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ESTIMATING THE SUPPLY RESPONSE OF MAIN CROPS IN DEVELOPING COUNTRIES: THE CASE OF PAKISTAN AND INDIA

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ABSTRACT

The production of main crops in developing countries is an important factor concerning farmers, population revenues and economic development. To contribute to better knowledge on the synthetic parameters describing supply response, this article exploits annual data set following Pakistan and India over 42 years (1966 - 2008) to develop two classic translog models estimating the responses of areas for wheat, cotton, rice, maize, sugarcane, dry beans, rapeseed, soybeans, sorghum and millet to changes in their gross product per hectare. The coefficients of each crop's equation in the system are estimated with the Full Information Maximum Likelihood. The own and cross gross product elasticities for each crop are calculated and compared to the data existing in literature, showing two results: firstly, the major crops areas are found to be weakly gross product-responsive as compared to minor crops, as well as to developed countries and secondly, Pakistani producers have responded weakly to gross product as compared to Indian producers. Policy reforms could help producers respond more easily to price changes, as well as to raise average productivity levels.

Keywords: crops, supply response, Pakistan, India, area allocation, FIML, gross product, elasticity, translog.

INTRODUCTION

Pakistan and India are very important developing countries of South-Asia in terms of agricultural area, population, production and consumption of raw agricultural products. These two countries have a common border. In spite of structural shift towards industrialization, agriculture sector is still a large sector of economy in these two countries. For India, agriculture contributes to Gross Domestic Product (GDP) at 17.8 percent (FAOSTAT) whether 52 percent of total employed force depends on agriculture for livelihood. Total surface area of India is 329 million hectares (Mha) in which arable land is 158 Mha. On the other hand for Pakistan, agriculture contributes to GDP at 21.8 percent (economic survey of Pakistan, 2008-2009) whether 44.7 percent of total employed force depends on agriculture for livelihood. Total surface area of Pakistan is 80 Mha in which arable land is 20 Mha.

Major crops such as wheat, rice, cotton and sugarcane on average contribute 29.8 percent to value added in overall agriculture and 6.5 percent to GDP of Pakistan. The minor crops contribute 12 percent of values added in overall agriculture. In Pakistan, farmers usually do subsistence farming. They keep a certain part of their own production for family consumption and put remaining for market sale.

In this article we will focus on analysis of the ten most important crops of these two countries: wheat, rice, cotton, sugarcane, maize, dry beans, soybean, rapeseed, sorghum and millet which account 138 Mha in India (87% of total arable land) and 18 Mha in Pakistan (89% of arable land).

Main reasons for selecting these two countries are same cultural and climatic conditions.

Pakistan and India should have higher production per hectare and more cultivated land to meet the need of growing population like other developing countries. Even if an important part of crop is consumed by farmer's families, producers are also increasingly responding to market prices and, eventually, policy decisions such as specific aids and support prices in their land allocation among crops. This article is composed of two parts: Firstly, the methodology is presented that has been used to estimate the combined influence of prices and yields (gross product per hectare) on allocation of land among crops and to calculate matrixes of own and cross elasticities. This is an important challenge for econometric simulations as in present economical literature either there is no standard data available or they are old or even not documented. These matrixes are necessary to calculate new market equilibrium, in association with food and feed demand elasticities, to some exogenous modifications such as national policy interventions, international prices modifications, human and animal population increases. The third part presents the obtained results and its comparison with the sparse data available in the literature. Lastly, the results obtained of the two countries are compared with each other and recommendations are given to improve production sector.

METHODOLOGY USED FOR ESTIMATIONS

From the farmer's point of view, within limits set by his own goals and by institution, infrastructure, technology and market structure, a given set of input and output prices makes some courses of actions more desirable than others. Thus, the incentive content of price has effect on the choice of production alternatives with available resources and their impact on resource accumulation.

On the price side, according to most researchers farmers anticipate prices from their knowledge of current and past price (Nerlove, 1985). Most time-series studies are for particular crops and use acreage as a proxy for output because acreage is thought to be more subject to the farmer's control than output because output is affected by other factors which have an impact on yields like climate, soil, water availability and technology etc.

