AN ANALYSIS OF INTERNATIONAL LAND PRICES

by

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BIOGRAPHY

Julian Mark Alston was born at Dromana in the state of Victoria, Australia, on the 30th of October, 1953. He received the degree of Bachelor of Agricultural Science from the University of Melbourne in 1975, and the degree of Master of Agricultural Science from La Trobe University in 1979. In August 1981, he entered the Graduate School at North Carolina State University to study economics. He is married to the former Deborah Anne Hilton, and they have a son, Cameron Robert.

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1. INTRODUCTION

1.1 MOTIVATION FOR THE STUDY

Between 1960 and 1980 the price of farmland in the United States more than doubled relative to the consumer price index. Most of the growth occurred in the mid-1970s. Land prices fell slightly in real terms in 1981 and fell in nominal terms, with large real decreases, in the two subsequent years.

Real growth of farmland prices has not been confined to the United States and it has not been uniform across the United States. For example, over the twenty years from 1961 to 1980, Canadian farmland prices grew by approximately the same percentage as farmland prices in the United States. However, particularly during the 1970s, land prices appear to have grown faster in the midwest states than in most other parts of the United States.

It would seem there are some influences that are common across land markets in different places and some that are not. Agricultural land markets in different countries and in different parts of the same country are linked through trade in agricultural products and arbitrage in factor markets. Thus, for instance, we might expect a boom in international grain trade to have similar effects in grain-producing regions of different countries. On the other hand we might expect the effects, if any, of domestic fiscal and monetary policies to be common within regions of a country but different between countries; a change in local property taxes might be expected to have local effects only.

The recent behavior of U.S. farmland prices has attracted the interest of many economists, and several explanations have been suggested. Of these, two hypotheses are of particular interest in this study. First, Feldstein (1979, 1980) has developed theoretical models of portfolio equilibrium in which anticipated inflation causes increases in the real price of land because of the characteristics of the U.S. tax system. Second, Melichar (1979) attributed general movements in the aggregate land price index to real growth in payments for the productive services of land. He conjectured that these were caused by technical change, government programs, and growth in foreign and domestic demand for farm products.

Both hypotheses have been tested subsequently using aggregate U.S. data. The general finding has been to reject inflation as a cause of real land price movements. This finding has been based on analysis of data reflecting a limited experience of both inflation and tax regimes. Changes in tax rates and inflation rates have been, in part, a common experience but have differed across countries. A more powerful test of Feldstein's hypothesis may be permitted by broadening the data base to include cross-sectional data by states of the United States and data from other countries.

Melichar's hypothesis is more conventional. Similar propositions have had a long history in the literature on land prices - for example, see Chambers (1924). It leads to some further questions. The 'Modern' or 'Heckscher-Ohlin' theory of international trade suggests that under certain conditions, even in the absence of arbitrage in factor markets, free trade in products will lead to equalization of factor (rental) prices. Under relatively weak assumptions, the theory suggests at least a tendency towards factor price equalization. This theory can be applied across regions of a country as well as between countries. Suppose Melichar is correct, and that growth in U.S. land prices has been caused by growth in payments for productive services of land. Then, if the growth in land rental incomes has been common across land markets - as implied by factor price equalization - we may expect similar patterns of land price movement in different states of the United States and in different countries. Different time paths of land prices in different places may arise either as a result of departure from factor price equalization or because of differences in other influential variables - such as inflation and tax laws.

1.2 OBJECTIVES AND PLAN OF THE STUDY

The objectives of this study are to: 1) integrate Feldstein's and Melichar's models of the determination of land prices and derive hypotheses as to the causes of land price growth, 2) measure the effects of inflation and growth of rental income to land on land prices, test the competing hypotheses, and evaluate the empirical importance of the different factors affecting land prices, 3) develop an empirical version of the factor price equalization theorem to be used to test for factor price equalization in the farmland market, both between states, within the United States, and between the United States and other countries.

These objectives are related but are pursued separately. The study is divided into two main parts. The first part is contained in Chapters 2 and 3. Chapter 2 contains the theoretical model of the determination of land prices within a country and the derivation of the hypotheses to be tested in Chapter 3. In Chapter 3, the model developed in Chapter 2 is applied to analyze the behavior of U.S. farmland prices during the interval 1963 to 1982. The empirical work uses data for eight midwestern states - in which, it is argued, nonfarm factors have been relatively unimportant - to test for effects of inflation, taxes, and growth of income to land. The second main part is contained in Chapter 4. Chapter 4 contains an outline of the factor price equalization theorem, the development of methodology to test for factor price equalization, and empirical work using data for the United States, Canada, New Zealand, and Australia. The final chapter, Chapter 5, is a brief review of the study and a summary of the conclusions of the analysis.

2. A WITHIN-COUNTRY MODEL OF THE DETERMINANTS OF LAND PRICES

2.1 INTRODUCTION

The literature on agricultural land prices is extensive. Several authors have reviewed the fraction that relates to modelling aggregate land prices. Hoover (1961) reviewed the literature for the period from 1920 to the late 1950s. Doll and Widdows' (1982) extensive critique of the literature (mainly from 1960 forward) covers several previous reviews. These reviews provide an overview of the literature that can be used to make some general points, to help cast the present work in perspective, and to develop a model.

There has not been a definitive study of land prices that can be taken as a basis for incremental improvement. Different models have been developed to address different issues. Despite this, many of the models have a great deal in common. It is widely accepted (perhaps a truism) that the value of land is determined by the future net benefits of owning it. The differences in the literature arise from different notions of the net benefits and different approaches to translating them into values. Some differences have been shown to be mistakes or inconsistencies (such as the use of net farm income as a measure of the net benefits of owning land - Melichar (1979); or mixing real and nominal variables - Hoover (1961)). Some differences relate to the choice of proxies to represent the theoretical constructs that have been agreed upon in principle.

It is a common, but not universal, practice to assume that the supply of land is perfectly inelastic. Nonfarm demand for land is often, but not always, treated trivially or ignored. Most analysts have assumed that funds for land purchase are rationed by exogenous interest rates, but Shalit and Schmitz (1982) assume absolute credit rationing.[1]

As inflation has become more important, more recent refinements have included more careful accounting for growth of the net benefits of owning land, the interaction between tax laws and inflation, and the relation between inflation and interest.[2]

Much of the work has assumed perfect knowledge and perfect foresight. In models allowing for uncertainty, 'naive', 'adaptive', various distributed lag, and 'rational' expectations models have been used. Risk has been incorporated in theoretical models (particularly at the micro level of analysis) but has not been incorporated explicitly in any empirical model of aggregate land prices.

Nearly all of the models have been essentially static. Dynamic optimization procedures were used by Phipps (1982) and Shalit and Schmitz (1982) to solve theoretical models of land accumulation by an individual. This approach offers insights into behavior at the individual level but seems to offer no advantage in specifying empirical models of aggregative behavior.

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[1] Under this assumption, unrealized capital gains become an important source of leverage for farm expansion, thus affecting land prices. This argument is pursued by Plaxico and Kletke (1979) and others.

[2] See Melichar (1979), Feldstein (1979,1980), Phipps (1982) and Castle and Hoch (1982), for examples.

Hoover (1961, p.8) wrote:

> A number of hypotheses have been advanced to explain the movement of ... land prices .... Urban use alternatives for land, inflation hedge, increased crop price certainty, technological advance, farm size changes and increasing asset preference for land have all been suggested. Few tests have been made.

Since then the list has been augmented with credit rationing, government programs, increased export demand, speculators, income taxes and capital gains taxes, property taxes, and the demand for farm enlargement. It remains true that few tests have been made.

Most of these hypotheses are intuitively plausible and can be deduced from some theory of land price determination. The relative empirical importance of the different hypothetical causes of land price changes has not been established. The model that follows is an attempt to synthesize some previous work in a manner that will permit formal derivation of the alternative hypotheses and will lead to a tractable empirical model. The first step is to derive an equation for the price of land under an assumption of perfect knowledge. This is used to examine the comparative static effects of inflation and taxes. Then the model is extended to the case of uncertainty, involving expectations variables and risk considerations.[3]

2.2 LAND PRICE DETERMINATION UNDER PERFECT KNOWLEDGE

A common approach to specifying the determinants of land prices is to assume that the price of land is equal, in equilibrium, to the present value of the future stream of net benefits of owning

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[3] The Knightian distinction between 'risk' and 'uncertainty' is not made here; the terms are used interchangeably.

land.[4] Assumptions of constant values for discount rates, tax rates, and growth rates of net benefits (or their components) are generally used. These assumptions lead to neat analytical solutions equivalent to those obtained by equating the rate of return to land to the discount rate. Using this approach, a final equation for the price of land follows from the definition of the stream of net benefits of owning land and how they are to be translated into a summary present value. One may interpret this equation as the maximum price that an individual would pay for land. Alternatively, under the assumption of competition, it is a condition for equilibrium in the land market. The present value of land is defined to be:

$$(2.1)\quad V_t = \int_0^\infty B_{t+n} e^{-\rho n}\, dn$$

where V_t = the present value (price) of land in time t,
B_{t+n} = the net benefit of owning land in time t+n,
and ρ = the discount rate, the opportunity cost of owning land.

Both ρ and B_t (and therefore V_t) are defined in nominal terms. The net benefits of owning land are the gross rental income minus any maintenance costs, depreciation, property taxes, income taxes, and capital gains taxes. This definition of net benefits ignores any non-pecuniary benefits of owning land. The use of a continuous rate of tax on nominal capital gains - whether they are realized or not

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[4] For examples, see Castle and Hoch (1982), Duncan (1979), Hoover (1961), Martin and Heady (1982), Melichar (1979), Pasour (1975), Tweeten (1981).

- permits one to ignore holding periods and to integrate over an infinite series. In the following formula for net benefits, property taxes, depreciation, and maintenance costs, are assumed to be tax deductible and are subsumed in net rental income.[5]

$$(2.2)\ B_t = (1-\tau_y)N_t - \tau_c\dot{V}_t$$

where N_t = net rental income to land in time t,

$\dot{V}_t$ = the change in the value of land in time t,

τ_y = the constant flat rate of income tax, $0<\tau_y<1$,

and τ_c = the constant rate of capital gains tax, $0<\tau_c<1$.

Now let us assume that rental income and land prices will grow exponentially at constant nominal rates, m and g. That is:

$$(2.3a)\ N_{t+n} = N_t e^{mn}$$

$$(2.3b)\ V_{t+n} = V_t e^{gn}$$

$$(2.3c)\ \dot{V}_{t+n} = gV_{t+n}$$

Combining (2.1), (2.2), (2.3a), (2.3b), and (2.3c) yields:

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[5] In reality, in the United States, only realized capital gains are taxed at 40 percent of the income tax rate. The formulation treats capital gains and losses symmetrically; the tax system does not. In Appendix D it is shown that for any rate of tax on realized capital gains there is an equivalent rate of tax that depends on the holding period, the rate of nominal capital gains, and the rate of interest. A continuous equivalent rate of 5 percent is suggested. Appendix E considers the effects of taxes on realizing accumulated capital gains and other wedges between buying and selling prices for farm real estate.

(2.4a) $V_t = \int_0^{\infty} (1-\tau_y)N_t e^{(m-\rho)n} - g\tau_c V_t e^{(g-\rho)n} \, dn$

Solving the integral and consolidating terms (noting that a finite solution exists only if $\rho > g$ and $\rho > m$) gives:

(2.4b) $V_t = (1-\tau_y)N_t(\rho-g)/(\rho-m)(\rho-(1-\tau_c)g)$

Taking logs of (2.4b) and differentiating with respect to time yields the result that $d\ln V_t/dt = d\ln N_t/dt$ (i.e. $g=m$). That is, subject to the assumptions, a constant growth rate of rental payments implies a constant growth rate of endogenous land prices - as was assumed to obtain a solution. In equilibrium, the two growth rates are equal. Using this result, and defining $\rho = (1-\tau_y)i$, where i is a nominal market interest rate with interest income taxable (interest payments deductible) at the income tax rate, (2.4b) becomes:

(2.4c) $V_t = N_t/D$; $D = i - g(1-\tau_c)/(1-\tau_y)$

In equation (2.4c) the price of land is equal to current rental income divided by a discount rate. It is in the form of the price of a perpetuity but the discount rate is adjusted for income growth (capital gains) and taxes. By making the same basic assumptions, equation (2.4c) may be obtained using portfolio theory (Feldstein (1979)) or optimal control theory (Phipps (1982) and Shalit and Schmitz (1982)).

2.3 COMPARATIVE STATIC EFFECTS OF INFLATION AND TAXES

In the case in which there is no real growth in rental income ($g=\pi$) and either all tax rates are zero or the inflation rate is zero, (2.4c) reduces to: $V=N/r$, where $r=i-\pi$ is a real interest rate. In the absence of inflation and real growth, income taxes have no effect on land prices; in the absence of taxes, inflation has a neutral effect on land prices.[6]

The basic neutrality of taxes and inflation may break down when their simultaneous effects are considered. That is the point of Feldstein's (1979, 1980) work. Under the assumption that inflation has a neutral effect on the growth rate of rental income ($dg/d\pi = 1$), differentiating (2.4c) with respect to the steady-state rate of inflation yields:

$$(2.5)\ dV/d\pi = [(1-\tau_c)/(1-\tau_y) - di/d\pi].V/D$$

and $dV/d\pi$ takes the sign of the term in square brackets [ ]. Differentiating (2.4c) with respect to the income tax rate, and assuming that the capital gains tax rate is a fixed fraction of the income tax rate ($d\tau_c/d\tau_y = \tau_c/\tau_y$) yields:

$$(2.6)\ dV/d\tau_y = [g(\tau_y-\tau_c)/\tau_y(1-\tau_y)^2 - di/d\tau_y].V/D$$

and $dV/d\tau_y$ takes the sign of the term in square brackets [ ]. The crucial magnitudes in (2.5) and (2.6) are $di/d\pi$ and $di/d\tau_y$, the multipliers

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[6] In this section, for ease of exposition, time subscripts are suppressed. When taxes are zero and $g=\pi$, we get $V=N/(i-\pi)=N/r$; and when $g=\pi=0$, we get $V=N/i=N/r$.

of nominal interest rates with respect to inflation and income taxes. Feldstein (1979, 1980) assumes $di/d\pi = 1$ in accord with the Fisher equation:

$$(2.7a)\ i = r + \pi$$

where r is a real rate of interest. This would also imply no effect of income taxes on interest rates: $di/d\tau_y = 0$. Combining these assumptions with (2.5) and (2.6) implies $dV/d\pi > 0$ and $dV/d\tau_y > 0$ when $\tau_y > \tau_c$. When the rate of tax on capital gains is smaller than the rate on other forms of income, an increase in either (a) the steady state rate of inflation or (b) the rate of income tax, will cause an increase in the real price of land.

Darby (1975) presents an alternative form of the Fisher hypothesis in which it is the after-tax real interest rate (r^*) that is unaffected by the inflation rate. That is,

$$(2.7b)\ r^* = (1-\tau_y)i - \pi;\ i = (r^* + \pi)/(1-\tau_y)$$

This implies $di/d\pi = 1/(1-\tau_y)$ and $di/d\tau_y = i/(1-\tau_y)$; in turn, in (2.5) and (2.6), these imply $dV/d\pi < 0$ if $\tau_c > 0$, and $dV/d\tau_y < 0$. Therefore, if (2.7b) is the appropriate form of the Fisher hypothesis rather than (2.7a), the effects of inflation and income taxes on land prices are reversed. Which equation is appropriate is strictly an empirical matter. The two hypotheses have been tested empirically, but the results are mixed and the issue remains unresolved.

Feldstein (1979, p.6) cites several references in support of the view that: 'in the United States it has long been true that the nominal interest rate [r] rises by approximately the rate of inflation, i.e., that $dr/d\pi=1$ provides a close approximation to historical experience.' Tanzi's (1980) more recent empirical work adds support to this view, but the results from Friedman's (1980) portfolio model suggest $di/d\pi=0.65$. Peek (1982) rejects the strict version of the Fisher hypothesis but fails to reject Darby's version. Ayanian (1983) finds evidence for the 'Darby Effect' and his estimates imply $di/d\pi=1.63$. Makin (1983) imposes the Darby hypothesis in a model designed to test for the effects of inflation on interest. He allows for the 'Mundell Effect', which would tend to offset the 'Darby Effect', but suggests the Darby Effect would dominate, leaving a multiplier of nominal interest rates with respect to expected inflation greater than 1.0. Using Livingston Survey data, he estimates a multiplier of 1.06, significantly less than that suggested by the Darby hypothesis alone, yet significantly greater than a value of 1.0 as suggested by the strict Fisher hypothesis. Clearly, there is as yet no concensus as to the effect of expected inflation on interest rates.[7] There is some evidence in support of the Darby hypothesis, but there may be offsetting influences such as the 'Mundell Effect'. The possible effect of inflation on risk premia is a further potential source of ambiguity. Overall, the weight of the evidence favors a multiplier of nominal interest rates with respect to expected inflation of greater than one ($di/d\pi>1.0$). The

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[7] Carmichael and Stebbing's (1983) 'inverted Fisher hypothesis' and their empirical results suggest an even broader range of possibility. They find $di/d\pi=0$.

empirical question is whether the multiplier is sufficiently greater than 1.0 so as to yield a negative effect of inflation on land prices.

The effects of the other components of equation (2.4c) are not ambiguous. Partial differentiation of (2.4c) yields the following intuitively plausible results:

(2.8a) $\partial V/\partial N = 1/D > 0$

(2.8b) $\partial V/\partial g = V(1-\tau_c)/(1-\tau_y)D > 0$

(2.8c) $\partial V/\partial \tau_c = -gV/(1-\tau_y)D < 0$

(2.8d) $\partial V/\partial i = -V/D < 0$

That is, an increase in either the current rental (N) or its growth rate (g) will cause the land price to increase. An increase in either the rate of capital gains tax (τ_c) or the nominal interest rate (i) will cause a decrease in land prices.

2.4 A SIMPLE TREATMENT OF UNCERTAINTY

Uncertainty is incorporated by assuming that the price of land is equal to the present value of expected net benefits of owning land, with the net benefits as net returns minus a 'cost of risk'. Up to this point, the model has been expressed in continuous time to facilitate the comparative statics. From this point on, in anticipation of empirical work using annual data, the models are expressed in discrete time. Consider a discrete time analogue to equation (2.1) incorporating uncertainty:

$$(2.1') \quad P_t = \sum_{n=0}^{\infty} E_t[B_{t+n}](1+\rho)^{-(n+1)}$$

$$\text{or,} \quad P_t = (E_t[B_t] + E_t[P_{t+1}])/(1+\rho)$$

where P_{t+1} is next year's land price. The expected net benefits, which are received at the end of each year, are defined as:

$$(2.2') \quad E_t[B_t] = E_t[(1-\tau_y)N_t - \tau_c\Delta P_t - C_t]$$

where all of the variables are annual analogues of the previous definitions, $\Delta P_t = P_{t+1}-P_t$, C_t is the cost of risk, and $E_t[.]$ denotes expectations at time t of [.].

