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Land Prices, Land Rents, and Technological Change: Evidence from Pakistan

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Summary. — The intertemporal behavior of land prices and land rents in two production environments of Pakistan is investigated. Empirical analyses indicate that: (a) agricultural technology adoption has had a strong positive impact on real land rents over the past 30 years in both irrigated and rainfed areas; (b) capitalization of rents into land prices has accounted for approximately 70% of observed increases in land prices during this period; (c) expected capital gains have been an important additional factor driving up land prices; and (d) neither expected inflation nor inflows of remittance income from abroad have had a significant effect on land prices.

1. INTRODUCTION

In the wake of the Green Revolution an extensive literature has examined various aspects of the welfare effects of rapid change in production technology for staple foods in developing countries. Areas of particular emphasis have included effects operating through labor demand and wages (Blyn 1983; Barker and Herdt, 1984), tenancy and contractual arrangements (Otsuka and Hayami, 1989), and output prices (Hayami and Herdt, 1977; Scobie and Posada, 1978). To date, however, little empirical research has been directed at the impact of technological change on land rents or land prices. As noted by Jatileksono in a recent paper, this is a rather striking gap in our knowledge for three reasons. First, land is an important, in many cases the most important, asset owned by the majority of rural households. As such, any factor affecting the value of land will have a significant impact on the wealth of rural households. Second, skewed land ownership is commonly an important source of inequality in income distribution. Increased returns to land associated with enhanced productivity would tend to exacerbate such inequality. Third, differential regional adoption of seed-fertilizer technologies has commonly widened existing interregional productivity differences. It therefore seems likely that such technologies have also widened interregional differences in land values.

This paper investigates the relationship between technological change and land values by examining the intertemporal behavior of land prices and land rents in rainfed and irrigated areas of the Punjab — Pakistan's most important wheat-producing province. Pakistan is a particularly appropriate choice for this analysis for at least two reasons. First, Pakistan was the site of some of the most dramatic increases in wheat productivity associated with the Green Revolution of the 1960s and 1970s Since high-yielding semidwarf wheat varieties (HYVs) were introduced in 1967, wheat yield increases have averaged 2.7% per year, and national wheat output has more than doubled. Second, Pakistan is a country marked by distinct production environments differentially suited to the diffusion of HYVs. The great bulk of the initial productivity gains resulting from the adoption of the seed-fertilizer technology were registered during 1968–75 in the irrigated areas of the Indus River Basin. Diffusion of HYVs suited to rainfed conditions began in the mid-1970s, with significant yield increases being achieved in many rainfed areas. Nevertheless, the rainfed areas continue to lag behind the irrigated areas, in terms of both yield and adoption.

Empirical analyses presented below are based

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on time-series cross-sectional land price data collected through a retrospective survey, and rental data taken from published sources. These are aimed at (a) linking movements of land rents over the past 30 years to movements of key price and technology variables; and (b) ascertaining the degree to which rents were capitalized into land prices. The results indicate a strong relationship between real land rents and adoption of improved production technologies in both irrigated and rainfed areas, and that capitalization of land rents has dominated the time-series behavior of land prices.

The next section of this paper describes the analytical framework used to investigate the behavior of land prices and land rents. The third section describes agricultural land markets in Pakistan and the major forces affecting the price of land. The fourth section presents land price data collected in a retrospective survey conducted in rainfed and irrigated areas. The fifth section presents empirical results of analyses of the determinants of land rents and land prices. The final section of the paper discusses the implications of the empirical findings for rural income distribution in Pakistan.

2. ANALYTICAL FRAMEWORK

The potential importance of technological change on land prices has been widely noted in the literature. In theory, the diffusion of a sustainable technology that increases profits per unit of land represents an increase in the expected value of current and future income flows generated by land. Adoption of the technology will drive up the derived demand for land such that land rents — and consequently land prices — are increased.

Empirical work in this area, primarily in the context of US agriculture, has generally found that productivity increases explain a significant portion (but by no means all) of observed price increases for agricultural land. Important nonproductivity factors to which increases in land prices have been attributed include: (a) increasing demand for land for nonagricultural or urban uses (Peterson 1986); (b) speculation on anticipated appreciation of land prices (Castle and Hoch, 1982); (c) increases in the value of farm assets (Melichar, 1979); (d) use of land as a hedge against inflation (Feldstein, 1980); (e) capitalization of government policies that enhance the value of land (Tweeten and Martin, 1966); and (f) the collateral value of land in areas where credit markets are poorly developed (Binswanger and Rosenzweig, 1986).