Individual crops respond more or less strongly and quickly to price factors, but growth in one crop usually takes resources away from other crops. The price elasticity of agriculture overall is very low in short run because the main factors of production (land, capital, and labor) are fixed.

Price elasticities of supply enter into a number of policy calculations, including support price and buffer stock operation (Gotsch *et al*., 1975; Pinckney, 1989). A study of the price response incorporating the interdependence of different crops can improve the knowledge and therefore the reliability of supply parameters used in calculations. Once the direction and magnitude of interactions among crops and the factors influencing the supply are determined, planners will be generally helped in assessing the effect of a price policy on the output of different crops as well as the welfare of the farmers.

Krishna (1963) estimated short run and long run elasticities of supply (acreage) of agricultural commodities derived from time series data for Punjab region of indo-Pakistan sub-continent.

Most research in economic literature on farmers' land allocation decisions focuses on determinants such as portfolio selection, safety-first behavior or learning, and uses market prices to value production (Feder, 1980; Just *et al*., 1983; Bellon *et al*., 1993; Brush *et al*., 1992; Smale *et al*., 1994). If, however, market prices fail to reflect the value of farmers' product, economic models may lead to wrong expectations and "surprising" farmer response to price signals. The inelastic supply response of maize farmers in rural Mexico in spite of decreasing maize prices after NAFTA is an example (Nadal, 2000).

We consider this question with reference to the problem of farmers' choice of land allocation. Farmers' land allocation decisions have long been a subject of economics. Especially those related to high yielding crop varieties that have been studied in detail by the technology adoption literature following the Green Revolution (Feder, 1980; Just *et al*., 1983; Bellon *et al*., 1993; Brush *et al*., 1992; Smale *et al*., 1994).

Smale *et al*., (1994) show that farmers' land allocation to high yielding and traditional crop varieties have multiple explanations such as input fixity, safety first behavior, learning and portfolio selection. They also value farmers' maize output at market prices in their empirical analysis of maize cultivation in Malawi

In this paper, statistical approach to determine influence of variation of gross product per hectare of different main crops on allocation of cultivated surface area in India and Pakistan is applied. In first part of this paper, direct and cross gross product elasticities to acreage of different crops are calculated while second party covers comparison between farmer reactions to gross product par hectare of one country with other.

In the field of microeconomics, the choice of allocating system of production when we know the price received by farmers (P_i), the yield (Y_i) and the direct cost of production per hectare (C_i) i.e., when we know the value of gross product $V_i = Y_i * P_i$ et the gross margin $M_i = Y_i * P_i - C_i$, is conventionally written as a linear program:

$$\text{Max} \sum_i (S_i * M_i) \quad (1)$$

Under general constraints:

$$\sum_i S_i = S_{total} \quad (2)$$

And different other constraints expressing agricultural parameters, availabilities in production factors (labor, machines, etc.) are taken into account.

As illustrated by linear programming problem, the key characteristic of the dual relationship is that all of the information about the solution to the primal can be obtained from the corresponding dual, and all of the information with respect to the solution of dual can be obtained from the corresponding primal. Either the maximization or the minimization problem may be solved as the primal, and all information regarding the solution to the dual is obtained without resolving the problem. Production (vs. demand) function has corresponding dual cost (revenue) function. The term dual used in this context means that all of the information needed to obtain the corresponding cost (revenue) function is contained in the production (demand) function and conversely the cost (revenue) function contains all the information needed to derive the production (demand) function.

