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The Multiple Effects of Procurement Price on Production and Procurement of Wheat in Pakistan

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An increase in the procurement price affects government procurement of wheat in at least four ways. Properly estimating the total effect requires taking account of both the direct effects of an increased share of marketed surplus being procured and the indirect effects through the impact on production, marketed surplus, and the wholesale price. Estimates are that a real one-rupee increase per 40 kilograms – approximately 1.25 percent – will raise procurement by about 90 thousand tons.

INTRODUCTION

There has been much debate in recent years about the proper level of official prices for agricultural products in less developed countries. Most of this discussion has revolved around the most appropriate relationship of domestic prices to world prices. Countries which adjust domestic prices to reflect changes in the world price clearly need to have some ability to forecast the effect on production.

Forecasting production, however, is not sufficient for those governments which actively intervene in their domestic markets by purchasing a large percentage of the crop. Government or para-statal procurement of agricultural commodities also must be forecast for several reasons. First, marketing boards or food authorities must be provided with credit for purchasing the crop in a timely manner if government policies regarding the enforcement of a guaranteed price are to be effective. Second, sufficient storage space must be set aside for the procured commodity. Third, in many countries the government loses money on every ton of grain that it handles. For Pakistan in 1987, the loss was about Rs 400 (about US $ 25) per ton [Pinckney

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(1988)]. Thus, the responsiveness of government procurement to a change in price is important for credit, storage, and fiscal policy.

For some commodities, the government procures virtually the entire crop and thus the change in procurement will be approximately equal to the change in production. Such is usually the case for export crops like tea and coffee. For staple foods, however, the percentage increase in procurement may be much larger than the percentage increase in production since consumption on-farm is unlikely to increase in proportion to production. The presence of an active private market which handles a substantial share of the crop complicates the analysis, however. Thus, price formation in the private market is important for the government to understand.

This paper traces the direct effects of a change in the procurement price of wheat in Pakistan on three different variables: (i) production of wheat in nine different agro-ecological zones, (ii) the wholesale price of wheat in the private market, and (iii) government procurement of wheat. Indirect effects of the first two variables on procurement are also measured. Thus, the conclusion is a comprehensive look at both the direct and indirect effects of a change in the government price on wheat procurement.

The first section of the paper presents estimates of the effects of a change in the procurement price on both the area and the yield of wheat in the major agro-ecological zones. This is followed by the development of a model which relates the changes in the procurement price and production to the changes in the marketed surplus, the wholesale price, and the procurement. The final section draws conclusions.

SUPPLY RESPONSE OF WHEAT IN PAKISTAN

There have been several attempts recently to measure the responsiveness of agricultural production in Pakistan to a change in price. Notable among these are three unpublished papers: Tweeten (1985), Imran (1986), and Ali (1987). None of these, however, attempts to estimate response by agro-climatic zone or to confine the estimation to post-Green Revolution years.

There are several reasons to do both. It is likely that farmers in the *barani* (rain-fed) areas of Punjab face quite different constraints as they respond to changes in price, compared to farmers in southern Sindh. The magnitude of the response coefficient and the cross-effects of other prices should also differ significantly, depending on the prevalent cropping pattern of the zone.

As for the period of estimation, the first year of the Green Revolution – crop year 1967-68 – was a watershed in many respects. Wheat technology changed quickly and dramatically in that year. Moreover, prior to 1967-68 the procurement price was ineffective, as virtually none of the crop was sold at that price. Government procurement began to constitute an important percentage of total production only in this year. In previous years virtually all of marketed production was sold through wholesale markets, where prices differed significantly from procurement prices. After 1967-68, the procurement price and the wholesale price at harvest time became highly correlated as the government agency absorbed a large share of the total marketed surplus. This is shown in Figure 1. Thus, the relationship between the procurement price and the production underwent a major change with the beginning of the Green Revolution; any estimate of supply response which includes years prior to 1967-68, therefore, is combining years with very different production technologies, market structures and, possibly, response coefficients.

Thus, the period for estimation in this analysis is 1967-68 to 1984-85. Estimation is conducted in nine different zones, differentiated primarily by *kharif* (summer season) crop and the date of harvest.[1] Since official data are published on a district basis, it is necessary to confine the breakdown of agro-climatic zones to district boundaries. Table 1 presents the list of districts by zone; Figure 2 presents a map of the zones.

In the irrigated areas, the two dominant *kharif* crops are rice and cotton. One is grown rather than the other primarily because of the level of the water table, the composition of the soil, and the expected rainfall. Harvest times vary as one moves from south to north, with the provincial border providing a convenient break. Thus there are cotton and rice zones in Sindh and Punjab. One additional zone centred on Faisalabad is defined as mixed because it is suitable for many crops, with no one crop dominating the *kharif* planting. A fourth Punjab zone, along the left bank of the Indus, experiences much lower cropping intensities partly because of inferior irrigation facilities, and thus is singled out as a low-intensity zone. The final zone in Punjab consists of rain-fed, or *barani*, agriculture.

The other two zones, Other NWFP and Other Balochistan, though not homogeneous, are not broken down further because they account for only 6.3 and 1.2 percent of total wheat production, respectively, over the time period in question. Two districts in these provinces, D. I. Khan and Nasirabad, are included in different zones since they share the same climatic and crop rotation characteristics.

For each zone, area and yield supply equations are estimated using the following general form:

$$A_t = f(A_{t-1}, E(RW_t), E(RO_t), E(PI_t), W_t, TK_t) \quad \ldots \quad \ldots \quad (1)$$

$$Y_t = f(E(PW_t), E(PO_t), PI_t, W_t, TK_t) \quad \ldots \quad \ldots \quad (2)$$

where $E(.)$ is the expectations operator, A is acreage planted to wheat, Y is wheat yield, RW is gross revenue per hectare from wheat production, PW is the price of

[1] These zones are similar but not identical to those delineated in PARC (1986).

