integrated of order one (I(1)). This implies that the real interest rate is likely to be stationary, an additional difficulty in the empirical modelling.

These two clear and definite differences from the present value model outlined in the previous chapter may be able to account for the variations in land prices and the divergences between land prices and the returns to land.

The land price model determined in this research is a function of the rent accruing to land, inflation and the rate of return. The next chapter focuses on the actual variables used in the estimated model, and the estimation process itself.

Chapter 5

LAND PRICE: EMPIRICAL MODEL

Introduction

The model of land prices developed in the last chapter was formulated using a combination of theory and previous empirical models. Yet, theory is not enough on its own as it states little about how the model differs in the short run and the long run, the adjustment processes within the land price model, the variables that are exogenous or constant. An econometric model can provide this and determine if the model is robust and congruent with the data. The model is determined using a method outlined by Hendry, Pagan and Sargan (1984) who argue a model is congruent with the data if;

> *the statistical properties of the model are Gaussian*

> *the empirical model is consistent with the theory from which it is defined*

> *and it encompasses rival models.*

By Gaussian statistical properties of the model, it is meant that the estimators of the model are unbiased and valid representations of the coefficients of the variables in the model. This is vitally important if implications are to be made with respect to the workings of the land market.

The second point, that the empirical model should be consistent with the economic theory, is intuitive and needs little explanation, suffice to say that the empirical model should state that the changes variables within the empirical model should have the effects expected, *a priori*. Finally, the model should be able to outperform other models that exist within the research. This is possible to test using encompassing testing, explored in the final section of this chapter.

Prior to the determination of the model, two points are kept in mind. Firstly, the accuracy of the model is dependent upon the variables or proxies utilised. Secondly, the statistical properties of the variables, especially properties such as stationarity, are highlighted. Although this research utilises various economic techniques, it is not the point of this research to explain in depth, and discuss the validity, of these techniques.

These are discussed is a variety of statistical and econometric texts by noted econometricians. However, is crucial to understand the basic concepts behind the techniques used for a complete understanding of the implications of the model determination.

The second section of this chapter briefly discusses the variables that are used in the research. The third section briefly explores the reasoning behind, and the step by step analysis of, determining the empirical model. The fourth section develops the model and highlights the major implications of it. The final section uses encompassing testing to compare the model with a variety of other models and determine which, if any, has the greatest explanatory power in land markets.

Variables

Any empirical analysis is determined by the data that underlies it and as a result it is vital to use data that reflect as accurately as possible the variables in the model. Often the variables themselves are not available and so proxies must be used. On the other hand, the opposite may be the case. In many instances, there are a variety of data series that may reflect the variables in the model and a decision must be made as to which is the most appropriate.

Land Price

The land price variable, in the model developed in the previous chapters, is an average price at a given point in time for a standard unit of land. A variable that reflects this well is the average land price, supplied by DEFRA. Details of all sales of agricultural land are required to be notified to the Inland Revenue and then, in turn, to the Valuation Office Agency (VOA) and DEFRA. The land price series includes the details of all sales of agricultural land[23], of 5 hectares and over. In particular, it includes:

> *sales of agricultural land which may, in the purchaser's view, have an element of future development value;*
>
> *sales where the vendor retains certain rights over the land, e.g. sporting;*
>
> *sales of agricultural land, generally small areas, in which the value of the farm dwelling represents a substantial part of the total;*
>
> *land sold for afforestation purposes.*

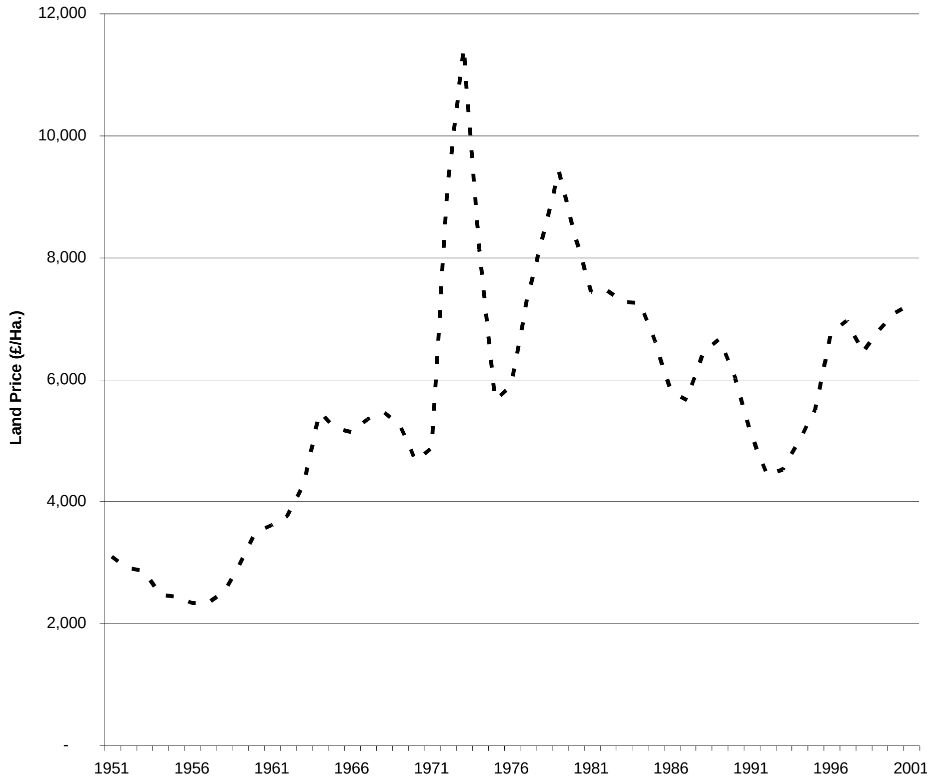
On the other hand, it excludes;

sales of agricultural land for development and other non-agricultural purposes e.g. gravel workings;

gifts and inheritances.

Its variation over time is illustrated in Figure 5.1;

Figure 5.1 – Real Land Price (1951-2001)



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[23] at prices which exclude Legal Fees and Stamp Duty

The real land price follows a general upward trend, even after the series has been deflated. Tests later in the chapter suggest that this upwards trended series is I(1) and can be transformed into a stationary series by simple differencing, if necessary. As highlighted previously, the series peaks in 1973 and 1979, during which there was not only substantial volatility in agricultural markets but also on a global economic scale.

Land Rent

Ideally, it would be possible to determine a variable that purely measures the benefit that derives from the land, exclusive of the labour and capital involved. However, this is problematic. Net rent is measured by DEFRA, who utilise an annual survey of tenanted land to determine a net rent. The net land rent is the payment for use of the land by the tenants to the landowners. As rental agreements between tenants and landlords tend to be fixed for a period of three years, the net rent is calculated by surveying those tenants that have undergone a rent change in the past calendar year, which is a relatively low number in comparison to the total number of farms in England, although it is still a statistically significant number of farms. Of more importance, however, the survey excludes agreements where no rent is paid or payments are in kind for the purposes of practicality. In doing this, the net rent excludes all the farms that are owner-occupied, for the simple reason that the land rent is not a measurable variable. The land rent in this case is an invisible transaction between the owner and occupier, the same people, or group of people. In using the net rent, the assumption is made that the rent from the farms on the tenanted land accurately reflects the rent accruing to the owner-occupied land. This is presents a problem of how well the net rent measure accurately measures land rent.

The proportion of tenanted land has decreased over time to the extent that it represents only a small percentage[24] of total land sales and whilst the number of tenanted land sales surveyed is still significant, so that inferences about the entire tenanted land market can be made, it is difficult to determine how well this represents the owner-occupied market. It is assumed that it represents the non-tenanted sector well and that net rent is the closest measure possible to this immeasurable rent. Another measure given by DEFRA is the imputed rent, an estimation of rents on all farms. However, this takes a smaller sample of farms and it does not distinguish between farms that have had a change in rent in the past year and farms in between rent negotiations. As a result, the rent series is less volatile, and less representative of the rents in any given year. The determination of a rent variable has been discussed in previous research[25] and as a result it is not the point of this research to repeat this. However, the validity of using

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[24] 13% of land sales during the 1990s were of tenanted land, from DEFRA website.

[25] explained in depth by Harvey (1974).

net rent as the most accurate measure of agricultural rent has been highlighted by authors such as Alston (1986), Falk (1991), Lloyd (1991) and Just and Miranowski (1993). The analysis of the Traill model in the previous chapter illustrated that one often used measure in particular, net farming income, is a poor reflection of the return to the land The figures for farming income are unsatisfactory as they represent the return to labour and capital, not the land itself. Net Farm Income is defined as:

> *The return to the principal farmer and spouse for their manual and managerial labour and on the tenant-type capital of the business. Tenant-type assets…include crops, machinery and livestock.*[26]

Net farming income excludes the return to land that is paid in the form of rent and it is possible that this is the reason that the re-estimation of the Traill model finds that there is a negative relationship between net farm income and the land price, in real terms. If gross farm income is only related to the land price because of its inclusion of net land rent, then once land rent is removed from gross farm income, (in addition to other items) then it is of little surprise that net farm income has a weak relationship with the land price.

Various economists have suggested the use of gross farm income, which is defined as:

> *The cash income that derives from receipts of sales of livestock, products, crops and subsidies, less the expenditure on variables costs, general overheads, fuel, repairs, rent paid, labour paid and interest.* [27]

However, gross farm income includes the depreciation and, as with net farm income, the imputed value of all items such as labour and capital. As a result, it would be expected to overstate the return to the land. In addition, the changes in gross farm income may conceivably arise from factors other than rises in the return to the land itself but using and using gross farm income could also overstate changes in the return to land. Weliwita and Govindasami (1997), using a variation on Harvey's 1989 land price model find a positive relationship between real gross farm income and the land price in three states in the USA, although it is likely that this derives from the high positive correlation between gross farm income and land rent, a determinant of gross farm income.

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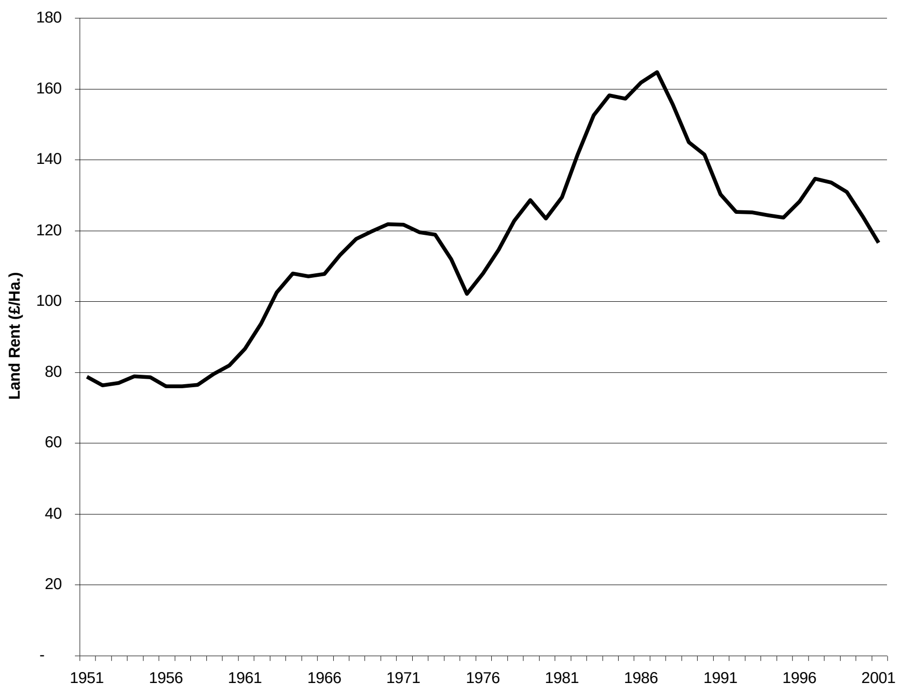
[26] Defra Annual Tenant Survey 2001

[27] Defra Annual Tenant Survey 2001

Its variation over time is illustrated in Figure 5.2;

Figure 5.2 – Real Land Rent (1951-2001)

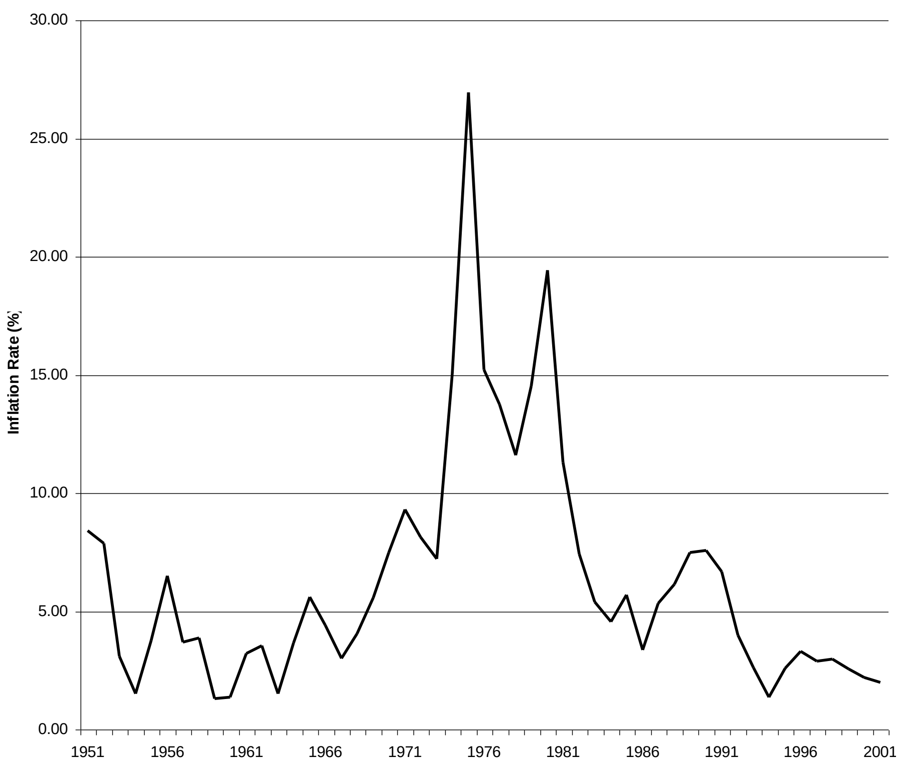


As with the land price, the land rent follows a general upward trend over the sample period, although as noted previously, the series is far less volatile than that of the land price. It averages £116 per ha. between 1951 and 2001, in real terms, ranging between £74 per ha. and £116 per ha.

Inflation Variable

Inflation is represented by the GDP Deflator. Generally, the Retail Price Index is used. However, this excludes inflation occurring in areas such as investments and agriculture. Its variation over time is shown in Figure 5.3;

Figure 5.3 – Inflation (1951-2001)



The inflation rate, as measured by the GDP inflation rate, averages 6.3% over the sample period, 1951-2001. However, although it peaks at 26.9% in 1975, for the vast majority of this period it is significantly below 10%.

There are two main exceptions; the aforementioned 1975 peak and a peak in 1980, when the inflation rate reached 19.4%. The peaks coincide rather with the after effects of the world oil crises in late 1973 and 1979. ADF tests, described later in the chapter, and given in Appendix – Unit Root Tests illustrate that inflation is also non-stationary of order I(1).

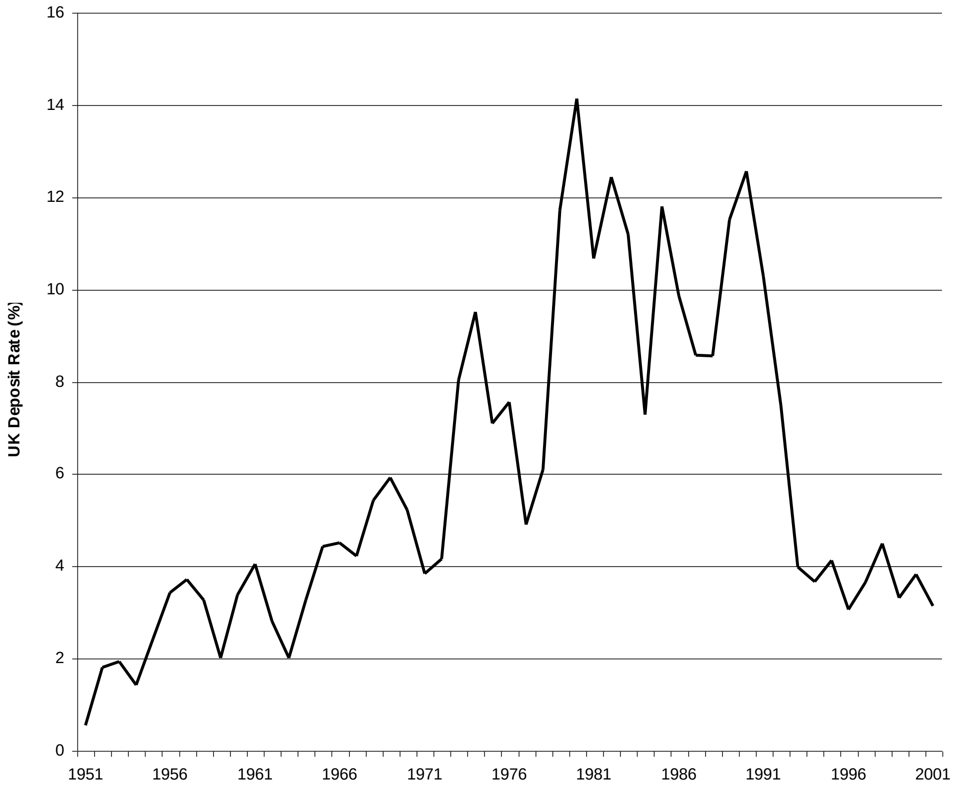
Rate of Return on Savings Variable

The choice of variable, for the rate of return on savings for farmers, is often somewhat arbitrary, although the changes in interest rates over time do not appear to differ greatly. It is assumed that farmers, as most individual economic agents, are risk averse and value liquidity relatively highly. They wish to have relatively quick access to savings and do not invest in risky assets. The rate of return is the UK deposit rate from the International Financial Statistics. The variation in the UK deposit rate over time is illustrated in Figure 5.4;

The variation in nominal interest rates follows a similar pattern to that of the inflation rate, as would be expected from macroeconomic theory, although the nominal interest rate is significantly more volatile and has peaks more often than the inflation rate series, reflecting the erratic relative profitability of other assets that could be invested in rather than land.

