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FACTOR PRICE EQUALISATION AMONG INTERNATIONAL FARMLAND MARKETS

JULIAN M. ALSTON and PAUL R. JOHNSON*
Department of Agricultural Economics, University of California, Davis, CA 95616, USA
North Carolina State University, Raleigh, NC, USA

One of the major components of the 'modern' or 'Heckscher-Ohlin' theory of international trade is the 'Factor Price Equalisation Theorem': international trade equalises factor rental prices between countries or regions. This theorem holds exactly under certain assumptions but most of the literature suggests only a tendency towards factor price equalisation because at least some of the assumptions are thought to be violated.[1] In the static context in which this theory is written, this means that factor prices will be more nearly equalised than in the complete absence of trade. Thus, a tendency towards product price equalisation through partial rather than complete arbitrage in products may mean, for instance, that international factor prices are partially, but not perfectly, equalised. Whether or not the assumptions are violated, the strength of the tendency towards factor price equalisation is an empirical question that might be answered by testing the theorem directly.[2]

The purpose of this paper is to seek evidence of factor price equalisation among agricultural land markets in Argentina, Australia, Canada, New Zealand and the United States. There are some measurement problems. One of these relates to the choice of exchange rate to convert prices to comparable units. Market exchange rates are used in this study but some reservations are raised.[3] A second problem is that land is by no means a homogeneous factor of production either within or among countries. To eliminate some effects of variations in land quality we compare growth rates rather than levels; this means that we are testing for equalisation of relative rental prices of land among countries rather than absolute equalisation of factor prices. In the first part of the empirical work, some data on agricultural land rents for some US states are used to study

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[1] The theorem was first proposed by Heckscher (1919). These arguments were extended by Ohlin (1933), and proved by Samuelson (1948, 1953, 1967). More detail may be found in Chacholiades (1978, ch. 10), Chipman (1966) and Leamer (1984).

[2] Alston (1984) and Alston and Johnson (1985) tested for international product price equalisation, a key assumption underlying the factor price equalisation theorem. The evidence is in favour of equalisation of both indexes of prices received by farmers and wheat prices between Argentina, Australia, New Zealand and the United States, but against product price equalisation between Canada and the other countries. None of the other underlying assumptions has been tested directly.

[3] Alston (1984) and Alston and Johnson (1985) discuss this issue in detail and provide some results using Purchasing Power Parity Indexes instead of market exchange rates. These results tend to favour the latter currency conversion.

factor price equalisation among US states. Unfortunately land rent data are not generally available, but under certain additional assumptions factor price equalisation implies land price equalisation, and we may use land prices as a proxy for land rents.[4]

In the last and main part of the empirical work, growth rates of land prices are compared internationally. The international comparisons use data for the United States, Canada, Argentina, New Zealand and Australia. Compared with most of the world, these countries have much in common. They are all net exporters of agricultural products. The United States, Canada, Argentina and Australia have been dominant exporters of wheat. All five countries export beef, especially the United States, New Zealand, Argentina 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 five countries trade in agricultural products with one another and with other countries.

Equalisation of Land Rents

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 (Lancaster 1966; Rosen 1974). 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 characteristics will also vary. Given different proportions of characteristics in different acres of land, relative composite rental prices for land will vary as product prices vary.

Ideally, one would test for equalisation of the prices of the characteristics of land, but to measure the relevant characteristics would be difficult. Even under factor price equalisation, one should not expect equalisation of the rental prices of different acres of land in absolute terms. The approach for the empirical work used here is to test for equalisation of the growth rates of factor prices. This is a joint test of factor price equalisation 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 equalisation of the per acre rental prices is defined as

$$R_k = E_{kj} R_j \tag{1}$$

[4] One of these assumptions is that inflation has no real effects on land prices. Feldstein (1979, 1980) hypothesised that when income and capital gains are taxed differentially, land prices should increase in real terms when the inflation rate increases. Analysis by Alston (1986) and Burt (1986) tended to reject this hypothesis.

where R denotes land rents and E_{kj} is the exchange rate of currency j in terms of currency k. Now suppose different acres of land differ in their total endowments of factors but have the same proportions of factors. Then factor price equalisation implies equalisation of the growth rates of the land rents between the countries, after currency conversion. That is,

$$(2) \qquad R_k = b_{kj}E_{kj}R_j \text{ and } \mathrm{dln}(R_k) = \mathrm{dln}(E_{kj}R_j)$$

where b_{kj} is a constant of proportionality that converts acres of land in country j to equivalent acres in country k.