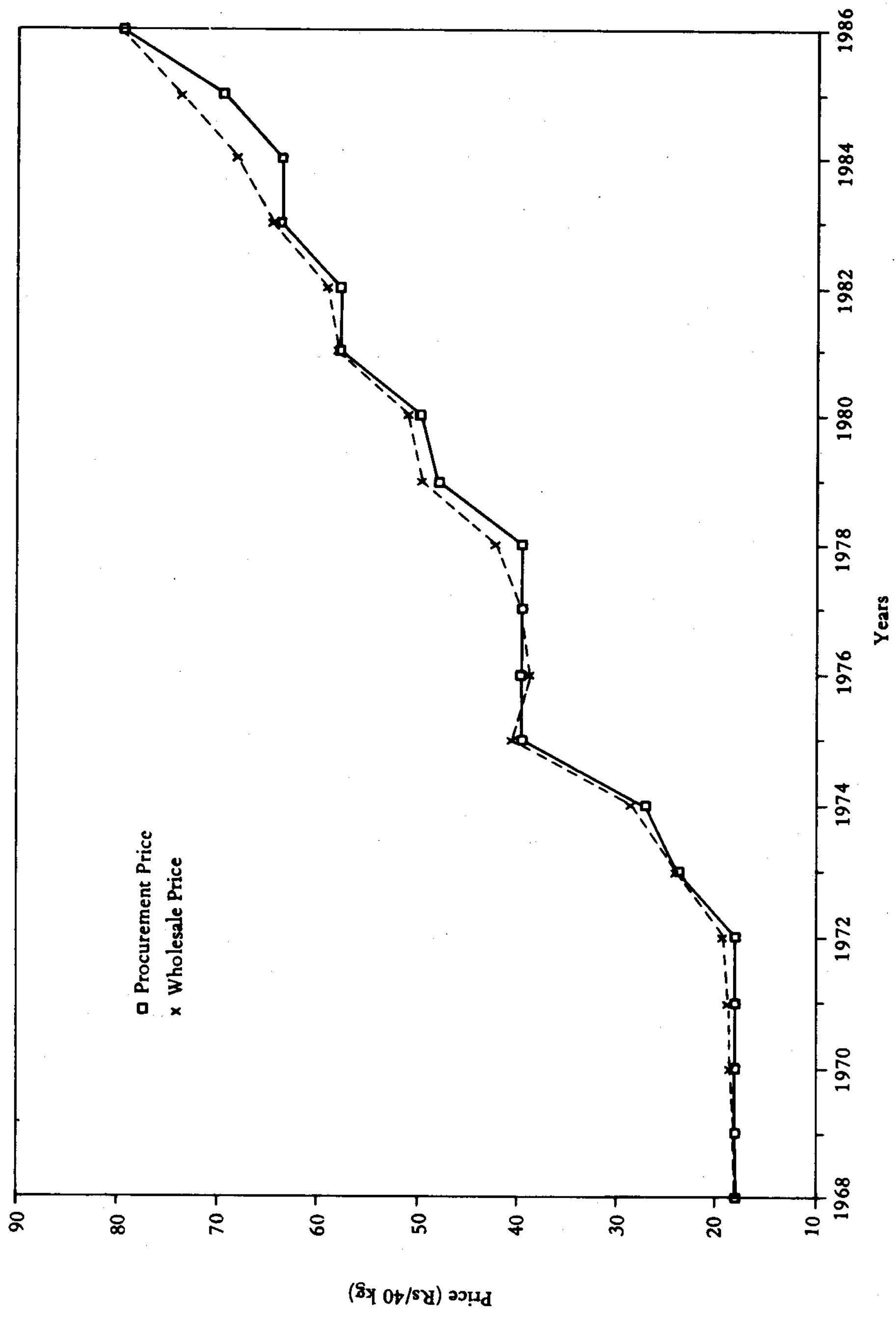

Fig. 1. Procurement and Wholesale Prices of Wheat

Table 1

Districts by Agro-climatic Zones

1. Rice/Wheat – Punjab Sialkot Gujrat Gujranwala Sheikhupura Lahore/Kasur	5. *Barani* – Punjab Attock Jhelum Rawalpindi/Islamabad
2. Mixed – Punjab Sargodha/Khushab Jhang Faisalabad/T.T. Singh Okara**	6. Cotton/Wheat – Sindh Sukkur ** Khairpur Nawabshah Hyderabad** Tharparkar
3. Cotton/Wheat – Punjab Sahiwal** Bahawalnagar Bahawalpur R. Y. Khan Multan/Vehari	7. Rice/Other – Sindh Jacobabad Larkana Dadu Thatta Badin** Shikarpur** Nasirabad** Karachi**
4. Low-intensity – Punjab D. G. Khan/Rajanpur Muzaffargarh/Leiah Mianwali/Bhakkar D. I. Khan	8. Other N.W.F.P. Except D. I. Khan 9. Other Balochistan Except Nasirabad

**These districts were divided or created after 1967-68. Data in subsequent tables referring to these districts prior to their creation assume that the proportion of each crop grown in the two districts after a partition is the same as the proportion prior to partition.

wheat, *RO* is gross revenue per hectare from an alternate crop, *PO* is the price of an alternate crop, *PI* is the price of inputs, *W* is weather, and *TK* is technology.