The ADF tests, described later in the chapter, and given in the Appendix illustrate that the interest rate is also non-stationary of order I(1). The implication of this is that the real interest rate (nominal interest rate-inflation rate) would be I(0), in other words, stationary. This would make empirical modelling substantially more difficult, given the non-stationary nature of the other variables.

Figure 5.4 – Nominal Interest Rate (1951-2001)



Dummy Variables

The model developed in this research includes two dummy variables, D73 and D79. The former dummy variable is included to take account of the sharp rise in land prices during 1972 and 1973. As a result, it is one for those two years and zero elsewhere in the sample. The inclusion of this dummy variable has been discussed in previous chapters. Essentially, it takes account of the sharp rise in the institutional investment and other non-agricultural demand investment in the land market at a time when agricultural demand in the land market had stalled. In addition, this variable takes account of the expected increase in benefits that were expected to accrue to land after joining the EEC and the sharp increases in world grain prices over this period. The second dummy variable is not as simple to determine or justify. D79 covers a period in the 1978 and 1979 when the second oil price crises led to a sharp rise in the land prices. While the oil price also led to a rise in the general level of prices, the rise in the land prices was significantly higher.

It should be noted that as the dummy variables cover relatively short periods of time within the sample, there is likely to be a tendency for the t-tests to under-reject the significance of the dummy variables within the model. In other words, it is unlikely that a variable with only two data points within the sample will be rejected as insignificant. As a consequence, the preference in this research is not to use the dummy variables unless there is another option that does not reduce explanatory power of the model.

The initial model developed in Chapter V utilises both the dummy variables. However, the final model developed in Chapter VII uses only one of the dummy variables, D72. The variables introduced into the model at the expense of land rent explain the variation in land prices without the use of the dummy variable, D79, which is found to be insignificant at the 5% level.

Model Determination – Introduction

The modelling technique used in this research is the Johansen procedure, which determines two models to reflect the land market; a short run and a long run model. Implicit in this are the empirical definitions of the short run, long run and equilibrium. The long run is a state of equilibrium where the forces of the variables are in balance whereas the short run depicts the disequilibrium state. In the long run model, there is no necessity that a static equilibrium be reached at any given point in time, all that is required is that all the variables move the system towards the equilibrium as defined by the long run relationship (cointegration).

The Johansen technique involves the determination of a Vector Error Correction Model (VECM) that contains information on both the short run and long run adjustments to changes in the variables contained in the model. This is then decomposed into the long run model. Once the long run estimates of cointegration relationships have been determined, the short run model must be determined as it provides important information on the short run adjustment behaviour of the variables in the model.

The Johansen procedure is used rather than single equation modelling techniques such as OLS, which suffer from a number of problems, that main one being that as there are more than two variables in the model[28], there may be more than one cointegration relationship among the variables. If so, single equation modelling provides an inefficient method of estimation as only one linear combination of a variety of vectors is estimated.

The purpose of this section is not to describe in detail the statistical techniques involved with econometrics. However, it is important to highlight the statistical properties of the processes that generate the series of data, and are necessary for the determination of a robust, congruent model. The most important of these is stationarity. A series is said to be stationary or I(0) if;

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[28] See Appendix – Variables for a full list of the variables

> *"...it has a constant mean and variance along with an autocovariance that is depends upon the distance between each other in time but not the actual point in time."*
>
> *Harris (1995)*

Ignoring stationarity and then estimating regressions with non-stationary variables generally leads to spurious results. As a consequence, it is vital that prior to modelling, the data is subjected to unit root testing, which determines the nature of the underlying data and states whether the data is stationary or not. One method of overcoming the problem of spurious regressions is to use differenced variables. However, this results in a loss of long run information crucial to the understanding of the land market. The concept of stationarity is vital to the model determination as it leads to an analysis of the long run properties of the model, specifically cointegration. If a relationship exists between two variables in the long run then these economic variables will not diverge from each other in the long run and any deviations are simply temporary, short run departures, determined from economic theories of equilibrium. The presence of the short run deviations from expected values represent temporary failures in the basic assumptions, such as imperfect information and transactions costs. It is the possibility of a long run relationship that leads to the concept of cointegration, whereby long run information is introduced into equations containing only stationary components. The alternative (where there may not be stationary components) is the possibility of spurious regressions in which case critical values are not valid, the R^2 is overvalued and the estimation is misleading. In this case, the theory postulated is that the price of land is directly related to the return from the land and the inflation in the economy, and indirectly related to the rate of savings. In the long run there should be an equilibrium relationship from which there may be short run deviations caused by changes in other factors and a part of this research is to determine and estimate the long run model. The model determination is conducted in a number of distinct steps for the purposes of clarity. Initially, the appropriate lag length of the variables in the model must be determined, to ensure that the error terms within the VECM are white noise. Secondly, the order (I(0) if stationary, I(>0) if not) of each of the variables that enters the model is found. Thirdly, the point of whether the model should be conditioned on any pre-determined I(0) variables such as policy intervention must be addressed. It is at this point that the model may be determined. The variables used in the analysis[29], determined in the previous chapter, are shown in the Table 5.1. For the purposes of the analysis later in the chapter, the variables used are in natural logs to give a constant variance and are in real terms to remove the general upward trend effect of inflation on nominal variables.

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[29] The data for these variables is shown in Appendix – Data Definitions

Table 5.1 - Data Definitions

LP	The log of real average land price (£/ha) for land sold in that period over 5 hectares for the calendar years 1951-2001
LR	The log of real average land rent paid (£/ha) on farms which have undergone a rent change in the period for the calendar years 1951-2001
I	The rate of growth (%) of the GDP inflation measure from International Financial Statistics for the calendar years 1951-2001
R	The Real Interest Rate, UK Deposit Rate, (%), from International Financial Statistics for the calendar years 1951-2001
D72	Dummy variable; 1 for 1972 and 1973, 0 elsewhere for the calendar years 1951-2001
D79	Dummy variable; 1 for 1978 and 1979, 0 elsewhere for the calendar years 1951-2001

Stationarity

If Z_t represents a set of observations Z_1, Z_2, Z_n where t = 1, 2, n, any given observation is simply one outcome from an infinite number of possibilities according to the joint probability function $p(Z_1, Z_2, \ldots, Z_n)$ and any future value of Z_t is generated by the conditional probability function given the previous values of Z_t.

Harris (1995) argues are two forms of stationarity, **strict** and **weak**. Z_t is strictly stationary if the joint distribution of the set is not dependent on the date at which the series started. i.e. t is not relevant as a starting point. Strict stationarity requires both joint and conditional probability distributions to be stationarity. However, it is rare that these binding constraints are met. However, it may be replaced by weak stationarity, which is defined as a situation where the parameters that describe any given value of Z_t and not dependent on the point in time.

To achieve this, it must have a constant mean (μ):

5.1) $E\left[Z_t\right] = \mu$

and constant variance (σ^2)

5.2) $\operatorname{var}(Z_t) = E\left[(Z_t - \mu)^2\right] = \sigma^2$

The autocovariance

5.3) $\operatorname{cov}(Z, Z_{t-k}) = E\left[(Z_t - \mu)(Z_{t-k} - \mu)\right] = \gamma_k$

and autocorrelations

5.4) $\tau_k = \dfrac{\gamma_k}{\gamma_0} = \dfrac{\operatorname{cov}(Z_t, Z_{t-1})}{\sqrt{\operatorname{var}(Z_t)\operatorname{var}(Z_{t-k})}}$

depend only upon the distance apart in time, not the actual point in time. If these conditions hold for all t then the series is weakly stationary.

Furthermore, each set of observations of Z_t has the same probability of occurring and the respective estimates are determined utilising the sample data

5.5) $\hat{\mu} = \hat{Z} = n^{-1}\sum_{t=1}^{n} Z_t$

5.6) $\hat{\sigma}^2 = \sum_{t=1}^{n} E\left[(Z_t - \hat{Z})^2\right]$

5.7) $\gamma_k \operatorname{cov}_k = n^{-1}\sum_{t=1}^{n}\left[\left(Z_t - \hat{Z}\right)\left(Z_{t-k} - \hat{Z}\right)\right]$

5.8) $\hat{\tau}_{k\,k} = \dfrac{\hat{\gamma}_k}{\hat{\gamma}_0}$

The most simplest example of a stationary stochastic process is the white noise process consisting of a series of uncorrelated random variables with a constant mean (assumed to be zero) and variance. As the observations are uncorrelated autocorrelation and autocovariances are zero for all lags > 0. However, this is rarely the case and few economic series display these properties. The majority of series are non-stationarity. This may be as a result of systematic trend such as business cycles or may be by chance.

There are two basic non-stationary processes of note, the trend deterministic and difference stationary stochastic processes. Both are similar when viewed graphically in small samples. However, each has different and distinct characteristics whereby mis-specification leads to severe consequences in terms of model estimation, inference and forecasting. In the Difference Stationary (DS) process, the endogenous variable is determined inherently by its own previous values and the simplest version is the random walk process which is a first order autoregression also known as AR(1) with an autoregressive coefficient $\phi = 1$

5.9) $Z_t = \alpha + \phi Z_{t-1} + \varepsilon_t \qquad \varepsilon_t \sim n.i.d.\left(0, \sigma^2\right)$

By definition, the transformation required to achieve stationarity is differencing and in this example ΔZ is the stationary variable. The Trend Stationary (TS) process requires detrending to achieve stationarity and the simplest example is

5.10) $Z_t = \alpha + \beta t + \varepsilon_t$

The graphical similarity that occurs between these two forms of model can be seen if the Difference Stationary process is viewed from a given point in time compounding changes in the variable Z_t

5.11) $Z_t = Z_0 + \alpha t + \sum_{i=1}^{t} \varepsilon_t$

Equation 5.11) is similar to the Trend Stationary process yet there remain differences. The intercept is not fixed but determined by previous values of Z_t and deviations from the trend are not stationary as they are a compound of stationary changes. Thereby, the Trend Stationary processes are deterministic as opposed to Difference Stationary processes that are stochastic.

As each process is different (due to the nature of its formation), each requires a different transformation to achieve stationarity and hence it is necessary to distinguish between the two processes. Furthermore, it is important to distinguish between TS and DS processes, since their disparate properties have important implications for modelling and statistical inference. For example, differencing on a Trend Stationary process may result in overparameterisation, mis-specification and serial correlation.

The problems are worse if detrending is utilised in an attempt to achieve stationarity with a Difference Stationary process. Econometric and statistical testing leads to spurious inferences;, high explanatory power, autocorrelation is implied in cyclical manner (inferring business cycles), the residual variance may be artificially low such that inference utilising t-tests is spurious and the variables are still I(1), even after detrending.

The simplest version of the Difference Stationary process (5.11) is the random walk process:

5.12) $Z_t = \phi Z_{t-1} + \varepsilon_t$

Testing for stationarity involves testing hypotheses on the value of the autoregressive parameter ϕ. Repeated substitution leads to equation 5.13):

5.13) $Z_t = \phi^n Z_{t-n} + \sum_{i=0}^{n-1} \phi^i \varepsilon_{t-1} = \sum_{i=0}^{\infty} \phi^i \varepsilon_{t-1}$

where the expected value of the mean is:

5.14) $E[Z_t] = E\left[\sum_{i=0}^{\infty} \phi^i \varepsilon_{t-1}\right] = 0$

and the expected variance is:

5.15) $E[Z^2{}_t] = E\left[\sum_{i=0}^{\infty} \phi^i \varepsilon_{t-1}\right]^2 = \sum_{i=0}^{\infty} \phi^{2i} E[\varepsilon^2{}_{t-1}] = \sigma^2 \sum_{i=0}^{\infty} \phi^{2i} = \frac{\sigma^2}{(1-\sigma^2)}$

When the AR(1) process has an autoregressive coefficient ϕ <1 then the expected value of Z_t is zero for all t with a finite variance time independent as shown above.

The autocovariance is also time independent at lag k:

5.16) $\gamma_k = E[Z_t, Z_{t-k}] = E\left[\left(\phi^k Z_{t-k} + \sum_{i=0}^{k-1} \phi^i\right) Z_{t-k}\right] = \phi^k E[Z_{t-k}^2] = \phi^k \sigma^2$

However, if $\phi = 1$ then the process is said to have a unit root and the expected mean is:

5.17) $$E[Z_t] = E\left[\sum_{i=0}^{\infty} \phi^i \varepsilon_{t-1}\right] = E[\phi^i Z_{t-i}] = Z_{t-\infty}$$

which is dependent on the starting value and furthermore, the process has an infinite variance. If $\phi > 1$ then the mean and variance grow exponentially through time. Therefore, testing for stationarity is simply a case of test for the presence of a unit root.

The main test used most widely in econometrics was developed by Dickey and Fuller (1979, 1981) based on the above derivations. The test above is only applicable for an AR(1) Difference Stationary process if Z_t has a zero mean. Dickey and Fuller (1981) extended the test to use for all processes. A non-zero mean was incorporated. Allowances were made for the possibility that the process may be deterministic Trend Stationary or stochastic Difference Stationary.

Nelson and Plosser (1982) extended the test so that it was not confined to a first order autoregression. The Augmented Dickey Fuller Test is:

5.18) $\Delta Z_t = \beta_1 + \beta_2 t + \beta_3 Z_{t-1} + \sum_{i=1}^{p} \delta_i \Delta Z_{t-i} + \varepsilon_t$

where β_1 represents a non-zero mean, t is a linear time trend and p is chosen such that the resulting residuals are non-zero. All the terms are stationary under the null. A time trend is included as inferences from testing for a unit root in the AR(1) model are only valid if there is no time trend. If there is a trend then the differenced process will have a mean that is time dependent and therefore not stationary such that any inferences made on the basis of the estimated autoregressive parameter β_3 are void. Fuller (1976) states that the OLS estimate of β_3 is biased such that any inferences from the t and F tests are not valid. As a result, Dickey and Fuller (1981) provided tables of statistics that take account of the bias. However, prior to testing for unit roots, the order of the autoregressive process must be determined. The importance is that the number of lags introduced affects the outcome of the unit root test. With too few lags, the test is biased to over-reject the null when it is true. With too many, the degrees of freedom falls, reducing the power of the test and there is a bias towards accepting non-stationarity.

The appropriate order corresponds to the minimum that induces white noise residuals. A general to specific procedure can be used, beginning with a high order and testing whether the highest lag is significant or not.

The correct number of lags used in the analysis is determined using the Schwarz Criterion (SC) and the Hannan-Quinn (HQ) criterion, which implied that the use of one lag was most appropriate. Although all the variables do not have the same autoregressive qualities, the VAR analysis requires that a consistent number of lags be used for each variable. With this knowledge, the ADF tests may be conducted. The Dickey-Fuller tests are utilised to determine the existence, or otherwise, of a unit root[30].

Table 5.2 – Unit Root Tests

Equation	Constant	Trend	LP_{t-1}	ΔLP_{t-1}
1	1.4139	0.0024432	-0.17333	0.40394
	(2.315)	(0.947)	(-2.242)	(2.693)
2	1.0364		-0.12178	0.35830
	(2.243)		(-2.221)	(2.572)
3	0.011243			-0.68967
	(0.476)			(-4.698)
4				-0.68522
				(-4.721)

The ADF test gives a statistic of -2.245 as compared to the Dickey and Fuller (1982) statistic of 1%=-4.184 and 5%=-3.516. Hence, the null of a unit root is not rejected. A trend is implausible, as there is a unit root.

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[30] More detail of all the ADF Tests, see Appendix – Unit Root Tests

However, for consistency, an f-test is conducted that restricts the Trend and LP_{t-1} to zero. As expected, the null cannot be rejected and it is assumed there is no trend.

This analysis is replicated for the other variables; land rent, inflation and the interest rate, and illustrates[31] that all the variables are I(1). The rejection of the trend in the DF test implies that the stationarity in the each of the variables is not systematic and stationarity can be achieved for all the variables in this research by differencing each variable, as stated previously, this leads to a loss in the long run information.

VAR Modelling

The use of VAR analysis accounts for the underlying economic forces in which the series converge over time to an equilibrium, without mistaking this for the common time trends within the data. In the land price model determined in the previous chapter there are four variables; land price, land rent, inflation and the interest rate. This means that there may be more than one cointegrating vector and it is possible for there to be up to 3 (or *n-1*, where *n* = the number of variables*)* linearly independent cointegrating vectors. In this case, if it is assumed that there is only one cointegrating vector when there may be more then, as a result, the regression is spurious

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[31] See Appendix – Unit Root Tests

with the estimates of the coefficients a combination of the vectors. VAR analysis attempts to determine the number of cointegrating vectors and estimate each vector, forming a long run model and allowing for the determination of a Vector Error Correction Model (VECM) that models the short run fluctuations away from the long run equilibrium.

Harris (1995) uses the general case of a *k* order VAR model:

5.19) $z_t = A_1 z_{t-1} + \dots A_k z_{t-k} + u_t$

$u_t \sim IN(0, \Sigma)$

where z_t is a vector $[y_{1t}, y_{2t}, x_{1t}]$ and allowing the three variables to be endogenous.

The VAR is shown in equation 5.28) and there is an associated VECM:

5.20) $\Delta z_t = \Gamma_1 \Delta z_{t-1} + \dots \Gamma_{k-1} \Delta z_{t-k+1} + \Pi z_{t-1} + u_t$

where $\Gamma_i = -(A_1 - \dots - A_i)$ and $\Pi = -(A_1 - \dots - A_k) = \alpha\beta'$. α represents the speed of adjustment to disequilibrium while β represents the long run coefficients.