Although complete factor price equalisation implies equalisation of the growth rates of land rents, the converse need not hold. Our constant of proportionality (b_{kj}) might conceal differences in rents other than those due to quality differences. Only when land rents are equal in the base period, as implied by factor price equalisation, does factor price equalisation in subsequent periods imply equalisation of the growth rates. Conversely, equalisation of growth rates over time implies factor price equalisation only when land rents were equal to begin with. Differences in land quality prevent the use of data on rent levels to resolve this problem.

The null hypothesis is that factor price equalisation holds in general as a long-run tendency, with departures from factor price equalisation occurring as transitory short-run phenomena. The data begin in 1961 following a decade of stability in the world agricultural economy during which, it is reasonable to assume, factor rental prices would have equilibrated. On the other hand, the 20 years of data to be analysed include periods of great turbulence, especially in international markets, with the middle 1970s witnessing unprecedented real growth in land rents and land prices in the US. In the absence of factor price equalisation there is little reason to anticipate any correlation between the growth rates of land rents in the US and in other countries. On the other hand, equalisation of growth rates of land rents would be consistent with equalisation of the levels of land rents in both 1961 and thereafter.

Land Price Equalisation

Land rent data are not available to apply the model in equation (2) for international comparisons, but some land price data are available. In this section, the relationship between land rents and land prices and the conditions under which factor price equalisation leads to land price equalisation are established.

An equation for the nominal price of land in a particular country k is:

$$(3) \qquad V_k = R_k/D_k$$

where V is the price of land, R is income to land and D is the 'discount factor'.[5] For present purposes, R is defined as the *ex ante* gross value of the marginal product of land and all of the other factors affecting land prices appear 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

[5] As shown by Alston (1984), this equation may be derived by solving for the present value of owning land (Melichar 1979), solving an optimal control problem (Phipps 1982) or solving a portfolio equilibrium problem (Feldstein 1979, 1980). The different approaches, depending on assumptions, yield different interpretations of the discount factor.

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 Equalisation Theorem' applies explicitly to factor rental prices: equalisation of marginal value products of factors. It implies asset price equalisation only if the discount factors are equated along with the rental prices. Factor price equalisation would imply equalisation 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 equalisation would imply equalisation 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 the assumption of factor price equalisation [equation (2)] with the land price equation (3) yields

$$V_k = b_{kj}E_{kj}R_j/D_k = b_{kj}E_{kj}V_jD_j/D_k \tag{4}$$

Taking logarithms of equation (4) and totally differentiating yields

$$\mathrm{dln}\, V_k = \mathrm{dln}(E_{kj}V_j) + \mathrm{dln}(b_{kj}) + \mathrm{dln}(D_j/D_k) \tag{5}$$

In equation (5) the growth rates of land prices are equalised between countries when land rental prices are proportional $[\mathrm{dln}(b_{kj}) = 0]$ and the discount factors are proportional $[\mathrm{dln}(D_j/D_k) = 0]$.

Appropriate data on rental incomes to land are available for some US states but not for other countries. However, some data on land prices are available for US states, provinces of Canada, and by types of land use in Argentina, Australia and New Zealand.[6] Using land prices rather than rental incomes avoids some problems of the measurement of rental income, especially where non-farm factors may be important. Using growth rates rather than levels involves some adjustment for quality differences so that one cannot test for absolute equalisation of land prices per acre. At the same time, however, equalisation of growth rates of land prices over time implies equalisation of the levels of land prices only if land prices were equal to begin with. As with land rents, it is assumed that land prices were equal in 1961 in order to use growth rates to test for equalisation of land prices during the 1960s and 1970s.

Empirical Results Using Only US Land Rents and Land Prices

The analysis reported in Table 1 uses only US data. The growth rates reported in Table 2 are nominal exponential growth rates of gross rental income to land and land prices over the interval 1961 to 1980. They were estimated by ordinary least squares regressions of the natural logarithms of the variables against years from 1961, for five US cornbelt states. These are states for which acceptable cash rent data were available and among which non-farm influences on land markets are likely to have been small.