The basic premise underlying the analysis to be conducted below is that while the market price of agricultural land may be affected by forces other than the productive capacity of the land, rents are likely to closely reflect the profitability of land in agricultural uses. Profit-enhancing increases in land productivity attributable to the adoption of improved technologies and changes in output and input prices are expected to be reflected in real increases in rents. The extent to which the time paths of rents and prices diverge should then indicate the relative importance of factors other than changes in the income-generating capacity of land in determining land prices.

In the empiricial section of this paper, regression analysis is employed to measure the impact of key price and technology variables on real land rents. The empirical model to be used follows from demand and supply functions for rental land given by

$$A^d = A^d\ (R_t,\ P_{Ot},\ P_{It},\ T,\ E)$$
$$A^s = A^s\ (R_t,\ E)$$

where A^s and A^d are the supply and demand for rental land, R_t is real land rent at time t, P_{Ot} and P_{It} are vectors of output and input prices at time t, T denotes production technology, and E denotes production environment. Combining these demand and supply functions yields the following reduced form equation for land rents:

$$R_t = R\ (P_{Ot},\ P_{It},\ T,\ E) \qquad (1)$$

Numerous studies have derived capitalization formulae linking land prices with land rents, interest rates, and inflation (Alston, 1986, Feldstein, 1980, Just and Miranowski, 1991). Here, a modification of the capitalization formula derived by Alston will be used to link the time series behavior of observed real land prices with real land rents. This formula is given by

$$P_t = \frac{R_t + \beta G_t^*}{\delta_0 + \delta_1 \pi_t^*}, \qquad (2)$$

where P_t is the real land price, G_t^* is expected capital gains at time t, π_t^* is the expected inflation rate at time t, δ_0 is the discount rate, and β and δ_1 are parameters. This formulation augments the standard capitalization formula ($P = R/\delta_0$) to incorporate the effects of expected capital gains and inflation on land prices. Capital gains are included to test for speculative motives in land acquisition, while inflation is included to examine whether land is purchased as a hedge against inflation. Both variables are expected to have a positive impact on prices. The discount rate (β_0) includes both the real interest rate (assumed constant over time) and a risk premium for agricultural land.

3. FACTORS AFFECTING AGRICULTURAL LAND PRICES IN PAKISTAN

Land is typically the most important asset owned by rural households in Pakistan. In addition, land ownership is highly valued for social and cultural reasons. The social status associated with owning land tends to make liquidation of all land holdings by a given land owner quite rare. In general, only in the event of extreme financial distress (such as crop failure from drought or disease) do rural households sell off all their land.[1] Nonetheless, sales of parcels of land, while not frequent, do occur for a variety of reasons. Land transactions may be used to dampen variability in income flows — e.g., sales following years of poor harvests. Alternatively, a parcel of land may be sold to finance a nonagricultural business venture. Yet another reason for selling land is to raise money for extraordinary expenses, such as dowries and educational fees.

On the demand side, land has proven to be a very sound investment, providing substantial real returns (both capital gains and current income). This, coupled with the above-noted sociocultural value attached to land ownership, encourages many rural dwellers to purchase agricultural land when investible funds are available. In addition to income earned through farming, an important source of investible funds has been remittance income from family members working abroad.[2] Beginning in the late 1970s large numbers of Pakistanis (up to three million people) temporarily migrated to oil-producing countries of the Middle East, sending home billions of dollars. According to official government statistics (which are undoubtedly an underestimate) remittances averaged $2.5 billion per year during 1979–88. Available evidence indicates that a portion of this remittance income (albeit a rather small share relative to expenditure on consumer durables and housing) has been used to purchase agricultural land (Rahman, 1981).

While foreign remittances represent a potentially important shifter of market demand for agricultural land, of more interest here is the effect of the introduction of new production technologies on agricultural land markets. The introduction of high-yielding semidwarf wheat varieties (and accompanying increases in fertilizer use) in Pakistan in the mid-1960s represents a dramatic example of a technological innovation that greatly enhanced both the productivity and profitability of wheat farming (Chaudhry, 1982).

The diffusion of HYVs occurred differentially across production environments, however (see Table 1). The initial releases were primarily suited to (and targeted toward) the irrigated areas of the Indus River Basin, and the rapid adoption and striking yield increases characterizing the Green Revolution were largely confined to those areas. Subequently, improved varieties better suited to rainfed conditions were developed and released in the mid-1970s. In some rainfed areas (particularly those with fairly high rainfall), yield increase associated with this second generation of HYVs were substantial but still much smaller than those recorded in irrigated areas.[3] In contrast, in the drier rainfed areas where HYVs perform less well, farmers continue to plant a large proportion of their land to traditional varieties (Hobbs, Saeed and Farooq, 1991). Sizable yield differences between irrigated and rainfed areas persist to this day.