The acreage equation is thus a normal Nerlovian supply equation, with the short-term response measured by the coefficient of expected revenue per hectare, and the long-term response calculated using the adjustment .parameter from the coefficient of lagged acreage [Nerlove (1958)]. In the yield equations, no lagged dependent variable is used, thus implying that there are few difficulties in adjusting desired amounts of variable inputs to a change in relative prices.

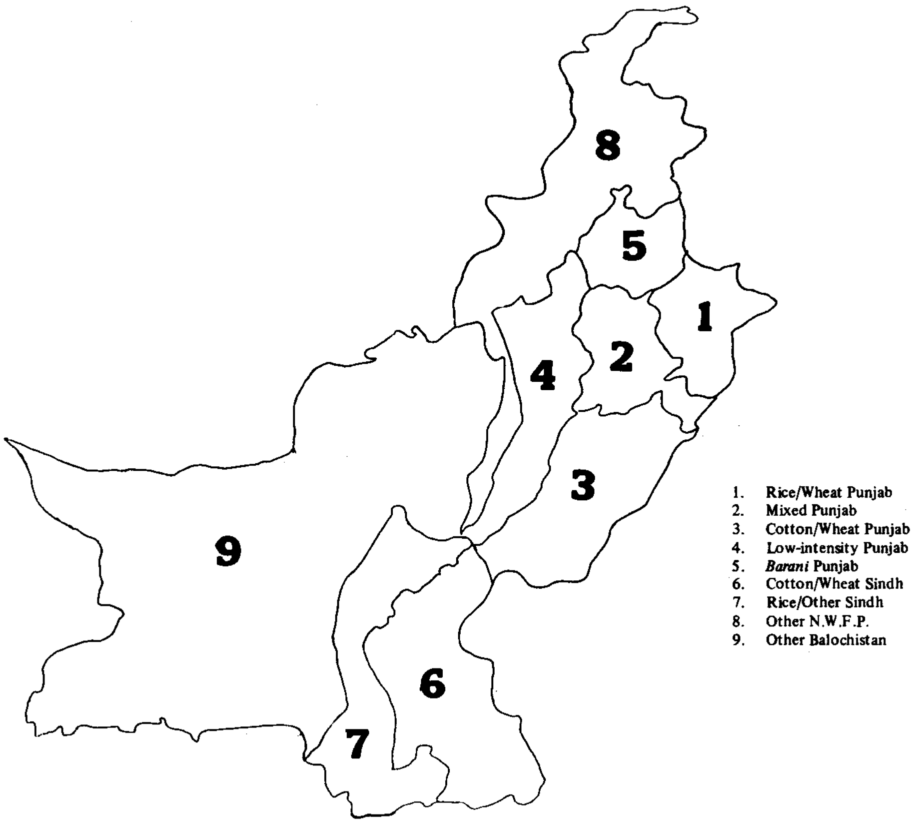

Fig. 2. Agro-climatic Zones in Pakistan

Since the focus of this study is on the response of production and procurement to a change in the procurement price, the variables are chosen in order to provide the most accurate estimates of price responsiveness. This is accomplished, first, by using expected gross revenue of wheat rather than the procurement price in most equations. When relative yields between crops change rapidly and at different rates over the period of estimation, as they do during rapid technological change, changes in expected gross revenue are more likely to provide accurate estimates of supply response than the changes in price alone. Clearly, a farmer has increased incentives to plant wheat if relative prices are constant but he expects wheat yields to be higher this year and yields of the competing crop to be unchanged. Using the expected revenue series is also superior to simply including a trend variable in the regression for several reasons, but primarily because the uneven pace of technological change is reflected in the former but not the latter. So the preferred variable for

Pakistan is expected gross revenue rather than price.[2]

Expected gross revenue is calculated by taking the announced procurement price at planting time – which differs in some years from the procurement price at harvest time – and multiplying it by expected yield. The procurement price at planting time is a far superior predictor of the procurement price at harvest time to any combination of lagged prices. In fact, the procurement price at planting time is a better predictor of harvest-time *wholesale* prices than any combination of past procurement or wholesale prices. The expected yield variable is more problematic since yields are generally increasing over the period. The technique used here is to estimate a yield trend for each zone for the previous five years and project that trend to the year in question. Thus, for most zones and for most series, the expected yield will be higher than the lagged yield.[3]

The variables used as cross-prices vary by zone among cotton, *basmati* rice, and IRRI rice. In most cases, the price variable performed better than the expected revenue variable for the cross-price terms. This could result from inaccuracies in the expected yield series which result from the absence of a clear trend in yields for *basmati* rice and cotton over the time-period in question.

The only input price included in the equation is the price of fertilizer, with the urea price serving as the proxy. This is not an ideal price as in some years availability was limited at the official price. Nevertheless, there is no alternate series that is clearly superior.

All price variables are deflated by the implicit GDP deflator for non-agriculture.

Weather variables differ by zone. Several variants of rainfall variables and two different temperature variables are used. The only rainfall variables to appear in area equations are those for the early months of the sowing season, when rainfall could affect plantings. Rainfall in other individual months or combinations of months can affect yields, and thus appear in the yield equations. Temperatures affect yields negatively when a sudden rise deters growth during certain sensitive periods in the life of the plant. Consequently, one variable measures the five highest temperatures during a fifteen-day critical period. Another variable uses the average high for the

[2]See Bhagat (1985) for evidence from Bihar state of India that, in a period of rapid technological change, expected revenue produces better estimates of supply response than price alone.

[3]An alternative method for calculating expected yields would have been to use the estimated yield equations. There are several difficulties with this approach. First, expected yields must be formulated at planting time when many of the variables in the estimated yield equations – including rainfall, temperature, water availability, and fertilizer sales variables – are yet future. Thus, to employ this procedure would have entailed taking expectations on each of these variables and then entering those series into the yield equations. In addition, it would have been necessary to re-estimate the area equations for each change in specification of the yield equations. Finally, the yield equations use data for the *entire* period to estimate the coefficients. Consequently, data which are unknown at the time when expectations are taken are used to forecast yields. For all these reasons, the trend method of measuring expected yields is judged superior.

month of March. For more details, see the notes to Table 2.