In the classical theory of production for each of the i crops (i = 1 to N), the total revenue (R) and production function can be written as

$$R = \sum_i x_i * p_i \quad (3)$$

And

$$x_i^* = f(p_i) \quad (4)$$

The optimal x_i (noted x_i^*) is given by the Shepard lemma:

$$x_i^* = dR/d\,p_i \quad (5)$$

Here we are more focused on relation of revenue per hectare of specific agricultural products with allocation of surface area to different agricultural commodities. We know that total revenue is a function of price, surface and yield.

$$R = f(P_i, S_i, Y_i) \quad (6)$$

Where

R = total revenue of the *i* crops planted by the farmer
P_i = price of crop $_i$
S_i = area of crop $_i$
Y_i = yield of crop i

To limit the number of parameters to estimate, we consider that the farmer is taking his decision of allocation, not on the basis of anticipated prices and of anticipated yields, but on the basis of the anticipated gross product per hectare of each product (V^a)[3] that is defined by:

$$V^a_i = P^a_i * Y^a_i \quad (7)$$

In the particular case of cotton we have to consider that the total revenue is composed together by the sale of the cotton lint with parameters Y_{lint} and P_{lint} and for the cottonseed with parameters Y_{cseed} and P_{cseed}. So for this crop, V_{cot} is written:

$$V^a_{cot} = Y^a_{lint}*P^a_{lint}+Y^a_{cseed}*P^a_{cseed} \quad (8)$$

With introduction of anticipated gross product the total revenue of the farmer can be written:

$$R^a = g\ (S_i,V^a_i)= \sum_i(S_i*V^a_i) \quad (9)$$

The translog production function was introduced in 1971 by Christensen, Jorgenson and Lau, and was logical choice given the difficulties posed by other functional forms. It is simply a second order Taylor's series expansion of ln (R) in ln (x_i) whereas the Cobb-Douglas is a first order expansion. The revenue function as a Taylor's series can be written as

$$\text{Ln } (Ra) = \beta_o + \sum_i\beta_i \ln (V^a_i) +1/2 \sum_{ij} \beta_{ij} \ln (Va_i) * \ln (V^a_j) \quad (10)$$

j (j = 1 to N) represents numbers of crops. Some mathematical relations are to be satisfied by the coefficients β_i and β_{ij} to express

- the equality of the two partial deviates of ln(R) in function of ln(V_i) and ln(V_J) which implies:

$$\beta_{ij} = \beta_{ji} \quad (11)$$

- the constant return of total revenue g(S_i,k*V_i) = k*g(S_i,V_i) implies:

$$\sum_i\beta_i =1 \quad (12)$$

$$\sum_i\beta_{ij} =\sum_j\beta_{ij} = 0 \quad (13)$$

For anticipated prices and yield we consider that the farmer uses a moving average of the preceding year's data.
For yield the equation is:

$$Y^a_i\ (t) = 1/N1*\sum_d Y_i\ (t\text{-}d) \text{ for } d = 1 \text{ to } N1 \quad (14)$$

For price:

$$P^a_i\ (t) = 1/\ (N2+1)*\sum_d P_i\ (t\text{-}d) \text{ for } d = 0 \text{ to } N2 \quad (15)$$

The difference between the two equations is due to the fact that price concerns calendar year's average, farmers have information about the price concerning the year of plantation and harvest. But for yields, they have to refer only on preceding years. One empirical advantage of using "smoothed" data for prices and yields is to limit the impact of equations estimated parameters of the uncertainty on the "true" values. The values of N1 and N2 (the same for all products) have been chosen for each country in a manner to get the best estimations on the basis of the R2ajusted and the sign of own gross product elasticities. The counterpart is that the estimated coefficients of equations (and the elasticities) are smaller (in absolute value) than those which would have been calculated with "true" annual values.
The transposition of Shepard lemma gives

$$S_i^* = dR^a/dV^a_i \quad (16)$$

We can write

$$S_i^* = R^a*(dR^a/R^a) / (V^a i*(dV^a_i/V^a i)) = (R^a/V^a_i) * (dR^a/R^a)/ (dV^a_i/V^a_i) \quad (17)$$

That is equivalent to:

$$S_i^*\ V^a_i/R^a= (dR^a/R^a)/ (dV^a_i/V^a_i) = d\ln(R^a)/d\ln(V^a_i) \quad (18)$$

Where

$S_i^*\ V^a_i/R^a = r_i$ is the anticipated share of the crop i in the total anticipated revenue.