Semidwarf wheat is by no means the only technology which has had major effects on agricultural production in the areas of the Punjab considered in this study. Two other important innovations will be discussed below. One is the introduction of a high-yielding, shorter duration variety of high quality Basmati rice (Basmati-385), an important cash crop grown by farmers in the rice-wheat zone of the irrigated Punjab. Basmati-385 was first introduced in 1986. Its adoption was very rapid; by 1988 approximately two-thirds of the total rice area in the rice-wheat zone was planted to Basmati-385 (Sharif, *et al.* 1991). Largely because of its superior response to nitrogenous fertilizer, Basmati-385 yields as much as 50% more than other Basmati varieties. Additionally, its shorter duration allows for more timely planting of wheat (typically the second crop in the dominant cropping system of the area), thus enhancing wheat production.

Tractors and associated mechanical technologies are the other improved production technology considered below. In irrigated areas of the Punjab, the diffusion of tractors roughly coincided with the spread of HYVs. Tractors promoted better land preparation and more timely planting of wheat and other crops and expedited the use of mechanical threshers. Tractors also facilitated the expansion of tubewell irrigation by allowing more land to be cultivated by a given farmer.[4] In rainfed areas, tractors were adopted more widely and somewhat earlier than biochemical technologies. Tractors promoted better land preparation, increased cropping intensity, and increased the use of seed drills (Sheikh, Byerlee and Azeem, 1988). In addition, tractors facilitated deep tillage, an effective

Table 1. *Wheat yield and HYV adoption in the Punjab, 1965–66 to 1988–89*

	Wheat yield (t/ha)			HYV adoption	
Year	Rice-wheat zone	Rainfed areas	All irrigated areas	Irrigated areas	Rainfed areas
1965–66	n/a	n/a	0.76	0	0
1966–67	n/a	n/a	0.81	0.03	0
1967–68	0.94	0.59	1.10	0.23	0
1968–69	0.95	0.44	1.47	0.59	0
1969–70	1.10	0.44	1.45	0.63	0
1970–71	1.34	0.40	1.54	0.69	0
1971–72	1.45	0.47	1.36	0.74	0
1972–73	1.50	0.54	1.47	0.73	0
1973–74	1.51	0.55	1.52	0.75	0
1974–75	1.55	0.58	1.51	0.82	0
1975–76	1.67	0.65	1.58	0.83	0.04
1976–77	1.69	0.65	1.69	0.92	0.07
1977–78	1.51	0.70	1.70	0.90	0.13
1978–79	1.68	0.84	1.49	0.91	0.16
1979–80	1.75	0.90	1.68	0.97	0.22
1980–81	1.85	0.93	1.75	0.96	0.27
1981–82	1.86	0.87	1.84	0.99	0.34
1982–83	1.89	0.95	1.70	0.99	0.46
1983–84	1.66	0.77	1.85	0.97	0.65
1984–85	1.82	0.77	1.59	0.98	0.71
1985–86	2.10	0.99	1.78	0.96	0.81
1986–87	1.02	1.00	2.11	0.97	0.84
1987–88	1.83	0.59	1.61	0.98	0.85
1988–89	1.97	0.97	1.88	0.97	0.82
Trend growth rate 1966–89 (% per year)	2.43	3.52	2.89		

Source: Ministry of Food and Agriculture.

method of conserving soil moisture that has had a positive impact on wheat yields in some areas (Hobbs, Saeed and Farooq, 1991).

4. LAND PRICES IN THE PUNJAB

A retrospective survey of land prices was conducted in two wheat producing areas of the Punjab during the 1989–90 crop year. The two areas covered in the survey were (a) the Punjab rice-wheat zone, comprising three Basmati rice-growing districts in the irrigated Indus River Basin; and (b) three rainfed districts in the western Punjab. The irrigated rice-wheat zone was among the earliest HYV-adopting areas in Pakistan. The rainfed area is relatively dry and was purposely chosen to provide a contrast with the favorable agronomic conditions of the rice-wheat zone.

The survey was extensive, covering 37 villages in the irrigated area and 42 villages in the rainfed area. This was necessary given the sporadic nature of land sales in most villages.[5] Care was taken to select villages far enough away from urban areas and major roads to minimize the impact of urbanization on the reported land prices. Farmers were asked to recall the details of specific land transactions about which they had first-hand knowledge, either through direct participation or the participation of a family member or neighbors. Respondents were asked about the year of the transaction, price paid, amount of land involved, soil type, and quality of the land (good, average, or poor). Additional village-level information collected included current average yields obtained on lands of different quality, distance from the nearest market center, current rent, and when improved production technologies (HYVs, fertilizers, and tractors) became available in the village.