With $k=2$, as determined in the previous section:

$$5.21)\ \begin{bmatrix} \Delta y_{1t} \\ \Delta y_{2t} \\ \Delta x_t \end{bmatrix} = \Gamma_1 \begin{bmatrix} \Delta y_{1t-1} \\ \Delta y_{2t-1} \\ \Delta x_{t-1} \end{bmatrix} + \begin{bmatrix} \alpha_{11} & \alpha_{12} \\ \alpha_{21} & \alpha_{22} \\ \alpha_{31} & \alpha_{32} \end{bmatrix} \begin{bmatrix} \beta_{11} & \beta_{12} & \beta_{13} \\ \beta_{21} & \beta_{22} & \beta_{23} \end{bmatrix} \begin{bmatrix} y_{1t-1} \\ y_{2t-1} \\ x_{t-1} \end{bmatrix}$$

If the first equation from 5.29) is taken:

$$5.22)\ \Pi_1 z_{t-1} = \left[(a_{11}\beta_{11} + a_{12}\beta_{12})(a_{11}\beta_{21} + a_{12}\beta_{22})(a_{11}\beta_{31} + a_{12}\beta_{32}) \right] \begin{bmatrix} y_{1t-1} \\ y_{2t-1} \\ x_{t-1} \end{bmatrix}$$

If the standard Error Correction Mechanism is then estimated then effectively there is a spurious regression as it is not possible to estimate either cointegrating vectors as the only parameter estimated is Π_1, the first line of Π, which is a linear combination of the two long run relationships.

Using the Vector Error Correction Mechanism means that information on the long run and short run adjusts to changes in z_t through estimates of $\hat{\Gamma}_i$ and $\hat{\Pi}$ and assuming z_t is a vector of I(1) non-stationary variables then all the terms in which involve Δz_{t-k} are I(0) while Πz_{t-k} must also be stationary[32] for $u_t \sim I(0)$ to be white noise. Only the cointegrating vectors in β enter the VECM otherwise $\Pi z_{t-k} \sim I(0)$ would not be the case.

The problem is to determine how many $r \leq (n-1)$ cointegrating vectors exist in β which is equivalent to testing how many columns in α are zero and, by definition, the number of *r* linearly independent columns in Π. In general it is not possible to utilise general regression techniques to obtain estimates of α and β as all that is determined is an estimate of Π such that Johansen (1988) uses the reduced rank procedure where 5.27) can be rewritten as:

5.23) $\Delta z_t + \alpha\beta' z_{t-k} = \Gamma_1 \Delta z_{t-k} + ... + \Gamma_{k-1}\Delta z_{t-k+1} + u_t$

and therefore the short run dynamics may be removed by regressing Δz_t and z_{t-k} separately giving the vectors L_{0t} and L_{kt}:

5.24) $$\begin{aligned} \Delta z_t &= M_1 \Delta z_{t-1} + ... + M_{k-1}\Delta z_{t-k+1} + L_{0t} \\ z_{t-k} &= P_1 \Delta z_{t-1} + ... + P_{k-1}\Delta z_{t-k+1} + L_{kt} \end{aligned}$$

from which the residual matrices can be formed:

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32 The cases for this are given in various econometric texts such as Enders (1995)

5.25) $S_{ij} = T^{1}\sum_{i=1}^{T} L_{it} L'_{jt}$

The Maximum Likelihood estimate of β is determined from the equation:

5.26) $\left| \lambda S_{kk} - S_{k0} S_{00}^{-1} S_{0k} \right| = 0$

which gives n eigenvalues, $\hat{\lambda}_1 > \hat{\lambda}_2 > ... > \hat{\lambda}_n$, and corresponding eigenvectors, $\hat{V} = (\hat{v}_1, \hat{v}_2, ... \hat{v}_n)$. The l elements in $\hat{V}$ represent the linear combinations of stationary relationships are the cointegration vectors, $\hat{\beta} = (\hat{v}_1, ..., \hat{v}_l)$, because the eigenvalues are the largest squared correlations between L_{0t} and L_{kt} and if estimates of $\hat{v}_i' z_t$ are determined which produce high correlations with stationary $\Delta z_t \approx I(0)$ then they themselves, by definition, must be I(0). $\hat{\lambda}_i$ represents the size of the correlation and hence the test for r=1 tests the null that $\hat{\lambda}_2 = \hat{\lambda}_3 = ... = \hat{\lambda}_n = 0$ against the null that $\hat{\lambda}_1 > 0$ and as Johansen (1988) shows that $\hat{\lambda}_i = \hat{\alpha}_i' S_{00}^{-1} \alpha_i$ and hence testing is equivalent to $\alpha_i \approx 0$.

The model determined argues that the agricultural land price is explained by the rent accruing to land, inflation and the rate of return.

5.27) $LP = f(LR, I, r)$

The determination of the number cointegrating vectors is shown in Table 5.2 using the adjusted maximum likelihood and trace eigenvalue statistics. The Maximum Likelihood and Trace eigenvalue statistics suggest that there is one cointegrating vector with the null being rejected for $r \leq 0$ and $r \leq 1$ while for $r \leq 2$ the null is not rejected.

Table 5.3 – Maximum Likelihood and Trace Eigenvalue Statistics

		Maximum Likelihood		Trace	
		-Tlog(1-\mu)	95%	-T\Sum log(.)	95%
H_o	H_1				
$r \leq 0$	$r \geq 1$	44.94	27.1	62.69	47.2
$r \leq 1$	$r \geq 2$	8.688	21.0	17.74	29.7
$r \leq 2$	$r \geq 3$	5.914	14.1	9.054	15.4

Once the number of cointegrating vectors is known, restrictions are then applied, based on statistical significance, to identify the unique cointegrating vector, the land price equation. As there are no linear trends in the levels of the data, there are no deterministic components in the VECM and as a consequence, the constant is only included in the long run model. In the short run, the land price model is found to be determined by the land rent and the real interest rate. However, in the long run, the rate of inflation is also found to be significant as a determinant of the real land price. In equation form the short run model is:

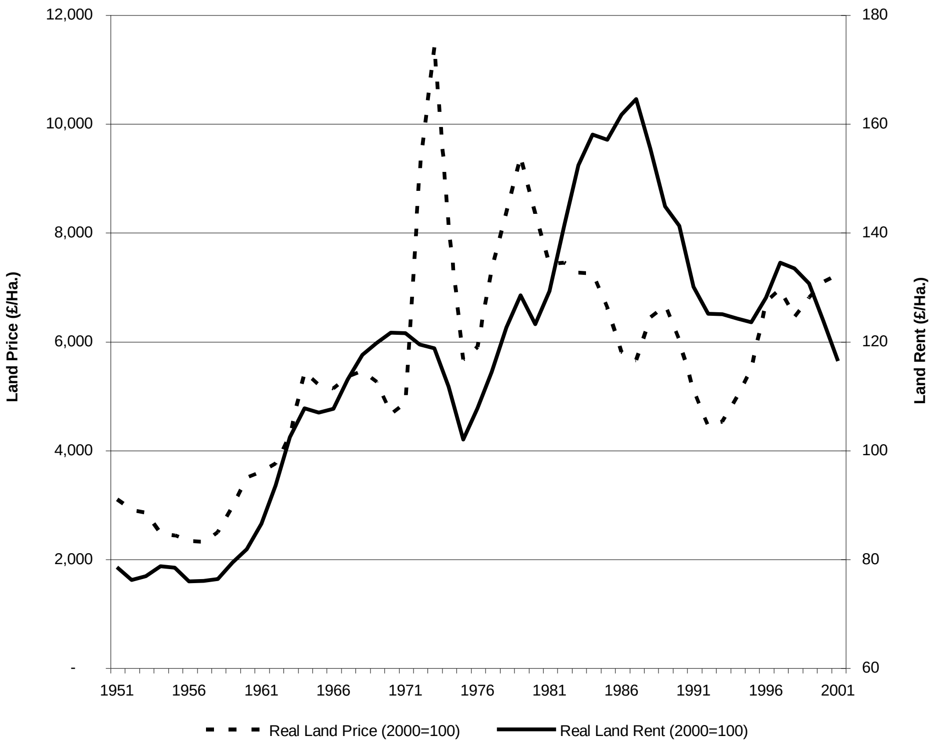
$$5.28)\ \Delta LP = \underset{(0.15)}{0.42}\Delta LP_{t-1} + \underset{(0.34)}{0.73}\Delta LR - \underset{(0.01)}{0.02}\Delta r + \underset{(0.14)}{0.39}CV_{t-1}$$

where CV_{t-1} represents the cointegrating vector error correction term. As expected, the short run model shows a positive relationship between the real land price and real land rent. The coefficient on the change in land rent is 0.73 and a *t* test, with the null hypothesis that the coefficient on land rent is not significantly different from 1, is not rejected. As a consequence, in the short run, it can only be inferred that a 1% change in the rent accruing to land leads to a 0.73% change in the real land price. In accordance with *a priori* expectations, there is a negative relationship between the real land price and the real interest rate. *t* tests, with the null hypothesis that the coefficient on inflation is not significantly different from zero, show that, at the 5% level, inflation is highly significant in the long run as the null is rejected. However, in the short run, inflation is excluded as it is found that the null hypothesis cannot be rejected and, as such, inflation is assumed to be insignificant at the 5% level in the short run. While the inflation rate is highly significant in the long run, in the short run it appears to play no part in determining land prices. The long run model is shown:

5.29) $$\underset{(1.23)}{LP = 3.77} \underset{(0.34)}{+1.03LR} \underset{(0.10)}{+0.27I} \underset{(0.01)}{-0.02r} \underset{(0.21)}{+0.40D72} \underset{(0.14)}{+0.3D79}$$

The rent accruing to land has a positive effect on the land price and the hypothesis that this is a unit elasticity relationship cannot be rejected. The hypothesis of unit elasticity for land rent with respect to land price can be tested utilising the tail probability test on β. With land rent restricted to unity there is no change in the chi-square statistic (0.022) and hence the null of unit elasticity is not rejected which, as expected, follows initial expectations. The long run model demonstrates how the apparent discrepancy in the plot of land prices and land rents (Figure 5.5) can be explained. In general, both land prices and land rents increase similarly over the 50 years, land prices are significantly more volatile. Furthermore, land prices and land rents often move in different directions. The present value model is unable to take account of this. However, with the model specification outlined in this chapter, the divergence that occurs between land prices and land rents can be accounted for by changes in other variables.

Figure 5.5 – Land Prices and Land Rents (1951-2001)



As expected, Equation 5.2 shows that the coefficient on inflation has a positive sign implying that an increase in the inflation rate will have a positive effect on the price of land. This is unsurprising given the discussion of the determinants in previous chapters. With large rises in inflation, economic agents see the debt incurred to purchase land falls in real terms and simultaneously, the value of the land increases as inflation increases the tax break benefit on land relative to other assets. As a consequence, increases in inflation lead to an increase in the demand for land. In addition, the rate of interest has a negative effect on the land price and this is also in line with expectations, *a priori*. The α coefficients represent the speed of adjustment towards equilibrium once the system is in disequilibrium[33]. A slow adjustment is represented by a low coefficient and alternatively a high coefficient represents a quick adjustment towards equilibrium. A negative coefficient would tend to suggest that if there is a point in time where there is disequilibrium then the system, rather than moving towards equilibrium, in fact moves away from it and the size of the coefficient measures the extent to which this correction to equilibrium occurs. In the land price equation, the α coefficient is estimated as 0.39. In this case, as expected, the system adjusts towards equilibrium. The size of the coefficient implies that there is only a 39% decrease in the extent of the disequilibrium in any given time period[34]. This is plausible given that there are long time lags in adjustment.

Each of the variables has a stronger effect, as their coefficients are larger, in the long run compared to their effect in the short run. This is possibly attributable to the fact that purchases of land tend to be long run decisions based upon the return. Short run changes appear to be attributable to other factors, not simply those factors in the long run model.

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[33] see Chapter 5

[34] in this case, each time period is given as a calendar year

The argument made by Lloyd (1991), that speculation was the cause of the sharp increases in land prices during the 1970s is not supported by the model. According to Lloyd, long run prices reflect the market fundamentals such as the return to the land whereas, in the short run, agents overreact as valuations of land are based upon expectations small changes in these can lead to large changes in prices. However, the short run coefficients, which are less than one, suggest that this is not the case.

The standard econometric tests are presented in Table 5.4.

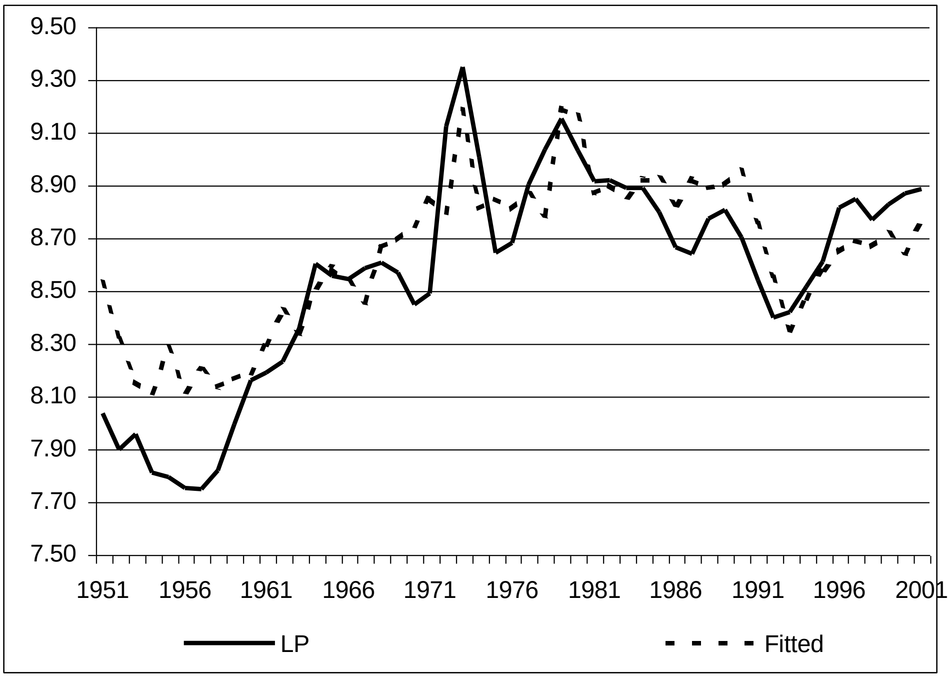
Table 5.4 – Standard Econometric Testing

AR 1- 2 F(2, 20)	3.3047	[0.2526]
ARCH 1 F(1, 20)	0.89189	[0.3537]
Normality Chi^2(2)	0.24953	[0.8827]
RESET F(1, 21)	0.21708	[0.6450]

The null of each of the tests suggests no econometric problems, which could not be rejected in all of the tests and as a result, it is that there assumed to be no econometric problems.

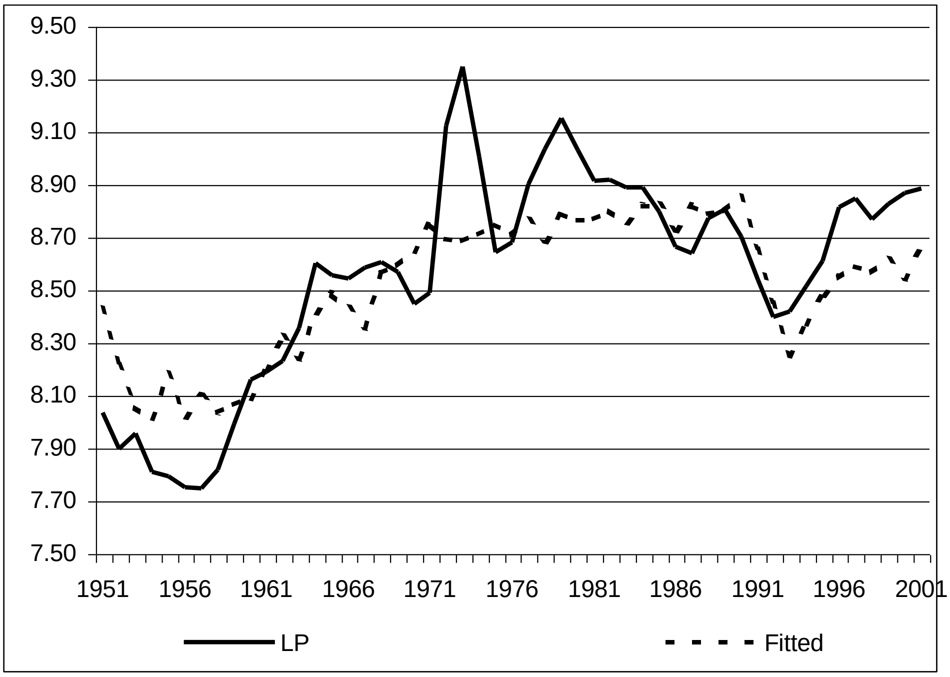
Figure 5.6 illustrates the variation in land price and the variation in the fitted values of the land price as predicted by the model over the sample period, 1951-2001. The model generally appears to predict well throughout the sample. There are sharp rises in the predicted land price, albeit not as sharp as the rises in the actual land price, in the early 1970s as expected *a priori*.

Figure 5.6 – Actual and Fitted Land Price Model



The necessity for the dummy variables is clearly highlighted in a comparison between Figures 5.6 and 5.7. In Figure 5.7, which illustrates the actual and fitted values of the land price model without the use of dummy variables, the model clearly underestimates land prices in the early and late 1970s.

Figure 5.7 – Actual and Fitted Land Price Model with no Dummy Variables



In addition, the model appears to underestimate the increase in land prices that occurred between 1993 and 2001. Although the rent variable appears to capture, in part, the benefits of the MacSharry reforms, it does not capture all the benefits.

The development of the land price model in this research attempts to establish a clear link between the land market and variables that are under the influence of the policy makers. The first stage of this was to determine a basic land price model.

The second stage, which the next chapters turn to, is to replace land rent in the model with its determinants. The additional benefit of this is that, although the net rents are clearly not always a perfect representation of the returns to land, this problem may be overcome by introducing the determinants of the return to land into the land market model. After this, it would be hoped that the model could account for the changes in the land market after the MacSharry reforms were introduced and remove the need for the dummy variable, D79. It would still be expected, however, that the model needs the dummy variable, D72, at least in part, as it accounts for the sharp increase in non-agricultural demand at that point in time.

Chapter 6

LAND RENTS: THEORETICAL & EMPIRICAL CONSIDERATIONS

Introduction

The previous chapter determined a model representing the land market that is determined by the land rent, inflation and the nominal interest rate. While this model is interesting in itself, it is important to keep in mind that the model can be improved. The basis for this assertion is that the model includes two dummy variables, D72 and D79.

The sharp increases in the land price in the early and late 1970s are not reflected in changes in the land rent, and although changes in inflation and the interest rate can account for a part of the land price increase, a significant part of the increase is left unexplained, with two dummy variables aiding the model.