In the particular case where we utilize a translog function for total revenue.

$$\ln (R) = \beta_0 + \sum\beta_i \ln (V_i) + \sum\beta_{ij} \ln (V_i)*\ln (V_j) \quad (19)$$

We have:

$$r_i = d\ln (R)/ d\ln (V_i) = \beta_i + \sum\beta_{ij} \ln (V_i) \ln (V_j) \quad (20)$$

For estimation purpose when we have chosen a functional form for the revenue function. We can use i equations of the revenue shares to estimate the coefficients of the revenue function and the value of the different gross product surface elasticities for each crop. By definition $\sum r_i = 1$, we have to estimate only *i-1* equations, the coefficients of the last one (in occurrence that concerning wheat) being calculated from those of the other equations. The system has been estimated with the free software GRETL and the method FIML (Full Information Maximum Likelihood) which is equivalent to the SUR method (Seemingly Unrelated Regression) iterative and gives results which are independent of the equation not included in the system.

In the case of translog, it can be demonstrated that the expressions of surface gross product elasticities can be calculated from the parameters of the system of equations (β_{ij}) and the part of each crop in the total revenue (r_i) and are obtained by formulas:

$$E_{ii} = d\ln (Si)/d\ln(Vi) = (\beta_{ii} + r_i r_i\text{-} r_i) / r_i \quad (21)$$

$$E_{ij} = d\ln (Si)/d\ln(Vj) = (\beta_{ij} + r_j r_i) / r_i \quad (22)$$

Where E_{ii} is own gross product elasticity of crop i surface to its gross product and E_{ij} is cross elasticity of crop i surface to gross revenue per hectare of crop j. To be consistent with economic theory, all the own elasticities must be positive, i.e., if all other revenues are constant, the area of a crop increases when its gross product increases.

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ANALYSIS OF EQUATIONS PARAMETERS AND ELASTICITIES FOR PAKISTAN AND INDIA

The Table-1(a, b, c) shows the eight and nine equations of the translog system for Pakistan and India, respectively. The R^2 values are nearly always high, more than 0.85. For the same crop they are higher in India as compared to Pakistan. The R^2 adjusted values are also generally high (more than 0.80) but slightly lower for Pakistan as compared to India. Although for some crops these values are lower, that indicates less good estimations when different relations between parameters of the different equations are taken into account. It is mainly the case concerning R^2 adjusted for some crops in Pakistan; soybean: 0.433, millet: 0.575.

The significance of different parameters at the probability levels of 1%, 5% and 10% are indicated on Table-1(a, b, c) by one star (*), two stars (**) and three stars (***) respectively. For the coefficients of own gross product value in the equation of each crop (in fact of each r_i that is the part of global revenue of i crop), the sign is always positive (in accordance with theory) and the value is generally significant at 5% probability. Many coefficients corresponding to cross effects are also significant.

The Durbin-Watson coefficients (DW) often indicate some autocorrelation between the residuals of each equation. This fact has not been corrected, as according to our opinion, the data are too much uncertain to justify this correction (for example by introducing the lagged value of r_i). This variable is calculated by a formula taking in account the lagged values of prices and yields.

The elasticities indicated in Table-2 express the variation of surface of each crop due to 1% change of the gross product per hectare of this crop or other. Confirming to what was expected, the signs of own elasticities are always positive for India and Pakistan for nine crops (Wheat, corn, cotton, sugar cane, rice, sorghum, millet, rapeseed, soybean), and for dry bean in India, but for Pakistan, it was necessary to exclude dry bean from the translog system so we made a specific estimation for dry bean for Pakistan with parameters independent of the equations of ~~the~~ other products based on the formula:

$$\text{Ln}(S_{db}) = a_0 + a_1 * \ln(S_{db}(-1)) + a_2 * \ln(P_{db}(-1)) + a_3 * \ln(P_r(-1)) \quad (23)$$

The coefficients are:

l_Sdb = 2, 07637 +0, 567427*l_Sdb_1+0, 120239*l_Pdb_1+0, 028171*l_Pr_1 (24)
(3.810) (4.964) (1.918) (0.4821)
R^2= 0.9355, R^2 adjusted=0.9304, () = t values

These results show that for dry bean in Pakistan, the surface at time t is linked to the value at time t-1 and a_2, which can be considered as the own and cross elasticities for dry bean. That is near to 0.12 but it is significant only at 10% probability. The price of rice (Pr) that is supposed to be the most linked product to dry bean (these two products are essentially festinated to farmer family food) is not significant.