Table 2 presents some descriptive information

Table 2. *Description of areas surveyed*

	Rice-wheat zone	Rainfed areas
No. of villages	37	42
Avg. farm size (acres)	2.9	4.7
Distance to market (km)	7.6	17.2
Crops per year	1–2	1
Major alternative crop	Rice	Groundnut, sorghum
Fertilizer use	All	Little
Year tractors introduced	1966	1973
HYV Wheat:		
Year introduced	1967	1980
Current adoption (%)	97	45
Avg. wheat yield (t/ha)	2.6	1.5
Basmati-385:		
Year introduced	1986	n/a
Current adoption	68	n/a

on the areas surveyed. Farms in the rainfed area tended to be larger, more remote, and much less technologically advanced than those in the irrigated rice-wheat zone. Practically all respondents in the rice-wheat zone reported using HYVs and chemical fertilizers, whereas less than half of those surveyed in the rainfed area planted HYVs and very few used chemical fertilizers. Most farmers in the rice-wheat zone grew two crops per year (rice in the rainy season, wheat in the winter). In the rainfed area farmers planted only one crop per year on average, usually wheat followed by a rainy season crop (groundnuts, sorghum, or millet) and one year of fallow. Average wheat yields in the rice-wheat zone were nearly double those of the rainfed area.

In both areas, transactions dating back to the 1950s or earlier were reported. Some of the transactions involved land that was not cultivated (either nonarable grazing land or village land sold for housing). The analyses presented here use only transactions in which all land involved was suited for agricultural purposes, and only those which took place after 1960. Ninety-nine such transactions were reported by respondents in the rice-wheat zone and 86 in the rainfed area.

Table 3 summarizes land price and quantity data collected in the survey. All price data were deflated by the wholesale price index, using 1989 as the base year. To facilitate discussion, the data have been grouped into three time periods: the pre-Green Revolution, Green Revolution, and post-Green Revolution eras. The post-Green Revolution era is subdivided into two periods, the breaking point corresponding to the year in which the rapidly adopted Basmati-385 rice variety was introduced (1986).

Over the past 30 years the price of land in the irrigated rice-wheat zone has been two to three times greater than the price of land in the rainfed area. Real land prices have been steadily increasing over time, with trend growth rates of 5.7% and 4.4% per year in the rainfed and irrigated areas, respectively. Interestingly, the data indicate that the rate of increase of real land prices has been greater in the rainfed area than that in the more productive rice-wheat zone. In the rice-wheat zone a substantial jump in average land prices occurred between the pre-Green Revolution and Green Revolution periods, and between the two post-Green Revolution periods. T-tests indicated that these differences were significant at the 5% level. That these jumps occurred after the introduction of rapidly adopted improved varieties (wheat in the earlier period and rice in the latter) would seem to link land price movements with those technologies. In the rainfed area, average land prices in the most recent period (1986–89) are significantly higher than in earlier periods. Again, it seems likely that both the diffusion of productivity enhancing HYVs (which were on average first adopted in the early 1980s among sample households) contributed to this increase in land prices.

5. LAND RENTS AND LAND PRICES

The analysis that follows relies heavily on data contained in a series of cost of production studies

Table 3. *Average prices and quantities or land transactions, 1960–89**

	Rainfed areas	Rice-wheat zone
Pre-Green Revolution (1960–67)		
Average price (Rs/ha)	14,400	44,000
Corrected variation of prices	0.53	0.53
Average quantity per transaction (ha)	2.8	7.3
No. of transactions	32	35
Green Revolution (1968–75)		
Average price (Rs/ha)	24,800	76,700†
Corrected variation of prices	0.85	0.41
Average quantity per transaction (ha)	3.6	3.8
No. of transactions	12	12
Post-Green Revolution I (1976–85)		
Average price (Rs/ha)	34,400	85,500
Corrected variation of prices	0.84	0.46
Average quantity per transaction (ha)	4.0	3.6
No. of transactions	12	19
Post-Green Revolution II (1986–89)		
Average price (Rs/ha)	58,600†	119,000†
Corrected variation of prices	0.41	0.34
Average quantity per transaction (ha)	1.2	3.3
No. of transactions	23	33
Trend growth rate of land prices, 1960–89 (% per year)	5.7	4.4

*All land prices are expressed in constant (1989) rupees. The official exchange rate in 1989 was Rs. 21 per US dollar.
†The average price is greater than the average price in the preceding period at the 5% significance level.

published by the Punjab Economic Research Institute (PERI). The PERI studies report land rental data for both rainfed and irrigated areas of the Punjab dating back to the early 1960s. In many instances, the data for the irrigated areas are sufficiently disaggregated to contain specific information on rent in the irrigated rice-wheat zone, allowing a direct comparison with the price data reported above. Two other sources of land rent data used here are a Water and Power Development Authority (WAPDA) survey conducted in 1976 and the PARC/CIMMYT National Maize Survey conducted in 1989.