[6] The data were provided generously by Charles Barnard of the NERD, Economics Research Service of the USDA, Peter Bushnell of the New Zealand Ministry of Agriculture and Fisheries, Pip Bruyn of the Department of Agriculture in Victoria, Australia, Willem Van Vuuren of the University of Guelph and Marcos Gallacher of the University of Buenos Aires. Some series of Brazil were obtained also, but were excluded from the analysis due to doubts about data quality. Copies of the data may be obtained from the authors.

TABLE 1

Annual Nominal Exponential Growth Rates of Land Prices and Rents for five US Cornbelt States (1961-1980)

	Growth rates		Levels in 1980	
State	Prices	Rents	Prices	Rents
	%	%	US$/acre	US$/acre
Iowa	10.53	9.62	1810	96.0
	(0.81)[a]	(0.39)		
Missouri	10.20	8.50	878	50.5
	(0.45)	(0.34)		
Ohio	8.20	9.32	1678	72.0
	(0.68)	(0.50)		
Indiana	9.89	8.84	1833	94.0
	(0.79)	(0.52)		
Illinois	9.82	8.56	2013	99.0
	(0.77)	(0.44)		
Pooled[b]	10.06	8.97		
	(0.71)	(0.44)		

[a] Figures in parentheses are standard errors.
[b] Pooled estimates are the mean of the growth rates and the pooled estimate of the standard deviation of the growth rates.

One would expect the conditions for factor price equalisation to be closely fulfilled among these states. 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 among the five states. The figures for Illinois are about twice those for Missouri. Land prices and gross rents are not equalised absolutely per acre. It was in anticipation of such differences that it was decided to compare growth rates rather than levels of land prices. The growth rates of land prices and gross rents over the 20 year period from 1961 to 1980 are remarkably similar among the states. None of the growth rates of land prices differs significantly from the mean, and the same is true for gross rents. These data seem to support land rental price equalisation, land price equalisation, and thus factor price equalisation among the states. Furthermore, the growth rates of land prices are very similar to the growth rates of rent, generally about 1 per cent lower. This supports Melichar's (1979) conclusion that most of the growth of US land prices can be accounted for by growth of income to land. Similar conclusions were drawn by Alston (1986) and Burt (1986). These results do not support Feldstein's (1979, 1980) hypothesis. In turn, this supports the use of land price growth as a proxy for growth of rental income when rent data are unavailable.

In Table 2, the annual nominal exponential growth rates of land prices are shown for each of the 48 contiguous US states over the interval 1961 to 1980, placed in order of rate. Pooling the estimates, the growth rates are distributed with a mean of 9.75 per cent and a standard deviation of 0.54 per cent, yielding a 95 per cent confidence interval from 8.70 to 10.80 per cent. Three-quarters of the states fall within that range. Most of the values falling in the tails of the distribution are for New England states where agriculture is relatively unimportant (New Hampshire, Rhode Island and Vermont), and states likely to have important non-farm influences (West Virginia). Californian agriculture, dominated by irrigated crops,

TABLE 2

Annual Nominal Exponential Growth Rates of Land Prices by US States (1961-1980)

State[a]	Growth rate[b]	State	Growth rate	State	Growth rate	State	Growth rate
NH	13.3	VT	12.3	WV	12.0	PA	11.1
GA	11.0	AL	10.8	ME	10.8	UT	10.8
WI	10.5	IA	10.5	ND	10.5	VA	10.4
WT	10.3	MN	10.2	MO	10.2	DE	10.1
TN	10.1	CO	9.9	NB	9.9	OH	9.9
IN	9.8	IL	9.8	AR	9.8	MD	9.7
MS	9.7	SC	9.7	KY	9.7	OK	9.7
NV	9.6	MT	9.6	NJ	9.5	LA	9.4
ID	9.4	OR	9.3	NM	9.2	FL	9.2
WA	9.1	CT	9.0	NC	9.0	MI	9.0
NY	9.0	KS	8.9	SD	8.6	MA	8.4
TX	8.3	AZ	8.0	RI	7.1	CA	5.4

[a] The abbreviations for states are those used in postal codes.
[b] The mean of the growth rates is 9.75 per cent. The standard errors of the individual growth rates range from about 0.2 to about 0.8, and the pooled estimate of the standard error for the population is 0.54 per cent.

is different from that in other states, and non-farm factors may have been important there also. For the majority, the growth rates differ by less than 1 per cent. Across most of the US, including a very wide range of types of land and types of land use, the nominal growth rates of land prices over a 20 year period fall within a narrow range. These data tend to support the hypothesis of factor price equalisation among US states.