The elasticities indicated in Table-2 have not been calculated for specific years but as mean values for the period 1966-2008. The values of ri and rj appearing in equations (21) and (22) have been replaced by their mean of the period.

Concerning the own revenue elasticities of crops areas in India, the value is high for sorghum (0.503) and rapeseed (0.273), 0.2 for millet, wheat and cotton, but lower than 0.1 for rice, dry bean, corn, soybean and sugar cane. For Pakistan, we have high values for soybean (0.944), rapeseed (0.612) and sorghum (0.399), 0.1 for rice, wheat, sugar cane and millet but low for cotton and corn (0.008). Globally, in the two countries sorghum and rapeseed areas appear to respond significantly to commercial revenue. This can be explained by the fact that these two crops are used in industry of animal feeding. For soybean, the elasticity is also relatively high for India as compared to Pakistan (but the elasticity is much important as area is very small compared to India). For all other crops, the own elasticities are generally low (compared to that in developed countries) and lower in Pakistan as compared to India. This indicates that the farmers are weakly influenced by prices as either 1) an important part of their crop (rice, wheat, dry bean, etc.) is necessary for family needs independently of prices and revenue per hectare or 2) the crop is sold to manufacturers (cotton by example) but in the areas where this crop is cultivated, there is no real alternatives to it.

Wheat and rice occupy a central position in the agricultural farming system in Pakistan and India. Own elasticity for rice is low in Pakistan and India (0.089 and 0.037, respectively). For wheat, elasticity in Pakistan is 0.066 but in India, it is 0.214. This can be explained by the fact that in Pakistan, wheat is the first cereal consumed as food so it is necessary for farmer to maintain a significant area of this crop even if gross product is less competitive compared to some other crops, but in India where food is more based on rice, the wheat's area is more influenced by gross product.

It is also interesting to analyze the positions of crops as substitutes and complements on the basis of the signs of the cross elasticities. When the sign is positive, this indicates that an increase in the gross revenue of a crop simultaneously increases the area of the other crops, they are said "complementary crops"). When the effect is opposite (cross elasticity is negative) the two crops are said to be substitutes. The values of gross products elasticities are much influenced by the importance of each crop area (a "small" crop having tendency to have a higher revenue elasticity compared to a "major" crop) and the matrix of these own and cross elasticities is not symmetric. So it is interesting to introduce the Allen-Uzawa partial elasticities of substitution (Christev A. 2007) that, in the case of a translog function are defined by $\sigma_{ij}=E_{ij}/r_j$ where E_{ij} is the gross product elasticity and r_j is the share of crop j in the total revenue. The Allen-Uzawa elasticities have the same sign than the gross product elasticities and form a symmetric matrix. Even if there has been a lot of discussion after the seminal work of Uzawa (1962), their statistical information is widely reported in empirical studies of production and can be considered as indication on the "ease to change" (or substitution) between two factors in a multiproduct technology. The matrix is not presented here but Table-3 summarizes our results for Pakistan and India. In this table all figures smaller than 0.5 in absolute value have been deleted as they are considered to be too small to draw valid conclusions on the two crops relationship.

For wheat that is a major crop in the two countries, it appears that this crop is a significant substitute for rapeseed and a complementary crop to soybean in the both countries. But relationships are different for corn, millet and sorghum for each country: wheat is a substitute for corn and millet in India but a complement in Pakistan. On contrary, wheat is a complement for sorghum in India but a substitute in Pakistan. At last, wheat is a substitute for dry bean in India and a substitute for sugarcane in Pakistan.