(a) *Determinants of land rents*

Table 4 presents data on real land rents in the rainfed area and the rice-wheat zone. While the data are scarce for some years (particularly the early 1970s), clear trends are nevertheless apparent. Not surprisingly, rents have been significantly lower in the rainfed area than in irrigated areas, ranging from 25% to 40% of those reported for the rice-wheat zone. Rents in the rice-wheat zone have on average been 75% of the average for the entire irrigated Punjab (although this gap appears to have narrowed in recent years). Land rents in both areas have been rising over time, with some year-to-year fluctuations. Over the 26-year period for which data are available, the trend growth rates for the rice-wheat zone and rainfed area were 3.1% and 4.1% per annum, respectively. The occasional declines may reflect sluggishness in the rental market's adjustment to inflation or structural rigidities due to institutional factors.[6] The persistent decline reported during 1980–85 is consistent with the decline in farm profits over the same period reported by Ahmed and Chaudhry.

The upward trend in real land rents in the irrigated areas of the Pakistani Punjab contrasts markedly with the behavior of rents just across the border in the Indian Punjab. Sidhu and Byerlee report the absence of any discernable trend in real land rents in India's Punjab during

Table 4. *Real land rents in the Punjab, 1963–89**

Time period	Rainfed areas	Rice-wheat zone	Entire irrigated Punjab
Pre-Green Revolution (1963–67)			
1963	287	1,440	1,830
1965	404	n/a	2,440
1966	381	1,920	2,690
1967	566	1,820	3,090
Avg	410	1,730	2,510
Green Revolution (1968–75)			
1968	534	1,880	2,840
1969	576	1,830	2,700
1970	561	1,820	2,670
1971	586	1,800	2,560
Avg	564	1,830	2,690
Post-Green Revolution I (1976–85)			
1976	685	1,990	2,680
1977	620	n/a	3,510
1978	702	n/a	4,240
1979	693	n/a	3,460
1980	847	n/a	3,630
1981	679	3,290	3,470
1982	781	3,280	3,260
1984	1,180	n/a	2,970
1985	629	n/a	2,770
Avg	757	2,850	3,330
Post-Green Revolution II (1986–89)			
1986	1,180	2,570	3,780
1987	1,180	2,880	3,470
1989	1,110	3,780	3,900
Avg	1,160	3,080	3,720
Trend growth rate of land rents, 1963–89 (% per year)	4.1	3.1	1.7

*All values expressed in constant (1989) rupes per hectare. All data are taken from various editions of PERI *Farm Accounts and Family Budgets* publications except for: (a) the rice-wheat zone in 1976 (which uses data from the WAPDA XAES survey); (b) the rainfed areas and rice-wheat zone in 1989 (which uses data collected in the land price survey); and (c) the entire irrigated Punjab in 1989 (which uses data from the PARC/CIMMYT National Maize Survey).

1972–87, while Kahlon and Kurien found that during 1970–78 real rents fell fairly steadily. The different time-paths of rents in the two contiguous areas is certainly not related to productivity differences since, if anything, technological progress has been greater in the Indian Punjab over the past 30 years. A more likely explanation is that the wheat-pricing mechanism operative in India has effectively transferred the rents generated by technological change away from Punjabi farmers to the rest of the economy, whereas Pakistani pricing policies have been relatively more favorable to farmers.[7]

To measure the determinants of real land rents, ordinary least squares regressions based on equation (1) were estimated. The ratio of wheat prices to the price of urea was used to capture the effects of movements in input and output prices. Technology variables used included area-specific adoption levels of HYV wheat and Basmati-385 rice. Tractor adoption was highly correlated with HYV wheat adoption, and hence regressions including both of these variables were unsatisfactory. Use of the tractor adoption variable instead of the HYV variable yielded qualitatively similar results to those presented here. In addition to individual regressions for the rainfed areas and rice-wheat zone, a regression using pooled data was run in order to test for significant differences in the levels of land rents and the impact of HYV wheat across the two areas.

Table 5 presents the parameter estimates for the land rent regressions. The results indicate a strong effect of technology adoption on land rents. In all cases, both HYV wheat and Basmati-385 variables were significant at least at the 5% level. Results of the regression using pooled data indicate that land prices were significantly greater in the rice-wheat zone. No significant difference in the impact of HYV wheat adoption across production environments (as measured by the interaction dummy) was found. Finally, the wheat-urea price ratio is significant in rainfed areas, but not in the rice-wheat zone nor in the pooled regression.[8]

The explanatory variables explain a very large proportion — up to 91% in the pooled regression — of the observed behavior of real land rents. In combination with the generally high level of precision of the parameter estimates, it may therefore be concluded that profitability factors (output and input prices, and technology adoption) have been dominant in the determination of real land rents over time.