A number of technology variables are used including water availability through the canals, water availability through canals and tubewells, the number of tubewells, and fertilizer sales. For the area equations, expected water availability is used instead of actual availability since the outcome was unknown at planting time.

The preferred variable for a change in seed technology would have been the percentage of land planted to high-yielding varieties. Unfortunately, consistent and complete series of this variable are unavailable by district, and thus could not be calculated for each zone.

The fertilizer sales variable is to some extent a proxy for a change in seed technology. Since this is a supply function, normally the level of variable input use would not appear. But in Pakistan, even if all relative prices had remained constant over this period, fertilizer use would have increased over time as more farmers switched to high-yielding varieties. Since many farmers introduced the high-yielding varieties and higher fertilizer use simultaneously, this series is a reasonably good proxy for the degree to which the seed/fertilizer revolution had spread at any one time. The limited availability of fertilizer in some years noted above also validates the use of this variable.

As mentioned above, the focus of the estimation is on the own price and revenue variables. High multicollinearity among all the technology variables – tubewells, water availability, and fertilizer sales – makes the estimates of these variables inaccurate. Thus, little emphasis should be put on the individual coefficients of these variables. Cumulatively, however, the effects of these variables should give a reasonably good estimate of the impact of water, seed, and fertilizer on wheat production.

A complete printout of the data used in these equations can be found in the data appendix of Pinckney (1988).

Results of Supply Equation Estimation[4]

Table 2 presents results of all of the area equations, while Table 3 presents yield equations. Implied elasticities at the mean are presented in Table 4.

Price Responsiveness

The most important results relate area and yield to price or expected revenue. All of these elasticities are positive with the exception of three negative and insignificant estimates. In general, the equations for Punjab are more satisfactory than those for Sindh, Balochistan, or NWFP, most likely reflecting more accurate data from that province.

[4]Many of the estimates reported here were first reported in Hamid *et al.* (1987).

Table 2

Area Equation Results by Agro-climatic Zones

Coefficient	Rice/ Wheat Punjab	Mixed Punjab	Cotton/ Wheat Punjab	Low-intensity Punjab	*Barani* Punjab	Rice/ Other Sindh	Cotton/ Wheat Sindh	Other N.W.F.P.	Other Balochis-tan
Constant	0.590	0.252	0.171	0.249	0.233	25.7	79.5	0.186	20.1
Lagged Area Wheat	0.343 (2.25)	0.821 (7.87)	0.699 (5.7)	0.498 (2.04)	0.329 (1.68)	0.381 (2.5)	–0.0263 (–0.11)	0.471 (2.32)	0.230 (1.03)
Expected Revenue Wheat	13.58 (2.94)	1.43 (0.432)	1.64 (.205)	6.71 (1.67)			–0.906 (–0.32)	8.47 (1.95)	3.33 (2.35)
Procurement Price Wheat					6.80 (2.78)	–0.432 (–0.08)			
Cotton Price			0.184 (0.33)						
Expected Revenue Cotton							0.904 (0.62)		
IRRI Rice Price						3.63 (1.09)			

Continued –

Table 2 – (*Continued*)

Coefficient	Rice/ Wheat Punjab	Mixed Punjab	Cotton/ Wheat Punjab	Low-intensity Punjab	*Barani* Punjab	Rice/ Other Sindh	Cotton/ Wheat Sindh	Other N.W.F.P.	Other Balochistan
Basmati Rice Price	–3.54 (–1.41)								
Urea Price		–0.175 (–2.07)	–0.145 (–0.86)	–0.146 (–0.97)		–0.0598 (–0.83)	–0.149 (–1.35)		0.0609 (0.85)
Rainfall, October					0.323 (1.51)	2.38 (2.76)			
Rainfall, November		1.06 (2.15)			0.578 (2.53)				
Rainfall, October/ November								0.519 (1.21)	
Rainfall, November/ December									1.19 (3.09)
Expected Water Availability			2.12 (2.13)	2.62 (1.14)			8.37 (4.06)		

Continued –

Table 2 – (*Continued*)

Surface Water Availability, *Rabi* Season						21.27 (2.63)			
Tubewells								0.00236 (0.3)	
R-squared	0.82	0.85	0.94	0.85	0.59	0.79	0.95	0.88	0.52
Adjusted R-squared	0.78	0.81	0.92	0.81	0.46	0.68	0.92	0.85	0.37
Standard Error	33.4	26	50	32	12.7	21.3	25.5	26.5	21.8
h-statistics	–0.80	–0.95	–0.32	a	1.10	0.25	a	1.13	0.25

Notes: T-statistics are in parentheses.

[a] H-Statistic cannot be computed. Durbin-Watson statistic is 2.09.

Note on Variables: The tubewell series for Punjab zones aggregate district data. For Sindh, NWFP and Balochistan, no district data are available, so the zonal series are constant proportions of provincial data.

The series for surface water availability have been created by the author by apportioning the water flowing through individual canals to zones based on the proportion of the canal in each zone. Total water availability adds to the surface water an amount from tubewell, computed by multiplying the number of tubewells in each zone by a standard withdrawal.

Expected water availability was constructed from the water availability series by computing a series of five-year trends and projecting those trends one year forward.

Rainfall series for each zone were computed by averaging rainfall stations within each district, and then computing a weighted average of the district rainfall by month for each zone, with the weights equal to the share of each district in zonal production.