It is clear that the imputed rent variable is unable to fully reflect the returns to land. One method of overcoming this problem is to use a theoretical model of the returns to land to establish its determinants and introduce these variables into the land price model at the expense of land rent.

While the observed rents may not fully reflect the return to the land, the equilibrium rent, as Harvey (1974) defines it, can be found as a function of input prices, output prices, technology available and the supply services from the given stock of land. In addition, the inclusion of the determinants of land rent provides a direct link between land prices and variables influenced by agricultural policy.

The second section of this chapter uses the Harvey (1974) model to determine a long run model for the level of equilibrium rent on agricultural land. The third section assesses the statistical properties of the additional data to be used in the model.

Land Rent Model – Harvey (1974)

Previously, it was noted that the supply of land, which may be utilised for agricultural uses, is considered strictly exogenous in the land price model on the basis that the land supply is independent of the price.

However, Harvey argues that the supply of services from the land is not dependent upon the land rent but on the supply of the land itself. In a situation where the quantity of land is limited, there is likely to be a greater the demand for the services from land and these services are likely to be utilised more intensively. For instance, if a more productive fertiliser is used then there is no increase in the flow of services from the land but the rent accruing to the land would be expected to increase. The land is used more intensively due to short supply. To take advantage of the increase in fertiliser other inputs such as labour and capital must also be increased. The price paid for the service flow is dependent upon the demand due to scarcity.

The rent paid (price of the flow of services from the land) is income earned after the purchase of land and is not one based upon the land itself but how it is used. Hence, the supply, given a positive rent, is perfectly inelastic, assuming a perfectly competitive market for the services. The landowners gain nothing from not utilising the land such that any gain, no matter how small, is better than nothing.

There are six main assumptions in the model;

Perfectly competitive input and output markets

Price taker in input and output markets

Each farm has the same 'U' shaped long run cost curves and production costs are minimised based on this

No economies or diseconomies of scale external to the firm but internal to the industry

Economic agents are profit maximisers

Free entry and exit for all economic agents such that there is a perfectly elastic supply curve

In long run equilibrium each firm operates at its minimum point ion the long run average cost curve and in these perfectly competitive markets economic agents can only earn normal profits. Changes in output can only occur in the long run by an increase in the number of producers and hence a corresponding increase in the quantities of inputs employed. By definition, profit maximisation occurs by equating marginal cost to marginal revenue subject to the production function, which for reasons of simplicity is defined as a linear homogenous production function; a doubling of inputs leads to a doubling of outputs.

The analysis is based on the input prices being given but Harvey (1979) argues that even if this is not the case, the analysis is similar. The market as a whole can be viewed as one single competitive firm maximising output subject to the market demand given input and output prices. The demand for the input will be equated with the supply of the input and there will be an equilibrium price and quantity for the input. The long run market supply curve will not be perfectly elastic but the market can be seen as competitive as it still the views the input and output prices as given. From this, the market is assumed to hire all inputs as flows of services making all the decisions at the beginning of each time period given input and output prices subject to the linearly homogenous production function. Additionally, the total quantity of the services from the services is given establishing a maximum constraint upon the resources although the analysis is simplified if it is assumed that all the land supplied is used. The land rent model can be derived from maximising a basic profit function given in equation 6.1;

6.1) $\Pi = P_q.Q_q - P_v.V_v$

where $\Pi = \text{Industry}\,\Pi\text{ including rent}$

$P_q = \text{Output Price Index},\qquad P_v = \text{Input Price Index}$

$\text{Q} = \text{Aggregate Output},\qquad \text{V} = \text{Aggregate Input}$

The Output Price Index is defined as an index of agricultural output, which is a weighted average utilising the current price revenue share as weights.

Likewise, the Input Price Index is defined as an index of agricultural inputs, which is a weighted average utilising the current price cost share as weights.

Profits are defined as revenues minus costs and it is assumed that the firm produces n outputs (q_1, q_2, q_3,) and utilises m inputs (v_1, v_2, v_3,). In the expressions for cost all factors of production are included and from basic microeconomics each of these is intuitively obvious. However, if a given farmer purchases land and utilises it in production the land should be valued at its market value for purposes of including the economics costs;

6.2) $\max \quad \Pi^* = P_q.Q - P_v.V - \mu\left(L - \bar{L}\right)$

6.3) $s.t. \quad Q = f\left[V, L\right]$

where $\bar{\mathrm{L}} = \mathrm{Supply\ of\ Land\ services}$

The Lagrangian function represents the marginal contribution to gross profit of a relaxation in the land supply constraint. In other words, it is the price the industry would pay for an additional unit of land services and will equal the equilibrium rent paid by tenants to landowners given a perfectly competitive land market. Equation 6.3 represents the industry production function, which in this case is assumed to be linearly homogenous. If 6.2 is differentiated with respect to P_q, P_v and L then the first order conditions are given by equations;

6.4) $$\frac{\partial \Pi^*}{\partial V} = P_q f_1 - P_V = 0$$

6.5) $$\frac{\partial \Pi^*}{\partial L} = P_q f_2 - \mu = 0$$

6.6) $$\frac{\partial \Pi^*}{\partial V} = L - \bar{L} = 0$$

and the first order conditions establish the equilibrium position for a profit maximising firm in the long run. The price of inputs should equal the marginal product of the inputs and a relaxation of this constraint would show the addition of the marginal product of the services from land to gross profit. The shadow price of services from land equals the marginal product of the services from land.

The constraint that the lagrangian is subject to represents the industry production function that is assumed to be linearly homogenous and hence provide constant returns to scale. If the Lagrangian is differentiated with respect to P_q, P_v and L as shown in Equations 6.7, 6.8 and 6.9 show the expected relationship between each exogenous variable (P_q, P_v and L) and the endogenous variables, μ (the implicit rent) and V;

6.7) $\frac{\partial V}{\partial P_q} > 0$

6.8) $\frac{\partial V}{\partial P_v} < 0$

6.9) $\frac{\partial V}{\partial \bar{L}} < 0$

the optimum quantities employed in the industry increase if there is an increase in the output price, the supply of land increases or the input price falls. The partial derivatives with respect to rent are;

6.10) $\frac{\partial \mu}{\partial P_q} > 0$

6.11) $\frac{\partial \mu}{\partial P_v} < 0$

6.12) $\frac{\partial \mu}{\partial \bar{L}} < 0$

The direct implication is that, theoretically, the profitability of land[35] is positively related to the Output Price index, negatively related to the Input

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[35] and hence the rent accruing to land

Price index[36] and negatively related to the supply of land. Given these conditions a reduction in the land stock, *ceteris paribus*, leads to a corresponding reduction in the quantity of other inputs and according to the linearly homogenous production function and no change in profit or rent. The Harvey (1974) model, to be estimated, is shown in Equation 6.13. The rent is determined by input prices, output prices and the supply of land.

6.13) $R_t^e = f\left[P_{vt} \;\; P_{qt} \;\; \bar{L}_t\right]$

$$\begin{aligned} \textit{where} \qquad R_t^e &= \textit{Equilibrium rent in time } t \\ P_{vt} &= \textit{Input Price Index} \\ P_{qt} &= \textit{Output Price Index} \\ \bar{L} &= \textit{Supply of flow of services from the land} \end{aligned}$$

Any model of land rents must take account of the effects of technological change or show that the effects are statistically insignificant. Harvey (1974) takes account of the effect of technological change upon the input price by adjusting the index of input prices to take account of changes in factor productivity.

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36 excluding land

Harvey (1989) extends the model to include technological change by adjusting the input price index for quality as in the equality 6.14;

6.14) $R_t^e = f\left[P_{vt} \;\; P_{qt} \;\; \bar{L}_t\right]$

$$\begin{aligned} \textit{where} \qquad & R_t^e = \textit{Equilibrium rent in time } t \\ & P_{vt} = \textit{Input Price Index adjusted for quality} \\ & P_{qt} = \textit{Output Price Index} \\ & \bar{L} = \textit{Supply of flow of services from the land} \end{aligned}$$

P_{vt} now represents the input price index adjusting for the fact that technological change allows a given amount of input to be utilised to create greater amounts of output.

However, the model developed in this research utilises Total Factor Productivity, the measure of technological change[37], as a separate variable. As opposed to determining the extent to which the Input Price Index should be adjusted for quality and what the variable represents, utilising technological change and an Input Price Index as separate variables allows implications to be drawn from each on the effect of the Input Price and technological change on land rent. Furthermore, using the input price and quality as separate explanatory variables enables the significance and the

[37] the nature of the variables is outlined in the next section

effect on land rent to be tested. It may be that the input price or quality is solely relevant in a model of land rent but if the variable is combined the results may wrongly imply that both are relevant.

The Harvey (1974) model is defined in terms of equilibrium rent which is based on the simplistic one period abstract model where there is perfect competition. The model assumes that all firms are at their optimum point, defined as the minimum point on the long run average cost curve, and the industry adjusts with no costs and instantaneously to changes in output prices and inputs as well as changes in the supply of land.

Actual observed rents are paid each year from landlords to tenants or an imputed figure for those who are owner-occupiers and the rental contracts are generally renegotiated every three years. However, as only $1/3$ of the rents change per year this does not give an accurate picture of the rental market.

Furthermore, the rental market is determined by new rents from prospective tenants who enter the land rental market. In a perfectly competitive market these rents would all converge to an identical figure for a given area of land. Hence, Harvey (1974) defines market rents as newly negotiated rents, the result of new tenants competing in the rental market and renegotiated rents in that period. The two parts that make up market rents may differ due to the assumption of no adjustment costs not holding, newly tendered rents and newly negotiated rents unlikely to be equal. Hence, markets rents are defined as the average rent in each period determined by either newly negotiated or newly tendered rents.

Harvey (1974) assumes that all rental contracts are for three years and as such the observed rents are an average of the rents over that period. Therefore, observed rents refer to current and past market transactions whereas market rents refer to simply the current period.

There are three main reasons why Harvey (1974) argues that market rents and equilibrium rents are unlikely to be the same. Firstly, uncertainty and imperfect knowledge mean that the industry will need time to adjust to changes in the pattern of prices. Time is needed to learn about changes[38] and adjust to the changes. Secondly, there is no reason that the adjustment of service flows will be costless and instantaneous even if there is perfect knowledge. For instance, if inputs are purchased as stocks then their effect will take time. Thirdly, market rents may not be the same as equilibrium due to the definition of market rents. Negotiated rents are likely to be slower than newly tenanted rents to adjust to changes because of the costs of changing tenancies and inertia in the tenant-landlord relationship.

[38] especially as Harvey (1974) notes if these changes are 'disguised' as quality changes

A fall in input prices or conversely a rise in output prices would be expected, *ceteris paribus,* increase the equilibrium rent while if it is assumed that the supply of inputs is not perfectly elastic then it would be expected that a reduction in land supply would increase equilibrium rent. The divisibility variable is inversely related to any economies of scale such that if the divisibility variable decreases it would be expected that there would be an associated increase in equilibrium rent.

The assumption is made in Harvey's analysis that the price of output is independent to the quantity of production. This is not seen as restrictive due to fixed prices that farmers encounter in some agricultural markets and subsidies given to farmers in other agricultural markets. Hence, while there may be a decrease in production, the price may be maintained either because it is set exogenously or because farm incomes are kept constant (and hence effectively fixing the output price) by compensation payments. The profit function excludes the concept of direct payments to farmers or subsidies as, by definition, they increase the profitability of the land. Hence, a variable to take account of these direct payments is included in the profit function.

Harvey (1974) assumes that subsidies are taken account of in virtual terms, as it is effectively included in the output price in that it acts the same way. Intuitively this makes sense if it assumed that either, all support given to farmers is in the form of output price support or that the structure of the support does not change over time.

By ‘the structure of the support not changing’, it is meant that the share of support in the form of direct subsidy payments and output price support does not differ over time. However, there are two significant occasions during which the structure of support shifted, initially from direct subsidies towards price support as the UK entered the EEC and adopted the CAP, and then in the 1980s and 1990s when support to agriculture was first limited and then shifted back towards direct payments with the EU’s adoption of the MacSharry reforms.

Although both direct payments and price support would be expected to be positively related the rent accruing to land as both increase the return to land, it is essential to include each as a separate variable as there is no reason to believe that each would have the same effects upon the rent. However, once the model is introduced into the land price model, the effects of each can be compared to determine if the given change in direct payments has a similar effect to a similar change in price support.

As a result, the rent model derived in this research is an augmented version of the Harvey (1974) model shown in Equation 6.15, where the rent is determined by the rent from previous periods, input prices, output prices, subsidies and the supply of land.

6.15) $R_t^e = f\left[R_{t-1} \;\; P_{vt} \;\; S_t \;\; P_{qt} \;\; \bar{L}_t\right]$

$$
\begin{aligned}
\textit{where} \quad & R_t^e = \textit{Equilibrium rent in time } t \\
& S_t = \textit{Subsidies at time } t \\
& P_{vt} = \textit{Input Price Index adjusted for quality} \\
& P_{qt} = \textit{Output Price Index} \\
& \bar{L} = \textit{Supply of flow of services from the land}
\end{aligned}
$$

In this model it would expected that the land rent would be positively related to output prices and net subsidies as an increase in net subsidies or output price would be expected to raise farming income. Likewise, input prices would be expected to be negatively related to land rent as an increase in input price would be expected to decrease farming income. It would be expected that the technology change variable, measured by total factor productivity, would be positively related to land rents as an increase in the technological parameter would either lower costs or increase yield.

Additional Variables

The three series that are found to be significant in the model, determined later in the chapter, are the input price, the output price and the subsidy series. In this section, each variable is highlighted. The supply of the flow of services is found to be insignificant in the model with *t* tests of significance. As a result, an analysis of the variable is not included.

Input Prices

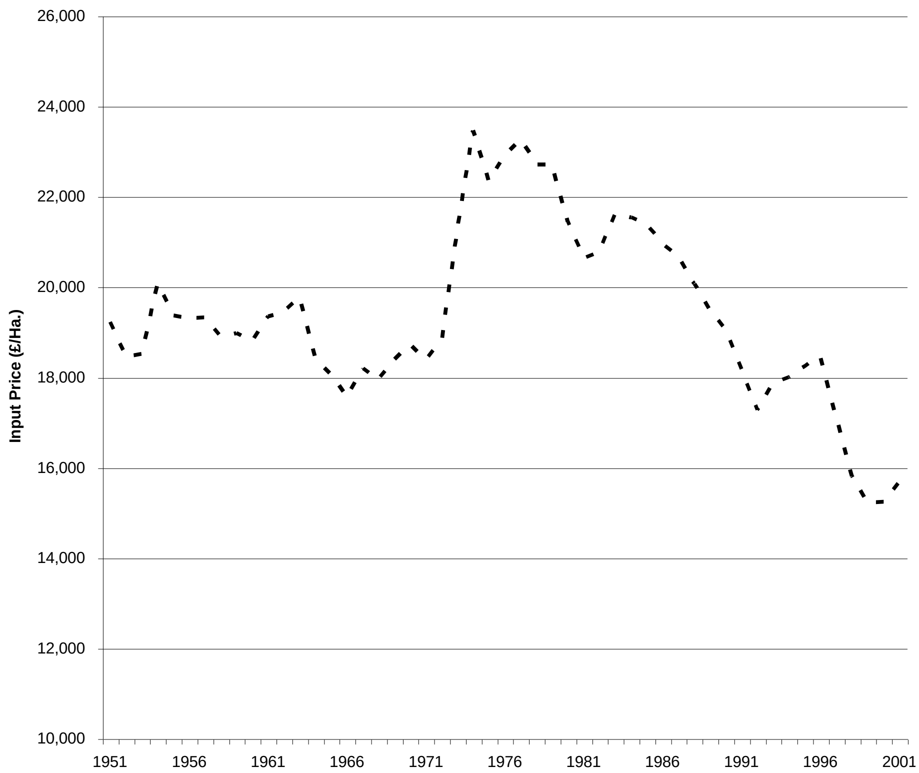
The input price index is a weighted average of the capital, labour and energy costs of farming production. It covers 31 main categories of capital and labour costs, a full list of which is given on the DEFRA website.

Its variation over time is illustrated in Figure 6.1.

Real Input Prices averaged £19,400 per ha. between 1951 and 2001. However, this masks the substantial changes that have occurred in agriculture over the last 50 years. Input prices, overall, increased 16% in 1973 alone as the effects of rises in grain prices, the first oil price shock and entry to the EEC combined to raise the average price of agricultural inputs.

Grains are used as a main feed ingredient for cattle and as a consequence, a change in its price has knock-on effects onto feedstock prices. The oil price shock, which occurred late in 1973, raised the price of a major input into agricultural production. Moreover, it also has indirect effects raising the price of other inputs, the majority of which also use oil in their production.

Figure 6.1 – Real Input Price (1951-2001)



The UK's entry into the EEC raised the demand for land and, in turn, the demand for inputs to take advantage of the land. In simplistic terms, inputs are relatively fixed in the short run and as a result, increases in demand are met almost purely by increases in the price. However, since the initial increases in the input prices, in 1973, prices have fallen by 33%. Although large rises in inflation late in the 1970s and early 1980s may account for a certain part of this, there is a clear downward trend that continues to the latter part of the sample period.