Substituting (2.2') into (2.1') and with the discount rate defined as $\rho = (1-\tau_y)i_t$, the solution for the price of land is:

$$(2.9) \quad P_t = E_t[(1-\tau_y)N_t + (1-\tau_c)\Delta P_t - C_t]/(1-\tau_y)i_t$$

An equivalent expression can be derived by assuming that the expected nominal net-of-tax rate of return to land is equal to the nominal net-of-tax rate of return to a risk-free asset plus a premium for illiquidity and risk. That is, (2.10) $(1-\tau_y)i_t = E_t[(1-\tau_y)N_t/P_t + (1-\tau_y)g_t - c_t]$

where g_t is the annual nominal growth rate of land prices and c_t is the risk premium. Equation (2.9) can be obtained by solving (2.10) for the price of land. Alternatively, equation (2.10) can be transformed into the form of (2.4c). The result of doing this is:[8]

(2.11) $P_t = E_t[N_t]/E_t[D_t]$

where $D_t = i_t + c_t/(1-\tau_y) - g_t(1-\tau_c)/(1-\tau y)$

2.5 SYNTHESIS OF DIFFERENT MODELS

Most theoretical models of the determination of land prices result in an equation that can be represented as follows:

(2.12) $P_t = E_t[R_t]/E_t[D_t]$

where R_t is some measure of current income to land and D_t is a discount factor. The models may not be presented in the form of (2.12) but usually can be represented as such. Differences in the details of models may arise in two ways. First, substantive differences may arise because of assumptions about tax laws, finance, risk, growth

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[8] It is shown in Appendix A that equation (2.11) is a result of portfolio equilibrium between risky land, corporate stock, and riskless treasury bills. The model is based on that used by Feldstein (1980). The resulting equation is equivalent to (2.11), with an explicit interpretation of the risk premium. To get these formal results requires restrictive assumptions. Feldstein uses a simple mean-variance framework and assumes fixed stocks of both land and corporate stocks. In a sense, equation (2.11) is more general; the explicit interpretation of the risk premium implied by the formal model is only one of many alternatives.

of income to land, capital gains, and so on. Second, apparent differences may arise because equivalent models may be represented differently. For instance, compare (2.10) and (2.11). In (2.10) the discount factor is $D_t=(1-\tau y)i_t$ and the numerator is adjusted for capital gains, taxes, and risk costs. In (2.11), the numerator is current net rent and all of the adjustments for risk, taxes, and capital gains are in the denominator.

For convenience, let us define the relevant measure of current income as net rental income (N) as used in (2.11). Then, dropping time subscripts for clarity of exposition, the following definitions of 'D' correspond to the assumptions underlying some different models:

1. Melichar (1979): $D = i - m \quad (=i-g)$
2. Feldstein (1979): $D = i - \pi(1-\tau_c)/(1-\tau_y)$
3. Equation (2.4c): $D = i - g(1-\tau_c)/(1-\tau_y)$
4. Equation (2.11): $D = i + c/(1-\tau_y) - g(1-\tau_c)/(1-\tau_y)$

where i is a nominal risk-free interest rate, m is the nominal growth rate of net rental income (N), π is the inflation rate, g is the nominal growth rate of land prices, τ_c and τ_y are the tax rates, and c is a risk premium.

With the models represented in this way, the distinctions become clear. The first two differ in that the first allows for real growth in net income to land whereas the second allows for tax effects assuming no real income growth. The third allows for both real income growth and tax effects; it is a combination of the first two. The fourth includes an additional term, a risk premium for land, and it contains the first three as special cases.

2.6 A MODEL OF THE DETERMINANTS OF RENTAL PAYMENTS

To model the determination of land rental income, the units of land are defined such that land is homogeneous with respect to all quality aspects relevant to agricultural production. Under this assumption the gross rental payment for services of land is determined by the intersection of the demand for the agricultural use of land with the supply of land to agriculture. The demand for the agricultural use of land is derived from the demand for agricultural products, the supplies of other factors of production, and the technology of production. Thus, an inverse demand for the agricultural use of land can be defined in which the gross rental price (G) - the value of land's marginal product - depends on the quantity of farmland (Lf), technology (Tn) and factor and product prices (W,Pf). Schematically:

$$(2.13)\ G_t = f[Pf_t, W_t, Tn_t, Lf_t]$$

Similarly, an equation for the supply of land to agriculture is defined in which the gross rental price in nonfarm use (G) is a function of exogenous variables (X) - such as population, nonfarm output, prices of forestry products - and the quantity of land in agriculture. This supply equation is really an excess supply/demand function, given by the difference between the total nonfarm land demand and total land supply.

$$(2.14)\ G_t = g[X_t, Lf_t]$$

In equilibrium, rental income is equated at the margin between the different uses of land. Solving (2.14) and (2.13) by eliminating the quantity of farmland (Lf) yields a reduced-form equation in which gross rental income to land depends on all of the exogenous variables. That is,

$$(2.15)\ G_t = h[Pf_t, W_t, Tn_t, X_t]$$

2.6.1 Property Taxes and Net Rents

If all land were taxed at the same rate, independent of use, net rental income to land (N) would be given by subtracting per unit property taxes (τ_p) and depreciation (d) from gross rental income (G):[9]

$$(2.16)\ N_t = G_t - \tau_{p,t} - d_t$$

More generally, equilibrium in the land use market should be defined in terms of net rental income. This would accommodate the effects of differences in property tax rates and depreciation rates according

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[9] Pasour (1975) found that property taxes are - as this model assumes - capitalized into land prices. However, his model was not constructed to permit testing whether the taxes were fully capitalized as would be expected to occur only if land were taxed identically in all uses. With differences in tax rates between uses, we would expect some shifting of the tax. Any elasticity of the total land supply would imply some shifting, too. An additional consideration is that property taxes earmarked to provide specific benefits to land owners (e.g., roads) should not be capitalized fully into land prices. The taxes could be treated equivalently as ad valorem taxes (as by Pasour). It is not obviously more realistic, and would be more complicating, to do that.

to use of land. In some instances agricultural use qualifies for concessional property taxes. This would require modifying (2.16) to include the rate of property tax in nonfarm use.

2.6.2 Rental Payments Under Uncertainty

Under uncertainty one must be careful to avoid confusing the role of land with that of the residual claimant. One way to deal with this is to interpret G_t as an ex ante gross rent contracted at time t (perhaps implicitly) on the basis of expected prices and yields. The ex ante demand for the use of land will be adjusted for costs of risks of farming. However, any ex post divergences of the value of the marginal product of land from the ex ante rental price will be borne by the residual claimant for agricultural production, the land user in this case.

2.6.3 Effects of Inflation on Net Rents

An additional hypothesis is that inflation affects land prices through real effects on net rents as well as through Feldstein's mechanism. Inflation may affect net rents in a variety of ways. For instance, unanticipated inflation may result in a real decline in the rate of property tax, given that properties are valued for tax at discrete intervals. In this case inflation would affect net rents but not gross rents. There are several ways in which inflation may affect gross rents and thus net rents. For instance, Tweeten (1980) argues that inflation has real effects on relative factor and product prices. Ruttan (1979) and Johnson (1980) disagree about whether inflation dampens productivity growth in agriculture.

There are several hypotheses here which could be tested directly and that might confound tests of Feldstein's hypothesis. The work that follows uses explicit measures of net rent. These are taken as exogenous data. The possible confounding due to effects of inflation on net rent thus is avoided and the question of whether inflation affects net rent is not pursued in this study.

2.7 CAUSES OF REAL CHANGES IN LAND PRICES

The model in (2.11) is expressed in real terms by dividing through by a general price index and denoting deflated variables by *. This procedure does not affect the denominator (D) which is already effectively defined in real terms. The equation for the real price of land is:

$$(2.11') \quad P^*_t = E_t[N^*_t]/Et[D_t]$$

$$D_t = i_t + c_t/(1-\tau_y) - g_t(1-\tau_c)/(1-\tau_y)$$

In models of this type, real changes in land prices may arise either from changes in real income to land (N*) or changes in the discount factor. Taking logs of (2.11') and differentiating gives:

$$(2.17) \quad d\ln[P^*_t] = d\ln E_t[N^*_t] - d\ln E_t[D_t]$$

Basically, Melichar (1979) attributed the real growth in U.S. land prices to real growth in net rent, holding D constant. Feldstein (1979, 1980), on the other hand, assumed no real growth in net rent and attributed the real growth in land prices to decreases in D caused by increases in the inflation rate. Equation (2.11') allows both possible causes at once.

Combining the model of net rents with the land price model, many of the hypotheses presented earlier can be derived formally. Land prices depend on net rents, their growth rate (the rate of capital gains), and tax rates. Most of the variables that have been postulated to cause land price changes do so indirectly. They have their direct effects only on net rents. Such would include nonfarm demand for land, government programs for farm commodities, increased export demand, changes in technology and farm size, and changes in riskiness of farming.

The other variables that have been postulated to affect land prices do so through the denominator (D) of (2.11'). These include interest on risk-free investments, a risk premium for land, the expected rate of capital gains on land, and the rates of tax on current income and capital gains. All of these variables may be functions of the inflation rate, but the tax rates are assumed to be constant. Even in the case of certainty and under the assumption that inflation has a neutral effect on the growth rate of land prices, the effect of inflation on land prices was shown to be ambiguous, depending on its effect on interest rates. Differentiating D from (2.11') with respect to inflation yields:

$$dD/d\pi = di/d\pi + [dc/d\pi - (1-\tau_c)dg/d\pi]/(1-\tau_y)$$

and the expression cannot be signed in general. That is, the effect of inflation on land prices is ambiguous. Taking net rent as exogenous to the problem, it depends on the effect on the discount factor (D), which in turn depends on the effect on nominal interest rates, the risk premium, and the nominal growth rate of land prices. These are empirical questions.

The next chapter is concerned with developing an empirical version of the model and applying it to determine the causes of real growth in U.S. farmland prices during the past twenty years. The transition from the theoretical work in this chapter to empirical work is quite direct. The main problems are problems of finding measures of real-world variables that correspond to the theoretical variables, particularly expectations variables.

3. EMPIRICAL ANALYSIS OF U.S. FARMLAND PRICES

3.1 INTRODUCTION

The model of agricultural land price determination developed in the previous chapter is summarized in equation (2.11') as:

$$P^*_t = E_t[N^*_t]/E_t[D_t]$$

$$D_t = i_t + c_t/(1-\tau_y) - g_t(1-\tau_c)/(1-\tau_y)$$

That is, the current real price of land is equal to current expectations of real net rental income to land divided by a discount factor. The discount factor (D) is equal to a risk-free nominal interest rate (i) plus a risk premium (c) minus the nominal rate of capital gains during the coming year (g) adjusted for taxes. The capital gains term captures the effects of the entire future of net benefits of owning land. In real terms, ex ante net rents are determined according to:

$$(3.1)\quad N^*_t = G^*_t - \tau^*_{p,t} - d^*_t$$

Net rent is equal to gross rent minus property taxes and depreciation. Ex ante gross rent for land is a function of expected prices of factors and products, the state of technology, and nonfarm factors.

The purpose of this chapter is to define measures of the variables in these equations and to analyze U.S. land price behavior. Previous empirical work on U.S. farmland prices has been of two types. Melichar (1979) and Castle and Hoch (1982) compared actual land prices with those that would be justified (through a model) by the ex post values of causal variables. Both studies thus implicitly involved an assumption of perfect foresight. Neither study involved any statistical analysis. Each explained general movements over long time periods but performed poorly at explaining year-to-year movements in land prices at the national aggregate level. In pointing this out, in a comprehensive comment on and extension of Melichar, Doll and Widdows (1982, p.732) say '...the key to all of this would appear to be the manner in which investors form expectations.' The other major type of empirical work has been regression analysis of aggregate time series data. Some studies have assumed perfect foresight (e.g., Shalit and Schmitz (1982)). Most have used some type of distributed lag model - beginning with Hoover (1961) - sometimes augmented with rational expectations theory (e.g. Martin and Heady (1982), Phipps (1982)).

Most of the data to be used in the analysis in this chapter are unpublished series obtained from the 'Land Branch' of the USDA in Washington D.C. They are annual time series by states of the United States for the period 1950 to 1982. The variables include the total value of farm real estate, total acres of farmland, total value of farm buildings, cash rent per acre of rented farm real estate, and the rate of property tax on farm real estate. The data are based on the prevailing USDA definition of farmland, which has changed from time to time. The series of value of farm real estate and cash rent are constructed using data from annual sample surveys of land owners. They refer to what the respondents think are the market prices for buying or renting land in their surrounding areas. In particular, it should be emphasized the prices are not transactions prices. This is potentially an important source of error. On the other hand, this measure will avoid the effects of sampling biases that could arise in actual transactions data. These data are combined with information obtained from the Census of Agriculture which takes place approximately every five years. The series on cash rent are incomplete for some, mainly Western, states.

The monetary variables are all undeflated. The GNP deflator for the United States as a whole is used as a general price index to convert the nominal values to 'real' terms. Data from the 'Livingston survey' are used to measure expected inflation. These data, which were provided by J.A. Seagraves,[13] measure what survey respondents say they expect the inflation rate to be over the ensuing twelve months.

3.2 RENTAL INCOME

Many studies have used variables such as gross farm income per acre, net farm income per acre, or product prices, to explain land prices. Such studies have implicitly or explicitly substituted a reduced-form model for rental prices into a land price model. Two alternative explicit measures of rental income have been proposed and used. The more common is the residual income to land, calculated by subtracting imputed costs of other factors from farm income (e.g., Melichar (1979), Phipps (1982)). The other is 'cash rent' for rented farm real estate (used by Castle and Hoch (1982)). There are problems with both explicit measures. Residual income measures incorrectly

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[13] J.A. Seagraves is an Associate Professor in the Department of Economics and Business at North Carolina State University.

treat land as the residual claimant. They suffer from serious problems of imputing opportunity costs to other factors, especially labor, management, and capital. All the errors are reflected in the imputed returns to land.[14]

Cash rents are market prices. However, only a fraction of farmland is rented for cash.[15] There may be systematic differences between rented and owner-operated farm real estate and, perhaps worse, these differences may be changing over time. Thus cash rents may not accurately represent rental incomes for all farm real estate and the bias may be changing over time. Finally, cash rents refer to rents for farm real estate, including fixed improvements. The problem is that fixed improvements may depreciate and may be a changing fraction of the value of farm real estate.

Time series of rental rates are not available for all farmland, for all states, or for the United States in aggregate. On the other hand, there are no published series of residual income to land by states of the U.S. Because there are problems with each of the measures, the choice between them is somewhat arbitrary. Cash rent is chosen for this study for several reasons. First, it seems that the problem of sampling bias with cash rent is less important overall than the

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[14] For instance, Phipps (1982) calculated residual returns to land that are negative for most of the twenty years from 1940 to 1960 and increasingly positive from 1960 to 1979. This may well be due to systematic measurement errors. Long periods of sustained negative incomes to land seem implausible, ex ante or ex post.

[15] Detailed data are not available but C. Barnard of the Land Branch of the USDA suggested in a personal communication that about 20 percent of U.S. farmland is rented for cash. Additional amounts are rented on a share basis.

measurement problems of imputed income. Second, cash rent (contracted in advance) corresponds closely to the concept of ex ante gross rent used earlier in developing the model. Residual income, on the other hand, is an ex post measure. Third, and perhaps most important, cash rent series are available by states. Time series data by states on the value of buildings and property taxes per acre are available also. These data are used to construct a measure of net rental income as equal to gross cash rent minus property taxes and depreciation on buildings per acre. Assuming a known constant rate of depreciation (d) on the real value of buildings (B*), the annual cost of depreciation is dB*, which is deducted in equation (3.1) to get real ex ante net rent to farm real estate:

$$(3.2)\ E_t[N^*_t] = G^*_t - \tau^*_{p,t} - dB^*_t$$

One potentially serious problem with using cash rent is that the data measure only income from agricultural use of land. The land price that they would imply is the price that would prevail if the land were expected to continue in agricultural production and to receive no other income, such as site rents, as well as income from agricultural production. This problem is likely to be more serious in some areas than in others. In densely populated areas in the northeastern United States, for instance, one might expect nonfarm factors to have important influences on both rental income and prices of farmland. In order to explain land price behavior, it may be important to account for nonfarm factors explicitly. To test the model and to account for the effects of inflation, the aim is to control for these factors by restricting the analysis to states where nonfarm factors have been unimportant.

Farmland as a percentage of total land and the rate of conversion of farmland to nonfarm uses, are used as guides to the potential for significant nonfarm influences on farmland markets. Between 1960 and 1982, 11.8 percent of U.S. farmland was converted to nonfarm uses. The conversion rate varied substantially across the country. Table 3.1 shows the percentage of farmland area in the United States in 1960 that had been converted to nonfarm uses by 1982. In 1970, 48.5 percent of the total land area in the United States was recorded as farmland. This percentage varied enormously across the country from a low of 10 percent in Maine to a high of 98 percent in Nebraska. Much of this variation may be attributed to variations between states in the importance of forests, mountainous areas, and deserts. Some may be due to variations in population density and associated urbanization pressures. Table 3.1 also shows land in farms as a percentage of total land by states for 1970.