"High Temperature" was computed as an average of the five highest daily highs during a critical fifteen-day period. The critical period was 5 February to 20 February for Hyderabad, and was progressively later for more northern zones. If the average on the five highest days was less than a given critical value, the value of the variable was zero. Otherwise, the value was the average of those five days minus the critical value. The "Temperature" variable is constructed similarly, but uses the average high for March.

Table 3

Yield Equation Results by Agro-climatic Zones

Coefficient	Rice/ Wheat Punjab	Mixed Punjab	Cotton/ Wheat Punjab	Low-intensity Punjab	*Barani* Punjab	Rice/ Other Sindh	Cotton/ Wheat Sindh	Other N.W.F.P.	Other Balochis-tan
Constant	–0.289	0.597	0.878	0.230	0.151	–0.285	1.09	0.176	0.0397
Procurement Price	0.0464 (1.41)	0.0461 (2.26)	0.0305 (2.05)	0.0420 (1.71)	0.00625 (3.63)	0.0324 (1.25)	–0.00717 (–0.4)	0.0192 (1.14)	0.00400 (0.17)
Cotton Price			–0.00196 (–2.04)				–0.00118 (–1.47)		
Urea Price	–0.000429 (–1.01)						–0.000102 (–0.46)		
Rainfall, November					0.00310 (3.30)				
Rainfall, December			–0.00166 (–1.74)	–0.00358 (–1.95)					
Rainfall, December to February					0.000733 (3.69)				

Continued –

Table 3 – (*Continued*)

Rainfall, Annual								0.000134 (0.58)	0.000982 (1.09)
High Temperature	–0.0135 (–0.49)		–0.0138 (–1.59)			–0.0103 (–0.58)			
Temperature				–0.0464 (–1.61)	–0.0316 (–1.9)				
Water Availability *Rabi* Season	0.0171 (6.06)		0.00339 (3.04)	0.00511 (0.95)					
Surface Water Availability, *Rabi* Season						0.076 (1.87)			
Fertilizer Sales		0.00311 (7.04)	0.000877 (3.54)	0.00271 (1.4)	0.02 (3.18)			0.00449 (2.56)	
Square Root of Tubewells						0.00643 (6.63)	0.0100 (16.4)		
Tubewells, Province Level								0.00007 (4.1)	0.000131 (3.4)

Continued –

Table 3 – (*Continued*)

R-squared	0.79	0.78	0.89	0.68	0.98	0.90	0.98	0.92	0.88
Adjusted *R*-squared	0.73	0.75	0.84	0.54	0.97	0.86	0.97	0.9	0.84
Standard Error	0.13	0.0826	0.0595	0.100	0.0438	0.103	0.064	0.0663	0.118
Durbin-Watson	1.96	2.52	2.96	1.58	2.01	1.48	1.98	1.62	a

Table 4

Wheat Supply Elasticities with Respect to Prices by Agro-climatic Zone

	Own Price			Fertilizer Price	Contton Price
	Area		Yield	Area	Yield
	Short Run	Long Run			
Rice/Wheat Punjab	0.25***	0.39***	0.57*	–	–
Mixed Punjab	0.04	0.21	0.43**	–0.09**	–
Cotton/Wheat Punjab	0.03	0.11	0.29**	–0.06	–0.14**
Low-intensity Punjab	0.16*	0.32*	0.57*	–0.11	–
Barani Punjab	0.21***	0.31***	0.15***	–	–
Rice/Other Sindh	–0.02	–0.04	0.41	–0.11	–
Cotton/Wheat Sindh	–0.04	–0.04	–0.07	–0.12*	–0.08**
Other N.W.F.P.	0.20**	0.38**	0.33	–	–
Other Balochistan	0.31***	0.40***	0.08	0.25	–
All Pakistan[1]	0.09	0.20	0.34	–0.06	–0.04
All Pakistan[2]	0.08	0.14	0.32	–0.03	–0.04

Notes: *Denotes 90 percent confidence level.
**Denotes 95 percent confidence level.
***Denotes 99 percent confidence level.
[1] All area elasticities, except those for *Barani* Punjab and Rice/other Sindh, were estimated with *expected* revenue instead of price.
[2] The own price area elasticity for All Pakistan is a weighted average of the Independently estimated area elasticities with respect to revenue and own price. All Pakistan[2] does not include insignificant elasticities.

The response of area to price in Sindh is apparently close to zero, as is the short-run response in the Cotton/Wheat and Mixed areas of Punjab. These two Punjab zones, however, have the largest differentials between long- and short-run parameters, bringing the long-run elasticities up closer to elasticities from other areas of Punjab. The short-run area elasticity for the country as a whole can be computed by adding elasticities of each zone weighted by production share. The result is an area response of 0.09, implying that a 10 percent increase in the procurement price of wheat will raise wheat plantings by just under 1 percent. In the long run, the weighted average increases to 0.20, with much of the increase resulting from the large difference between short- and long-run in the Mixed Punjab zone. A more conservative long-run estimate results from setting the insignificant parameters to zero in both the short and long run. This has only marginal effects in the short run, as that elasticity falls to 0.08, but the long run elasticity falls more substantially to 0.14.

Yield responses are considerably higher than area responses in most zones, averaging 0.34 for the country. Understandably, the yield response in the *Barani* Punjab is the lowest of the significant estimates as it is more difficult in a rain-fed system to increase yields through the application of increased variable inputs to wheat production. Cotton/Wheat Sindh and other Balochistan are the only zones that fail to show a large response, although none of the yield responses outside of Punjab are significant. Nevertheless, the weighted average yield elasticity for the country as a whole falls only slightly to 0.32 when insignificant coefficients are set to zero.