Agricultural Support: Output Prices and Subsidies

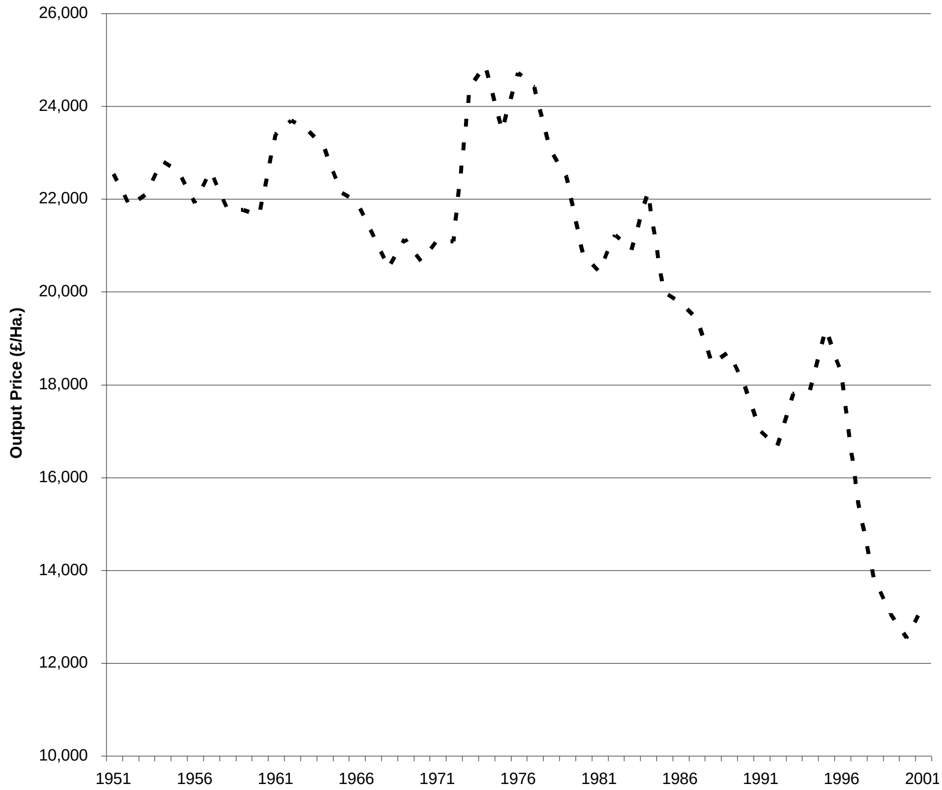
There are three different types of support; market support in the form of intervention prices and import tariffs, direct payments to production and direct payments for rural development. Output prices reflect the first of these, market support. The subsidy variable, however, covers direct payments for production and rural development.

The majority of direct payments and also all support given to farmers, is now in the form of payments for production. Payments for production cover two main categories; arable area payments and direct support to livestock producers, costing £1.0 billion and £1.2 billion in 2001 respectively within the UK. The output price index is also a weighted average of each category of farming (for example cereals, cattle, etc.) for 33 main categories of farming. The accurately reflect the prices that farmers receive for production but importantly exclude direct payments. The subsidy variable takes account of this.

Output Prices

The output price index is a weighted average of the crop, cattle and dairy prices for production per ha. The series covers 33 main categories of agricultural production, a full list of which is given on the DEFRA website. Its variation over time is illustrated in Figure 6.2;

Figure 6.2 – Real Output Price (1951-2001)



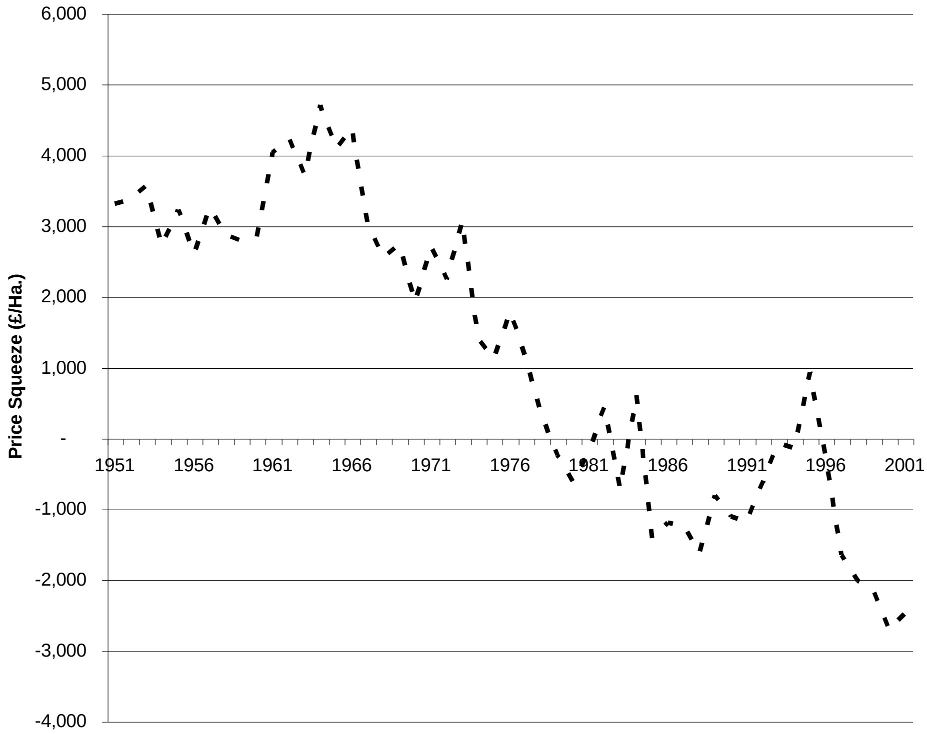
An average of £21,000 belies the change in output prices over the 50 years and the variation in real output prices is notable in two main respects. Firstly, output prices follow a similar general trend to that of input prices, implying that there may be a problem of multicollinearity. In one way this is an unsurprising finding, as increases in input prices would be expected, to some extent, to be pushed onto the consumer through higher output prices.

As output prices are, in general, dictated by agricultural policy rather than market forces, it appears that it is output prices that are dictating the extent to which input prices may change. This implies that a linear time trend must be included in the model. Secondly, however, output prices fell by a staggering 47% between 1973 and 2001 and, furthermore, in 2001, output prices were actually below input prices, implying that with only the price support, agriculture in England is not profitable. Chapter 2 highlighted, however, that this is explained by the change in the structure of support in the latter part of the 20th century and the movement away from price support towards direct payments. The price squeeze (output price-input price) over time is illustrated in Figure 6.3.

The price squeeze in agriculture illustrates that there has been a significant narrowing of the gap between the two, so much so that input prices are now greater than output prices (inclusive of price support), highlighting the current and growing, importance of direct payments to agriculture.

Despite the similar appearance of the two curves of input prices and output prices, the price squeeze has not changed monotonically but oscillated considerably, and multicollinearity may not exist as a serious problem within the model.

Figure 6.3 – Real Price Squeeze (1951-2001)

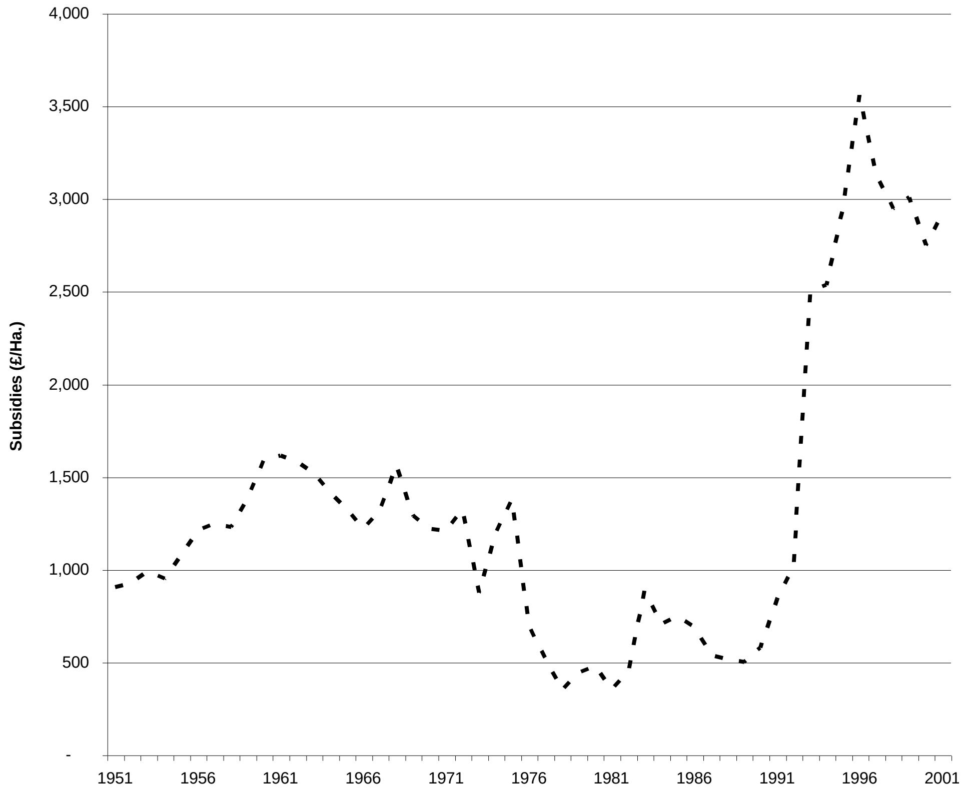


The presence of multicollinearity, to the extent that it is a significant problem for the determined model, is tested in the next chapter to ensure that the model is sound.

Subsidies

The subsidies variable covers all direct payments to farmers under the Arable Area Payments Scheme, introduced following the MacSharry reforms, direct payments to livestock and dairy producers. In addition to direct payments to all farmers in response to rural environmental issues, highlighting the shift in policy, from policy incentives for production towards the protection of the environment. Its variation over time is illustrated in Figure 6.4;

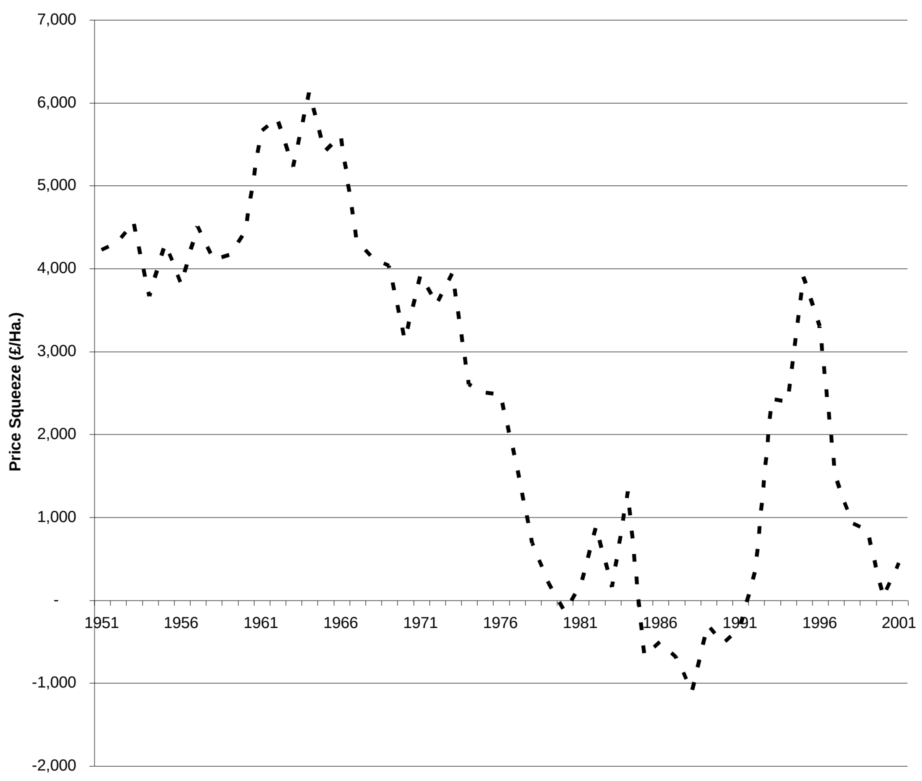
Figure 6.4 – Real Subsidies (1951-2001)



The effect of the MacSharry reforms on subsidies, once inflation has been taken account of, is clear. Subsidies, in real terms, were 200% higher between 1993 and 2001 than in the 40 year period (1951-91) and 340% higher than in the same period ten years earlier (1983-1991). The subsidies, per ha., demonstrate how farming, despite falls in the price output squeeze, has still been profitable in the 1990s.

The variation in the real price squeeze (including subsidies) over time is illustrated in Figure 6.4;

Figure 6.5 – Real Price Squeeze with Subsidies (1951-2001)



Although there is still a general downward trend, this has been arrested to a certain extent by the increase in direct payments in recent years. However, Figure 6.5 implies that farming, during the late 80s, was simply not profitable and this coincides conveniently with periods during which the land price was falling sharply, illustrated in Figure 6.6.

Figure 6.6 – Real Land Prices (1951-2001)

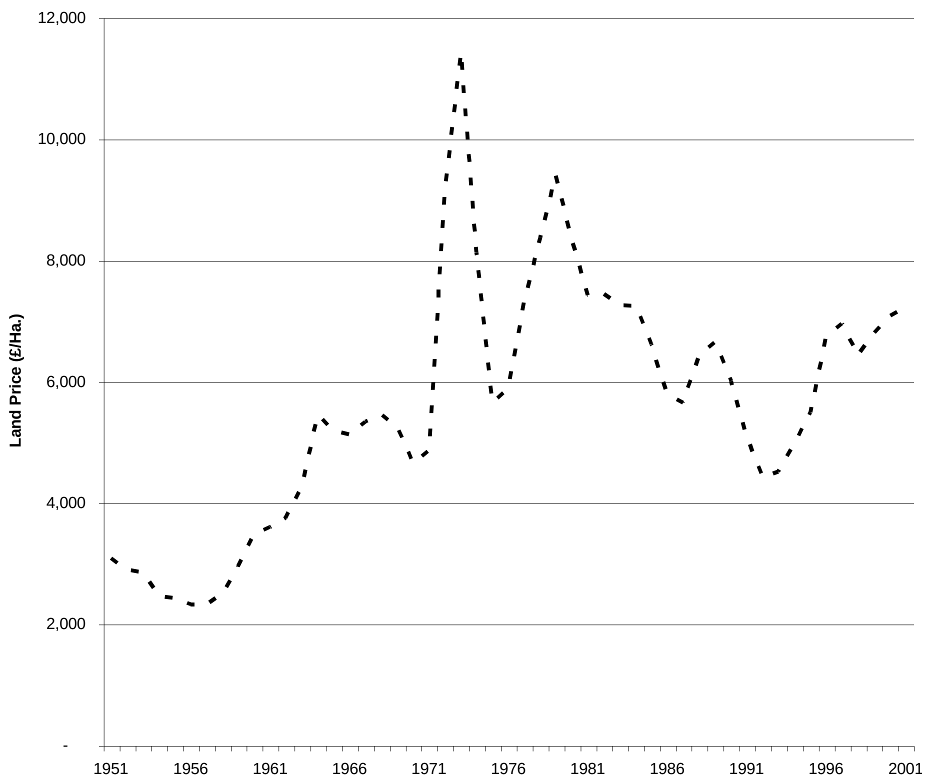


Figure 6.6 also illustrates the increase in the profitability that arose after the introduction of the MacSharry reforms (and sharp increase in direct payments) in 1993.

Chapter 7

FINAL LAND PRICE MODEL: IMPLICATIONS

This chapter attempts to combine the land price and land rent models developed in previous chapters, creating one model that covers the entire research. i.e. A combined land rent and land price model. Once the model is established, it is subjected to encompassing testing, in line with the definition of model congruency provided by Hendry, Pagan and Sargan (1984), to illustrate that the model derived in this research is statistically superior others already present in the research.

The second section of this chapter utilises a similar VAR framework to that in Chapter 5 to determine a model of the land market that allows for policy analysis in the following chapter.

Land Price Model

Table 7.1 reviews the variables utilised in the analysis.

Table 7.1 - Data Definitions

LP	Real average land price (£/ha) for land sold in that period over 5 hectares for the calendar years 1951-2001
LR	Real average land rent paid on farms which have undergone a rent change in the period for the calendar years 1951-2001
D72	Dummy Variable, one for 1972 and 1973, zero elsewhere
IP	Agricultural Input Price index for the calendar years 1951-2001
OP	Agricultural Output Price index for the calendar years 1951-2001
S	Direct Subsidies for the calendar years 1951-2001
I	The rate of Inflation for the calendar years 1951-2001
r	The interest rate (UK Deposit rate) for the calendar years 1951-2001
t	Time trend

The stationarity tests outlined in Chapter 5 found all the variables in the original land price model to be I(1) and a similar analysis, using Augmented Dickey Fuller tests, determines that the indices of input prices, output prices and subsidies are also I(1)[39]. Table 6.2, tests the reduced rank of the VAR and determines that there is only one cointegrating vector. The number of lags used in the analysis can be determined using the Schwarz Criterion (SC) and the Hannan Quinn (HQ) criterion, which implied that the use of one lag was again most appropriate.

Table 7.2 - Maximum Likelihood and Trace Eigenvalue Statistics

		Maximum Likelihood		Trace	
		-Tlog(1-\mu)	95%	-T\Sum log(.)	95%
H_o	H_1				
$r \leq 0$	$r \geq 1$	52.86	39.4	116.1	94.2
$r \leq 1$	$r \geq 2$	36.82	33.5	63.77	67.22
$r \leq 2$	$r \geq 3$	13.54	27.1	26.95	47.2

The Maximum Likelihood and Trace eigenvalue are compared with the finite sample critical values (Reimers, 1992) shown in Table 7.2 and the statistics suggest that there is one cointegrating vector with the null being rejected for $r \leq 0$ and $r \leq 1$ while for $r \leq 2$ the null is not rejected.

[39] Appendix – Unit Root Tests

Restrictions are then applied once the number of cointegrating vectors is known to identify the unique cointegrating vector, which is the land price equation. This is shown in Equation 7.1.

$$\begin{aligned} LP = {} & \underset{(1.2)}{6.60} - \underset{(0.05)}{0.20}\ IP + \underset{(0.04)}{0.22}\ OP + \underset{(0.08)}{0.15}\ S \\ & + \underset{(0.04)}{0.30}\ I - \underset{(0.01)}{0.02}\ r + \underset{(0.24)}{0.60}\ D72 + \underset{(0.01)}{0.02}\ t \end{aligned} \qquad 7.1)$$

s.e. in parentheses

The land price equation is in keeping with *a priori* expectations and the previous model developed[40] earlier in the research. However, the inclusion of input prices, output prices and subsidies in the model at the expense of land rent leads to the exclusion of the dummy variable D79. Although the rent variable is the most accurate measure of rents available, by using the determinants of equilibrium rents, it is possible to account for changes in the land price that land rents cannot account for. This is also a finding of the decomposition later in the chapter. However, the dummy variable, D72, is still found to be highly significant in the model.