International Comparisons of Land Price Growth Rates

Annual land price data are available for the interval 1961 to 1980 for Argentina, Canada, New Zealand and the United States and for a shorter interval for the state of Victoria, Australia. The data are for nine Canadian provinces, 48 US states and by four types of land use in New Zealand (arable, fattening, grazing and dairying), Australia (cereals, beef cattle, sheep and dairying) and Argentina (corn, wheat, cattle fattening and cattle breeding). From the US series, data for eight northeastern states (Maine, New Hampshire, Vermont, Massachusetts, 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 some regions are excluded is to reduce the effect of non-farm factors, a potential source of variation which has already been controlled for in the data by land use type for the other countries. Agriculture is relatively unimportant in the states and provinces excluded from analysis. Thus, time series of farm land prices for 40 US states, six Canadian provinces, and four types of land use in Argentina, Australia and New Zealand are included in the analysis.

Three sets of international comparisons are made. First, annual growth rates of land prices during the interval 1961 to 1980 are compared among the United States, Argentina, Canada and New Zealand. Second, that analysis is repeated, including the Australian data, for the interval 1971 to 1980 for which Australian data are available. This also allows the comparison of results between the decade of the 1960s and the decade of the 1970s for four of the five countries. Third, the growth rates of wheat land prices are compared among the countries for the two time intervals. The land prices are converted using market exchange rates to nominal US$ and real US$. Then, to remove some effects of differences in absolute levels of prices due to quality differences, each series is indexed to 1 in 1971 and, with the exception of the Australian series, 1 in 1961.

For the two time periods, using both real and nominal prices in US$, regressions of the following forms were

$$\ln(P_{jkt}) = a + bT_t + \sum_{j=1}^{n-1} a_jC_j + \sum_{j=1}^{n-1} b_jC_jT_t + e_{jkt} \tag{6}$$

where P_{jkt} is the index of the price of land of type k in country j in year t, a is the intercept for US land prices, b is the growth rate of US land prices, T_t is a time trend set to 1 in the base year, a_j is an intercept dummy for country j, b_j is a growth rate dummy for country j, C_j is a (0, 1) dummy variable for country j, e_{jkt} is a random error assumed to be normally distributed with a mean of zero and a constant variance, and n is the number of countries included in the analysis (4 or 5).

TABLE 3

Regressions of Land Price Indexes Against Time Using Slope and Intercept Dummies for Countries (1961-1980)[a]

	Dependent land price variable (logarithm)	
	Nominal	Real
Intercept	-0.312*[b]	-0.105*
	(0.024)	(0.020)
Intercept dummies		
Canada	0.099	0.091
	(0.064)	(0.053)
New Zealand	0.099	0.086
	(0.072)	(0.061)
Argentina	0.021	-0.000
	(0.080)	(0.066)
Growth rate (time)	9.94*	4.61*
	(0.10)	(0.09)
Slope dummies[c]		
Canada	-0.90*	-0.89*
	(0.29)	(0.27)
New Zealand	-1.79*	-1.77*
	(0.35)	(0.33)
Argentina	0.29	0.33
	(0.36)	(0.33)
R^2	0.92	0.74
DFE	1071	1071

[a] All price indexes are expressed in US$ using market exchange rates. Real values are obtained by deflating using the US consumer price index.
[b]* Denotes significant differences from zero at the 5 per cent level.
[c] Significant slope dummies imply significant differences of growth rates from the overall US growth rate.

The maintained hypothesis underlying this specification is that land price growth rates are equalised within each country between states, provinces and types of land use. Equalisation of the growth rates of land prices between countries is tested using t-tests on the growth rate dummy parameters (b_j). If the growth rates are equal between the US and any other country, the parameter for that country will be zero. The results of the regressions and hypothesis tests for the two time periods are reported in Tables 3 and 4. The estimates in Tables 3 and 4 were obtained after correcting for first-order autocorrelation using generalised least squares.

During the interval 1961 to 1980 (Table 3), US land prices grew at an annual exponential rate of 9.9 per cent in nominal terms, a real rate of 4.6 per cent. The growth rates for Argentina were not significantly different from the US but those for Canada and New Zealand were significantly lower, by 0.9 and 1.8 per cent respectively. During the shorter interval from 1971 to 1980 (Table 4), US land prices grew at annual exponential rates of 14.5 per cent in nominal terms and 6.6 per cent in real terms. The growth rates for New Zealand and Argentina were not significantly different, the growth rates for Canada were lower by 1.8 per cent and those for Australia were higher by about 1.7 per cent.