It should be noted that a significant response to procurement price is found even in areas of the country where virtually no procurement takes place. This is accounted for by the high correlations between procurement and wholesale prices shown above in Figure 1. As noted, the procurement price at planting time is the best predictor of wholesale prices at planting time. Thus, in non-procurement areas the procurement price still serves the role of an expected price.

Combining the yield and area estimates, the total short-run supply response of wheat to an increase in the procurement price is 0.40 conservatively, or 0.43 including insignificant coefficients. The long-run estimates range from a conservative 0.46 to 0.54, with the latter figure including insignificant coefficients. These numbers will be used to measure the total responsiveness of procurement to an increase in the procurement price.

Other Variables in Supply Equations

Before presenting the procurement model, however, other variables in the equations should be considered briefly. The only cross-prices which have significant effects are *basmati* prices on area in the Rice/Wheat Punjab and cotton prices on yields in the two cotton zones. A high cotton price increases the incentive to leave the cotton crop in the ground longer, thus delaying the planting of wheat and decreasing wheat yields. It is interesting that the cotton price also has a small though insignificant positive effect on wheat area in both zones. One possible rationale for this phenomenon is that there are a fairly large number of subsistence wheat farmers who grow cotton as a cash crop. Households in this category have a target level of wheat production in order to avoid buying wheat later in the market year at a much higher price than their wheat selling price. When wheat planting is delayed due to higher prices for cotton, expected wheat yields decline and thus wheat area must be increased in order to meet the production target.

The fertilizer price has a small negative effect on areas, although this effect is only significant in two zones. Rainfall variables are highly significant in some zones, with the monthly rainfall variables generally performing much better than seasonal or annual variables. The temperature variables are of the right sign but only significant in the Cotton/Wheat Punjab and Low-intensity Punjab. This highlights the difficulty of correctly specifying a weather variable which is known to be important agronomically.

As mentioned above, multicollinearity makes the exact estimates of the technology variables suspect. Water availability in its various specifications is quite often highly significant, particularly in the Cotton/Wheat Sindh where the wheat price variables performed poorly. The tubewells variable in the yield equation is extremely significant when entered as the square root of the total number, implying that the yield effects of additional tubewells have declined over the years. One possible explanation is that the first tubewells in this zone were installed in areas of highest profitability. More recent tubewells may have been installed in areas where effects on yields are only marginal.

This concludes the discussion of the impact of an increase in the procurement price on production. The next section examines the other ways in which a change in the procurement price can affect procurement.

DETERMINANTS OF PROCUREMENT SIZE[5]

As seen above, a ten percent increase in the government's procurement price will lead to an increase in production of about four percent. The next step in understanding the forces that impinge upon procurement is to develop a model that explains marketed surplus and the wholesale price.

Some knowledge of the market structure in Pakistan is helpful in order to understand the model. That cannot be provided in this brief paper, but an excellent description can be found in Cornelisse and Naqvi (1984). For the purposes at hand, it is sufficient to make four points:

(1) There is an active and legal private market alongside the government procurement and distribution system. Farmers may sell either to private agents or to the government agency. The government has no direct control over prices paid in the private market.

(2) Private traders can and do buy wheat from farmers and sell the same wheat to the government agency.

(3) The government procurement price usually is formulated and announced at planting time, prior to any knowledge about the size of the crop.

[5] Results in this section were first reported in Pinckney (1988).

(4) A large proportion of the total wheat harvest does not enter the formal marketing system. Most of this wheat is retained on farm for own consumption.

A Model of Procurement

A simple three-equation model is used here to characterized the determinants of procurement:

$$MS = f_1(Q, PP, WP, T) \quad \ldots \quad \ldots \quad \ldots \quad (3)$$

$$WP = f_2(MS, PP, D) \quad \ldots \quad \ldots \quad \ldots \quad (4)$$

$$PC = f_3(MS, PP, WP, T) \quad \ldots \quad \ldots \quad \ldots \quad (5)$$

where *MS* is marketed surplus, *Q* is production, *PP* is procurement price at harvest time, *WP* is the wholesale price at harvest time, *PC* is procurement, *D* is demand at the wholesale level, and *T* is time. The equations will be discussed in turn.

In Equation 3, marketed surplus – that is, the total amount of wheat entering the formal marketing system – is expected to be a positive function of all four variables. Even though the output has a positive effect on farm income and thus on own consumption of the commodity by farmers, it is unlikely that the income effect is large enough to cause the marketed surplus to decrease when production increases. Indeed, if the income elasticity of the demand for wheat is less than one (as it is for wheat in Pakistan), an increase in output, *ceteris paribus*, must lead to an increase in the marketed surplus.

The relationship between the marketed surplus and the price variables holding the output constant is somewhat less clear since price increases also raise farm income. The income effect alone increases on-farm consumption for most commodities. Estimates of rural income and demand elasticities for wheat presented in Alderman (1988) indicate that even if all income comes from wheat production, a rise in price will increase marketed surplus since the absolute value of the price elasticity is larger than the income elasticity; that is, the decline in consumption because of higher prices is greater than the increase in consumption because of higher income. Moreover, the income effect will be dampened further since wheat production is not the only source of income for any Pakistani farm households. Consequently, both price variables are expected to positively affect the marketed surplus.

The time variable is the least clear. In general one would expect that farmers will become more market-oriented over time due to increased demand for purchased items and a reduction in transaction costs because of improvements in infrastructure. In this case, marketed surplus would be positively correlated with time. In

Pakistan, however, there is some evidence that procurement agents forced farmers to sell their wheat in the early seventies, which possibly could lead to higher than desired levels of marketed surplus in the early years of the time series. Therefore, the anticipated effect of the time variable is positive, but the earlier forced procurement makes this expectation tentative.