(b) *Determinants of land prices*

Table 6 summarizes land price and land rent data by time period. In the rainfed area, the rent-to-price ratio fell steadily over the entire time period, from 2.8% to 2.0%. In the rice-wheat zone, this ratio has been somewhat higher and much more variable, ranging between 2.4% and 3.9%. By way of comparison, data collected in a wide assortment of agronomic zones in the PARC/CIMMYT National Maize Survey indicate that rent/price ratios average approximately 2% thoughout Pakistan.

That increases in land rents were capitalized into land prices is evident in the comparison of the growth rates over the entire sample period. In both areas, the trend rate of growth of rents over the entire sample period was about 70% of the growth of land prices. This suggests that while profitability has been the major force

Table 5. *Land rent regression results*

Variable	Rainfed areas	Rice-wheat zone	Pooled results
Intercept	251.5* (1.97)‡	2092.1† (3.16)	447.8 (1.28)
Wheat-urea price ratio	347.1§ (2.16)	−898.6 (0.91)	90.9 (0.21)
HYV wheat adoption	674.4† (5.02)	1163.1§ (2.83)	688.5† (3.18)
Basmati-385 adoption	—	1416.6§ (3.80)	1285.2† (3.49)
Rice-wheat zone dummy	—	—	948.1† (4.52)
HYV × Rice-wheat zone dummy	—	—	393.59 (1.16)
D-W	2.71	1.50	2.34
R^2	0.743	0.685	0.911
n	20	13	33

‡T-statistics in parentheses.
*Significant at the 0.10 level.
†Significant at the 0.01 level.
§Significant at the 0.05 level.

Table 6. *Land rents and land prices in the Punjab over time**

	Rainfed areas	Rice-wheat zone
Pre-Green Revolution (1960–67)		
Average land rent	410	1,730
Average land price	14,400	44,000
Rent/price ratio (%)	2.8	3.9
Green Revolution (1968–75)		
Average land rent	564	1,830
Average land price	24,800	76,700
Rent/price ratio (%)	2.3	2.4
Post-Green Revolution I (1976–85)		
Average land rent	757	2,850
Average land price	34,400	85,500
Rent/price ratio (%)	2.2	3.3
Post-Green Revolution II (1986–89)		
Average land rent	1,160	3,080
Average land price	58,600	119,000
Rent/price ratio (%)	2.0	2.6
Trend growth rate, 1960–89 (% per year)		
Land rent	4.1	3.1
Land price	5.7	4.4
Trend growth rates, 1976–89 (% per year)		
Land rent	4.6	3.0
Land price	10.4	5.9

*All values expressed in constant (1989) rupees per hectare.

driving real land prices, other factors may also have accounted for a substantial portion of increases in the price of land.

The trends over the entire sample period mask some interesting differences in the growth of rents and prices during different time periods. This can be seen in Figure 1, which shows the growth of rent and price indices over time. Of particular interest is the widening of the difference between the growth of prices and rents since the mid-1980s. A possible explanation for this is that remittances from abroad during the period of high outmigration have shifted out the demand for land during this period, thereby driving up land prices. In order to get a rough idea of the importance of foreign remittances, trend growth rates of rents and prices were computed for the period since 1976 — the year marking the beginning of the large-scale migration of Pakistanis to the Middle East. These are given in the last two rows of Table 6. Since 1976, the rate of increase in land prices has accelerated above the long-run trend in both locations — particularly the rainfed area[9] — and the divergence between the growth rates of rents and prices has also widened. This suggests that factors other than the capitalization of land rents into land prices — among which the flow of remittances associated with the foreign employment boom predominates — have played a more important role in the determination of land prices in the post-Green Revolution period than in earlier periods.