Clearly nonfarm factors have been important in land markets in some parts of the United States. In most of the New England states, for instance, more than 50 percent of land in farms in 1960 had been converted to nonfarm uses by 1982. Generally, along the eastern seaboard of the United States more than 30 percent of land in farms was converted to nonfarm uses during that 23-year period. Farther west, the conversion rates are lower, negligible in the northcentral states and rising again on the West Coast. Unfortunately, for most of the states where

TABLE 3.1

Farmland Conversion Rate (1960-1982) and Share of Total Land in 1970 by States of the United States

State	L_f	L_t	$\%L_f$	$\%\Delta L_f$	State	L_f	L_t	$\%L_f$	$\%\Delta L_f$
ME	1.9	19.8	9.6	52.9	NH	0.7	5.8	12.1	58.3
VT	2.0	5.9	33.7	46.9	MA	0.8	5.0	16.0	50.0
RI-	0.1	0.7	14.9	50.0	CT	0.6	3.1	19.3	68.8
NY-	11.2	30.6	36.6	33.6	NJ	1.1	4.8	22.9	33.3
PA	10.2	28.8	35.4	28.5	DE	0.7	1.3	55.2	12.5
MD	3.1	6.3	49.0	26.3	MI	12.7	36.4	34.9	25.3
WI	20.1	34.9	57.7	16.7	MN*	30.9	50.7	60.9	6.2
OH*	17.6	26.2	67.1	15.6	IN*	17.5	23.1	75.8	12.4
IL*	29.5	35.7	82.7	6.5	IA*	34.4	35.8	96.1	2.6
MO*	33.2	44.2	75.2	9.5	ND*	41.9	44.3	94.5	1.0
SD*	45.5	48.6	93.6	2.4	NB-	48.1	48.9	98.3	1.2
KS-	49.9	52.3	95.3	3.4	VA-	11.4	25.5	44.8	27.4
WV	5.1	15.4	33.1	35.8	NC	15.2	31.2	48.7	37.6
KY	16.3	25.4	64.2	19.4	TN	15.4	26.4	58.2	20.2
SC	8.3	19.4	42.9	28.5	GA	17.4	37.2	46.8	25.3
FL-	14.8	34.6	42.8	30.9	AL	14.8	32.5	45.6	39.0
MS	17.3	30.3	57.2	32.6	AR	17.6	33.2	52.9	14.1
LA-	11.8	28.8	41.0	12.1	OK-	37.1	44.0	84.3	8.5
TX-	142.8	167.8	85.1	7.7	MT-	64.2	93.2	68.9	6.9
ID-	15.5	52.9	29.3	1.3	WY-	35.5	62.2	57.1	2.2
CO-	39.7	66.4	59.8	9.4	NM-	47.8	77.7	61.5	8.0
AZ-	41.3	72.6	56.9	12.6	UT-	13.2	52.5	25.1	9.6
NV-	9.0	70.3	12.8	3.2	WA-	16.6	42.6	39.0	9.4
OR-	20.1	61.6	32.7	13.8	CA-	36.6	100.1	36.6	13.1

Notes: L_f denotes land in farms in 1970 in millions of acres. The data were supplied by the USDA, Land Branch.

L_t denotes total land area in 1970 in millions of acres. The data were drawn from Statistical Abstracts of the United States, 1971, Department of Commerce.

$\%L_f$ - percent land in farms - is calculated as $100*L_f/L_t$.

$\%\Delta L_f$ is the percentage decrease in land in farms 1960-1982.

'-'denotes states for which rental series are incomplete.

'*' denotes states for which data are used in analysis.

conversion rates have been smallest - states in which nonfarm influences are likely to have been smallest - the series of rental income are incomplete.

The empirical problem is to control for nonfarm factors while keeping enough data to measure the effects of other factors. Therefore, the analysis in this chapter is restricted to data for eight states in the Midwest: Iowa (IA), Illinois (IL), Indiana (IN), Missouri (MO), Ohio (OH), Minnesota (MN), North Dakota (ND), and South Dakota (SD). For these, the series of rental income are complete from 1950 to 1982 and conversion rates have been relatively small, ranging from a minimum of 1 percent in North Dakota to 16 percent in Ohio; and, these states have relatively high proportions of land designated as farmland, ranging from 61 percent in Minnesota to 94 percent in North Dakota. Some neighboring states (e.g. Kentucky and Arkansas) are excluded because they either have high conversion rates or low proportions of farmland, or both.

3.3 GROWTH OF THE 'DISCOUNT FACTOR'

Equation (2.17) indicates how the real growth of land prices can be decomposed into growth of real ex ante net rents minus growth of the discount factor.

$$(2.17)\ d\ln[P^*_t] = d\ln E_t[N^*_t] - d\ln E_t[D_t]$$

Equation (2.11'), for instance, contains an explicit representation of the discount factor in which growth of the discount factor may arise from the net effects of changes in nominal interest rates, the risk premium, and expected capital gains.

$$(2.11') \quad P^*_t = E_t[N^*_t]/E_t[D_t]$$

$$D_t = i_t + c_t/(1-\tau_y) - g_t(1-\tau_c)/(1-\tau_y)$$

More generally, one may think of the discount factor as a residual, incorporating the effects of all variables other than expected net rent. The measure of ex ante net rent in (3.2) is completed by assuming a value of 5 percent for annual depreciation on buildings attached to farmland. The equation is expressed in real terms and the data are converted to real terms by dividing throughout by the GNP deflator. Then the effects of growth of the discount factor on land prices can be measured as the difference between the growth of land prices and the growth of net rents. Equation (3.3) is a discrete time approximation to (2.18) that expresses this relationship.

$$(3.3) \quad -\%\Delta E_t[D_t] = \%\Delta P^*_t - \%\Delta E_t[N^*_t]$$

where $\%\Delta$ denotes annual percentage change, and the equation measures the percentage real change in land prices due to changes in the discount factor (that is, net of changes in real net rent).

Data are pooled across years and states to test for statistically significant contributions of growth of net rent and growth of the discount factor to growth of land prices. A two-way analysis of variance of the three variables in equation (3.3), by states and years for the twenty-year period 1963 to 1982, is applied as a check on the appropriateness of pooling. The results, shown in Table 3.2, are that there are no significant contributions to sums of squares by states; there are no significant differences between the states, so pooling seems justified.

Table 3.3 includes the average values - across the eight states being analyzed - of the annual growth rates of land prices, net rents, and the discount factor (residual growth) for different periods during the twenty years 1963 to 1982. Across the twenty-year period, land prices grew at an average annual real rate of 4.41 percent and net rents grew at 4.19 percent. The growth in land prices not 'explained' by growth of net rents averaged 0.22 percent per year, but the average is not significantly different from zero. For sub-periods of ten years or five years, there are no significant contributions of changes in the discount factor to the growth of land prices. The periods of greatest growth of land prices were during the mid-1960s and the mid-1970s. These were periods of dramatic growth of net rents. During the periods 1968-1972 and 1978-1982 the growth rates of land prices and net rents were not significantly different from zero. The time intervals for comparison were selected arbitrarily by dividing the twenty year period into two and then four sub-periods of equal sizes. The results may be sensitive to the time intervals chosen. But the broad picture is that Melichar's view (1979 p.1090) is supported generally for the twenty-year period: '... capital gains ... are, in a sense, fully explained by the growth exhibited by the current return to assets.'

TABLE 3.2

Analysis of Variance of Growth Rates of Land Prices (GP), Net Rents (GN), and the Discount Factors for Eight U.S. States (1961-1980)

Dependent Variable	Source	D.F.	Sum of Squares	Mean Square	F-Value
GP	Model	26	8170.975	314.27	19.26
	Error	133	2170.719	16.32	
	Corrected Total	159	10341.694		
	State	7	75.982		0.67
	Year	19	8094.993		26.10
GN	Model	26	6314.702	242.87	4.20
	Error	133	7693.880	57.85	
	Corrected Total	159	14008.582		
	State	7	226.319		0.56
	Year	19	6088.383		5.54
GD	Model	26	4802.970	184.73	2.94
	Error	133	8344.427	62.74	
	Corrected Total	159	13147.397		
	State	7	261.612		0.60
	Year	19	4541.359		3.81

TABLE 3.3

Annual Percentage Changes in Land Prices and Their Components Across Eight Midwestern States of the United States

Period	Real Growth			Nominal Growth		Obs.
	%ΔP*	%ΔN*	-%ΔP*	%ΔP	%ΔN	
1963-1982	4.41	4.19	0.22	10.25	9.99	160
	(0.64)[a]	(0.74)	(0.72)	(0.74)	(0.82)	
1963-1972	1.84	3.30	-1.46	5.42	6.94	80
	(0.41)	(1.00)	(0.94)	(0.36)	(1.01)	
1973-1982	6.98	5.09	1.89	15.07	13.05	80
	(1.14)	(1.10)	(1.06)	(1.22)	(1.20)	
1963-1967	4.23	4.80	-0.58	6.62	7.21	40
	(0.43)	(1.31)	(1.30)	(0.50)	(1.34)	
1968-1972	-0.55	1.79	-2.34	4.23	6.67	40
	(0.45)	(1.48)	(1.37)	(0.44)	(1.52)	
1973-1977	13.48	10.67	2.80	21.40	18.46	40
	(1.24)	(1.69)	(1.64)	(1.34)	(1.94)	
1978-1982	0.49	-0.49	0.98	8.74	7.83	40
	(1.25)	(0.65)	(1.34)	(1.47)	(0.75)	

[a] Figures in parentheses are standard errors of estimates.

Note:
For the relation: $(1+g)=(1+m)/(1+d)$, an exact estimate of d is $d=(m-g)/(1+g)$ where d=%ΔD, g=%ΔP, and m=%ΔN. The estimates in the table use the approximation: $-d=g-m$. For the interval 1973 to 1977 the estimate ($d=2.8$) is biased up because g is positive. Correcting for the discrete time approximation yields $d=2.5$. In all the other cases the approximation error is negligible.

Table 3.4 reports average growth rates across the twenty years from 1963 to 1982 by states. Because most of the variation in the growth rates is due to differences between years rather than to differences between states, the standard errors of the figures in Table 3.4 are relatively large. The average growth rates of land prices vary between states from a low of 3.12 percent per year in South Dakota to a high of 5.18 percent per year in North Dakota. Over a twenty year period these differences imply substantial differences in total growth. However, none of these growth rates are significantly different from the overall average of 4.41 percent. Similarly, the average contribution of changes in the discount factor to land price growth rates differs somewhat between the states but is nowhere significantly different from zero.

The results in Tables 3.2, 3.3, and 3.4 suggest that most of the growth in land prices during the past twenty years can be explained by growth in net rental income to land, and that the growth has been common among the states considered. Most of the variation among the sample is due to differences over time, which make detecting differences between states difficult. There was no statistically significant growth of land prices due to growth of the discount factor over the twenty years. However, this need not imply that changes in the components of the discount factor - interest rates, tax rates, rates of capital gains, and so forth - have been unimportant. It may be that changes in the components of the discount factor have been largely offsetting in their effects on land prices. To pursue this possibility, the

TABLE 3.4

Average Annual Growth Rates of Land Prices, Net Rents and the Discount Factor by U.S States (1963-1982)

State	Real Growth			Nominal Growth		Obs.
	$\%\Delta P^*$	$\%\Delta N^*$	$-\%\Delta D$	$\%\Delta P$	$\%\Delta N$	
OH	3.66	6.43	-2.77	9.43	12.33	20
	(1.95)[a]	(2.75)	(3.22)	(2.19)	(2.90)	
IA	4.97	4.66	0.31	10.84	10.47	20
	(2.13)	(1.72)	(1.87)	(2.42)	(1.95)	
IL	4.16	4.19	-0.03	9.96	9.99	20
	(2.12)	(1.73)	(1.33)	(2.34)	(1.95)	
IN	4.45	4.21	0.24	10.28	10.03	20
	(2.07)	(2.05)	(1.79)	(2.32)	(2.36)	
MN	5.16	3.14	2.01	11.10	8.97	20
	(1.63)	(2.47)	(2.05)	(2.09)	(2.85)	
MO	4.58	4.05	0.53	10.39	9.80	20
	(1.57)	(1.65)	(1.70)	(1.79)	(1.68)	
ND	5.18	4.81	0.37	11.09	10.63	20
	(1.70)	(2.49)	(2.12)	(2.11)	(2.70)	
SD	3.12	2.05	1.07	8.87	7.72	20
	(1.38)	(1.89)	(1.87)	(1.07)	(2.07)	

[a] Figures in parentheses are standard errors of estimates.

Note: As in Table 3.3, the estimate of $\%\Delta D$ is biased upward by taking a discrete time approximation. However, the bias is negligible, on the order of 4 percent of the value reported.

next step is to fit an empirical model of the form of (2.11′), including explicit representations of the components of the discount factor, to the data.

3.4 AN EMPIRICAL MODEL OF LAND PRICE DETERMINATION

The idea is to estimate a model of land price determination based on the work in Chapter 2. The procedure is as follows. First, equation (2.11′) is transformed into a convenient form for empirical work. Second, measures of the variables in the resulting equation are defined. Third, least squares estimates of the parameters in the equation are obtained. Theoretically, the effect of inflation on the discount factor in (2.11′) - and thus on land prices - is ambiguous; it depends on the effect of inflation on interest rates. One cannot test for the effect of inflation without imposing some restriction on the equation. Two alternative restrictions are the 'Darby Hypothesis' and the 'strict Fisher Hypothesis' described above. These hypotheses may be represented as different definitions of a real interest rate that is unaffected by the rate of expected inflation or different equations for nominal interest rates:

1. Fisher: $r_t = i_t - E_t[\pi_t]$

   or $i_t = r_t + E_t[\pi_t]$

2. Darby: $r^*_t = (1-\tau_y)i_t - E_t[\pi_t]$

   or $i_t = \{r^*_t + E_t[\pi_t]\}/(1-\tau_y)$

Also, one can impose hypotheses as to the effects of inflation on the risk premium and the rate of expected capital gains. It has been suggested that land is a 'good hedge' against inflation. That statement may be interpreted in terms of Feldstein's hypothesis that inflation causes real capital gains to land. Alternatively, it might imply that inflation reduces the risk premium on land. In the absence of an explicit measure of the risk premium, the following relation is assumed:

$$(3.4)\ c_t = c_0 + c_1 E_t[\pi_t]$$

where c_0 and and c_1 are constant parameters in a linear relation between the risk premium and expected inflation, with $c_0>0$ if land is a risky asset and, $c_1<0$ if land is a 'good hedge'. The rate of expected nominal capital gains is equal to the sum of the expected rate of real capital gains (γ) and the expected rate of inflation:

$$(3.5)\ E_t[g_t] = E_t[\gamma_t] + E_t[\pi_t]$$

Substituting (3.4), (3.5), and the alternative equations for nominal interest rates into (2.11') yields the following land price equation:

$$(3.6)\ P^*_t = E_t[N^*_t]/E_t[D_t]$$

Fisher Hypothesis:

$$D_t = [c_0 + (1-\tau_y)r_t - (1-\tau_c)\gamma_t - (\tau_y-\tau_c-c_1)\pi_t]/(1-\tau_y)$$

Darby Hypothesis:

$$D_t = [c_0 + r^*_t - (1-\tau_c)\gamma_t + (\tau_c+c_1)\pi_t]/(1-\tau_y)$$

All of the variables are as previously defined and there are two equivalent representations of the denominator based on the two alternative notions of the relevant real interest rate that is unaffected by inflation. These imply two alternative composite parameters on the expected inflation rate. In either case, the effect of inflation is ambiguous. If inflation does not affect the risk premium, however, the Fisher Hypothesis implies a negative effect of inflation on the discount factor (a positive effect on land prices) and the Darby Hypothesis implies the converse.

For econometric work, equation (3.6) is transformed so that the expected rate of capital gains term in the denominator appears instead as the expected amount of capital gains in the numerator. To make this transformation, the following definition is used:

$$Et[\Delta P^*_t] = E_t[\gamma_t]P^*_t$$

First, both sides of (3.6) are multiplied by the discount factor, $E_t[D_t]$. Then the term containing expected real capital gains - $(1-\tau_c)E_t[P^*_t]/(1-\tau_y)$ - is subtracted from both sides. Finally, the equation is divided throughout by the remaining terms (other than the expected rate of capital gains) of the discount factor. This yields:

$$(3.7)\ P^*_t = \{E_t[N^*_t] + E_t[\Delta P^*_t](1-\tau_c)/(1-\tau_y)\}/E_t[D'_t]$$

where $\Delta P^*_t = P^*_{t+1} - P^*_t$ represents real capital gains during year t, and the two alternative definitions of the discount factor are:

Fisher Hypothesis:

$$E_t[D'_t] = \{c_0 + (1-\tau_y)r_t - (\tau_y-\tau_c-c_1)E_t[\pi_t]\}/(1-\tau_y)$$

Darby Hypothesis:

$$E_t[D'_t] = \{c_0 + r^*_t + (\tau_c+c_1)E_t[\pi_t]\}/(1-\tau_y)$$

The next step is to define measures of the variables in this equation before proceeding with empirical work.

3.4.1 Expected Inflation

Various measures of expected inflation have been used in land price studies and elsewhere. In this study the measure is based on the 'Livingston Survey' data. The data are recorded each quarter as the expected rate of inflation over the ensuing twelve months. The figure for the December quarter of the preceding year is used as the measure of expected inflation at the start of the present year.

3.4.2 Expected Capital Gains

The expected capital gains variable is defined as the expected value of the real land price next year minus the current real land price. The uncertain component is next year's land price. Next year's land price depends ultimately on the entire future of the net benefits of owning land, tax rates, discount rates, and so on.

Under rational expectations, ' ... expectations are the same as the predictions of the relevant economic theory.' [Muth (1961, p.316).] Applying this literally to the model, expected capital gains will be a linear combination of current forecasts of the entire future of net benefits of owning land, tax rates, and so on. The problem is to devise a compact representation of this infinity of future variables to get a measure of expectations that is consistent with rational behavior.

One solution, suggested by Wallis (1980), is to define a finite autoregressive representation of the exogenous variables (in our case the net benefits of owning land or their components). If the autoregression is of order p, then each forecast is a linear combination of the past p observations and so are rational expectations. Phipps (1982) applies this approach to the U.S. land market. He assumes the net benefits of owning land are generated by a first-order autoregression. The result is that the entire future is represented by lagged net benefits and an autoregression parameter.[16] A rational expectations model of this type is presented in Appendix C.

The distinction between this type of rational expectations scheme and ad hoc distributed lag models is somewhat blurred. The alternatives are to assume an autoregressive relation for the variable to be forecast or to assume autoregressive relations for its determinants. Either method permits the imposition of rational expectations. The first is simpler. The second gives more structure to the model, allows joint estimation of the autoregressive relations and the equation

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[16] Phipps' (1982) model is more complicated because he includes shift variables in both the land price equation and autoregressions for net rents and the stock of land. The reduced-form parameters become non-linear functions of the autoregression parameters and the discount rate. These are estimated by fitting the land price equation and the two autoregressions simultaneously with non-linear cross equation restrictions.

involving expectations, but can lead to very complicated models even using only low order-autoregressions.

Distributed lag models have been used extensively in modelling land prices, net rents, future land prices, or capital gains.[17] In these models, the expected value of a variable is defined to be some linear combination of its past values (sometimes with the constraint that the 'weights' must sum to unity). The models range in complexity from the 'cobweb' model (last year's value only) through fixed-weight moving averages, adaptive expectations, free-form distributed lags, up to the optimal linear forecast or Box-Jenkins approach.[18] These models have been criticized on the grounds that decisionmakers have available relevant information on other variables so that 'extrapolative' forecasts are not 'rational.' Consider the following moving average predictor of real capital gains:

$$(3.8)\quad E_t[\Delta P^*_t] = \sum_{j=1}^{J} b_j \Delta P^*_{t-j} = b(L)\Delta P^*_{t-1}$$

This would be a rational expectation only if real capital gains were indeed to follow a Jth order moving average process, generated by some unknown underlying time series relationship among the determinants of real capital gains. That is, if

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[17] For example, see Hoover (1961), Martin and Heady (1982), Duncan (1979).