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[40] in Chapter 5

A time trend is found to be significant within the model as a result of the variation in the input and output price series. There are, however, no problems of multicollinearity within the model. The possibility of multicollinearity within the model was explored in the previous chapter, where both input and output price series may be collinear. The easiest method of testing for multicollinearity within the model is to look at the standard errors. If several of the variables have high standard errors, and either the input price or output price variable is dropped from the model, then s significant lowering of the standard errors implies that there is a multicollinearity problem. However, the standard errors are relatively low, in comparison to the variable coefficients, and dropping input prices and output prices does not significantly alter the standard errors.

The land price is determined by the land rent, inflation, interest rate, output price and direct payments. The supply of land and total factor productivity variables are not found to be significant at the 5% level. The land price is dependent on the prices of the inputs and the outputs. An increase in input prices represents an increase in costs, *ceteris paribus*, and hence would be expected to decrease the rental return to land. Alternatively, an increase in the output price would be expected to increase revenue and hence increase the rental return to land.

The input price is negatively related to the rental return to land and conversely the output price is positively related to the land rent. A 1% increase in the input price leads to a 0.2% increase in the land price. Alternatively, a 1% increase in the land price leads to a 0.22% increase in the land price. Importantly, the coefficients on input prices and land prices appear to be similar and a *t* test of restriction, the null hypothesis of which is that the coefficients on input price and output price are equal, cannot be rejected and hence it is implied that the coefficients on input price and output price are of equal size.

Inflation is found to be positive, as expected, with a unit change in the inflation rate leading to a 0.3% change in land prices, *ceteris paribus*. In addition, it has a similar coefficient to that on inflation in the land price model developed in the previous chapter, and using a *t* test, we are unable to reject the hypotheses that the coefficients on inflation in each model are the same. The interest rate, as expected, is relatively unchanged from the original land price model and it has a small negative coefficient (-0.02). As with inflation, it has a similar coefficient to that on inflation in the land price model developed in the previous chapter, and using a *t* test, we are unable to reject the hypotheses that the coefficients on inflation in each model are the same.

The subsidy variable, S, has a positive coefficient as expected. Subsidies represent income to the farmer that in turn would be expected to increase land price and any increase in direct payments would be expected to be capitalised into the land price. However, a 1% increase in subsidies, *ceteris paribus*, increases land prices by only 0.15%. Furthermore, the coefficient on the subsidies variable is less than that on the output prices, which implies that a rise in output prices is seen as increasing the value of the land more than a similar increase in the subsidies variable. It is possible that this is because, despite the growing importance of subsidies as a form of income for farmers and a general long-term fall in output prices, output prices still account for five times the income that subsidies provide.

Figure 7.1 – Fitted and Actual Results Long Run Model

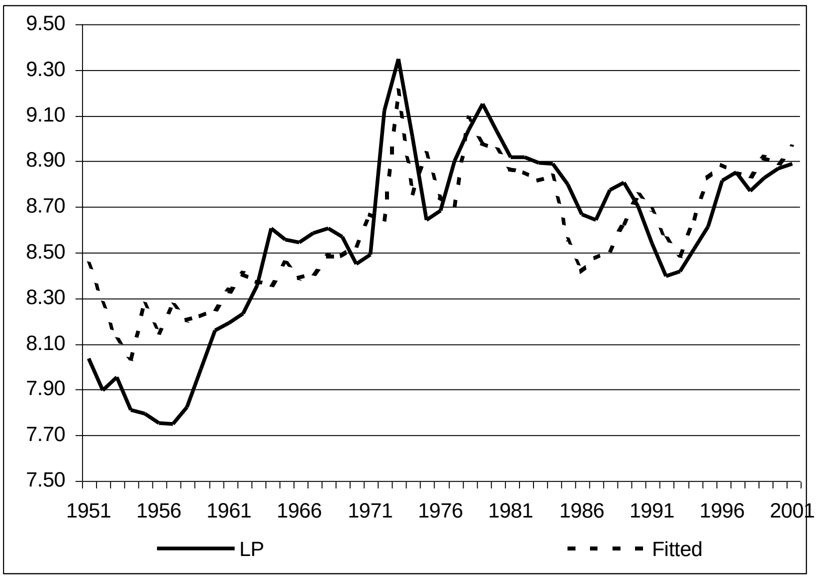


Figure 7.1 shows the actual and fitted results from the long run model, with an adjusted R^2 value of 0.9. The model shows a good fit confirming the results that show a robust model that explains the variation in land prices over the long run.

The short run effects can be determined by forming a Vector Error Correction Model (VECM) which includes the term CR_{t-1}, the cointegrating vector from the period *t-1* to act as an adjustment mechanism for the system and as such it would be expected that this would be negative.

In the short run;

$$\Delta LP = \underset{(0.01)}{0.02} + \underset{(0.18)}{0.50}\ \Delta LP_{t-1} + \underset{(0.2)}{0.52}\ \Delta OP_t$$

7.2)

$$+ \underset{(0.07)}{0.19}\ \Delta S_{t-1} - \underset{(0.01)}{0.03}\ \Delta r_{t-1} + \underset{(0.06)}{0.33}\ CV_{t-1}$$

s.e. in parentheses

The short run model is, as expected *a priori*, with 2 exceptions. It is found that in the short run input prices and D72 are no longer significant at even the 10% levels, in that for a restriction test, where the null hypothesis is that the coefficient on either inflation or net subsidies is equal to zero, the null could not be rejected at the 1% level. This is in keeping with the short run findings of the land price model in Chapter 5. The implication is that subsidies, input prices and inflation have only long run effects on the model.

The signs of the other coefficients are consistent with those in the long run model. However, the sizes of the coefficients are different to that in the long run. The coefficients on input price and output price are lower than that in the long run model. The fact that these coefficients are lower in the short run is, perhaps unsurprising, and can be attributed to the fact that their influence on land prices is indirect, through land rents and as land rents are only changed on a tri-annual basis there is limited scope for change and hence the effect of the input and output price variables on land price in the short run is somewhat limited.

In the short run, land prices are seen to be dependent on the previous period's land price. The implication from this is that a change in the growth rate from the previous period has no effect on the change in prices in the current period.

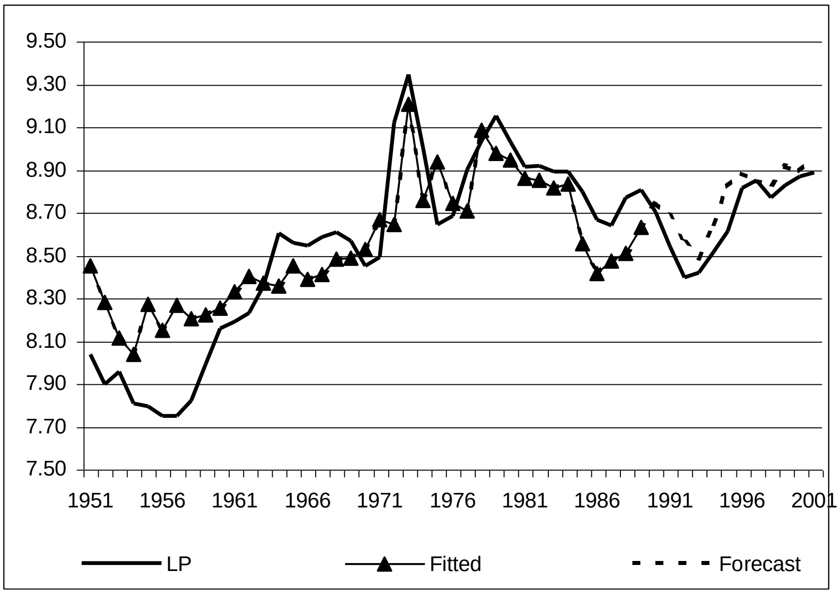
Most notably, the coefficient on input price is substantially higher than the coefficient on output prices in the short run. Both input prices and output prices have a large effect on the land price in the long run. However, while an increase in the input price of 1% increases the land price by 1.3%, an increase of 1% in the output price only increases the land price by 0.49%.

The inference is that, while land prices are seen as reflecting the long run effects of changes in output prices as changes in output tend to be EU determined and are changed relatively seldom.

While the EU tends not to set prices, *per se*, it does, as part of the Common Agricultural Policy, enforce production quotas and set intervention prices such that there is an effective controlling of output prices which primarily determine income from the land. Input prices, on the other hand, reflect factors such as technology changes, that are, in general, long term as well as the demand for inputs that, in turn, reflect the current demand for farming the land which is short term.

Figure 7.2 presents a re-estimation of the model over a shorter sample (1951-1990), and utilises the coefficients of the re-estimated model to forecast the final ten years of the sample period, between 1991 and 2001.

Figure 7.2 – Re-estimation of Model



The model shows a good fit, with an adjusted R^2 value of 0.87, confirming, similar to that in the in Figure 7.1. The adjusted R^2 in the smaller sample is also similar to that taken over the full sample and illustrate a robust model that explains the variation in land prices in the long run. Equation 7.3) presents the model estimated over the shorter sample period, 1951-1990.

$$LP = \underset{(1.2)}{6.54} - \underset{(0.05)}{0.18}\ IP + \underset{(0.04)}{0.23}\ OP + \underset{(0.08)}{0.13}\ S \qquad 7.3)$$

$$+ \underset{(0.04)}{0.31}\ I - \underset{(0.01)}{0.02}\ r + \underset{(0.2)}{0.57}\ D72 + \underset{(0.01)}{0.02}\ t$$

The α coefficients represent the speed of adjustment towards equilibrium once the system is in disequilibrium[41]. A slow adjustment is represented by a low coefficient and alternatively a high coefficient represents a quick adjustment towards equilibrium.

The system adjusts towards equilibrium. The size of the coefficient implies that there is a 33% decrease in the extent of the disequilibrium in any given time period[42]. The speed of adjustment is lower than that found in the original land price model (39%).

The combined land price model replaces the land rent variable with its determinants. In the land rent model there is some land rent unaccounted for. The original land price model does not have this measurement error and hence it is plausible that this may account for a part of this difference.

Once a model has been determined in this research, encompassing tests are moved onto as they provide a theoretically sound method of choosing between the model developed in this research an previous models that exist in the literature.

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41 see Chapter 5

42 in this case, each time period is given as a calendar year

Encompassing Tests

The preceding sections have dealt with the development of a model to explain the variation in the land price over the time period 1951-2001. The standard econometric tests of (structural stability, heteroscedasticity, autocorrelation, functional form and normality) conclude that there are no statistical problems with the model. However, with the proliferation of present value models of land prices there is no reason to suggest that the model developed has any additional value over and above those presently in existence unless tests are conducted proving to the contrary.

Encompassing seeks to do this and the model produced by this research should be compared with three models in existence; the Lloyd, Orme and Rayner (1991), Lloyd (1993) and Weliwita and Govindasami (1997). A lengthy examination of each of the tests used is not conducted as this can be found in a range of econometric texts. However, for a better understanding of the basic concepts involved, it is useful to explain encompassing.

The principle of encompassing derives from the fact that, with differing explanatory variables there are likely to be various categories of models and for each categories of model, various models, each utilising different data sets. The need for encompassing evolves from the nature of economics at a macro level in the fact that different types of economists analyse the same data from differing perspectives.

Encompassing is an idea that derives essentially from intuition, attempting to both explain and compare various models based on the same data from the perspective of one of the models in the comparison (Hendry, 1975) and the concept of encompassing attempts to reduce the number of different specifications .

If two models are chosen for comparison and one of the models is simply a subset of the other then it is said to be nested and the larger of the models will explain more of the variation of the dependent variable by definition. In this case, encompassing is not useful and provides no additional information on model choice. The interest of encompassing lies in the comparison of two competing, non-nested, models.

If a variable $\boldsymbol{y}$ is taken, where

7.4) $H_0 : y = \beta X + \varepsilon_0$

and

7.5) $H_1 : y = \gamma Z + \varepsilon_1$

where β and γ are vectors of length L1 and L2 respectively. These models are said to be non-nested if it is not possible to find restrictions on β such that for any given value of γ, $\beta X = \gamma Z$ and (for completeness and consistency) it is impossible to find restrictions on γ for any given value of β such that $\beta X = \gamma Z$.

In linear regression models such as those discussed in this research, there must be at least one independent variable that is embodied in one model that is not in the other;

7.6) $X_t(\beta) = \beta_0 + \beta_1 X_{t1} + \beta_2 X_{t2}$

and

7.7) $Z_t(\gamma) = \gamma_0 + \gamma_1 X_{t1} + \gamma_2 X_{t2}$

However, if the variable X_{t2} were also used, then it would be rewritten as

7.8) $W_t(\phi) = \phi_0 + \phi_1 X_{t1} + \phi_2 X_{t2} + \phi_3 X_{t3}$

Equations 7.6) and 7.7) are nested within equation 7.8) as setting $\phi_3 = 0$ makes equation 7.6) and equation 7.8) equivalent and setting $\phi_2 = 0$ makes equation 7.7) and equation 7.7) equivalent.

The central tenet of the encompassing principle is the ability of one model to account for the behaviour of its non-nested competitors. If the models for comparison are subjected to standard econometric (diagnostic) tests such as those of autocorrelation, normality, heteroscedasticity, functional form, parameter constancy and predictive failure tests, then any model can be eliminated if it fails these tests when other models show no diagnostic problems.

If encompassing tests are not utilised and where the various models are found not to display standard diagnostic problems then model choice is problematic due to the problem of choice criteria. In other words, unless econometric testing is conducted, it is difficult to discern if any model is superior since, for example, using R^2 is not a justifiable statistic for comparison as it is entirely possible that one model may have many more exogenous variables which artificially boost the R^2.

Hence, if both models possess no diagnostic problems then it is necessary to adopt the use of general models that contain the information from both (parsimonious) models. The use of general models is problematic as these models are often highly parameterised. Therefore it may be subject to diagnostic problems itself and may be spurious. Nevertheless, general models still have an important role to play as they are the standard by which parsimonious models are compared. If one model is not statistically different from the general model then it is implied that it copies the behaviour of the general model and hence encompasses the model to which it is compared. It is important to note that throughout this analysis, the comparison of various models cannot present a definitive model. Whilst encompassing allows distinction between models, it is dependent upon the selection criteria. Given that the implications for policy may be different depending upon which model is utilised it is important to determine what various models can and cannot do. If it inferred that one model is superior to its competitors then it is simply the best given the data generating process, the best approximation and any system of ranking is relative not absolute.

In the two equations;

7.9) $H_0 : y = \beta X + \varepsilon_0$

7.10) $H_1 : y = \gamma Z + \varepsilon_1$

where Z contains at least one variable that is not in X, are taken for comparison, the point of encompassing testing is to determine whether the model in equation 7.8) can explain any of the variation of the endogenous variable that cannot be explained by the model in equation 7.7).

Encompassing tests are generally conducted on the model in equation 7.9) with an alternative hypothesis that the model in equation 7.10) explains information that the model in equation 7.9) cannot. For completeness the opposite test must also be done) that the model in equation 7.10) cannot explain more of the variation in the endogenous variable.

However, in the case where one model is compared directly with another there is a problem. The implication from a test derived on this basis is that one model is rejected in favour of another. This is not necessarily the case, though, as neither model may be representative of the process at hand although this may be overcome by use of a general model.

When H_1 cannot be written as a restriction on H_0 the procedure above is not suitable. A better option may be to combine the hypotheses H_0 and H_1 in a new, general, model that is then subjected to conventional testing;

7.11) $y = \beta\overline{X} + \gamma\overline{Z} + \delta W + \varepsilon$

where:

$\overline{X}$ = set of variables in X that are not in Z
$\overline{Z}$ = set of variables in Z that are not in X
W = variables in both models

If $\gamma = 0$ (as found by a conventional F test) then $H_{1,}$ from equations 7.9) and 7.10), is rejected whereas H_0 is rejected when $\beta = 0$. There are, however, two problems with this approach. Firstly, δ represents the coefficients on variables which are combinations from both models and hence δ is a compound of β and γ. In this case an F test cannot determine whether either of the separate parts is significantly different from zero or not and hence which model, if any, is superior since neither H_0 or H_1 may best approximate *y*. Secondly, the model may have a large number of regressors. In this case the model, which has parts from β and γ, is likely to have problems of collinearity in times series econometrics.

Mizon and Richard (1986) take a different approach that results in a similar general model however with an important difference, that the model is testable due to different estimation and a different hypothesis. If H_0 is assumed correct then *y* will be fully explained by *X* apart from the disturbance term, ε_0.

If γ is estimated by regressing *y* on *Z* then a set of parameters, c, is estimated. In this case c = β under H_0 and if H_0 is correct, regressing $\hat{\beta}X$ on *Z* should lead to the same parameter estimates as ε_0 is the error term (white noise error term) under H_0. As β must be estimated, if βX is utilised and c_0 determined by regressing *y* on *X* then a test that the model in equation 7.9) encompasses the model in equation 7.11) would be that $E[c - c_0] = 0$.Davidson and Mackinnon (1993) show that this can be carried out using a standard F test to test the hypothesis that γ_1 = 0 in an augmented regression:

7.12) $y = X\beta + \bar{Z}\gamma_1 + \varepsilon_1$

$\bar{Z} = variables\ that\ are\ in\ Z\ but\ not\ in\ X$

It is this test that is the basis for the majority of encompassing tests and directs attention towards the **encompassing principle**, the question of whether a given model can explain features of its competitors. The encompassing principle has the intention of sifting through various models to determine which, if any, is superior in its explanation of the variation of a variable. This is done by comparing two models at a given time. The second model must be able to explain the variation that is explained by model 1, otherwise it is said to be encompassed and statistically inferior.

The null hypothesis from here on is that model 1 (in the theoretical case equation 7.9) encompasses model 2 (in the theoretical case equation 7.11) and the alternative is that model 1 does not encompass model 2.

The models considered are the Lloyd, Rayner and Orme model (1991), the Weliwita and Govindasami (1997) model and the new model developed in the last chapter.

In equation form

7.13)

$$\Delta LP = 0.06 + \underset{(0.08)}{0.56}\Delta LP_{t-1} + \underset{(0.22)}{1.25}\Delta LR - \underset{(0.008)}{0.017}\Delta r + \underset{(0.07)}{0.56}Two - \underset{(0.06)}{0.34}CV_{t-1}$$

The Lloyd, Rayner and Orme model (1991) is a strict error correction model based on present value returns

7.14) $\Delta P_t = \Delta R_t + \left(P_{t-1} - R_{t-1}\right)$

And as this model does not take account of other theoretical aspects such as inflation hedging and business cycles we would expect that this model be encompassed by the new model.