TABLE 4

Regressions of Land Price Indexes Against Time Using Slope and Intercept Dummies for Countries (1971-1980)[a]

	Dependent land price variable (logarithm)	
	Nominal	Real
Intercept	−0.183*	−0.062*
	(0.018)	(0.018)
Intercept dummies		
Canada	0.074	0.075
	(0.051)	(0.051)
Australia	0.072	0.075
	(0.061)	(0.061)
New Zealand	0.154*	0.153*
	(0.061)	(0.061)
Argentina	0.142*	0.136*
	(0.063)	(0.062)
Growth rate	14.45*	6.57*
(time)	(0.24)	(0.23)
Slope dummies		
Canada	−1.83*	−1.83*
	(0.68)	(0.66)
Australia	1.69*	1.75*
	(0.82)	(0.81)
New Zealand	−1.26	−1.23
	(0.82)	(0.81)
Argentina	−0.47	−0.38
	(0.83)	(0.82)
R^2	0.90	0.67
DFE	569	569

[a] See footnotes to Table 3.

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 US, Kansas, Oklahoma, North Dakota and Washington 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 per cent of farmland was used to grow wheat in 1980, and the total acreage comprised 44 per cent of US wheat plantings. Minnesota is the next ranked state with 12 per cent of its farmland planted to wheat in 1980. For Canada, Alberta and Saskatchewan are included. For Argentina, wheat land, for Australia, crop land, and for New Zealand, arable land, are included.

The nominal growth rate estimates for these states, provinces and land use types are reported in Table 5. The estimates are placed in order of size in the first column. Overall, the results using wheat land only are similar to those using all of the data. The growth rates for North Dakota and crop land in Australia and New Zealand are the extremes. None of the growth rates differed significantly between 1961 and 1980. The growth rate for Australian wheat land was significantly larger than all of the others except that for North Dakota over the shorter period 1971 to 1980. This was the only significant difference. Limiting the sample to only land used

TABLE 5

Nominal US Dollar Exponential Growth Rates of Prices of Land Used Primarily to Grow Wheat: 1961-1980 and 1971-1980[a]

	1961-1980	1971-1980
New Zealand		
Arable land	8.6	11.9
	(0.8)[b]	(1.9)
Canada		
Alberta	8.6	11.9
	(0.5)	(1.0)
Saskatchewan	8.7	13.4
	(0.7)	(0.9)
United States		
Kansas	8.9	13.9
	(0.6)	(0.6)
Washington	9.1	13.5
	(0.5)	(0.7)
Oklahoma	9.7	13.1
	(0.4)	(0.4)
North Dakota	10.5	16.5
	(0.7)	(1.0)
Argentina		
Wheat land	10.6	13.6
	(1.3)	(3.4)
Australia		
Crop land	-	18.1
		(1.0)

[a] Growth rates were estimated by regressing the natural logs of land prices against time from the base year.
[b] Figures in parentheses ...dard errors.

primarily to grow wheat may have controlled for some quality differences, but the precision of the estimates of growth rates was reduced, making detection of significant differences more difficult.

Conclusion

The modern theory of international trade suggests a tendency towards equalisation of factor rental prices due to equalisation of product prices via trade. Land is a composite of productive factors. The growth rates of rental prices of different acres of land will be equalised under factor price equalisation if different acres contain equi-proportional endowments of productive factors. In turn, this implies equalisation of growth rates of (asset) prices of land if the discount factors are proportional.

Among the five countries the annual growth rates of land prices (pooled across land types) were approximately equal between 1961 and 1980 and between 1971 and 1980. There were some statistically significant differences but the magnitudes of the differences were generally small.

Over the shorter interval, Australian crop land prices grew significantly faster than the other series included except those for North Dakota. However, over the longer interval there were no significant differences among growth rates of prices of land used primarily to grow wheat.

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 equalisation, proportional endowments and proportional discount factors was possible. These are strong additional restrictions. Growth rates of land prices (and, by implication, land rental prices) were very similar among the countries during 1960s and 1970s. On balance, it is concluded that the evidence presented here is more in favour of factor price equalisation than against it.

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