[18] These various approaches are described in more detail, and discussed in the context of land price models, by Phipps (1982).

(3.9) $P^*_t = b(L)\Delta P^*_{t-1} + u_t$

where u_t is orthogonal to the 'available' information in time t.[19]

Most past studies have imposed some restriction on the length or form of the lags. In finite lags, common restrictions are fixed weights or Almon polynomials; geometrically declining (Koyck lag) weights may be used to represent an infinite series. The tradeoff is between the greater flexibility of free-form lags and the econometric problems - multicollinearity and loss of data and degrees of freedom - which arise when several lagged observations of a variable are included. An additional disadvantage of free-form lags is that individual weights may not make economic sense.

In the model that follows, free-form distributed lags are used to proxy for expected capital gains as a moving average of a finite number of past capital gains. It seems reasonable to suppose that current and prospective land owners would take a lot of past data into account in forming expectations, since holding periods for farm real estate are long. Lag lengths of up to thirteen years will be included. It is anticipated that some problems of overparameterization may arise. The idea is to fit generously long lags and then to test

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[19] Maddock and Carter (1982, p. 41) define: ' ... rational expectations is the application of the principle of rational behavior to the acquisition and processing of information and to the formation of expectations.' Recognizing that information is costly to acquire and process, one should perhaps read 'optimum information' in place of 'available information'. Then it becomes less clear that equation (3.8) is not a rational expectation.

for the appropriate length of lag. Any remaining problems of overparameterization and nonsensical individual parameters may be reduced by imposing some structure - such as Almon polynomial restrictions - on the form of the lags. Such restrictions at least would force the lag weights to satisfy 'smoothness' priors.

3.4.3 Ex Ante Real Interest Rates

Equation (3.7) contains two alternative definitions of the relevant ex ante real interest rate. For the empirical work, the approach will be to assume that the relevant real interest rate (either r* or r) has been a constant during the sample period. Under this assumption a single reduced-form equation for the discount factor represents the two interest rate hypotheses:

$$(3.10)\ E_t[D_t] = d_0 + d_1 E_t[\pi_t]$$

In this equation d_0 is the sum of the constant component of the risk premium and the relevant constant risk free real rate (the certainty equivalent real rate) and d_1 measures the total effect of inflation. The sign of d_1 indicates the effect of inflation on the discount factor, but the effects of inflation on the risk premium and nominal interest rates are confounded.

3.5 LAND PRICE REGRESSIONS AND HYPOTHESIS TESTS

After replacing the variables in equation (3.7) with the expectations variables defined above, the equation for empirical work is:

$$(3.11)\ P^*(s,t) = b_0 + [N^*(s,t) + b_1 CGEn^*(s,t)]/[d_0 + d_1 LIV_t] + e(s,t)$$

The indexes s and t denote states and years. $P^*(s,t)$ is the price of farm real estate per acre in state s in year t divided by the GNP deflator. $N^*(s,t)$ is net rents per acre in state s in year t divided by the GNP deflator. LIV_t is the Livingston measure of expected inflation at the start of year t. $CGEn^*(s,t)$ is a moving average of n past annual first differences in the dependent variable. For empirical work, up to thirteen lagged values of annual capital gains are included in the moving average. These enter as 'free-form' lags so the data determine the individual 'weights.' The weights are assumed to sum to one, so the sum of the individual parameters on lagged capital gains terms is an estimate of b_1.

$$(3.12)\quad b_1 CGEn^*(s,t) = \sum_{j=1}^{n} w_j \Delta P^*_{t-j} \;; \qquad b_1 = \sum_{j=1}^{n} w_j$$

The theoretical parameters and structural coefficients in the model are:

1. $b1 = (1-\tau_c)/(1-\tau_y)$
2. Fisher: $d_0 = r+c_0/(1-\tau_y)$

   Darby: $d_0 = (r^*+c_0)/(1-\tau_y)$
3. Fisher: $d_1 = (\tau_c+c_1-\tau_y)/(1-\tau_y)$

   Darby: $d1 = (\tau_c+c_1)/(1-\tau_y)$
4. The intercept term (b_0) is theoretically zero.

If the tax rates were $\tau_y=0.3$ and $\tau_c=0.1$, the implied value for b_1 would be 0.9/0.7, about 1.3. One would expect d_0 to be positive, but the value depends on the magnitude of the risk premium. The last parameter, d_1 may be positive or negative.

3.5.1 Regression Results

The model is non-linear in parameters. Non-linear least squares estimates are obtained by the GAUSS-NEWTON method as used by SAS SYSNLIN. These would be maximum likelihood estimates if the errors were normal. To conserve data for constructing moving averages for expected capital gains, the model is applied to data for the eight states over the twenty years 1963 to 1982. The results of the regression are reported in Table 3.5.

The model explains a high proportion of the variation in the data and the estimated parameters are all consistent with priors. The intercept is small and not significantly different from zero. Somewhat surprisingly, the estimated weights on lagged capital gains are all positive, of plausible magnitudes, and nearly all significantly different from zero. The estimates suggest one should not truncate the lags to fewer than thirteen years. Given that the estimates are generally reasonable, there is no obvious advantage to be gained by restricting the form of the lag distribution. The estimates sum to 1.54 which is an estimate of b_1. This estimate is somewhat higher than the suggested prior of about 1.3. It is consistent with an income tax rate of, say, 35 percent (as suggested by Makin (1983)), and an effective rate of capital gains tax of near zero, say, 5 percent, as suggested in Appendix D. The constant term in the discount factor(d_0) is estimated as 0.073. If the relevant real rate of interest were

TABLE 3.5

Nonlinear Regression Results Pooling Data for Eight States[a] 1963-1982

Parameter	Estimate	Standard Error	T-Ratio
b0	-14.65	12.57	-1.17
w1	0.0919	0.0217	4.23
w2	0.0776	0.0217	3.57
w3	0.1044	0.0241	4.34
w4	0.1200	0.0264	4.54
w5	0.1693	0.0326	5.19
w6	0.0322	0.0295	1.09
w7	0.1806	0.0472	3.82
w8	0.2080	0.0484	4.30
w9	0.1865	0.0521	3.58
w10	0.1305	0.0532	2.45
w11	0.1331	0.0566	2.35
w12	0.0704	0.0523	1.35
w13	0.1666	0.0515	3.23
d0	0.0725	0.0062	11.72
d1	0.3511	0.0744	4.72

[a] There are 160 observations, 16 parameters, and 144 degrees of freedom for error.

The R-square is 0.9522.

3 percent, this would suggest a risk premium of about 4.3 percent: a plausible value (see Appendix D).

The parameter on expected inflation (d_1) is significantly positive at 0.35. This value is consistent with the Darby hypothesis under the assumption that inflation does not affect the risk premium. It is also consistent with the estimate of b_1 under the assumption of relatively small effective rates of capital gains tax. It implies that an increase in expected inflation would cause a decrease in real land prices, ceteris paribus. However, the magnitude of the effect would be relatively small. For example, suppose the expected inflation rate were 10 percent so the discount factor [d0+d1(0.1)] would be about 10.8 percent. This may seem to be a large value for the <u>real</u> discount rate but is, in fact, close to the average ex post real rates of return to U.S. farm real estate over the period analyzed (see Appendix B). If the expected rate of inflation were to fall to 5 percent, the discount factor would fall to about 9 percent. This would in turn imply a one-shot increase in land prices by about 17 percent. This is a comparatively small effect of a large change in expected inflation compared to the real annual growth rates of land prices, which averaged 13.5 percent in the mid 1970s. The implication is that land is not a 'good hedge' against inflation in the sense that a higher inflation rate would cause people to discount returns to land at a lower rate and therefore cause real capital gains to land. As it happened, U.S. farmland was a good 'hedge' against the rapid inflation that occurred during the early 1970s. Farm real estate earned very high real rates of return, the greater part made up of real capital gains (see Appendix B). However, most of these gains were inspired by massive growth of rental income that occurred, perhaps coincidentally, at the same time as the rapid inflation. If the real growth in net rent had not occurred, the findings of this analysis imply that the inflation of the early 1970s would have caused real capital losses on farm real estate. While the other parameters seemed quite robust, the parameter on expected inflation was somewhat sensitive to specification.

3.6 CONCLUSION

The empirical work in this chapter has involved two parts. The first part decomposed the growth of land prices into that which was due to growth of net rents and a residual that was attributed to (negative) growth of a general notion of a discount factor. The results of that part were that growth of the discount factor was not significantly different from zero and, in a sense, all growth of land prices may be attributed to growth in net rental income. There were no statistically significant differences in the growth rates between the eight states included in the analysis. This may be a result of offsetting movements in the different components of the 'discount factor.' The second part includes explicit representations of the components of the discount factor: a 'certainty equivalent' real rate of interest, expected real capital gains adjusted for taxes, and expected inflation. The empirical results are that the model explains a high proportion of the variation in land prices across the eight states over the twenty years analyzed. The parameter estimates are consistent with priors. The estimates support the hypothesis that income taxes affect land prices and provide tentative support for the Darby hypothesis in the context of land markets. At least, the results imply that an increase in expected inflation would increase the 'discount factor' and would therefore result in a reduction in the real price of land.

4. FACTOR PRICE EQUALIZATION

4.1 INTRODUCTION

International trade arises from differences in relative prices of commodities between countries in the absence of trade.[1] In the context of the neoclassical theory, these differences in relative prices may arise from differences in technology, differences in factor endowments, or differences in preferences. The 'modern' or 'Heckscher-Ohlin' theory may be thought of as an extension of the neoclassical theory in which additional assumptions are imposed in order to obtain additional predictions.

The additional assumptions are that production functions for different products are identical between countries and that tastes are largely similar between countries. The resulting propositions are:

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[1] Much of the material in this section in particular and in this chapter in general is drawn from Chacholiades' (1978) text, which provides a comparison of the modern and neoclassical theories and an extensive review of factor price equalization. The discussion also draws heavily on Chipman's (1966) survey of the modern theory. The relevant theory is mostly written with 'international' trade explicitly in mind. As the title of Ohlin's (1935) seminal work 'International and Interregional Trade' suggests, the theory applies as well to trade between regions of a country. The choice of geographical units between which to study trade is somewhat arbitrary. The approach suggested by Ohlin (1935, p.9) is to group districts into separate regions (between which factors are relatively immobile) so that differences in endowments within regions should be smaller than differences between them. National and state borders provide a natural, ready classification in terms of which data are available. It should be borne in mind that this may not be the most appropriate classification. Throughout the chapter, wherever the term 'international' appears, one may read 'international or interregional.'

1. The Heckscher Ohlin Theorem

The cause of international trade is to be found largely in differences between the factor endowments of different countries. In particular, a country has a comparative advantage in the production of that commodity which uses more intensively the country's most abundant factor.

2. Factor Price Equalization

The effect of international trade is to tend to equalize factor rental prices between countries and thus serve to some extent as a substitute for factor mobility.

The assumptions leading to these propositions may seem unreasonable. Apparently quite different techniques are used to produce a particular product in different places; people who have apparently similar opportunities in different places consume different bundles of goods. However, in a sense the assumptions are tautological; to be so, however, they require more careful definitions of commodities and factors. One can prove neither a violation of the assumption of constant tastes nor that of uniform technological possibilities.[2]

> By including ... [concrete input items, nonappropriable factors (such as weather), and conditions bearing on production (such as technological knowledge)] ... under 'factors of production' we can no doubt make the production functions identical between countries [Chacholiades (1978, p.281)].

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[2] The argument regarding fundamentally stable tastes is made by Stigler and Becker (1977). An analogous argument could be made regarding technology.

This does not mean the Heckscher-Ohlin theorem and the Factor Price Equalization Theorem are tautologies that it would be pointless to attempt to test. Both propositions - especially Factor Price Equalization - are subject to many caveats and involve additional restrictive assumptions. Most of the literature on the subject suggests only a tendency towards more equal factor prices under free trade in products than in the total absence of trade. The purpose of this chapter is to define a testable version of the Factor Price Equalization Theorem to be applied to seek evidence of international equalization of the price of services of land.

4.2 THE FACTOR PRICE EQUALIZATION THEOREM

4.2.1 Fundamental Assumptions and the Simple Case

Some fundamental assumptions underlying the Factor Price Equalization Theorem are:

1. pure competition in factor and product markets;
2. identical production functions for each commodity between countries;
3. linear homogeneous production functions;
4. non-reversible and different factor intensities in each commodity at all factor prices; and
5. absence of production externalities, factor indifference between uses, and identical factor quality between countries.

In addition, the argument abstracts from transport costs, taxes, and any other impediments to trade that may prevent the equalization of product prices between countries.

The simplest version of the theorem is the case of two countries with different fixed endowments of two primary factors that they use to produce two commodities. The basic assumptions lead to a one-to-one correspondence between commodity prices and factor prices in the two countries. Then it follows that, if free trade leads to product price equalization with incomplete specialization in production in each country, both relative and absolute factor prices are completely equalized between the countries.[3]

4.2.2 Generalization of the Theorem

Chacholiades (1978) argues that the analysis of Factor Price Equalization applies equally to the case in which factor supplies are not perfectly inelastic (at least in the simple case). Chipman (1966) discusses factor price equalization in the case of many factors, many products, and many countries. In the case in which the number of employed factors is greater than the number of products, the one-to-one correspondence between factor and product prices breaks down and factor price equalization will not take place. This objection is important but seems artificial; the conceptual problem is one of aggregation: what is a 'commodity' and what is a 'factor.' In the more interesting case of more products than factors, the relevant consideration is whether the assumption of incomplete specialization

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[3] These assumptions and arguments, along with heuristic, algebraic and geometric proofs, may be found in Chacholiades (1978, chapter 10). A more complete discussion of Factor Price Equalization in the more general case can be found in Chipman's (1966) review of the modern theory.

is violated. This assumption takes a slightly different form in the more general case:

> ... factor prices will be equalized between any pair of countries that produce simultaneously any set of m commodities, where m is the number of factors .... Thus if there is a chain of countries such that any consecutive pair both produce positive amounts of the same m commodities, then factor prices will be equalized among all countries of the chain [Chipman (1966, p.34)].

Thus, if the basic assumptions are fulfilled, the Factor Price Equalization Theorem generalizes to the case of many countries, many factors, and many products. For the more general case, a modified version of the assumption of incomplete specialization is required. The question then becomes: How closely are the assumptions fulfilled in reality and, if assumptions were violated, how would the theorem be affected?

The assumption of perfect competition cannot be relaxed. Constant returns to scale cannot be relaxed either, but it can be argued that constant returns to scale in the aggregate is an implication of competition, and the assumption may be redundant. Factor intensity reversals need not impede factor price equalization, but they might. International disparities in production functions are conceivable, given a restrictive notion of what constitutes a 'factor.' If the differences were neutral - of the sort arising from neutral technical change - factor prices would be equalized in relative, but not absolute, terms. Incomplete specialization (or complete variegation) is essential. If this assumption were violated, there might be only a tendency towards factor price equalization. Differences in factor quality have been suggested as a cause of departure from factor price equalization. Conceptually, this is simply a problem of proper definition of factors. As a practical matter, it raises serious problems for empirical work, that will be addressed later. An essential assumption, which is obviously violated in reality, is that of product price equalization. Possible causes of departure from product price equalization include (a) transport costs, (b) trade barriers, (c) taxes and other interventions in domestic markets, (d) foreign exchange market intervention, and (e) the existence of non-traded goods. These exist and together may imply substantial international disparities in product prices. Product price equalization is tested in Appendix F. On the other hand, the theorem is based on the assumption that factors are not internationally mobile. In fact, there is considerable migration of labor and capital within and between countries. Arbitrage in markets for some factors implies a tendency towards equalization of prices of products and immobile factors, even when the conditions of the Factor Price Equalization Theorem are not met.

Overall, complete factor price equalization seems unlikely. It requires assumptions that are clearly violated, probably in important ways. Nevertheless, one may expect a tendency towards factor price equalization and the empirical question is how great is the tendency: how important are the objections? The next step is to develop an empirical version of the theorem to be applied to land markets.

4.3 EQUALIZATION OF LAND RENTS

In the abstract theory, all factors are homogeneous. In reality, land is far from homogeneous. Different acres of land earn very different incomes according to differences in their characteristics:

location, arability, topography, climate, soil fertility, and so on. In the context of the modern theory, it is not the rental prices of 'land' that should be everywhere equated, but rather the rental prices of the characteristics of land that may be conceived of as the relevant homogeneous factors. The rental price of an acre of land is equal to the sum of the rental prices of the different characteristics multiplied by the quantities of those characteristics per acre.

One special case occurs when different acres have different amounts of different characteristics but where the proportions of the different characteristics are everywhere the same. In this case, rental prices of different acres will be equated up to a constant of proportionality and the problem of heterogeneity may be solved by rescaling the units in which land is measured. Then land rental prices will be equated in absolute terms. More generally, different acres of land will have different amounts of different characteristics and the proportions of the different characteristics also will vary. This would be less of a problem if the prices of the underlying characteristics were always in fixed proportions; but that is unlikely. Given different proportions of characteristics in different acres of land, relative composite rental prices for land will vary as product prices vary. This follows from an application of the Stolper Samuelson Theorem. For example, suppose one acre of land is arable and used to grow wheat while another is rocky and used for grazing. The Stolper Samuelson Theorem would predict that an increase in the price of wheat would increase the price of 'arability' and thus the price of the land that is relatively arable.

Ideally one would test for equalization of the prices of the characteristics of land, but to measure the relevant characteristics would be difficult. Even under factor price equalization, one should not expect equalization of the rental prices of different acres of land in absolute terms. The approach for empirical work is to test for equalization of the growth rates of factor prices. This is a joint test of factor price equalization and proportionality of characteristics between different parcels of land.

Consider two countries or regions, j and k. For clarity of exposition, time subscripts and expectations operators are suppressed. Absolute equalization of the per acre rental prices implies:

$$(4.1)\ R_k = \pi_{kj}R_j$$

where R denotes land rents and π_{kj} is the exchange rate that converts units of currency j into equivalent units of currency k. Now suppose that different acres of land differ in their total endowments of factors but have the same proportions of factors. Then factor price equalization implies:

$$(4.2)\ R_k = \beta_{kj}\pi_{kj}R_j$$

where β_{kj} is a constant of proportionality that converts acres of land in country j to equivalent acres in country k. Equation (4.2) implies equalization of the growth rates of the land rents between the countries, after currency conversion, as long as β_{kj} is constant. That is:

$$(4.3)\ d\ln(R_k) = d\ln(\beta_{kj}) + d\ln(\pi_{kj}R_j)$$

This approach will be applied among the eight U.S. states for which appropriate land rental data are available.