After re-estimating the Lloyd, Rayner and Orme (1991) model over the series, 1951-2001:

7.15) $\Delta P_t = 0.53 + 0.83\ \Delta R_t - 0.13\ (P_{t-1} - R_{t-1})$

$\qquad\qquad\quad (0.29) \quad (0.40) \qquad\quad (0.07)$

The Lloyd, Rayner and Orme (1991) model is in line with a priori expectations and the coefficient on each variable is significantly different from zero.

The change in rent accruing to land is positively related to the land price and a simple *t* test confirms that the coefficient is significantly different from one. The error correction term is negative as expected and the coefficient of 0.13 shows a slow speed of adjustment. The diagnostic tests show that there are no statistical problems with the model

The Lloyd (1993) model is similar in principle to the previous model in that it does not utilise a variable for the interest rate that is included in the subsequent models.

However, the Lloyd (1993) model does include a dummy variable to take account of the UK's entry into the EC

7.16) $\Delta P_t = \Delta R_t + \Delta I_t + D72$

$\boldsymbol{I_t}$ = level of inflation in year t

After re-estimating the Lloyd (1993) model over the series, 1951-2001:

$$7.17)\ \Delta P_t = -0.011 + \underset{(0.33)}{0.90}\ \Delta R_t + \underset{(0.13)}{0.66}\ D72$$
$$(0.019)$$

The change in rent accruing to land is positively related to the land price and a simple *t* test that the coefficient is significantly different from one cannot be rejected. As such the model implies that a 1% increase in land rents leads to a 1% increase in the land price.

Most notably, inflation is not found to be significant, a result that mirrors the model developed in this research. As expected the dummy variable is highly significant and the diagnostic tests[43] show that there are no statistical problems with the model.

The Weliwita and Govindasami (1997) model works from the basis that the theoretical derivation of land prices consistent with the work of Lloyd (1993) does not identify the precise effects to be expected of changes in

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[43] see Appendix 2

farm values except to identify the importance of rent to be earned in agriculture.

Weliwita and Govindasami (1997) argues that the net earnings from land can be proxied by net farming income despite evidence from Traill (1982) that the evidence for a direct link between farm returns and land prices is not reliable.

The Weliwita and Govindasami (1997) model utilises farm income rather than rent as a measure of returns to land. The encompassing tests will be of interest to determine which model, if any, encompasses the other and draw implications for the choice of explanatory variable for returns.

The model also includes a variable to measure the supply of land (crops and grass area):

7.18) $\Delta P_t = \Delta FI_t + \Delta I_t + \Delta LNr_t + \Delta CG_t$

FI_t = Real Gross Farm Income in year t
LNr_t = Long term nominal interest rate in year t
CG = Area under Crops, Grass and Pasture

It would be expected that CG and land price are inversely related and it would be expected that the coefficient on farm income should be less than one. Weliwita and Govindasami (1997) find, using data from three different states in the US, that there is a very stable relationship in each of the three US states such that increases in land prices have a long run relationship with real gross farm income, inflation, a long term interest rate and the area under crops and grass.

Weliwita and Govindasami (1997) find, in line with expectations, that in each of the three states the long term interest rate is positively related to the land price, inflation is also positively related to the land price, that the coefficient on farm income is less than one and in two out of the three states the area under crops and grass is negatively related to the land price.

After re-estimating the Weliwita and Govindasami (1997) model over the series, 1951-2001:

7.19) $$\underset{(0.03)}{\Delta P_t = 0.005} + \underset{(0.04)}{0.11}\ \Delta FI_t - \underset{(0.006)}{0.068}\,\Delta I_t - \underset{(0.027)}{0.044}\ \Delta LNr_t + \underset{(0.05)}{0.015}\,\Delta CG_t$$

The change in farm income is positively related to the land price as expected and is below one as expected. Most notably, inflation is found to be significant and negatively related to the land price, a result that contradicts the model developed by Weliwita and Govindasami (1997).

The diagnostic tests[44] show that there are no statistical problems with the model. The Weliwita and Govindasami (1997) model is a model based upon that of Harvey (1989) and while Hallam et al. (1992) estimate the Harvey model on a different sample, it is curious that Hallam et al. (1992) find that the model does not illustrate cointegration. There are two possible reasons for this why Hallam et al. do not find cointegration. Firstly, Hallam et al. (1992) test purely for pairwise cointegration, and this may not exist, a relationship may occur with more than just the two variables. In addition, Hendry (1975) argues that the Dickey Fuller test has a tendency to over-reject and it is possible that over the sample period chose, this is the case.

The tests are conducted twice, once to determine if model 2 encompasses model 1 and vice versa. Each of the models is compared to the new model to determine whether the new model encompasses each of the other 2 models.

Model 1 Lloyd (1993) model

H0 Lloyd (1993) model does not encompass new model

H1 Lloyd (1993) model encompasses new model

[44] see Appendix

Table 7.3 – Encompassing Test

Test	**Distribution**	**Statistic**	**Critical Value (1%)**
Cox Test	N(0,1)	-1.47	2.58
Ericsson Test	N(0,1)	1.29	2.58
Sargan	χ^2	3.24	11.52

It is clear from each of the statistics in Table 7.3 that the null hypothesis is not rejected and hence the Lloyd (1993) model does not encompass the new model.

Conducting the opposite tests yields the results

H0 New model does not encompass Lloyd (1993) model

H1 New model encompasses Lloyd (1993) model

Table 7.4 – Encompassing Test

Test	**Distribution**	**Statistic**	**Critical Value (1%)**
Cox Test	N(0,1)	-11	2.58
Ericsson Test	N(0,1)	5.93	2.58
Sargan	χ^2	25.25	11.52

The results from Table 7.4 clearly imply that the null is rejected and the new model encompasses the Lloyd (1993) model in each test. Hence, the new model is assumed to be 'superior' in its explanatory power to the Lloyd (1993) model, an unsurprising finding as it has many more explanatory variables.

Model 2 Lloyd, Rayner and Orme (1991) model

H0 Lloyd, Rayner and Orme (1991) model does not encompass new model

H1 Lloyd, Rayner and Orme (1991) model encompasses new model

Table 7.5 – Encompassing Test

Test	**Distribution**	**Statistic**	**Critical Value (1%)**
Cox Test	N(0,1)	-0.42	2.58
Ericsson Test	N(0,1)	0.29	2.58
Sargan	χ^2	0.09	11.52

It is clear from each of the statistics in Table 7.5 that the null hypothesis is not rejected and hence the Lloyd, Rayner and Orme (1991) model does not encompass the new model. Conducting the opposite tests yields the results:

H0 New model does not encompass Lloyd, Rayner and Orme (1991) model

H1 New model encompasses Lloyd, Rayner and Orme (1991) model

Table 7.6 – Encompassing Test

Test	**Distribution**	**Statistic**	**Critical Value (1%)**
Cox Test	N(0,1)	-116	2.58
Ericsson Test	N(0,1)	30.2	2.58
Sargan	χ^2	35	11.52

The results from Table 7.6 clearly imply that the null is rejected and the new model encompasses the Lloyd, Rayner and Orme (1991) model in each test.

It is clear from each of the statistics that the null hypothesis is not rejected and hence the Lloyd, Rayner and Orme (1991) model does not encompass the new model.

Model 3 Weliwita and Govindasami (1997) model

H0 Weliwita and Govindasami (1997) model does not encompass new model

H1 Weliwita and Govindasami (1997) model encompasses new model

Table 7.7 – Encompassing Test

Test	**Distribution**	**Statistic**	**Critical Value (1%)**
Cox Test	N(0,1)	-0.35	2.58
Ericsson Test	N(0,1)	0.25	2.58
Sargan	χ^2	6.16	9.54

It is clear from each of the statistics in Table 7.7 that the null hypothesis is not rejected and hence the Weliwita and Govindasami (1997) model does not encompass the new model.

Conducting the opposite tests yields the results

H0 New model does not encompass Weliwita and Govindasami (1997) model

H1 New model encompasses Weliwita and Govindasami (1997) model

Table 7.8 – Encompassing Test

Test	Distribution	Statistic	Critical Value (1%)
Cox Test	N(0,1)	-77.9	2.58
Ericsson Test	N(0,1)	20.1	2.58
Sargan	χ^2	33.2	9.54

The results from Table 7.8 clearly imply that the null is rejected and the new model encompasses the Weliwita and Govindasami (1997) model in each test. From the encompassing tests conducted it is clear that the model developed in previous chapters encompasses the previous models which intuitively makes sense as it includes numerous other variables to take account of other effects when compared to the Lloyd, Rayner and Orme (1991) model in the first case. Furthermore, it utilises different variables to the Weliwita and Govindasami (1997) model.

The direct implication from the encompassing tests with the Weliwita and Govindasami (1997) model is that the new model is 'superior' and, as a result, the choice of variables is more appropriate in representing the land market in England.

This previous sections have been concerned with the determination of a basic land price model that seeks to explain the variation in land price. Additionally, any sound model must be able to explain the divergences between land price and land rents that are not predicted by the basic present value theory. This is found to be the case. The model developed is shown to be stable, congruent and robust explaining both the variation in land price and the divergence between land price and land rents through changes in the other variables.

Furthermore, the model is compared to previous models and using encompassing testing the model developed in this research is proven to be statistically superior to three other models that exist in the literature, in terms of explaining the variation in land prices.

Extensions to the Model

The benefit of utilising VAR analysis over such previous modelling techniques is that it is possible to determine the operation of the model when it is in dis-equilibrium. As previous chapters have illustrated, the long run model determines the equilibrium state and that short run illustrates disequilibrium and the time taken to move the system towards the long run state (looking at the values of α).

In addition, the use of VAR analysis in determining the land price model is that it enables the use of impulse response analysis to further investigate the properties of the model. In its simplest form, impulse response modelling attempts to determine the effects on a model once a shock has been applied to one of the variables. More specifically, impulse response modelling attempts to determine the dynamic effects on a system's endogenous variables to exogenous shocks.

Impulse response functions therefore measure the time, and the path taken, for the endogenous variables to return to equilibrium from a shock at time t=0, assuming that there are no other shocks in the system.

Depending on the properties of the variables, impulse responses can be determined when all the variables are stationary or when the variables are a first-order non-stationary process but cointegrated if a first difference model is utilised.

Impulse Response Modelling

Banerjee, Hendry and Mizon (1996) state that if z is defined as a vector with k potentially endogenous variables with each z having m lags:

7.20) $A_0 z_t = A_1 z_{t-1} + A_2 z_{t-2} + ... + A_m z_{t-m} + \varepsilon_t$

where A_i, i = 0, 1, ... m is a $(k \times k)$ matrix of coefficients and $\varepsilon_t \sim NID(0,\Sigma)$ is a diagonal covariance matrix. Assuming that the matrix A_0 is non-singular its inverse A_0^{-1} exists, multiplying by A_0^{-1} gives

7.21) $N_1 z_{t-1} + N_2 z_{t-2} + ... + N_p z_{t-p} + u_t$

where $N_i = A_0^{-1} A_i$, $\forall$ i = 1,2,..., m; $u_t = A_0^{-1} \varepsilon_t \sim NID(0,\Omega)$, with the covariance matrix $\Omega = A_0^{-1} \Sigma A_0^{-1,t}$ being non-diagonal.

7.22) $z_t\{I - N(L)\} = u_t$

where I is an identity matrix, L is a lag operator[45] and

7.23) $N(L) = N_1L + N_2L^2 + ... + N_mL^m$

Then the moving average representation of the equation is given by

7.24) $z_t = \{I - N(L)\}^{-1}u_t$

A necessary condition is that the eigenvalues of the matrix N must all be less than one. In the same way, equation 7.6 can be re-written;

7.25) $z_t = B(L)u_t$

where

7.26) $\{I - N(L)\}^{-1} = B(L) = (I + BL + B_2L^2 + ...)$

The matrix of responses of z_{t+h} to unit impulses in each of the element u_t is

7.27) $B_h = \frac{\partial \mathbf{z}_{t+h}}{\partial u_t^{/}}$

45 In other words $L^s\mathbf{y_t} = \mathbf{y}_{t-s}$

Interpreting the impulse responses directly from Equation 7.27) is difficult as the residuals are be correlated across equations. The Choleski decomposition attempts to overcome this problem by transforming the residuals into an orthogonalised form. This is done by multiplying the residuals by a lower triangular matrix, A_0^{-1}, used to recover the diagonal error matrix of the structural model. As such, orthogonalisation is a method, though not the only method, of retrieving the diagonal covariance matrix of the structural model.

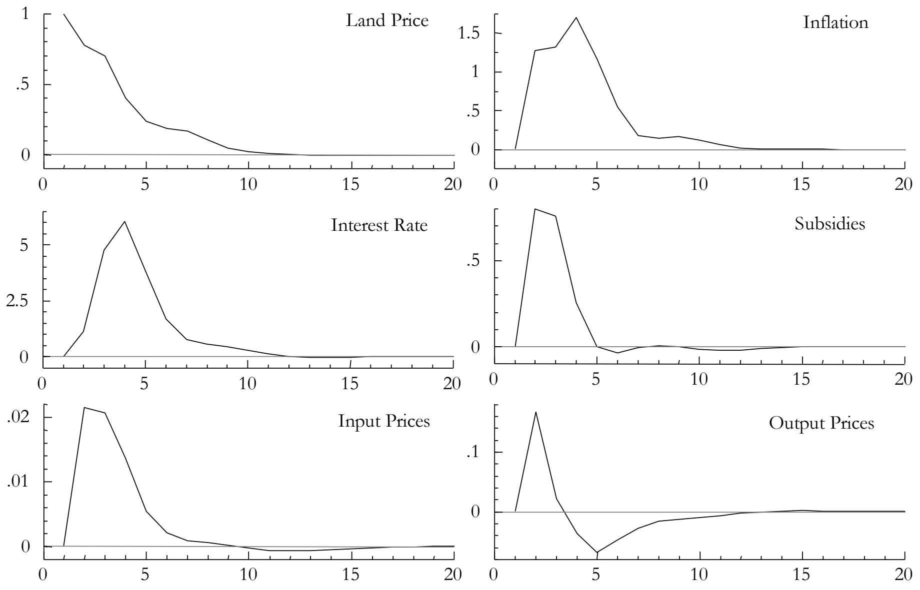
Orthogonalisation has its problems. For example, it is not invariant to the ordering of the variables in the VAR (Peseran *et al*, 1997). It is difficult to order the variables in the VAR without, *a priori*, assumptions about their exogeneity/endogeneity. Additionally, many orthoganilisations violate weak exogeneity and different specifications of exogeneity affect impulse responses to the extent that, Ericsson, Hendry and Mizon (1998) argue that it is preferable to develop a valid conditional representation and avoid the use of orthogonalised impulse responses.

Peseran and Shin (1998) argue that the use of generalised impulse response analysis for linear multivariate models is invariant to the ordering of the variables in the VAR. Rather than allowing the shock affect all the elements in the residuals and then orthogonalising them, the generalised impulse response analysis takes a direct approach. The shock is affects one element in the residual and its effect on the other variables is traced using the historically observed distribution of the errors. The two approaches are similar when the covariance matrix is diagonal. In the case of a non-diagonal matrix the approaches are the same when the shock affects the first equation in the system.

Although the generalised impulse response is unique in the sense that it is invariant to the ordering of the variables in the VAR, a concept of *exogeneity*, either from economic theory or from empirical testing is required for any analysis of intervention as the variable that is shocked must be in some sense exogenous to the other variables in the VAR for any meaningful policy statements to be inferred from the results.

The effects of the impulse response modelling are best visualised using graphical interpretations (Falk and Lee, 1998) such as in Figure 7.18. The impulse response analysis is simply a dynamic simulation from $t = 0$ where a shock is introduced to the short run model at $t = 1$ and the pattern of the variables is followed. In analysing the impulse responses graphically, it is the long run total multipliers from the matrix that are plotted. The graphs in 7.18 present the response of the growth in land price to a shock in each of the variables.

Figure 7.18 – Impulse Responses



In this system, the growth in land price returns to the equilibrium state within around 11 time periods, gradually decreasing throughout. The other variables increase to varying degrees immediately after a one unit shock and when each of the variables is shocked, while the system returns to equilibrium relatively quickly.

However, output prices react rather differently. After an initial one unit shock, output prices adjust very quickly towards equilibrium and reach the equilibrium point within less than 4 time periods. However, output prices continue past equilibrium and then re-adjust afterwards, taking longer than the other variables to settle back at equilibrium.

This is indicative of nature of the response and the length of the response period. Both imply that output prices tend to overreact to temporary shocks. This is perhaps a reflection of the fact that output price changes as a result of changes in price related policy occur relatively infrequently. However, when these changes do occur they tend to be significant and persist for a considerable time.

Although it is possible to show the orthogonal impulse responses, Doornik and Hendry (1997) argue that this alters the conditioning assumptions that may lead to a violation of the weak exogeneity conditions.

Lütkepohl (1991) goes further arguing that there are other limitations to the impulse response methodology, the main of which is the incompleteness of any model which means that, by definition, the effects of any shock are incomplete. Additionally, the effects of the omitted variables themselves are also not included in the system. This may lead to great distortions making them '…useless for structural interpretations' although Lütkepohl goes on to state that the system may still be useful for prediction. However, as this is the main use of the impulse response modelling in this research there is not seen to be a problem.

Decomposition

One of the main reasons for developing the land price model was to illustrate the effects of changes in the quantity, and type, of support on the land market. The long run land price model in Equation 7.28) illustrates that a change in the direct payments to agriculture has a different effect upon the land market than a similar change in the output price.

It is worthwhile to use a simple decomposition of the model to analyse the changes that occurred after the MacSharry reforms to illustrate the model's use. The time period used, between 1992 and 1999, covers a period during which the MacSharry reforms but prior to the Agenda 2000.

The decomposition involves the determination of the amount of change in the land price that is accounted for by the change in each variable. For example, after the MacSharry reforms, real land prices increased by 6%. The decomposition tells us what amount of this 6% change in real land price is accounted for, by output prices, input prices, inflation, interest rates and the subsidy variable.