To measure the determinants of real land prices, a modified version of equation (2) that incorporated shifters in the demand for agricultural land was estimated.[10] The estimated equation was of the following form:

$$P_t = \frac{R_t + \beta \cdot \Delta P}{\delta_0 + \delta_1 \pi_t^*} + \alpha_1 L_{t-1} + \alpha_2 Q. \qquad (3)$$

Here, $\Delta P = P_{t-1} - P_{t-2}$ is the first difference of average prices for each area — a proxy for expected capital gains.[11] Expected inflation (π_t*) was based on the one-step-ahead ARMA forecast of the next period's inflation, using the wholesale price index. L_{t-1} denotes lagged remittances from abroad as reported in *International Financial Statistics* (IMF), and was included to test whether remittances from abroad

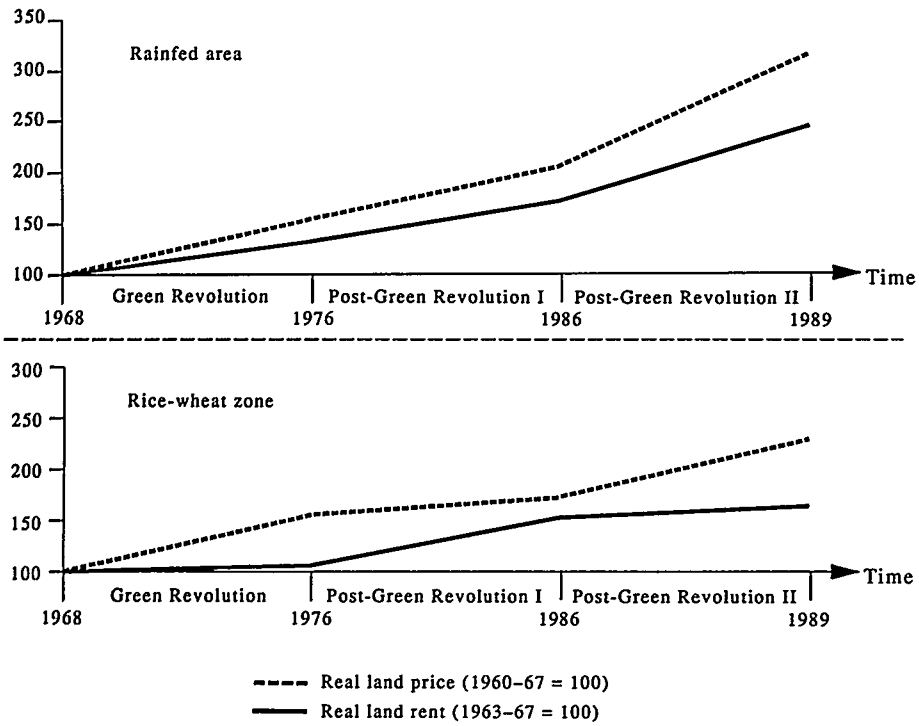

Figure 1. *The growth of real land rents and prices in the Punjab.*

have had a significant impact on land prices. Ideally, this variable would have been specific to the village and year for which land transactions were reported; because such information was not available, aggregate remittances were used as a proxy. Q is a dummy variable denoting the quality of land involved in reported transactions.[12]

Equation (3) was estimated by nonlinear least squares using the SYSNLIN procedure of SAS. To correct for the endogeneity of land rents, predicted values of R_t from the regression reported earlier were used. Because no information was available on interest rates in rural areas, the discount rate (δ_0) was estimated as a parameter. Finally, significant autocorrelation was evident, and was corrected using a modified Cochrane-Orcutt procedure. Autocorrelation coefficients (ϱ) were computed using the formula $\varrho = 1 - d/2$, where d is the Durbin-Watson statistic.

Table 7 presents the parameter estimates for the land price regressions. These indicate that for both the rainfed areas and the rice-wheat zone, expected capital gains and land quality have had significant effects on land prices. The estimated discount rates are also significant and of plausible magnitudes. Neither expected inflation nor remittance income appear to have exerted a significant impact on land prices. That remittances are not significant was somewhat surprising, given that these appeared the most likely candidate for explaining the marked divergence between land rents and land prices over the past 10 years. It is possible that the use of aggregate remittance income for all of Pakistan did not adequately capture inflow of foreign earnings into the specific villages surveyed — particularly those villages located in the rainfed area. A second possibility is that inflows of remittance income have been used primarily for expenditures other than land acquisition — e.g., to finance consumption expenditures. Yet another possibility is that remittances have allowed some farm households unable to completely meet household demands for basic staples and cash income through agricultural production to continue farming, thereby leading to an inward shift in the market supply of agricultural land that has to some extent "canceled out" the effect on land prices of outward shifts in demand for land.

Table 7. *Land price regression results*

Variable	Rainfed areas	Rice-wheat zone
Discount rate	0.0686*	0.0614†
	(2.61)‡	(4.19)
Expected capital gains	0.0332*	0.0577†
	(2.53)	(2.80)
Expected inflation	−0.0890	0.3258
	(0.51)‡	(1.52)
Remittances from abroad	0.2350	0.2163
	(1.17)	(0.90)
Land quality dummy	9835.5*	4337.9*
	(2.08)	(2.13)
ϱ	0.43	0.49
R^2	0.627	0.639
n	60	69

‡Asymptotic t-statistics in parentheses.
*Significant at the 0.05 level.
†Significant at the 0.01 level.