Equation (4) expresses the wholesale price as a function of the procurement price, marketed surplus, and demand. Thus, the wholesale price is determined simultaneously with marketed surplus. If all farmers are identical and the government truly buys all of the wheat offered to it at the procurement price, then the procurement price will serve as a floor for the wholesale price. Since farmers are not identical, with different farmers facing different transaction costs for entering the government or the private market, farmers shift from selling in one market to the other as the difference in the prices increases. Thus, a strong positive relationship is expected, but the procurement price will not explain all of the movement in the wholesale price.

The second independent variable in Equation (4) is marketed surplus, and the wholesale price is expected to decrease as supplies in the market increase. The final variable in the equation is demand in the non-farm sector. Fluctuations in this component from year to year should be small relative to fluctuations in the marketed surplus. Consequently, time will be used as a proxy for demand in this equation. The expected sign, then, would be positive.

Finally, Equation (5) – the procurement equation – is expected to yield positive coefficients for marketed surplus and the procurement price, and a negative coefficient for the wholesale price. The relationship between the procurement price and the wholesale price should determine the proportion of marketed surplus going to the procurement agencies. Thus, an increase in marketed surplus clearly raises procurement. An increase in the procurement price or a decline in the wholesale price will raise procurement even if the marketed surplus is constant, as procurement's share will increase. The time trend may be negative because of forced procurement in the early seventies, as mentioned above.

Thus the model described in this section has three variables considered endogenous – procurement, marketed surplus, and wholesale price; and three variables considered exogenous – production, procurement price, and time [after substituting time for demand in Equation (4)]. Production is again considered a function of procurement price in the final section of the paper. With production still considered exogenous, this section proceeds by modifying the model for the purposes of estimation.

Estimation of the Procurement Model

The model outlined above cannot be estimated because the marketed surplus variable is unobserved. For estimation this model is collapsed into a two-equation model with only the wholesale price and procurement as endogenous variables by substituting Equation (3) for marketed surplus into Equations (4) and (5), the procurement and wholesale price equations:

$$WP = f_4(Q, PP, T) \quad \ldots \quad \ldots \quad \ldots \quad (6)$$

$$PC = f_5(Q, PP, WP, T) \quad \ldots \quad \ldots \quad \ldots \quad (7)$$

As before, *WP* is the wholesale price, *Q* is production, *PP* is the procurement price, *T* is time, and *PC* is procurement. The earlier model remains useful for understanding the estimated coefficients. For example, the coefficient of the wholesale price in Equation (7) has two offsetting components: wholesale price positively affects marketed surplus and via the marketed surplus positively affects procurement; on the other hand, wholesale price has a direct negative effect from Equation (5) on procurement. Thus both effects will be included in the coefficient of the wholesale price in the procurement equation.

One advantage of the two-equation model is the absence of simultaneity in the system. Since Equation (6) has only exogenous variables on the right-hand side, the system is recursive and thus both equations can be estimated consistently and without bias by ordinary least squares [Johnston (1984)].

The time-period for estimation is again the post-Green Revolution period, extended to include 1986. Variables used for estimation are as follows. The procurement variable is national purchases of wheat by the provincial food departments and PASSCO, measured in thousand metric tons. The wholesale price variable is a weighted average of the wholesale prices during harvest months in 15 surplus zones.[6] Procurement price is the effective procurement price at harvest time, which as mentioned above is higher than the procurement price announced at planting time for a few years in the seventies. The units for price variables are rupees per 40 kilograms, deflated by the GDP deflator for the non-agricultural sector with a 1985 base year. Production is total wheat production in Pakistan, in thousand metric tons.

[6]Months used are May and June for Punjab cities, April and May for Sindh cities. The weights are derived from the proportion of total wheat procurement that comes from surrounding districts. The cities and their weights are as follows:

Bahawalnagar	(.0352)	Bahawalpur	(.0262)
Gujranwala	(.1084)	Faisalabad	(.1224)
Multan	(.2085)	Okara	(.1086)
R. Y. Khan	(.0358)	Sahiwal	(.0758)
Sargodha	(.0535)	Hyderabad	(.0240)
Khairpur	(.0215)	Larkana	(.0179)
Mirpur Khas	(.0314)	Nawabshah	(.1106)
Sukkur	(.0201)		

Procurement Equation Results

Equations (6) and (7) above are estimated and reported in Table 5. The wholesale price equation has an R^2 of 0.93 and highly significant coefficients, all with the expected signs. The coefficient of 0.87 on the procurement price indicates that if the procurement price is raised 10 rupees per 40 kilograms, the wholesale price would be expected to increase by 8.7 rupees with production held constant. The production coefficient suggests that a rise in production of 100 thousand tons leads to a decline in the wholesale price of 0.16 rupees per 40 kilograms. Thus, the effect of production on wholesale price is small even though it is highly significant.

The estimation of Equation (7) is also statistically strong, with an R^2 of .96 and all coefficients except trend significant at least at the 10 percent level. The sign of trend in this equation was ambiguous *a priori.* Trend was expected to have a negative direct effect, but also to have a positive impact on marketed surplus. The estimated coefficient picks up both components, and thus is insignificant. The other coefficients are significant despite the presence of high multicollinearity, which does not bias the results but tends to increase estimates of standard errors.

The equation indicates that, holding production and wholesale price constant, procurement increases by 118 thousand metric tons when the procurement price is raised by 1 rupee per 40 kilograms. This captures both the indirect positive effect of a rise in the procurement price on marketed surplus and the direct positive effect on the percentage of marketed surplus purchased by procurement agents.