4.4 LAND PRICE EQUALIZATION

The 'general' equation for the price of land in country k is:

$$(4.4)\ P_k = R_k/D_k$$

where P denotes the price of land, R denotes income to land, and D denotes the 'discount factor.' In this chapter, R is defined as the ex ante gross value of the marginal product of land. Thus, all of the other factors affecting land prices appear, in this instance, in the denominator. The discount factor in country j may be a function of the values in country j of a risk-free interest rate, a risk premium for land, the rate of capital gains, a depreciation rate, and the rates of tax on income, property, and capital gains.

The Factor Price Equalization Theorem applies explicitly to factor rental prices: equalization of marginal value products of factors. It implies asset price equalization only if the discount factors are equated along with the rental prices. Factor price equalization would imply equalization of both the level and growth rate of gross rental income to land. To the extent that capital gains are derived ultimately from growth of rental income, factor price equalization would imply equalization of rates of expected capital gains. In addition, free arbitrage in capital markets would imply the equation of net-of-tax real interest rates between places. Residual differences in discount factors would arise from differences in tax laws, differences in risk premia, and differences in inflation rates. Combining (4.4) with (4.2) yields:

$$(4.5)\ P_k = \beta_{kj}\pi_{kj}R_j/D_k = \beta_{kj}\pi_{kj}P_jD_j/D_k$$

Taking logs of (4.5) and totally differentiating yields:

$$(4.6)\ d\ln P_k = d\ln[\pi_{kj}P_j] + d\ln[\beta_{kj}] + d\ln[D_j/D_k]$$

In equation (4.6) the growth rates of land prices are equalized between countries when land rental prices are proportional ($d\ln[\beta_{kj}]=0$) and the discount factors are proportional ($d\ln[D_j/D_k]=0$). Differences in the growth of land prices between countries may arise from differences in the growth of rental income or differences in the growth of the discount factor. Under factor price equalization, and proportionality of factor endowments between different acres, any differences in land price growth are due to differences in growth of the discount factors.

Appropriate data on rental incomes to land are not available for most states of the United States or for other countries. However, some data on land prices are available for states of the United States, Canada, Australia, and New Zealand. As shown in (4.6), equalization of the growth rates of rental income, proportionality of factor endowments per acre, and equalization of the growth rates of the discount factors together imply equalization of land price growth rates. Again, using growth rates rather than levels involves some adjustment for quality differences so that one cannot test for absolute equalization of land prices per acre. Using land prices rather than rental incomes avoids some problems of the measurement of rental income, especially where nonfarm factors may be important. This approach will be used to test for asset price equalization across states of the United States, and between the United States, Canada, Australia, and New Zealand.

4.5 EMPIRICAL RESULTS FOR THE UNITED STATES

4.5.1 Rental Price Equalization among Eight U.S. States

Data on Canadian land prices are available from 1961 to 1980. In anticipation of international comparisons, only data from that period are used for the analysis of growth of U.S. land prices and rental incomes to land. The growth rates reported in Table 4.1 are average nominal growth rates of gross rental income to land and land prices. The other numbers in the table are the actual values of land prices and gross rents per acre in 1980.

The levels of gross rents and land prices in 1980 differed markedly between the eight states. The figures for Illinois are more than five times those for South Dakota. Land prices and gross rents are not equalized per acre. However, the growth rates of land prices and gross rents over the twenty years from 1961 to 1980 are remarkably

TABLE 4.1

Average Annual Nominal Growth Rates of Land Prices (GP) and Net Rents (GR) for Eight U.S. States 1961-1980[a]

State	GP %	GR %	P(1980) $/ac	R(1980) $/ac
IA	11.60 (2.4)[b]	9.73 (1.7)	1810	96.0
ND	11.36 (2.2)	9.58 (2.4)	399	24.1
IN	11.26 (2.1)	9.26 (1.8)	1833	94.0
MO	11.25 (1.6)	8.92 (1.5)	878	50.5
MN	11.18 (2.1)	8.46 (2.4)	1061	59.5
OH	10.87 (1.8)	9.67 (1.9)	1678	72.0
IL	10.81 (2.3)	8.78 (1.8)	2013	99.0
SD	9.36 (1.7)	7.00 (1.8)	273	19.2
Mean	10.96 (0.7)	8.93 (0.7)		

[a] Data from 1961 to 1980 yield 19 growth rate observations for each state.

[b] Figures in parentheses are standard errors.

similar between the states. With the exception of South Dakota, the average growth rates vary by less than 1 percent between the states. Even including South Dakota, none of the growth rates of land prices differs significantly from any of the others; the same is true for gross rents. The annual growth rate data were subjected to analysis of variance by states and years and, for both gross rents and land prices, there were no significant state effects. These data seem to support land rental price equalization, land price equalization, and thus factor price equalization between these eight states.

4.5.2 Asset Price Equalization among U.S. States

In Table 4.2, the average annual nominal growth rates of land prices are shown for each of the forty-eight contiguous mainland states of the United States over the interval 1961 to 1980.

A two-way analysis of variance by states and years indicates that there are no significant differences in growth rates due to states. The growth rates in Table 4.2 are placed in order of size. Even though the differences are not statistically significant, the magnitudes of the differences may be economically important. Most of the values falling in the tails of the distribution are for New England states where agriculture is relatively unimportant (NH, RI, MA, CT), and states likely to have important non-farm influences (NY, NJ, WV, VT). Californian agriculture, dominated by irrigated crops, is different from that in other states, and non-farm factors may have been important there too. For the bulk (over five-sixths) of the states the growth rates averaged between 9 and 12 percent over the twenty years. For the majority the average rates are between

TABLE 4.2

Average Annual Nominal Growth Rates of Land Prices (GP) by U.S. States (1961-1980)

State	GP	State	GP	State	GP	State	GP
NH	13.4	WV	12.7	UT	12.3	VT	12.2
AL	11.9	NV	11.7	AR	11.6	IA	11.6
MS	11.4	NM	11.4	LA	11.4	ND	11.4
IN	11.3	MO	11.3	PA	11.2	MN	11.2
WI	11.1	MD	11.0	MT	10.9	OH	10.9
TN	10.9	NB	10.8	IL	10.8	OK	10.8
VA	10.8	CO	10.8	KY	10.6	WY	10.6
DE	10.5	ME	10.5	SC	10.3	GA	10.3
NC	10.2	OR	10.2	FL	10.1	ID	9.9
KS	9.7	AZ	9.6	MI	9.5	WA	9.4
SD	9.4	NY	9.3	NJ	9.2	CT	9.0
TX	9.0	MA	8.6	CA	7.5	RI	7.2

10 and 11.5 percent. These are remarkable results. Across most of the United States, including a very wide range of types of land and types of land use, the nominal growth rates of land prices over a twenty-year period fall within a narrow range. These data tend to support the hypothesis of factor price equalization between states of the United States.

The data in Tables 4.1 and 4.2 are all in nominal terms. They are based on an implicit assumption of purchasing power parity between states of the United States with a unitary exchange rate for U.S. dollars between states. The statistical results would not be affected by using deflated data. There is a problem of deciding which deflator to use. For instance, during the interval studied the aggregate U.S. Consumer Price Index (U.S. CPI) grew at an average annual rate of 5.5 percent; the GNP deflator grew at an annual rate of 5.1 percent. If either of these deflators were used, the real growth rates would be around 5 percent compared to nominal rates of around 11 percent. It is questionable whether either of these deflators is appropriate. Perhaps worse, a single deflator is probably inappropriate for all states of the United States: it is probably inappropriate to assume exact purchasing power parity among states. This issue is more important when making international comparisons. Currencies must be converted into comparable units. This problem is addressed in the next section in comparing growth rates of land prices between countries.

4.6 INTERNATIONAL COMPARISONS

4.6.1 Data and Methodology

Annual land price data are available for the interval 1961 to 1980 by Canadian provinces, and for 1950 to 1982 by U.S. states. For New Zealand, Peter Bushnell of the New Zealand Ministry of Agriculture and Fisheries provided annual land price indices from 1954 to 1980 by four types of land: arable, fattening, grazing, and dairying. For Australia, Pip Bruyn of the Department of Agriculture in Victoria supplied annual land prices from 1968 to 1980 for the state of Victoria by four types of land use: cereals, beef cattle, sheep, and dairying. The U.S. data are based on surveys, as described in Chapter 3. The basis of the Canadian data, which were obtained by Paul R. Johnson, is unknown. The Australian and New Zealand data are based on records of actual transactions. From the U.S. series, data for eight northeastern states (Maine, New Hampshire, Vermont, Massachussetts, Rhode Island, Connecticut, New York, and New Jersey) are excluded. From the Canadian series, data for three provinces (Prince Edward Island, Nova Scotia, and New Brunswick) are excluded. In both cases the reason is to reduce the effect of nonfarm factors. Agriculture is relatively unimportant in the states and provinces excluded from analysis. Thus, forty U.S. states and six Canadian provinces are included in the analysis.

Three sets of comparisons are made. First, average annual growth rates of land prices during the interval 1961 to 1980 are compared between the United States, Canada, and New Zealand. Second, land price growth rates are compared among the four countries during the interval 1968 to 1980 for which Australian data are available. Third, the growth rates of cropland prices are compared among the countries for the two time intervals.

All of the data are expressed in nominal domestic dollars. The problem is to convert these different dollars into comparable units. This is an example of the general problem of measurement for international comparisons, and there is an extensive literature on the subject. The three reports of the International Comparisons Project (ICP), the summary article by Kravis (1984) and critique by Marris (1984) cover the relevant issues. A major point is that market exchange rates do not fully reflect non-traded goods prices and therefore may be inaccurate measures of relative purchasing power of currencies. Specifically, market exchange rates tend to understate the purchasing power of the currency of the lower income country of any pair of countries - basically because the cost of non-traded labor-intensive services is lower in poorer countries. The alternative approach is to compute a notional exchange rate - a purchasing power parity index. This type of approach was used in the ICP to compare prices and incomes between countries in 1975. The main problem with this approach is the 'index number problem' of finding an appropriate set of quantity weights for the individual commodity prices used in the index. There are massive data requirements and significant measurement problems. For intertemporal international comparisons, these problems are manifold.

In the ICP comparisons, exchange rate deviation indexes were computed as the ratio of the market exchange rate to the ICP notional (purchasing power parity) exchange rate. For countries having a Gross Domestic Product (GDP) per capita of 60 to 100 percent of that of the United States, there was little deviation from a U.S. dollar exchange rate deviation index of 100, the value for the United States. In the four countries included for analysis in this study, GDP per capita falls within a narrow range. Thus, market exchange rates may well reflect purchasing power parities among the countries.[4]

Purchasing power parity indexes are not available for the four countries across the time periods of interest. A fairly crude measure of purchasing power parities is the ratio of domestic Consumer Price Indexes (CPIs). This measure will be misleading to the extent that different CPIs may be defined differently and may be less accurate than market exchange rates.

Two approaches for currency conversions are used: (a) measures based on market exchange rates, and (b) measures based on the ratio of CPIs which is used as a notional purchasing power parity exchange rate. Under absolute purchasing power parity, by definition, these two measures would be equivalent. For each of the four countries nominal land prices are converted, using market exchange rates, into nominal Special Drawing Rights (SDR's), and nominal U.S. dollars. Using the ratio of the U.S. CPI to the other countries' CPIs (all CPIs based 1975=100) as exchange rates, they are converted into purchasing

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[4] In U.S. dollars, based on market exchange rates, values for GDP per capita in the four countries in 1980 were: United States, $11,362; Canada, $10,600; Australia, $10,211; New Zealand, $7,061. These figures were drawn from the World Bank's <u>World Development Report</u>, 1982, Oxford University Press.

power parity nominal U.S. dollars. Nominal land prices in domestic dollars are converted into 'real' 1975 base domestic dollars by dividing by the domestic consumer price index (CPI), base 1975; an equivalent calculation would be to deflate the measure in purchasing power parity nominal U.S. dollars by the U.S. CPI. Nominal prices in U.S. dollars for the four countries are converted into real U.S. dollars by dividing through by the U.S. CPI; an equivalent calculation would be to multiply the real domestic price by the real exchange rate.[5]

Annual growth rates of land prices are computed in (a) nominal SDRs (GPS), (b) nominal (market exchange rate) U.S. dollars (GPU), (c) nominal (purchasing power parity) U.S. dollars (GPP), (d) real U.S. dollars (GRU), and (e) real domestic dollars (GRD). For the sample period a three-way analysis of variance of the growth rates is conducted - by state (province or land use type), country, and year. If the F-test in the analysis of variance reveals a significant state or country effect on the growth rates, then the average annual growth rates of the land prices between states and countries are compared using a 'Duncan's Multiple Range Test.'

4.6.2 Results for the United States, Canada and New Zealand: 1961-1980

Table 4.3 includes the average annual growth rates of land prices for the United States, Canada, and New Zealand between 1961 and 1980. For the United States and Canada, the numbers are simple averages

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[5] The exchange rates are expressed in $US/$foreign currency. The real exchange rate is obtained by dividing through by the ratio of the U.S. CPI to the foreign CPI.

across states or provinces. For New Zealand the numbers are averages across land types.

In Table 4.3 the average growth rates, based on market exchange rates, in nominal SDRs (GPS) and in real and nominal U.S. dollars (GRU, GPU) are very similar between the three countries. The growth rates for the United States are generally higher, but not by more than 1 percent per year. From the analysis of variance, there were no significant effects of countries or states (provinces, land use) on these three growth rates. There were no significant differences between countries. Further, there were no significant differences between any pair of states, provinces, or types of land use. However, the results are different for the nominal purchasing power parity U.S. dollar (GPP) and real domestic dollar (GRD) comparisons. For these two growth rates, the analysis of variance detected a significant country effect (at the 1 percent level). There were no significant state effects. The average growth rates for New Zealand land prices were significantly less than those for Canada and the United States at the 5 percent significance level.

The difference in results between the different growth rates may be attributed to departures from purchasing power parity - in terms of CPIs - between the countries. Using the measures based on market exchange rates, there are no significant differences between countries or states. Using the CPI-based measures, the growth rate for Canada is closer to that for the U.S., whereas the rate for New Zealand is farther from that for the U.S. This suggests there have been changes in real exchange rates between the three countries.

TABLE 4.3

Mean Growth Rates of Land Prices for the United States Canada and New Zealand (1961-1980)

Country	GPS	GPU	GPP	GRU	GRD	Obs.
United States	9.21 (0.29)	10.70 (0.27)	10.70 (0.27)	4.87 (0.20)	4.87 (0.20)	760
Canada	8.43 (0.96)	9.87 (0.88)	10.55 (0.88)	4.09 (0.74)	4.71 (0.66)	114
New Zealand	8.21 (1.89)	9.94 (2.05)	8.50* (1.62)	4.09 (1.80)	2.72* (0.21)	76
All Pooled	9.03 (0.30)	10.54 (0.29)	10.50 (0.27)	4.71 (0.24)	4.68 (0.21)	950

Figures in parentheses are standard errors of means.

Notes:
The average annual growth rates of land prices are in:
nominal SDR's (GPS);
nominal (market exchange rate) U.S. dollars (GPU);
nominal (purchasing power parity) U.S. dollars (GPP);
real U.S. dollars (GRU);
real domestic dollars (GRD).

The figures denoted * are New Zealand growth rates that differed significantly from the other growth rates in those columns.

4.6.3 Results for the United States, Canada, Australia, and New Zealand: 1968-1980

Table 4.4 includes the average annual growth rates of land prices for the United States, Canada, New Zealand, and Australia between 1968 and 1980. These are averages across states, provinces, and land types within each country. Preliminary results show Australian beef cattle land prices to have grown at a higher average rate and much more erratically than other land prices. Two sets of results are shown in the table: (1) those excluding Australian beef cattle land, and (2) those including Australian beef cattle land.

It is convenient to discuss the results in Table 4.4 in reverse order. The second set of results (2) includes the effect of Australian cattle land. The analysis of variance detected no significant country or state effects on any of the growth rates. The average growth rates for Australian cattle land were the largest in all five measures and, in spite of the statistical results, Australian cattle land appears to be different. The standard errors of the growth rates are nearly as large as the means for Australian cattle land, whereas they are generally much smaller than the means. To test for a significant difference between Australian cattle land and the other 'states', dummy variable regressions were run. The mean growth rates for Australian cattle land were (marginally) significantly larger than the overall mean at around the 97 percent confidence level.

The first set of results (1) excludes Australian cattle land. The result is that the mean growth rates are closer together and the standard errors for Australia and pooled data are smaller. For these data the analysis of variance could not detect any significant

TABLE 4.4

Average Nominal Growth Rates of Land Prices in the United States Canada, New Zealand and Australia (1968-1980)

Country	GPS	GPU	GPP	GRU	GRD	Obs.
United States	10.81 (0.42)[a]	13.17 (0.37)	13.17 (0.30)	5.26 (0.30)	5.26 (0.30)	480
Canada	8.75 (0.96)	10.99 (1.26)	11.84 (1.23)	3.19 (1.04)	3.94 (0.94)	72
New Zealand	11.00 (1.89)	13.76 (2.84)	10.59 (2.35)	5.74 (2.52)	2.73 (1.95)	48
Australia (1)	10.61 (3.74)	13.67 (4.29)	11.03 (3.67)	5.73 (3.98)	3.21 (3.33)	36
All Pooled (1)	10.58 (0.46)	12.91 (0.45)	12.70 (0.41)	5.08 (0.39)	4.80 (0.35)	636
Australia (2)	12.67 (4.80)	15.56 (5.05)	13.17 (4.68)	7.36 (4.55)	5.08 (4.17)	48
All Pooled (2)	10.73 (0.53)	13.15 (0.53)	12.83 (0.49)	5.22 (0.46)	4.91 (0.41)	648

[a] Figures in parentheses are standard errors of means.

Notes:
The average annual growth rates of land prices are in:
nominal SDR's (GPS);
nominal (market exchange rate) U.S. dollars (GPU);
nominal (purchasing power parity) U.S. dollars (GPP);
real U.S. dollars (GRU);
real domestic dollars (GRD).