6. CONCLUSION

This paper has examined available evidence on the intertemporal behavior of land prices and land rents in two distinct production environments of the Pakistani Punjab. The empirical results provide evidence that adoption of improved agricultural technologies has had a strong positive impact on real land rents over the past 30 years in both irrigated and rainfed areas, and that capitalization of rents into land prices has accounted for about a substantial share (approximately 70%) of observed increases in land prices during this period. Additional analysis indicates that expected capital gains have been significant in driving up land prices, but that neither expected inflation nor inflows of remittance income from abroad have had significant effects.

These findings bear some interesting implications regarding the income distributional impacts of technological change. Skewed land ownership is considered an important source of inequality in income distribution in rural Pakistan (Guisinger and Hicks, 1978). The data clearly show that land has provided substantial and increasing real returns over the long run, in terms of both current income and capital gains, and that technology adoption has been central in this long-term appreciation of land values. In the absence of countervailing changes in the distribution of land ownership, long-run appreciation of real returns to land brought about by improved technologies will have served to worsen the absolute level of inequality within each of the areas considered. Insofar as increases in returns to land have applied to all farm-size classes, relative inequality among landowning households need not have changed. However, long-run appreciation of land values, has probably exacerbated income inequality between landed and landless households.[13]

Perhaps most interesting is the finding that both land rents and land prices have been growing faster in the rainfed *vis-à-vis* the irrigated rice-wheat zone, an indication that interregional disparities in returns to land have lessened over time. In that agricultural incomes of farm households in the rainfed area are comparatively lower than in irrigated areas, this suggests a possible improvement of interregional income distribution among landowning households.

NOTES

1. An exception to this behavior has been the sale of land occupied by immigrants from India at the time of Pakistan's independence. These immigrants were not so deeply attached to their newly occupied land, and many subsequently sold out and moved to cities.

2. Remittance income from family members working in Pakistani cities is also important. The focus on foreign remittances here is explained by the fact that the foreign employment boom represents one of the more profound macroeconomic shocks to Pakistan's economy during the past 15 years, whereas there is no evidence that the pattern of urban-rural remittances has changed markedly during that time.

3. Using data from on-farm trials, Nagy calculated the yield advantages from adoption of improved varieties to be 16% in rainfed land and 45% in irrigated land.

4. Available evidence does not indicate that tractors had a positive impact on yields *per se* in the irrigated Punjab (McInerney and Donaldson, 1975). There is some indication that tractors and associated mechanical technologies were cost-reducing (Chaudhry, 1982).

5. In seven of the 79 villages surveyed, respondents could not recall a single land sale. The average number of reported transactions for the other villages was 3.0 in the rainfed areas and 3.8 in the irrigated area.

6. For the rice-wheat zone, this is especially true of earlier years when most rental contracts were on a share basis. Under share rentals, the value of land rent is in large measure a reflection of the prices of wheat and rice and how good the harvests are. Over time, an increasing proportion of rental contracts in the rice-wheat zone were put on a cash basis. In the rainfed areas, share rentals are still the dominant contractual arrangement.

7. Sidhu and Byerlee report that over 1972–87 the real procurement price of wheat fell at the rate of 3.6% per year. The real procurement price has fallen in Pakistan over time, too, but at a much slower rate (less than 1% per year).

8. The nonsignificance of the wheat-urea price ratio in rice-wheat zone and pooled regressions is puzzling. In comparable regressions using rental data for the entire irrigated Punjab (not reported here), a significant positive relationship between the wheat-urea price ratio and land rents was found.

9. This is consistent with the widely held belief in Pakistan that most laborers working overseas come from the rainfed areas.

10. An alternative empirical strategy would have been to simply regress land prices on technology variables and other demand shifters (e.g., remittances) to establish the determinants of land prices. However, severe multicollinearity — due to a high degree of correlation between remittances and the key technology variable (HYV wheat adoption) — precluded this more direct approach.

11. In cases where no price data were recorded for the previous year, linear interpolation was used to generate prices in the previous period.

12. In rainfed areas, $Q = 1$ for land located close to villages (on which farmers typically apply significant amounts of farmyard manure), and $Q = 0$ otherwise. In the rice-wheat zone, $Q = 1$ for land possessing lighter, loamy soils, and $Q = 0$ for land possessing heavy clay soils.

13. It should be noted, however, that real agricultural wages have grown substantially over the period considered in this paper (Renkow, 1991). To some extent, this may well have mitigated the negative income distributional effects of increases in the wealth of landowners.

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