The decomposition is conducted using the coefficients from the combined long run model of land:

$$LP = 6.60 - 0.20\ IP + 0.22\ OP + 0.15\ S$$
$$(1.2)\quad (0.05)\quad (0.04)\quad (0.08)$$

7.28)

$$+\ 0.30\ I - 0.02\ r + 0.60\ D72 + 0.02\ t$$
$$(0.04)\quad (0.01)\quad (0.24)\quad (0.01)$$

The coefficients are multiplied by the change in the actual variables over the period 1990-01, illustrating before and after MacSharry. The average log real land price over the sample period, between 1951 and 2001, is 8.56. This compares well with the value estimated by the model of 8.58, calculated by multiplying the average value of each explanatory by the coefficient on each variables and calculating the sum.

Table 7.9 – Decomposition; The Effects of the MacSharry Reforms

Variables	LP	OP	IP	I	r	S
% change	5%	-1%	1%	2%	1%	2%

Table 7.9 illustrates the decompostion. Between 1992 and 1999, the real land price rose 6%. The estimated model determines the fall to be 5% and again highlights the importance of utilising input prices, output prices and direct subsidies rather than rents as variables explaining the variation in land prices. Whereas the simple plot of land prices illustrated that land rents has in fact fallen over the period 1992-2001, appearing to only capture the changes in output prices and input prices, the change in the subsidies variable has a large impact upon the model.

Between 1992 and 2001, the input and output prices vary little, and their effects counteract each other but direct payments rose by 15% in real terms and this caused a 2% rise in the land price. However, this implies that less than half the increase in land prices between 1992 and 2001 were as a consequence of the MacSharry reforms. Increases in inflation, which increased 6%, caused a 2% rise in the land price and a considerable fall in the interest rate led to a 1% rise in land prices.

Chapter 8

CONCLUSIONS

This research has dealt with the agricultural land market in England. Previous research is littered with models that have, based on present value theory, failed to account for the workings of the land market. These models have been unable to fully explain the variation in the English land price, explain why land prices and land rents may diverge or establish a link between the land price, in England, and variables that have are influenced by policy. Linking the land price to variables, such as output prices and direct payments is essential, not only because it is crucial for policy makers, who control land prices to a large extent, but also farmers, for whom land constitutes a large proportion of their total wealth. Additionally, the difficulties in determining an appropriate measure of net returns to land, imply that using its determinants, avoids this problem.

The basic theoretical model is developed using the work of Harvey (1974) and Just (1988).

This research argues that the land price is determined by the return to land, the rate of inflation and the rate of interest. The return to land is determined using the net rent in time t, a measure of rent agreements that have been negotiated over the past year. Although not a perfect measure, in general, over the time period, it is seen as a good measure of the variation in the return to land. The inflation rate takes account of the fact that in periods of high inflation, the total debt incurred when taking out a loan to purchase land, falls. In addition, the inflation rate reduces the value of savings and other investments. As farmers have a break on the capital gains tax that must be paid on income earning assets, high rates of inflation increase the value of this break and increase the demand for, and hence the price of, land. The model also includes two dummy variables, D72 and D79. These take account of two periods in the 1970s where the model seemingly cannot account for the variation in land prices.

The basic long run land price model is illustrated in Equation 8.1:

$$8.1)\quad LP = \underset{(1.23)}{3.77} + \underset{(0.34)}{1.03}LR + \underset{(0.10)}{0.27}I - \underset{(0.01)}{0.02}r + \underset{(0.21)}{0.40}D72 + \underset{(0.14)}{0.3}D79$$

The next stage of the analysis concerns the model of land prices that establishes the link to policy variables. This is done by using a theoretical model of land price, determined by Harvey (1974), and introducing the determinants of equilibrium rent, an unobservable variable, into the land price model. The result is a model that finds land prices to be a function of input and output prices, subsidies, the rate of inflation and the interest rate.

The final long run land price model is illustrated in the Equation 8.2):

$$\begin{aligned} LP = {} & \underset{(1.2)}{6.60} - \underset{(0.05)}{0.20}\ IP + \underset{(0.04)}{0.22}\ OP + \underset{(0.08)}{0.15}\ S \\ & + \underset{(0.04)}{0.30}\ I - \underset{(0.01)}{0.02}\ r + \underset{(0.24)}{0.60}\ D72 + \underset{(0.01)}{0.02}\ t \end{aligned} \qquad 8.2)$$

The model is shown to be congruent and robust using the definitions provided by Hendry, Pagan and Sargan (1984) who argue that a model is congruent with the data if;

the statistical properties of the model are Gaussian

the empirical model is consistent with the theory from which it is defined

and it encompasses rival models.

The coefficients are in general, as expected, *a priori*, and can be used to illustrate the effects of changes in support to agriculture and changes in the structure of support. This is highlighted in the decomposition of the MacSharry reforms, where the sharp increase in the land prices between 1993 and 2001 was not wholly accounted for by the basic land price model (that included net rents). However, the final land price model fully accounts for the increase in land price since 1993, and finds that the increase was only partly as a result of the enactment of the MacSharry reforms. Increases in inflation and decreases in interest rates also played a considerable part.

Utilising VAR modelling techniques also mean that it is possible to determine properties of the model when it is not in equilibrium. These are illustrated by the short run models in Chapters 5 and 7. Additionally, however, the α coefficients and the impulse response modelling also illustrate qualities inherent within the model regarding the speed at which it returns to an equilibrium state when shocked.

Limitations of the model and Possible Further Research

The greatest limitations in the research regard issues that remain unresolved in the research. Ideally, a series for the non-agricultural demand would be available to include within the model. Additionally, if a specific form of expectations could be theoretically justified and found to be appropriate then it would be used.

These would be expected to improve the explanatory power of the model, and, at the very least, remove the need for the dummy variable D72.

In addition to the unresolved issues, the further research may look at the different types of farming (cereals, dairy and cattle producers) as each receives differing levels of support and is subject to differing costs.

As the model has explained the increase in land prices since 1993, partly as a consequence of the MacSharry reforms, it would be interesting to return to the subject area in some few years. It is too early, at this stage, to determine the long run effects of the Agenda 2000 reforms. However, when sufficient data has been collated, the effects of the Agenda 2000 reforms can be analysed.

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Appendix - Data Definitions

LP	Real average land price (£/ha) for land sold in that period over 5 hectares for the calendar years 1951-2001
LR	Real average land rent paid on farms which have undergone a rent change in the period for the calendar years 1951-2001
D72	Dummy Variable, one for 1972 and 1973, zero elsewhere
IP	Agricultural Input Price index for the calendar years 1951-2001
OP	Agricultural Output Price index for the calendar years 1951-2001
S	Direct Subsidies for the calendar years 1951-2001
I	The rate of Inflation for the calendar years 1951-2001
r	The interest rate (UK Deposit rate) for the calendar years 1951-2001

Appendix - Deriving the Basic Present Value Model

In perfectly competitive markets, the price will be equal to the expected income over that time;

$$1)\ P_0 = \frac{E[R_1]}{1+r} + \frac{E[P_1]}{1+r}$$

P_0 represents the price of the land. $E(d_1)$ represents the net return to land ownership at the end of the year. P_1 represents the value of the land is sold at the end of the year. r is market determined rate of discount of the cost of capital. The return on the land comprises of two elements; income and capital gain. d_t represents the income element and P_1-P_0 represents the capital gain of the land.

For the second time period;

$$2)\ P_1 = \frac{E[R_2]}{1+r} + \frac{E[P_2]}{1+r}$$

By substituting 2 into 1;

$$3)\ P_0 = \frac{E[R_1]}{1+r} + \frac{E[R_2]}{1+r} + \frac{E[P_2]}{(1+r)^2}$$

If this is extended for $E[P_3]$, $E[P_4]$,.., $E[P_T]$;

$$4)\ E_t[P_t] = \sum_{t=1}^{T-1} \frac{E_t[R_t]}{(1+r)^t} + \frac{E_t[P_T]}{(1+r)^{T-1}}$$

E_t represents the expectations based upon the information that is available at time $t = 0$. R_t represents the net return to land ownership in the time period *t* which available at the point where *t* ends. P_t represents the value of the land is sold at the end of time period *T*. P_T represents the value of the land is sold at the beginning of time period *T*. r is said to represent the rate at which the returns to land are discounted.

E_t represents the expectations based upon the information that is available at time $t = 0$. R_t represents the net return to land ownership in the time period *t* which available at the point where *t* ends. P_t represents the value of the land is sold at the end of time period *T*. P_T represents the value of the land is sold at the beginning of time period *T*. r is said to represent the rate at which the returns to land are discounted.

If there is no intention at time 0 to sell the land at time T then the right hand term falls to zero as $T \rightarrow \infty$, which occurs if $E(P_{\infty})$ if finite, then;

$$3.3)\quad E_t[P_t] = \sum_{t=1}^{\infty} \frac{E_t[R_t]}{(1+r)^t}$$

The expected net present value, effectively price, of a unit of land equal to the sum of returns from time period T to ∞.

Appendix - The Just Model

Just's model utilises several assumptions attempting to make the model less restrictive, the first assumption of which is that the utility level of farmers depends upon consumption and wealth (evaluated on a 'cash-out' basis), is strongly separable in each category and follows constant absolute risk aversion in each. Secondly it is assumed that production follows constant returns to scale and thirdly capital markets are assumed to be imperfect in that the savings interest rate is less than that for borrowing, finance charges are incurred in obtaining new loans and debt limits can be encountered. The fourth assumption is that transaction costs are incurred for the sale of land and fifth building sales are tied to land sales.

It should be noted that in this model farming is viewed as risky both in terms of operating income and wealth as both farm income and land price variation are dependent upon government policies, which are subject to unpredictable changes over long horizons. As such farmers cannot make decisions in the long run with certainty as production plans and investment portfolios may be altered due to unexpected events. Hence, the farmer's assumed objective is on a short-run basis with decisions altered on a frequent basis to meet the short run goals with changing economic conditions.

The following notation represents the variables used in the Just (1988) model:

Farmer Specific Decision Variables

a_t = *net current land purchases (negative if sales)*

x_t = *vector of variable inputs per acre applied in farming*

R_t = *net returns per acre from farming including government program payments*

d_t = *net current borrowing*

C_t = *current consumption*

s_t = *current savings before operating income, consumption and taxes*

Producer Specific Expectation Variables

A_t = *current land holdings after purchases/sales*

S_t = *current savings after income, consumption and taxes*

D_t = *current debt after land and capital transactions and current inflation*

F_t = *current taxable cash flow*

W_t = *current wealth after transactions, consumption and taxes*

T_t^* = *total current taxes*

P_t = *land price at the end of the current period*

P_t^0 = *average basis price of land for tax purposes*

Economy Wide Parameters and Prices are represented by

$f_t = 1$ *plus the current inflation rate*

$\pi_t =$ *current rate of principle repayment on debt*

$d_t =$ *net current real borrowing (at the beginning of period t)*

$w_t =$ *vector of prices of variable inputs used in farming*

$\Delta =$ *rate of finance charge and other transaction costs on new debt*

$1-\rho =$ *rate of sales commission and other transaction costs on land sales*

$\tau_t =$ *current tax rate on income*

$\nu_t =$ *proportion of capital gains (losses) applied to taxable income*

$\nu_t^* =$ *effective proportion of capital losses usable for reducing taxable income*

$\psi_t =$ *property tax rate on real estate*

$r_t =$ *real interest rate on savings*

$G_t =$ *average government program payment per acre*

$\mu =$ *maximum debt/asset ratio for credit*

$\theta =$ *maximum debt-service/cash flow for credit*

All values and prices are assumed to be in real terms. The equations of motion that determine the temporal relationship of producer variables are

1) $A_t = A_{t-1} + a_t$

2) $D_t = \frac{1}{f_t}\left[(1-\pi)D_{t-1} + d_t\right]$

Equation 3) takes account of the fact that real debt is reduced when repaid utilising inflated money.

3) $S_t = \frac{1+\gamma_t}{f_t} s_t + F_t - C_t - T_t$

Equation 3) takes account of the eroding effect of inflation on savings with cash flow, consumption and taxes treated as they occur at the end of the accounting period.

4) $A_t p_t^0 = \frac{1}{f_t}\left[p_{t-1}^0 A_{t-1} + \psi_t p_t a_t + (1-\psi_a) p_{t-1}^0 a_t\right]$

Equation 4) takes account of the effect of inflation which lead due to the tax break leads to preferential capital gains treatment.

5) $\psi_t = \begin{Bmatrix} \boldsymbol{1} \ \boldsymbol{if} \ a_t \geq \boldsymbol{0} \\ \boldsymbol{0} \ \boldsymbol{if} \ a_t < \boldsymbol{0} \end{Bmatrix}$

These equations of motion assume that the basis of land sold is valued at the average of all land held at the beginning of the period which Just argues is not a restrictive assumption since

> "…this is a reasonable simplification since no data is found to the contrary are available."

However, as a bigger tax break can be obtained by selling assets with the lowest basis then this procedure likely overvalues the basis of land assets sold by those holding large amounts of land.

The accounting equations are

6) $F_t = A_t R_t - r_t D_t$

Equation 6) shows the taxable operating income and expenses

7) $s_t = S_{t-1} - a_t p_t + d_t - \pi D_{t-1} - \psi_d \Delta d_t + (1-\rho)(1-\psi_a) a_t p_t$

Equation 7) states the savings after transactions and any transactions costs associated with new debt financing and asset sales.

8) $W_t = \rho A_t P_t + S_t - D_t - \pi\tau\nu A_t V_t$

Equation 8) states expected wealth at the end of each period on a cash out basis i.e. if all assets are sold, debt is repaid and resulting tax obligations and transactions costs are paid.

9) $T_t = \tau_t \left\{ F_t + \frac{1}{f_t}\left[\gamma_t s_t - \psi_d \Delta d_t - (1-\Psi_a)\psi_v \nu a_t v_t - \psi_a \psi_v \nu^* a_t v_t\right]\right\} + \frac{\psi}{f_t} A_t p_t$

where

$$V_t = \begin{cases} \rho P_t - p_t^o & if\ \rho P_t - p_t^o \\ 0 & otherwise \end{cases}$$

10)

$$v_t = \rho p_t - p_{t-1}^0$$

$$\psi_d = \begin{cases} 1\ if\ d_t \geq 0 \\ 0\ if\ d_t < 0 \end{cases}$$

$$\psi_v = \begin{cases} 1\ if\ v_t \geq 0 \\ 0\ if\ v_t < 0 \end{cases}$$

The current tax obligation in 4) includes the specific tax considerations associated with operating income, interest, transactions costs on debt payments, asset sales, land taxes and basis values of assets.

Appendix – Transactions and Land Prices

Land Prices	=	3828	+	0.63	Land Transactions
		(2707)		(0.85)	

T stats of significance in parentheses

The coefficient on transactions is positive (implying a positive effect upon land prices). However, the variable transactions is not significant at the 1%, 5% or 10% levels.

Table – Unit Root Tests

Unit-root tests 1953 to 2001
Critical values: 5%=-3.502 1%=-4.154; Constant and Trend included

	t-adf	beta Y1	\sigma	lag	t-DYlag	t-prob
LP	-2.7575	0.81078	0.13949	1	3.1126	0.0032
LP	-1.8479	0.86653	0.15209	0	0.0032	
LR	-1.4809	0.93619	0.036904	1	4.6004	0.0000
LR	-0.17913	0.99111	0.044259	0	0.0000	
LI	-2.7354	0.71686	0.48447	1	0.98548	0.3297
LI	-2.5533	0.75137	0.48431	0	0.3297	
r	-1.5107	0.85370	1.5901	1	0.039103	0.9690
r	-1.6177	0.85503	1.5728	0	0.9690	
IP	-1.5286	0.90993	0.038496	1	1.8432	0.0719
IP	-0.97103	0.94434	0.039486	0	0.0719	
OP	-1.7390	0.86757	0.050809	1	1.3753	0.1758
OP	-1.2798	0.91006	0.051299	0	0.1758	
S	-1.2398	0.91332	0.29477	1	-0.057886	0.9541
S	-1.3182	0.91223	0.29156	0	0.9541	

Unit-root tests 1953 to 2001
Critical values: 5%=-2.921 1%=-3.568; Constant included

	t-adf	beta Y1	\sigma	lag	t-DY lag	t-prob
LP	-2.3674	0.87828	0.14120	1	2.8352	0.0068
LP	-1.7932	0.90251	0.15141	0	0.0068	
LR	-2.1551	0.94991	0.036559	1	4.8156	0.0000
LR	-1.9112	0.94613	0.044357	0	0.0000	
LI	-2.7038	0.72793	0.48069	1	0.97398	0.3352
LI	-2.5244	0.76106	0.48043	0	0.3352	
r	-1.8633	0.87415	1.5743	1	-0.069274	0.9451
r	-1.9198	0.87339	1.5575	0	0.9451	
IP	-1.3379	0.92086	0.038963	1	2.0933	0.0419
IP	-0.63185	0.96369	0.040340	0	0.0419	
OP	-0.13961	0.99230	0.053063	1	1.0681	0.2911
OP	0.40401	1.0198	0.053142	0	0.2911	
S	-1.1747	0.91852	0.29370	1	0.9943	
S	-1.2379	0.91838	0.29056	0	0.9943	

Unit-root tests 1952 to 2001
Critical values: 5%=-2.92 1%=-3.565; Constant included

	t-adf	beta Y1	\sigma	lag	t-DY lag	t-prob
LP	-1.5555	0.91615	0.15275	0		
LR	-1.6484	0.95446	0.044663	0		
LI	-2.6612	0.75145	0.47832	0		
r	-2.1236	0.86566	1.5447	0		
IP	-0.62439	0.96418	0.040274	0		
OP	0.36974	1.0178	0.052690	0		
S	-1.2531	0.91834	0.28751	0		

Unit-root tests 1952 to 2001
Critical values: 5%=-1.947 1%=-2.609

	t-adf	beta Y1	\sigma	lag	t-DY lag	t-prob
LP	0.70353	1.0018	0.15511	0		
LR	1.1446	1.0016	0.045527	0		
LI	-1.2788	0.94838	0.49918	0		
r	-0.29659	0.99374	1.6001	0		
IP	-0.72519	0.99958	0.040019	0		
OP	-1.4418	0.99893	0.052233	0		
S	0.47560	1.0028	0.28954	0		