Means denoted (1) exclude Australian cattle land.
Means denoted (2) include Australian cattle land.

effects of states or countries at the 95 percent confidence level. For the growth rates based on CPIs (GPP, GRD), country had a significant effect at the 94 and 91.4 percent confidence levels, respectively. The growth rates based on market exchange rates (GPS, GPU, GRU) are very similar between countries. The growth rates for Canada are lower by about 2 percent. For the other three countries the range is less than .5 percent. The results are quite different for the other growth rates (GPP, GRD). As before, using the CPI based measures, the growth rates for Canada are closer to those for the United States. The growth rates for Australia and New Zealand are smaller, and the ranking of the countries is changed markedly. These differences may be attributed to changes in real exchange rates.

4.6.4 International Comparisons for Cropland

The final set of international comparisons uses data for land in areas where wheat is a major product. This is an attempt to control for quality differences and relative product price movements. For the United States, Kansas (USKS), Oklahoma (USOK), North Dakota (USND) and Washington (USWA) are included. The first three are the biggest states in terms of wheat production. The reason for including these states, however, is not absolute importance but rather the relative importance of wheat in the states. In all four states more than 20 percent of farmland was used to grow wheat in 1980, and the total acreage comprised 44 percent of U.S. wheat plantings. Minnesota is the next ranked state with 12 percent of its farmland planted to wheat in 1980. For Canada, Alberta (CNAB) and Saskatchewan (CNSK) are included. For Australia, cropland (AUCP), and for New Zealand, arable land (NZAR), are included.

From the analysis of variance, there were no significant differences between states or countries in any of the growth rates. Table 4.5 includes the average growth rates (GPS, GPU, GPP, GRU, and GRD) for the two periods 1961 to 1980 and 1968 to 1980. As with the aggregate national figures, the growth rates based on market exchange rates are very similar between the different countries and between states and provinces among countries. The standard errors are large and there are no significant differences. The Canadian growth rates tend to be lower than the others in the latter period, 1968 to 1980. Again, using the CPI-based figures (GPP, GRD), the ranking changed markedly, but because the standard errors were relatively large, the differences were not statistically significant.

4.5 REAL EXCHANGE RATE MOVEMENTS

Table 4.6 includes real exchange rates in real (1975) U.S. dollars per real domestic (1975) dollars for Australia, Canada, and New Zealand for the years 1961 to 1983. The exchange rates are computed by dividing the market exchange rate (with U.S. dollars in the numerator) by the ratio of the U.S. CPI to the CPI for the other countries.

From an inspection of the real exchange rate data in Table 4.6, the cause of the disparities in the different growth rate measures is apparent. Over the period of the sample data (1961-1980 or 1968-1980), the real price of Canadian dollars in U.S. dollars fell generally, whereas the real prices of Australian and New Zealand dollars in U.S. dollars rose. In other words, the market exchange rate (U.S.

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TABLE 4.5

Growth Rates of Cropland Prices in the Four Countries 1961–1980 and 1961–1968

	1961–1980			1968–1980		
State	GPS	GPU	GPP	GPS	GPU	GPP
CNAB	8.97 (2.66)[a]	10.42 (2.53)	11.17 (2.63)	8.68 (4.15)	10.94 (3.94)	11.88 (4.18)
CNSK	9.30 (2.75)	10.72 (2.52)	11.43 (2.48)	7.75 (4.08)	9.79 (3.74)	10.85 (3.77)
NZAB	7.81 (4.44)	9.52 (4.71)	8.07 (3.91)	10.32 (6.18)	13.01 (6.57)	9.81 (5.57)
USKS	8.28 (1.81)	9.74 (1.67)	9.74 (1.67)	9.43 (2.82)	11.75 (2.45)	11.75 (2.45)
USND	9.93 (2.44)	11.36 (2.21)	11.36 (2.21)	12.10 (3.76)	14.37 (3.20)	14.37 (3.20)
USWA	7.97 (2.31)	9.42 (2.01)	9.42 (2.01)	9.32 (3.60)	11.61 (2.96)	11.61 (2.96)
USOK	9.31 (1.78)	10.79 (1.55)	10.79 (1.55)	9.70 (2.71)	12.04 (2.13)	12.04 (2.13)
AUCP				11.69 (7.48)	14.74 (8.32)	12.27 (8.32)

[a] Figures in parentheses are standard errors of means.

Notes:
The average annual growth rates of land prices are in:
nominal SDRs (GPS);
nominal (market exchange rate) U.S. dollars (GPU);
nominal (purchasing power parity) U.S. dollars (GPP);

The 'states' are Alberta (CNAB) and Saskatchewan (CNSK) in Canada, 'arable land' (NZAB) in New Zealand, cropland (AUCP) in Australia, and four U.S. states – Kansas (USKS), North Dakota (USND), Washington (USWA), and Oklahoma (USOK).

TABLE 4.6

Real Exchange Rates: 1961 to 1983

Year	Australia	New Zealand	Canada
1961	0.9920	1.0779	0.9622
1962	0.9794	1.0976	0.9123
1963	0.9704	1.1011	0.9077
1964	0.9772	1.1232	0.9143
1965	1.0018	1.1435	0.9197
1966	0.9986	1.1384	0.9267
1967	1.0048	1.1510	0.9345
1968	0.9885	0.9499	0.9338
1969	0.9642	0.9439	0.9260
1970	0.9484	0.9494	0.9324
1971	0.9835	1.0291	0.9508
1972	1.0588	1.1166	0.9842
1973	1.2975	1.2954	0.9854
1974	1.3653	1.3369	1.0080
1975	1.3102	1.2146	0.9833
1976	1.3144	1.1028	1.0305
1977	1.2546	1.1534	0.9687
1978	1.2996	1.2836	0.9150
1979	1.2439	1.2913	0.8739
1980	1.2311	1.2690	0.8496
1981	1.2336	1.1381	0.8440
1982	1.1439	1.0969	0.8567
1983	1.0470	1.0100	0.8830

Notes:
The exchange rates are all expressed in real (1975 CPI) U.S. $ per real (1975 CPI) foreign $. They were calculated by dividing the market exchange rate with U.S. $ in the numerator by the ratio of the U.S. CPI to the other countries' CPI's. The CPI's were all based 1975=100.

dollars per dollar of foreign currency) did not grow as fast as the ratio of the U.S. CPI to the domestic CPI in Canada; it grew faster than the ratios of U.S. CPI to domestic CPI for Australia and New Zealand. All of the real exchange rates rose somewhat in the early 1970s, particularly in 1973 with the devaluation of the U.S. dollar and the move to floating exchange rates. Between 1980, the end of the sample data for land prices, and 1983 the real exchange rates had all returned approximately to their early 1960s levels. In 1980, however, the rates were still substantially different from their 1960s levels. These data suggest a tendency towards purchasing power parity (PPP) in terms of CPIs between the four countries in the long term. However, during the periods of interest there seems to have been a significant departure from PPP.

4.6 CONCLUSION

The modern theory of international trade suggests a tendency towards equalization of factor rental prices due to equalization of product prices via trade. Factor price equalization is more likely among regions or countries that produce similar products using similar technologies and whose residents have similar preferences. Land is a composite of productive factors. The growth rates of rental prices of different acres of land will be equalized under factor price equalization if different acres contain equi-proportional endowments of productive factors. In turn, this implies equalization of growth rates of (asset) prices of land if the discount factors are proportional.

The first set of comparisons uses data for U.S. states. Between U.S. states, one would expect most of the conditions for factor price equalization to be fulfilled. Among eight mid-western states, between which absolute rents per acre and land prices vary widely, land rents and land prices grew at remarkably similar rates over twenty years. Across the forty-eight contiguous states, the average growth rates of land prices were similar and most fell within a relatively close range.

The second set of comparisons uses data for the United States, Canada, New Zealand, and Australia. Compared with most of the world, these countries have a great deal in common. They are all former British colonies, technologically advanced 'Western' democracies, populated mainly by people of European descent who earn comparably high per capita incomes. The four countries are all net exporters of agricultural products. The United States, Canada, and Australia have been dominant exporters of wheat. All four countries export beef, especially the United States and Australia. Australia and New Zealand dominate international trade in wool, and export sheep meats. Dairy products are important exports for Australia and New Zealand. The four countries trade in agricultural products with one another and with other countries.

It is reasonable to suppose that the product prices will be equalized approximately, at least at points of delivery to importing countries such as Japan. Some evidence in support of product price equalization, at f.o.b. export and at the farm level, is presented in Appendix F. Over all types of land, among both the countries and the 'states,' the average annual growth rates of land prices based on market exchange rates were approximately equal between 1961 and 1980 and between 1968 and 1980. This result is consistent with factor price equalization arising from product price equalization at delivery to importing countries.

Divergences in product prices - in common currency units based on market exchange rates (e.g., SDRs or U.S. dollars) - between the countries may arise from a variety of sources (e.g., trade barriers or transport costs). Differences in the CPI-based measures of land price growth may arise from this or as a result of departure from purchasing power parity. Over the past twenty years, and particularly during the 1970s, there have been significant movements in real exchange rates between the countries. Land price growth rates were almost exactly equated in market exchange rate based measures between the United States, Australia, and New Zealand, with somewhat lower rates in Canada. However, using the CPI based measures, the growth rate for Canada was closer to that for the United States and the rates for Australia and New Zealand were much smaller. A similar pattern of results was found in the comparisons of product prices that are reported in Appendix F. Between 1980, the end of the land price sample data, and 1983, real exchange rates had returned approximately to the levels of the early 1960s. Another three years of land price data may reveal more comparable results between the different growth rates, but such data are not available.

The problems of quality differences between different acres and paucity of rental data, meant that only a joint test of the hypotheses of factor price equalization, proportional endowments, and proportional discount factors, was possible. These are strong additional restrictions.

The strength of the tendency towards equalization of growth rates of land prices is surprising, given the reservations surrounding factor price equalization and the additional restrictions. Overall, the evidence is in favor of factor price equalization. It would seem that the objections to the Theorem, discussed at the beginning of this chapter, are relatively unimportant.

5. SUMMARY AND CONCLUSION

5.1 INFLATION AND U.S. LAND PRICES

The first part of the study involved a theoretical model of land price determination in the United States and empirical work to test for effects of inflation and growth of rental income. The theoretical model is a synthesis of the models developed by Feldstein (1979, 1980) and Melichar (1979). It was shown that, theoretically, the effect of inflation on land prices is ambiguous, depending on the effect on nominal interest rates and the effect on the risk premium for owning land. A comparison of the growth rates of land prices and net rents (based on cash rents) across eight states suggests most of the growth in land prices may be accounted for by growth in net rents. A regression model suggests that an increase in expected inflation has a negative effect on real land prices, in contrast to Feldstein's hypothesis. However, the effect of inflation is relatively small. These results leave an interesting question unanswered: What accounts for the massive growth of rental incomes – at average annual real rates in excess of 13 percent – in the mid-1970s? Perhaps coincidentally, the mid-1970s was a period following a substantial devaluation of the U.S. dollar, a period of rapid and increasing inflation, and a period of huge growth in agricultural exports.

5.2 FACTOR PRICE EQUALIZATION

The second part of the study involved some interstate and international comparisons of growth rates of land rents and land prices, seeking evidence in support of the Factor Price Equalization Theorem. Land price measures based on market exchange rates grew at remarkably similar rates within the United States and between the United States, Canada, New Zealand and Australia in recent years. The results seem to support factor price equalization. There were significant changes in real exchange rates, and as a result the growth rates based on CPI's were different, but in most cases the differences were not statistically significant.

5.3 COMBINING THE PARTS

The theoretical model of land price determination involves tax rates, inflation rates, and risk premia that differ between countries. The United States has capital gains taxes; Australia, Canada and New Zealand do not. The inflation rates in Australia and New Zealand have tended to be higher than those in the United States and Canada. Combining this information with the theoretical model, if Feldstein's (1979, 1980) hypothesis was correct, one would expect land prices to be higher and to have grown faster in Australia and New Zealand than in the United States. In fact, in terms of real domestic currency, if there were any differences, Australian and New Zealand land prices have not grown as fast as those in the United States. The difficulty is to separate the real exchange rate effect from the domestic tax and inflation effects. Perhaps the effects shouldn't be separated. It may be that the more important effect of inflation is through effects on real exchange rates and thus on real net rents. Theory would suggest that any effects of inflation on real exchange rates would be short-lived, and the behavior of the real exchange rates tends to support this view. Unfortunately, more recent land price data are not yet available.

This research has provided some tentative answers to some important questions about land markets. However, the answers lead to further and perhaps more important questions. In particular, why did land rental incomes and exchange rates behave as they did in the mid-1970s and what role did changes in inflation play?

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7. APPENDICES

7.1 APPENDIX A: A PORTFOLIO EQUILIBRIUM MODEL

A.1 INTRODUCTION

In a riskless world, all assets are perfect substitutes and competitive portfolio equilibrium requires the equation of rates of return between assets. Under conditions of uncertainty and risk aversion, assets need not be perfect substitutes and portfolio equilibrium is more complicated, depending on variances and covariances of returns to assets as well as their means. The portfolio equilibrium model developed below is based on that of Feldstein (1980). In the model it is assumed that each of a fixed population of identical individuals maximizes expected utility which, assuming a quadratic utility function, is a linear function of the mean and variance of wealth. Equivalently, and more simply, it is a linear function of the mean and variance of holding-period returns to the portfoio. The optimization problem is to select portfolios of risky land, risky capital and riskless bonds subject to an initial wealth constraint.

The first step is to derive a condition for individual portfolio equilibrium. That condition yields equations for the representative individual's demand for assets as functions of expected values and variances of holding-period returns to the assets. Next these demand functions are aggregated and equated to the asset supply equations. Feldstein (1980) assumed fixed supplies of both land and capital. For simplicity, that assumption is retained. Since the individuals are identical in every respect, the holdings of land and capital per individual are also fixed. The adjustments in the economy are in the holdings of bonds and in the prices of land and capital. The third step is to solve the market equilibrium condition for equations for prices of land and capital (leaving the bond market implicit) as functions of expected values and variances of holding period returns to the assets. Next, equations for returns to assets are defined and used to obtain equations for expected values and variances of returns. Finally, these are substituted into the asset price equations and the comparative static effects of inflation are examined.

A.2 PORTFOLIO EQUILIBRIUM

Each individual has initial endowments (L', K', and B') of land, capital, and bonds and chooses new holdings of each asset (L, K, and B) subject to the wealth constraint:

$$(A.1)\ B + P_l L + P_k K = B' + P_l L' + P_k K'$$

where P_l and P_k are the prices per unit of land and capital. The objective is to maximize expected utility, which is assumed to be quadratic in wealth and thus can be expressed as a linear function of the mean and variance of holding period returns to the portfolio (R_p):

$$(A.2)\ \text{Max } E[U(W)] = E[R_p] - 0.5\gamma V[Rp]$$

where γ is a coefficient of risk aversion. Holding-period returns to the portfolio are defined as:

(A.3) $R_p = R_l L + R_k K + R_b B$

where R_l, R_k, and R_b are defined as the net holding-period returns per unit of land, capital, and bonds. Combining (A.1) and (A.3) by eliminating B, and taking expected values and variances of the result yields:

(A.4) $E[R_p] = E[R_l]L + E[R_k]K + R_b[B'-P_l(L-L')-P_k(K-K')]$

(A.5) $V[R_p]=\sigma_{ll}L^2+\sigma_{kk}K^2+2\sigma_{kl}KL$

where σ_{ll}, σ_{kk}, and σ_{kl} are the variances and covariances of holding-period returns for the land and capital. Substituting (A.4) and (A.5) into (A.2), the first-order conditions for a maximum are:

(A.6a) $0 = E[R_l] - R_b P_l - \gamma[\sigma_{ll}L+\sigma_{lk}K]$

(A.6b) $0 = E[R_k] - R_b P_k - \gamma[\sigma_{kl}L+\sigma_{kk}K]$

Equations (A.6) may be solved for a pair of simultaneous equations for the representative individual's demands for land and capital. By aggregating these across the population and fixing the total stocks of land and capital, the following pair of equations defines the equilibrium asset prices:

(A.7a) $P_l = [E(R_l) - \gamma(\sigma_{ll}L+\sigma_{lk}K)]/R_b$

(A.7b) $P_k = [E(R_k) - \gamma(\sigma_{kl}L+\sigma_{kk}K)]/R_b$

A.3 RETURNS TO ASSETS

Feldstein used real net-of-tax returns to assets. The model is equivalent if nominal returns are used instead (as long as one is consistent) and is simpler. The net of tax nominal returns to the assets are defined as:

(A.8a) $R_b = (1-\tau_y)i$

(A.8b) $R_l = (1-\tau_y)N_l - (1-\tau_c)\Delta P_l$

(A.8c) $R_k = (1-\tau_y)N_k - (1-\tau_c)\Delta P_k$

where τ_y is the income tax rate, τ_c is the effective accrual rate of tax on nominal capital gains, N_l and N_k denote current income to land and capital, ΔP_l and ΔP_k denote amounts of nominal capital gains on land and capital, and i is the market interest rate on bonds. Note that land and capital are treated symmetrically, whereas Feldstein emphasizes the effects of historical cost accounting rules, which make the rate of effective tax on capital income a function of the rate of inflation.

The returns to bonds are certain. The stochastic components in the returns to land and capital are current income and the rate of nominal capital gains. These are defined as follows:

(A.9a) $N_1 = E[N_1] + e$

(A.9b) $\Delta P_1 = E[\Delta P_1] + u$

(A.9c) $N_k = E[N_k] + v$

(A.9d) $\Delta P_k = E[\Delta P_k] + w$

where $U=[e,u,v,w]'$ is a vector of random variables that are jointly distributed with a mean of zero and covariance matrix $V=E[UU']=[\sigma_{ij}]$ for $i,j = e,u,v,w$. Substituting equations (A.9) into equations (A.8), the equations for expected returns and variances of returns are:

(A.10a) $E[R_1] = (1-\tau_y)E[N_1] + (1-\tau_c)E[\Delta P_1]$

(A.10b) $E[R_k] = (1-\tau_y)E[N_k] + (1-\tau_c)E[\Delta P_k]$

(A.10c) $V[R1] = \sigma_{11} = (1-\tau_y)^2\sigma_{ee} + (1-\tau_c)^2\sigma_{uu} + 2(1-\tau_y)(1-\tau_c)\sigma_{eu}$

(A.10d) $V[Rk] = \sigma_{kk} = (1-\tau_y)^2\sigma_{vv} + (1-\tau_c)^2\sigma_{ww} + 2(1-\tau_y)(1-\tau_c)\sigma_{vw}$

(A.10e) $C[R1,Rk] = \sigma_{1k} =(1-\tau_y)^2\sigma_{ev} + (1-\tau_y)(1-\tau_c)[\sigma_{ew}+\sigma_{uv}] + (1-\tau_c)^2\sigma_{uw}$

A.4 THE LAND PRICE EQUATION

After substituting equations (A.10) into equations (A.7), the equations for prices of land and capital are completely specified in terms of the underlying expected values, variances and covariances of the components of the returns to the assets.[1] The equations for land and capital are exact analogues to one another. The equation for the price of land becomes:

$$(A.11)\ P_1 = [(1-\tau_y)E(N_1) + (1-\tau_c)E(\Delta P_1) - C]/(1-\tau_y)i$$

where $C = \gamma[\sigma_{11}L+\sigma_{1k}K]$ and σ_{11} and σ_{1k} are as defined in (A.10c) and (A.10e).