As expected, the wholesale price coefficient is negative and somewhat smaller in absolute value than the procurement price coefficient. A rise in the wholesale price, *ceteris paribus,* has a positive effect on total marketed surplus, but a negative effect on the percentage of marketed surplus procured by the government. The latter effect outweighs the former.

Since Equation (7) includes an endogenous variable (wholesale price), the coefficients reflect only the direct effects, and not the indirect effects, of the exogenous changes. For this reason, all results in the previous paragraph should be interpreted with the understanding that other variables are held constant. If production increases, for instance, the wholesale price will go down, thus increasing procurement over and above the direct production effect. In Equation (7a) of the table, Equations (6) and (7) are combined to give an overall effect of the exogenous variables on procurement. This is accomplished by substituting Equation (6) for the wholesale price into Equation (7) and combining terms. The result can be considered a reduced form equation for procurement since only exogenous variables are on the right-hand side. The same equation is estimated directly in Equation (8), with quite similar results.

The estimated percentage procured from an increase in the crop is considerably higher in Equations (7a) and (8) than in Equation (7). This estimate combines

Table 5

Wheat Procurement Model 1968–1986

Equation No.	Dependent Variable	Independent Variable/Estimated Coefficient: Constant	Wholesale Price	Procurement Price	Price Ratio	Trend	Production	Adj. R^2	*D.W.*
(6)	WP	20.2	–	0.873*** (0.07)	–	0.653*** (0.21)	–0.0016*** (0.0005)	0.93	2.00
(7)	PC	–5277	–95.6** (50.9)	118.3** (46.3)	–	–48.9 (53.5)	0.680*** (0.13)	0.96	2.38
(7a)	PC	–7209	–	35.2		–111.0	0.837	–	–
(8)	PC	–7208	–	34.9** (14.1)	–	–111.3** (45.3)	0.837*** (0.10)	0.95	2.59

Notes: The standard errors of the estimated coefficients are presented in brackets.
The statistical significance of the estimated coefficients are indicated as follows:
*10 percent significance level.
**5 percent significance level.
***1 percent significance level.

the direct effect of an increase in production on procurement and the indirect effect through the resulting decline in the wholesale price. Thus, almost 84 percent of an increase in production is procured. This is much higher than the average percentage of production procured. In understanding this high percentage, it is important to distinguish between the estimated marginal effect and the average effect. Farmers hold a considerable portion of their crop for own consumption, and this amount is relatively inelastic to the size of the crop. Consequently, the marginal procurement ratio will always be higher than the average procurement ratio. Thus, in good years such as 1973, 1976, and 1981, the percentage increase in procurement can be considerably greater than the percentage increase in production.

The coefficient of procurement price in Equations (7a) and (8) incorporates the direct positive effect of an increase in the procurement price on procurement, and the indirect negative effect via the increase in the wholesale price. The total effect of a one-rupee increase in the procurement price is an increase of only 35 thousand tons in procurement, holding production constant. The indirect negative effect via wholesale prices is thus more than two-thirds as large as the direct positive effect. The effects including supply response are examined in the next section.

THE TOTAL EFFECT ON PROCUREMENT OF AN INCREASE IN PRICE

At this point, results from the two previous sections can be combined to estimate the total effect of an increase in the procurement price on procurement.

The conservative estimate of supply response estimated above is 0.40. This can be converted to thousand tons per one-rupee increase in the procurement price by taking the percentage increase in the procurement price (1/80), multiplying by the supply elasticity, and multiplying by expected production (13 million tons). This yields a total increase in supply of 65 thousand tons. The higher estimate of supply response – 0.43 – yields an increase of 70 thousand tons.

Equations (7a) and (8) show that 83.7 percent of an increase in production is procured, implying that 54 to 58 thousand tons of additional procurement will result from the increase in production, thus the total increase in procurement that results from the direct effect of the increase in price, the negative indirect effect via the wholesale price, and the positive indirect effect via the increase in production is (35 + 54) or (35 + 58), and thus 89 to 93 thousand tons.

Several caveats are in order. First, these calculations represent the effect of having a price one rupee higher *next* year compared to another price *next* year. A one-rupee nominal increase in the procurement price from this year to next year would *not* be expected to engender this increased procurement, as the real procurement price – deflated by non-agricultural sector prices – most probably would decline under such circumstances. In addition, there is some expected change in procurement from one year to the next, which results from the expected increase in production holding prices constant as well as from the negative trend factor on procurement, which is significant in Equation (8).

Furthermore, the calculation above considers only the change in the wheat procurement price. The supply equations suggest that prices of other crops, prices of fertilizers, technology changes, expected yields, and weather factors all will have an impact on production which is independent of price. In addition, it has been shown elsewhere [Pinckney (1988)] that, under the present pricing system, changes in the release price can affect the size of procurement even if the buying price is held constant. The calculations, thus, are only valid for comparing two possible prices in a single year, holding these other variables constant.

CONCLUSIONS

An increase in the procurement price affects procurement in four different ways. First, there is the direct positive effect on the share of marketed surplus procured. Second, there is the indirect positive effect via the increase in total marketed surplus. These two effects are estimated together at 118 thousand tons per one-rupee increase in the price. Third, there is the negative indirect effect of the increase in the wholesale price that results from a rise in the procurement price. This higher wholesale price reduces government procurement by about 83 thousand tons. Finally, an increase in the procurement price increases production which, thus, raises marketed surplus and procurement. This final effect works through a short-run supply elasticity of about 0.4, with the resulting effect on procurement of approximately 55 thousand tons. Thus, the net effect on procurement of a one-rupee increase in the procurement price is an increase of about 90 thousand tons. All of these effects must be included for a complete understanding of the effects of changes in official prices on procurement.

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