By transforming the equation so that the risk costs term (C) and capital gains (ΔP_1) appear in the denominator, the following land price equation is obtained:

$$(A.12)\ P_1 = E[N_1]/E[D]$$

$$\text{where } D = i + c/(1-\tau_y) - g(1-\tau_c)/(1-\tau_y)$$

This is exactly equivalent to equation (2.11') but with an explicit interpretation of the 'risk premium': c=C/P. This explicit interpretation of the risk premium allows an explicit examination of the possible

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[1] Different specifications result when different definitions of the stochastic components are used. For example, Feldstein (1980) used rates rather than levels of growth of asset prices. That definition leads to involving the asset prices in the variance and covariance terms. Further, he assumed that the mean growth rates of the asset prices were equal, in equilibrium, to the inflation rate.

effects of inflation on the risk premium. The risk premium involves tax rates and a risk aversion parameter that are assumed constant, and variances and covariances. If the variances and covariances were all independent of the inflation rate and all positive (as seems likely), the effect of introducing the risk premium is to dampen, but not reverse whatever effects inflation has on land prices. The variances may not be independent of the rate of inflation. It can be argued that the higher the rate of inflation, the greater the extent of general uncertainty in the economy, including uncertainty about the inflation rate. Should the variances be positively related to the level of inflation, the effect of inflation on land prices would be less positive than in the case of risk neutrality.

This model may easily be extended beyond three assets. One interpretation of the model is that 'capital' represents a composite of all risky assets other than land. Then the model is more general. Some interesting special cases are those in which the risk aversion parameter is zero, the covariance of returns between land and capital is zero (the underlying covariances are zero), or the portfolios are not diversified.

7.2 APPENDIX B: REAL RATES OF RETURN TO FARM REAL ESTATE

B.1 INTRODUCTION

The real rate of return to holding farm real estate is the sum of current rental income as a percentage of the price of farm real estate and the rate of real capital gains. To get net-of-tax real rates of return, these values should be adjusted for income taxes and capital gains taxes. To get ex ante real rates, one should use expected values for current income and the rate of capital gains.

B.2 ESTIMATES

The following tables include both ex ante and ex post rates of return to farm real estate. The figures are gross of income and capital gains taxes. Current net rental rates (gross cash rents minus property taxes and 5 percent annual depreciation on buildings, all divided by the price of farm real estate) are used to proxy for both ex ante and ex post rental rates. Rates of real capital gains are computed as the annual percentage change in the real price of farm real estate (the nominal price divided by the GNP deflator). The actual rate of capital gains during each year is the ex post rate. A moving average of the rates of capital gains over the past thirteen years is used as an estimate of the ex ante rate. The ex ante and ex post rates of return are computed by summing the rates of current rental and the rates of ex ante and ex post capital gains, respectively. Table B.1 includes the average rates for six states (Iowa, Illinois, Indiana, Minnesota, Missouri, and North Dakota) over the period 1963 to 1982. Table B.2 includes the annual averages across the six states from 1963 to 1982.

There are no statistically significant differences in the average ex post rates of returns between the six states studied. Across the six states, the range of means was from 8.6 to 11.8 percent per year. The average was 10.3 percent. If real risk free rates of return before taxes were about 3 percent, these figures imply a risk premium for land of about 7.3 percent to justify the large ex post real rates of return. The average ex ante real rates of return were lower because the thirteen-year moving average of capital gains had a lower mean than the more recent data. The average ex ante rate of return was 9 percent, implying a risk premium on the order of 6 percent, given a risk-free rate of 3 percent. This estimate of the risk premium is not inconsistent with the results of the regression analysis reported in the text. The ex ante rates had much smaller standard errors because the ex ante rates of capital gains had much smaller standard errors, as would be expected. About half the returns were capital gains.

The annual averages show the movements in the real rates of return and their components over time. Between 1963 and 1976 the rental rate ranged between 5.5 and 6.2 percent. The constancy of this rate indicates that land prices grew at roughly the same rate as rental income during that interval. But between 1976 and 1981, the rental rate fell from 5.9 percent to 4.3 percent, indicating that land prices grew faster than net rents during that period. An inspection of the ex post rates of capital gains may provide an

APPPENDIX TABLE B.1

Real Rates of Return to Farm Real Estate by States 1963-1982

State	Current Income (%)	Ex Post Capital Gain(%)	Ex Post Returns (%)	Ex Ante Capital Gain(%)	Ex Ante Returns (%)
IA	5.5 (0.2)[a]	5.0 (2.1)	10.4 (2.2)	3.1 (0.7)	8.6 (0.6)
IL	4.5 (0.1)	4.2 (2.1)	8.6 (2.1)	3.2 (0.5)	7.7 (0.4)
IN	4.9 (0.1)	4.5 (2.1)	9.3 (2.2)	3.4 (0.5)	8.3 (0.4)
MN	6.0 (0.2)	5.2 (1.6)	11.1 (1.6)	3.2 (0.6)	9.1 (0.5)
MO	5.6 (0.1)	4.6 (1.6)	10.2 (1.6)	4.2 (0.4)	9.8 (0.4)
ND	6.7 (0.2)	5.2 (1.7)	11.8 (1.8)	4.1 (0.5)	10.8 (0.5)
Mean[b]	5.5 (0.1)	4.8 (0.8)	10.3 (0.8)	3.5 (0.2)	9.0 (0.2)

[a] Figures in parentheses are standard errors.

[b] This row uses pooled data for the six states.

APPENDIX TABLE B.2

Real Rates of Return to U.S. Farm Real Estate by Year 1963-1982

Year	Current Income (%)	Ex Post Capital Gain(%)	Ex Post Returns (%)	Ex Ante Capital Gain(%)	Ex Ante Returns (%)
1963	5.5	4.2	9.7	2.9	8.4
	(0.4)[a]	(1.0)	(1.1)	(0.3)	(0.6)
1964	5.6	3.3	9.0	2.5	8.2
	(0.4)	(0.6)	(0.6)	(0.6)	(0.7)
1965	5.4	6.6	12.1	2.2	7.6
	(0.3)	(1.4)	(1.1)	(0.4)	(0.5)
1966	5.8	5.5	11.3	2.7	8.5
	(0.5)	(0.8)	(0.9)	(0.3)	(0.6)
1967	5.6	1.7	7.3	3.4	9.0
	(0.4)	(0.4)	(0.8)	(0.4)	(0.5)
1968	5.9	0.6	6.5	3.4	9.2
	(0.5)	(1.2)	(1.6)	(0.4)	(0.6)
1969	5.8	-3.4	2.4	3.2	9.0
	(0.5)	(1.1)	(1.4)	(0.4)	(0.7)
1970	5.8	-2.6	3.2	2.5	8.4
	(0.4)	(0.8)	(0.8)	(0.4)	(0.7)
1971	6.0	1.2	7.2	1.9	7.9
	(0.4)	(1.1)	(1.1)	(0.4)	(0.6)
1972	5.9	5.5	11.4	1.6	7.5
	(0.5)	(0.7)	(0.9)	(0.5)	(0.8)
1973	5.8	17.1	22.9	1.9	7.7
	(0.4)	(1.7)	(2.1)	(0.5)	(0.7)
1974	6.2	10.6	16.7	3.4	9.5
	(0.6)	(4.0)	(4.4)	(0.4)	(0.7)
1975	6.1	16.6	22.7	4.1	10.2
	(0.3)	(1.7)	(1.7)	(0.3)	(0.6)
1976	5.9	21.5	27.4	5.1	11.0
	(0.3)	(3.4)	(3.2)	(0.3)	(0.6)
1977	5.2	4.1	9.3	6.5	11.7
	(0.3)	(1.5)	(1.5)	(0.3)	(0.3)
1978	4.8	6.7	11.5	6.5	11.4
	(0.2)	(0.7)	(0.8)	(0.2)	(0.3)
1979	4.6	5.8	10.4	6.5	11.1
	(0.2)	(1.6)	(1.7)	(0.3)	(0.4)
1980	4.4	-1.0	3.4	6.6	10.9
	(0.2)	(1.4)	(1.4)	(0.3)	(0.4)
1981	4.3	-11.4	-7.1	6.4	10.6
	(0.2)	(2.1)	(2.3)	(0.4)	(0.4)

[a] Figures in parentheses are standard errors of means

explanation. Until 1972, rates of capital gains fluctuated between -3.4 and 6.6 percent. Suddenly, in 1973 land prices grew 17 percent, and in the next three years they grew another 10.6 percent, 16.6 percent and 21.5 percent. During that interval ex post real rates of return to land exceeded 15 and even 20 percent. One explanation is that actual and prospective land owners extrapolated beyond this bonanza in land price growth and bid the price beyond its equilibrium value in the succeeding few years. By 1979 the rate of return to land had fallen towards its more normal value of about 10 percent. In 1980 and 1981 land prices fell, in real terms, by 1 and then by 11.4 percent. This may be explained in part by a real decline in net rents per acre. Part of the explanation may be that land prices had overshot their equilibrium values and a downward adjustment was required.

The ex ante rates of return tell a similar story. If landowners indeed base their expectations of capital gains on a long moving-average, they will miss turning points in actual capital gains. If expectations were formed this way, a violent surge in rental income would lead to a delayed reaction, then land prices overshooting equilibrium, and finally a downwards readjustment. That is the pattern of land prices in recent years. The ex ante rates of return are much more stable and have much smaller standard errors than the ex post ones, as one would expect. Even in the last few years, when ex post rates of return were negative, the ex ante rates remained high at around 11 percent.

7.3 APPENDIX C: A SIMPLE RATIONAL EXPECTATIONS MODEL

C.1 INTRODUCTION

The most vexing problem in the development of empirical models of land prices is the modelling of expectations. In the text, the entire future of net benefits of owning land is represented as next year's capital gains. This doesn't change or remove the problem of modelling expectations. It enters as the problem of measuring expected capital gains. The chosen approach is to use distributed lag models of past capital gains to represent expected future capital gains. This appendix presents an alternative approach to representing the entire future of net benefits, using rational expectations theory, and leads to an alternative model. It is intended to be suggestive only of the alternative approach, not a workable model. It is based largely on Phipps (1982).

C.2 THE MODEL

Equation (2.1') in Chapter 2 - augmented with a random error term - defines the present value (price) of land as:

$$(C.1)\quad P_t = \sum_{n=0}^{\infty} E_t[B_{t+n}]\partial^{n+1} + e_{1,t}; \quad e_{1,t} \text{ is distributed } (0,\sigma^2_1)$$

where P_t is the price of land in time t, B_{t+n} is the net benefit of owning land in time t+n, ∂ is the discount factor $(1+\rho)^{-1}$, and E_t denotes expectations at time t, conditioned on information available at time t.

Now, let us define all of the variables as expressed in real terms and, in particular, assume a constant real discount factor (rate):∂. Next, assume that the net benefits are generated by a first-order autoregressive process with a shift variable (X) that follows a random walk:

$$(C.2)\ B_t = \alpha B_{t-1} + \beta X_{t-1} + e_{2,t}; \quad e_{2,t} \text{ is distributed } (0,\sigma^2{}_2)$$

$$(C.3)\ X_t = X_{t-1} + e_{3,t}; \quad e_{3,t} \text{ is distributed } (0,\sigma^2{}_3)$$

where α and β are constant parameters. Projecting recursively (using Wold's chain rule of forecasting) combining equations (C.2) and (C.3) yields:

$$(C.4)\ E_t[B_{t+n}] = \alpha^{n+1}B_{t-1} + \beta \sum_{i=0}^{n} \alpha^i X_{t-1}$$

Substituting (4) as a rational expectation into (1) gives:

$$(C.5)\ P_t = \sum_{n=0}^{\infty} \partial^{n+1}[\alpha^{n+1}B_{t-1} + \beta \sum_{i=0}^{n} \alpha^i X_{t-1}] + e_{1,t}$$

$$= B_{t-1} \sum_{n=0}^{\infty}(\alpha\partial)^{n+1} + \beta X_{t-1} \sum_{n=0}^{\infty} D^{n+1} \sum_{i=0}^{n} \alpha^i + e_{1,t}$$

It can be shown (see Phipps (1982, p.161) that the above two infinite series are equivalent to:

(C.6) $P_t=[\alpha\partial/(1-\alpha\partial)]B_{t-1} + \beta\{[\alpha\partial/(1-\alpha\partial)] + [\partial/(1-\partial)(1-\alpha\partial)]\}X_{t-1} + e_{1,t}$

if $|\alpha\partial|<1$ and $|\partial|<1$

C.3 APPLICATIONS

One could fit (C.2), (C.3), and (C.6) jointly with non-linear cross-equation restrictions on the parameters. Because only first-order autoregressions were assumed, the entire future (and thus the price of land) depends only on last year's values for exogenous variables. Many simplifying assumptions were made in order to impose rational expectations, and this may be worse than using a less sophisticated expectations model. The model could be made more complicated in several obvious ways. For example, we could assume higher order autoregressions, which would lead to more complicated (perhaps unsolvable) final equations. One could (as Phipps did) involve shift variables in the land price equation (stock of farmland, nonfarm factors) with autoregressions generating them. One could expand net benefits into their components, allowing different autoregressive processes for each of the components. This is obviated by Phipps because he ignores taxes so that land rents are equivalent to net benefits.

7.4 APPENDIX D: AN EQUIVALENT CONTINUOUS RATE OF CAPITAL GAINS TAX

D.1 CONTINUOUS TAX

Assume tax is paid continuously at a rate τ_c on unrealized capital gains over a finite holding period of T years. The present value of the stream of capital gains taxes over the next T years at time t is:

$$\text{(D.1)}\quad TAX_t = \int_{n=0}^{T} \tau_c \dot{V}_{t+n} e^{-\rho n} dn$$

where $\dot{V}_t$ is the change in the value of land in time t, and ρ is the nominal rate of discount. Assuming a constant growth rate of land prices at a nominal rate, g, the solution to (D.1) is:

$$\text{(D.2)}\quad TAX_t = \tau_c g V_t e^{-\rho T}[e^{\rho T} - e^{gT}]/(\rho - g)$$

D.2 DISCRETE TAX

Alternatively, assume capital gains tax is paid at a rate c only upon realization of the gains in time t+T. Then the formula for the present value of the tax is:

$$\text{(D.3)}\quad TAX_t = c[V_T - V_t]e^{-\rho T}$$

Making the same assumption as above, that land prices are growing at a continuous rate g, the solution to (D.3) is:

$$\text{(D.4)}\quad TAX_t = cV_t e^{-\rho T}[e^{gT} - 1]$$

D.3 EQUATING THE TAXES

In fact, capital gains taxes are paid only upon realization of the gains. Equating (D.2) and (D.4) yields the 'equivalent' rate of continuous capital gains tax - which would yield an equivalent present value - given c:

$$(D.5)\ \tau_c = c(\rho - g)[1 - e^{gT}]/g[e^{\rho T} - e^{gT}]$$

Thus, the equivalent rate of continuous tax is proportional to the rate of tax on realized nominal capital gains; the proportion depends on the growth rate of land prices, the discount rate, and the holding period. Under the maintained hypothesis that $\rho > g$ (required for solution of the present value of land), τ_c will be positive when g is positive. The effective rate of tax declines with holding period ($d\tau_c/dT < 0$). As T approaches ∞, τ_c approaches 0. That is, the present value of taxes on realized capital gains approaches zero as the holding period approaches infinity. The tax rate decreases as the discount rate increases ($d\tau_c/d\rho < 0$). The effective tax rate increases as the growth rate increases ($d\tau_c/dg > 0$).

D.4 LIKELY MAGNITUDES FOR THE CONTINUOUS TAX RATE

The maximum rate of capital gains tax under current U.S. law is 20 percent (40 percent of the maximum income tax rate); the maximum prior to recent changes in tax law was 35 percent (50 percent of the maximum income tax rate). In the calculations below a value of 20 percent is used for c - the rate of tax on realized nominal capital gains - and this value is probably larger than would be faced by most land owners under current or previous law. For illustrative purposes, the following values for the variables in equation (D.5) are used to compute a range of 20 effective continuous rates of tax (τ_c): (a) Holding period: T=10, 20, or 30 years. (b) Rate of Nominal Capital Gains: g=5 percent or 10 percent per year. (c) Certainty Equivalent Nominal Interest Rate: ρ=8 percent, 9.9 percent, 12 percent, or 15 percent. The effective continuous rates of capital gains tax are shown in Table D.1.

As suggested by the comparative statics, the effective continuous tax rates decrease generally from the top to bottom of the table and from right to left: as the holding period or the nominal interest rate increase, the present value of future taxes decreases and the equivalent rate of tax falls. Also, a higher nominal growth rate of land prices implies a higher effective rate of continuous tax, ceteris paribus. For the range of variables tried, the computed tax rates range from 2 percent to 14 percent. Over the past twenty years, a nominal growth rate of land prices of 10 percent per year and a certainty equivalent nominal interest rate of between 10 and 15 percent are representative. For holding periods of 20 years, a continuous tax rate of between 4 percent and 10 percent seems plausible. A figure of 5 percent may be a reasonable approximation.

APPENDIX TABLE D.1

Effective Rates of Continuous Capital Gains Tax

	Holding Period					
	10 years		20 years		30 years	
Nominal Interest(ρ)	g=.10	g=.05	g=.10	g=.05	g=.10	g=.05
0.080	-	13.5	-	9.2	-	6.3
0.099	12.7	12.2	8.7	7.4	6.4	4.5
0.120	11.4	10.9	7.0	5.8	4.6	3.0
0.150	9.7	9.1	5.0	4.0	2.7	1.6

Note: g is the annual nominal rate of capital gains.

7.5 APPENDIX E: THE EFFECTS OF WEDGES IN THE LAND OWNERSHIP MARKET

E.1 INTRODUCTION

We may interpret equation (2.11′) in two ways. In the context of the portfolio equilibrium and present value models presented in the text it has been interpreted as a condition for equilibrium in an aggregate land market, based on the optimizing behavior of a representative individual. All landowners are assumed to be identical in all relevant respects in the formal derivation of the condition for aggregate portfolio equilibrium. Alternatively, we may interpret it as the equation for the maximum bid price that a particular individual would be willing to pay for land. For example, see Harris and Nehring (1976), Lee and Rask (1976), and Plaxico and Kletke (1980).

The latter interpretation permits us to consider differences between individuals' maximum bid prices that may arise from differences in expectations, tax rates, discount rates (credit), or risk preferences. Considerations of these types may be necessary if we are to explain changes in farm size distribution, tenure patterns, or the occurrence of any transactions in the land ownership market. The aggregative interpretation of the model abstracts from these differences and leaves us unable to explain many land market phenomena. The purpose of this appendix is to consider the implications of relaxing some assumptions.

E.2 WEDGES AT THE LEVEL OF THE INDIVIDUAL LANDOWNER

Let us, for the moment, interpret equation (2.11′) as the equation for the maximum bid price that a particular individual would be willing to pay for land. Although it is not explicit in the equation, we may suppose that the bid price would be a decreasing function of the quantity of land owned by the individual.[1]

We may therefore think of equation (2.11′) as an individual's inverse demand function. Aggregating such functions across all owners and would-be owners would yield an aggregate demand. For simplicity, let us assume a fixed stock (perfectly inelastic supply) of land in agriculture. The price of land is given by the intersection of the aggregate demand with the supply.

As specified in (2.11′), the demand incorporates the effects of the prospect of taxes on future capital gains. We have shown that, for any given holding period, there is an equivalent rate of continuous capital gains tax to be used to compute future capital gains tax obligations. In fact, however, capital gains taxes are paid only upon realization of the gains. The model may be modified to incorporate the effects of accumulated capital gains tax obligations and any other selling costs that drive a wedge between buying and selling price for land.

In Panel 1a of Figure E.1, D_j is individual j's demand for land - as implied by equation (2.11′) - incorporating the effects of the

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[1] In equation (2.11′) this is implicit because the risk costs term C(t) is increasing in the quantity of land owned by the individual if we apply Feldstein's (1980) definitions. Alternatively, it could be made explicit by relaxing other assumptions. For instance, we may allow the interest rate to be an increasing function of the amount of land owned (though it may be more plausibly a function of the amount to be purchased). An extreme case would be Shalit and Schmitz's (1982) absolute credit rationing model. The rental income may be a decreasing function of the quantity of land owned.

prospect of future capital gains and taxes on them. Now, suppose the individual owns S_j of land. Ignoring selling costs, at prices above P_j the individual would be a net seller; at prices below P_j, a net buyer. The introduction of selling costs causes the demand to become discontinuous at S_j. In order to sell land, the individual requires compensation for both the value of keeping the land and the costs of selling. The distance between the two demand curves D_j and D_j' represents the selling costs. The overall demand is $D_j'abD_j$.

We may split the demand into two parts. The upper segment is the reservation demand for owned land whose mirror image around S_j in Panel 1b is the owner's excess supply. The lower segment is the owner's excess demand in Panel 1c.

E.3 WEDGES AT THE AGGREGATE LEVEL

Summing these excess supplies and demands across all owners and would-be owners of land yields aggregate excess supply (XS) and demand (XD) for land. The intersection of these curves in Figure E.2 yields a market clearing price P and transfers of T. In the absence of selling costs, the excess supply would be lower at XS', the land price would be P' and transfers would be T'.

This simple analysis has some interesting implications. First, selling costs increase the price of land and reduce the amount of transactions. In the context of Figure E.1, a price of land between a and b would leave individual j content to hold his current stock Sj. Large selling costs may therefore help to explain the 'thinness' of the land transactions market. Second, the existence of any transactions requires differences among individuals. A buyer's benefits of owning

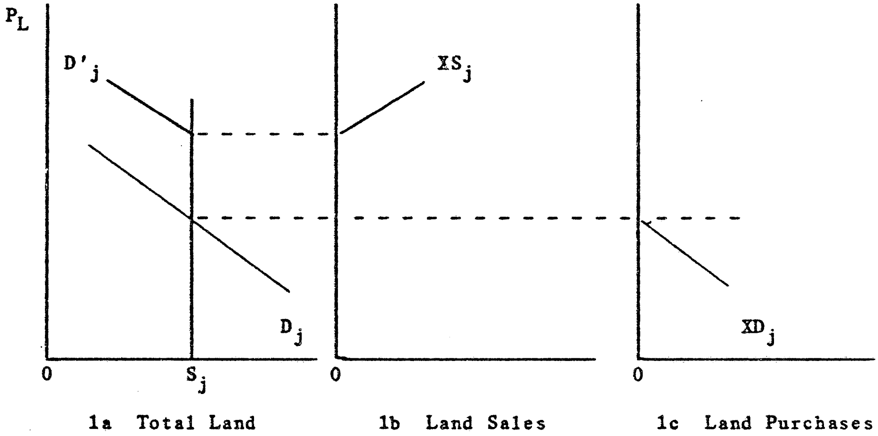

Figure E.1: Wedges at the Level of the Individual Landowner

Note: P_L = the price of land.

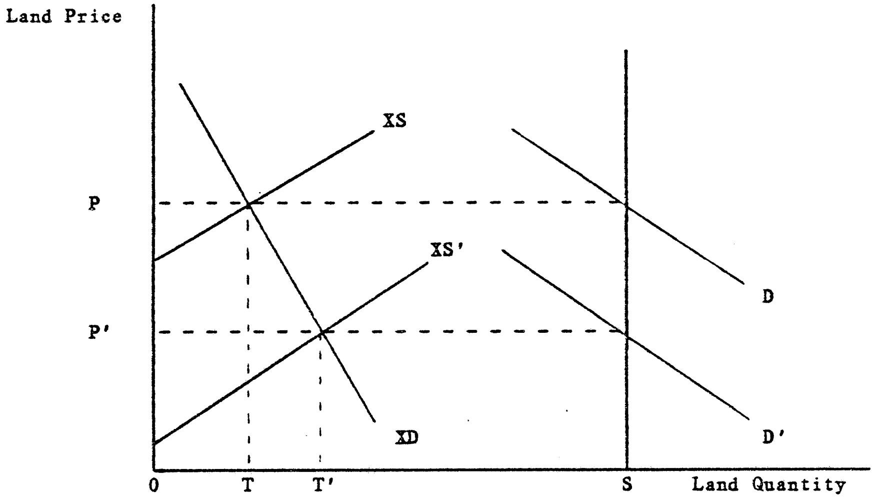

Figure E.2 Wedges in the Aggregate Land Market land must exceed the seller's by at least the amount of any transactions costs. The selling costs are distributed between buyers and sellers according to their elasticities of demand (excess supply and demand) for land. Third, continued transactions over time require relative shifts of the excess demand and supply curves.

To see this last point, consider Figure E.3. Panel 3a corresponds to Figure E.2. Panel 3b represents the same market in the subsequent period. Once equilibrium has been established in the first period, unless any changes have occurred in the underlying demands, there will be no transactions in the second period. Transactions require an upwards shift of the excess demand relative to the excess supply.

Continuing transactions require continual shifts of the excess demand relative to the excess supply (reservation demand) of current owners. To explain this phenomenon in principle would require an explicitly dynamic model of the behavior of landowners and, probably, the use of some concept of the 'economic age' of land owners such as that used by Shalit and Schmitz (1982).

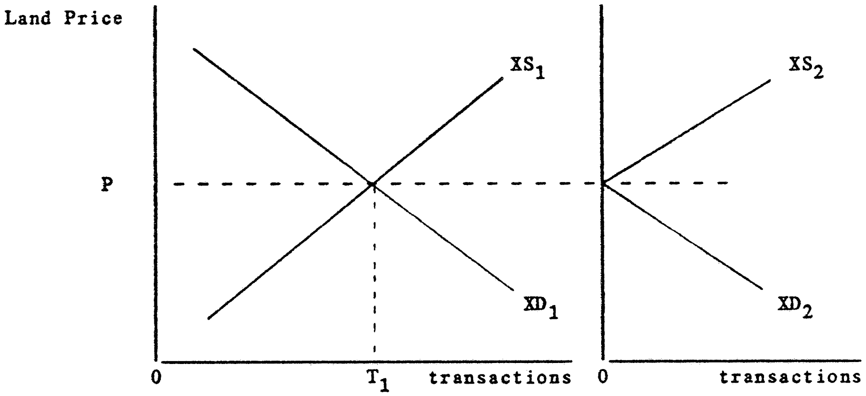

Figure E.3 Two-period Equilibrium in the Land Transactions Market

7.6 APPENDIX F: INTERNATIONAL PRODUCT PRICE EQUALIZATION

F.1 INTRODUCTION

The Factor Price Equalization Theorem assumes equalization of product prices through free international trade in commodities. The theorem abstracts completely from currency units and therefore from any issues of exchange rates. The assumption of product price equalization is an abstraction from transport costs, trade barriers, and so on.

The tests for equalization of the growth rates of land prices between countries are joint tests of the hypothesis of product price equalization and some other assumptions. The results were somewhat sensitive to the approach taken to convert currencies into comparable units. This appendix presents direct tests of the hypothesis of agricultural product price equalization between the United States, Canada, Australia, and New Zealand. Some further issues regarding the use of market exchange rates and purchasing power parity indexes for international comparisons are raised in this context, and some implications for the land price comparisons are drawn.

F.2 METHODOLOGY AND DATA

The approach for empirical work is to convert product price measures into comparable currency units and fit regressions of the following form:

$$(F.1)\ P_{cj} = \alpha_{cj} + \beta_{cj}\ P_{cu}$$

where P_{cj} = currency c product price in country j,

P_{cu} = currency c product price in the United States,

and α_{cj} and β_{cj} are the parameters to be estimated. Under the null hypotheses of product price equalization and purchasing power parity, the parameters are $\alpha_{cj}=0$ and $\beta_{cj}=1$ for all currencies (c) and countries (j). These two hypotheses are tested using t-tests on the parameter estimates.

One would expect product price equalization to hold more closely for more narrowly defined commodities because the effects of aggregating across different products having different prices would be reduced. Further, one would expect f.o.b. export prices to be more closely equated than prices received by farmers because the latter would include the effects of domestic taxes, price support programs, marketing margins, and so on, which are likely to differ internationally.[1]

Regressions of the form of (F.1) were fit to data for the period 1961 to 1980 of (a) indexes of prices received by farmers in the four countries (i.e., indexes across the broad aggregate of total agriculture), base 1961=100; and (b) f.o.b. export prices for wheat for the United States (No. 2 Hard Red Winter, 13 percent, Gulf), Australia (FAQ and, from 1974, Australian Standard White), and Canada

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[1] Some discussion of these issues in a closely related context, is contained in T. Grennes, P. R. Johnson, and M. Thursby: 'A Skeptical Note on the Law of One Price', unpublished. P.R. Johnson, T. Grennes and M. Thursby consider effects of exchange rates on wheat prices, and thus land prices, in 'Devaluation, Foreign Trade Controls, and Domestic Wheat Prices' American Journal of Agricultural Economics 59(1977):619-627.

(No. 2 Manitoba Northern and, from August 1971, No. 1 Canadian Western Red Spring, 13.5%, St. Lawrence).[2]

The approach for currency conversions parallels the approach taken in Chapter 4. The nominal prices in domestic currencies are converted using market exchange rates into (a) nominal SDRs (SDR), (b) nominal U.S. dollars (NUS), and (c) real U.S. dollars (RUS) by deflating NUS by the U.S. CPI base (1975=100). The alternative measures based on the notional exchange rate (U.S. CPI divided by the other country's CPI) are (d) nominal U.S. dollars (NPP) and (e) real domestic dollars (RPP), obtained by dividing NPP by the U.S. CPI. The results of the 25 regressions for the different countries, price measures, and currency conversions, are reported in Tables F.1, F.2, F.3, and F.4.

F.3 RESULTS

For the regressions of indexes of prices received by farmers based on market exchange rates, only one slope (Canada NUS) was significantly different from 1.0 at the 5 percent significance level. None of the intercepts were statistically significant. These results are reported

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[2] The indexes of prices received by farmers were obtained from the following sources:

Australia - Quarterly Review of the Rural Economy, Bureau of Agricultural Economics, Australian Government Publishing Service, 1960 to 1983; the data are for the state of Victoria.

Canada and New Zealand - FAO Production Yearbook, United Nations, New York, 1960 to 1983;

United States - Agricultural Statistics, 1960 to 1983.

The wheat prices were obtained from World Wheat Statistics, International Wheat Council, London, 1960 to 1983.

in Table F.1. For the other regressions of indexes of prices received by farmers (Table F.2), all of the intercepts were significantly different from zero at the 10 percent significance level, all but one at the 5 percent level.

The wheat price regressions are reported in Tables F.3 and F.4. In the case of Australia, the results for the wheat price regressions are similar to those for the price indexes. Product price equalization is accepted for the measures based on market exchange rates and strongly rejected for the other measures. The results for Canada are different. All of the slopes in the Canadian wheat price regressions are significantly greater than 1.0 at the 10 percent significance level, all but one at the 5 percent level. It has been suggested that Canadian wheat is of significantly higher quality than U.S. and Australian wheat. For Canada, neither of the alternative currency conversions is obviously better. A part of the explanation may be that Canadian consumer prices have moved approximately in parallel with U.S. consumer prices. The real exchange rate between U.S. and Canadian dollars fell, but only slightly, during the sample period (see Table 4.6). In contrast, the U.S. dollar real exchange rates for Australian and New Zealand dollars rose dramatically during the 1970s.

Overall, the results are: (a) for the measures based on market exchange rates (SDR, NUS, RUS), product price equalization generally is not rejected; (b) for the measures based on the notional purchasing power parity exchange rate (NPP, RPP), product price equalization is generally rejected; and (c) the statistical properties are generally better for the wheat price regressions than they are for indexes

APPENDIX TABLE F.1

Regressions of Prices Received by Farmers in Australia, Canada, and New Zealand against Prices Received by U.S. Farmers; Based on Market Exchange Rates 1961-1980, 1960=100

Producer Price Index	Parameter Estimates α	β	R^2	D.W.
Australia (SDR)	-0.6 (13.0)[a]	1.02 (0.10)	0.86	1.08
New Zealand (SDR)	-4.9 (14.6)	0.98 (0.11)	0.82	0.71
Canada (SDR)	13.5* (7.8)	0.88* (0.06)	0.93	0.88
Australia (NUS)	-4.6 (11.1)	1.05 (0.07)	0.93	1.07
New Zealand (NUS)	-8.8 (12.1)	1.01 (0.08)	0.91	0.73
Canada (NUS)	13.1* (6.7)	0.89** (0.04)	0.96	0.83
Australia (RUS)	-13.5 (22.2)	1.15 (0.22)	0.60	1.17
New Zealand (RUS)	-22.3 (26.2)	1.17 (0.26)	0.52	0.68
Canada (RUS)	-2.0 (13.6)	1.01 (0.14)	0.75	1.13

[a] Figures in parentheses are standard errors of estimates. SDR=nominal SDRs, NUS=nominal U.S. dollars based on market exchange rates, RUS=real (1975=100) U.S. dollars=NUS/U.S. CPI. For the intercepts (α), we test for significant differences from zero; for the slopes (β), we test for significant differences from 1.0. Significant differences at 10 percent confidence are denoted * and significant differences at 5 percent are denoted **.

APPENDIX TABLE F.2

Regressions of Prices Received by Farmers in Australia, New Zealand, and Canada against Prices Received by U.S. Farmers; Based on PPP Exchange Rates 1961-1980, 1960=100

Producer Price Index	Parameter Estimates		R^2	D.W.
	α	β		
Australia (NPP)	41.5**	0.61**	0.79	0.76
	(11.8)	(0.07)		
New Zealand (NPP)	21.8**	0.73**	0.90	0.92
	(8.8)	(0.06)		
Canada (NPP)	8.6**	0.95*	0.98	1.89
	(3.9)	(0.03)		
Australia (RPP)	71.8**	0.19**	0.02	0.50
	(32.4)	(0.33)		
New Zealand (RPP)	45.2*	0.43**	0.18	0.78
	(22.1)	(0.22)		
Canada (RPP)	20.1**	0.81*	0.81	1.46
	(9.1)	(0.09)		

[a] Figures in parentheses are standard errors of estimates. NPP is defined as the nominal producer price index for any country mutiplied by the ratio of the U.S. CPI (1975=100) to the country's CPI (1975=100). RPP is defined as NPP divided by the U.S. CPI. For the intercepts (α), we test for significant differences from 0, for the slopes (β), we test for differences from 1.0. Significance at 10 percent is denoted *, ** denotes significant at 5 percent.

APPENDIX TABLE F.3

Regressions of Australian and Canadian f.o.b. Wheat Export Prices against U.S. Wheat Export Prices; Based on Market Exchange Rates 1961-1980

Dependent Wheat Price	Parameter Estimates α	β	R^2	D.W.
Australia (SDR)	-4.3 (3.4)	1.01 (0.04)	0.98	1.6
Canada (SDR)	-3.9 (2.0)	1.19** (0.02)	0.99	1.6
Australia (NUS)	-4.8 (3.2)	1.01 (0.03)	0.98	1.7
Canada (NUS)	-2.9 (2.0)	1.17** (0.02)	0.99	1.5
Australia (RUS)	-0.09 (0.06)	1.04 (0.05)	0.96	1.4
Canada (RUS)	-0.07 (0.04)	1.20** (0.04)	0.98	1.5

Note: for explanation of variables in this table, see footnotes to Appendix Table F.1.

APPENDIX TABLE F.4

Regressions of Australian and Canadian f.o.b Wheat Export Prices against U.S. Wheat Export Prices; Based on PPP Exchange Rates, 1961-1980

Dependent Wheat Price	Parameter Estimates α	β	R^2	D.W.
Australia (NPP)	18.3** (2.7)	0.64** (0.03)	0.97	1.3
Canada (NPP)	-1.03 (4.3)	1.22** (0.04)	0.98	0.8
Australia (RPP)	0.32** (0.08)	0.58** (0.07)	0.78	0.6
Canada (RPP)	0.10 (0.07)	1.17* (0.06)	0.95	1.1

Note: for explanation of entries in this table, see the footnotes to Appendix Table F.2.

of prices received. These results parallel the results for land price growth rates reported in Chapter 4, where the only significant differences between countries were for measures based on the notional (purchasing power parity) exchange rate. The results of the International Comparisons Project support the use of market exchange rates as a suitable proxy for purchasing power parity between countries earning comparable per capita incomes. With this in mind, the results here may be interpreted as suggesting that the ratio of CPIs is a poor proxy for purchasing power parity between the United States and both Australia and New Zealand; it may be a better proxy for purchasing power parity between the United States and Canada.