For rice that is also a very important crop in India and Pakistan, this crop is a substitute for millet and soybean in both countries, but relations are opposite for corn and sorghum. In both countries, there appeared no significant relation between wheat and rice.

Globally, there are only ten relationships between crops which are the same in the two countries : cotton-millet (C), cotton-soybean (S), millet-rapeseed (S), millet-rice (S), millet-soybean (S), rapeseed-sorghum (C), rapeseed-wheat (S), rice-millet (S), rice-soybean (S), sugarcane-soybean (C), wheat-soybean (C). Where "C" represents compliments and "S" represents substitute.

In fact three types of crops are taken in analysis: food crops, cash crops and feed crops. In Pakistan and India, wheat and rice are used as staple food so they are less competitive to each other and are generally considered as complementary crops, but in our results there is no significant relationship. Cash crops (cotton, sugarcane) are more responsive to own gross product; they are substitutes in India, but have no significant relationship in Pakistan. Feed crops like millet, sorghum, maize are generally considered as substitutes of each other at demand level, but this relationship does not appear at supply level. In India feed industry is more developed than in Pakistan, so traditional feed like millet, sorghum, maize are generally sold to feed manufactures in India while they are directly used by farmers as feed in Pakistan.

It is difficult to explain, the different results of gross products elasticities, Allen-Uzawa partial substitution elasticities for the different crops. However it seems possible to draw some conclusions from our results, even if, as it was said previously, the Figures presented are highly dependent on the quality of data used in the estimations (mainly concerning prices received by farmers indicated by FAO, but also in some cases concerning areas evolutions which have been corrected with national data when possible).

COMPARISON OF PAKISTAN AND INDIA ELASTICITIES WITH LITERATURE DATA

As elasticities are important parameters widely used in empirical works with agricultural models, it is important to compare our results with the values calculated by other authors. In fact, in general literature, there is only information on the own elasticities. We have used the data available in the elasticity database of FAPRI and Table-4 summarizes the results. In general, there are important differences between our results and cited by FAPRI, but we have no information on the sources and methodologies concerning FAPRI data. Concerning wheat we observe that for India, our elasticity is near that of FAPRI for India (0.214 versus 0.290), but for Pakistan it is much smaller (0.066 versus 0.230) and is also smaller than that calculated by Khan (0.31). The data of FAPRI and Khan for a "subsistence" crop in Pakistan seems high as they are near those of developed countries where farmers are very responsible to market prices such as Australia and even European Union, even if, in this zone, the impact of direct and indirect aids can be important. Concerning rice, our Figures are lower than those of FAPRI for India and Pakistan. Concerning corn, we have the same conclusion, but we can observe that FAPRI Figures are higher for India and Pakistan than for Australia.

For Pakistan, it is possible to compare our results with those published by Khan (2003). There could be two reasons for this difference: First, it can be due to data used and period taken in account for the econometric estimations. Second, it can be due to differences in the methodology used.

In Khan's approach, as prices used are expressed in current value, the rate of inflation is implicitly supposed to have important role on absolute area growth rate of each crop. In Pakistan the average inflation rate on the period taken was 8.2% and it was 7.8% in India. In our methodology, due to relationship imposed on parameters: $\sum\beta_{ij} = 0$, inflation has no impact on allocation of crops.

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Table-1(a). Value and significance of equations coefficients.

	Rapeseed	**Rapeseed**	**Rice**	**Rice**	**Cotton**	**Cotton**
	Pakistan	India	Pakistan	India	Pakistan	India
Const.	3.91%***	1.78%**	15.74%***	47.10%***	13.24%***	-4.16%**
l_Vc	1.65%***	3.53%***	-0.10%	-0.52%	-0.59%***	-0.53%
l_Vr	-0.10%	-0.52%	11.51%***	23.99%***	-5.47%***	-11.32%***
l-Vdb		-0.21%		-0.44%**		-0.16%
l_Vco	-0.59%***	-0.53%	-5.47%***	-11.32%***	25.77%***	23.76%***
l_Vm	0.07%	-0.32%*	-0.52%***	-0.67%***	-1.29%***	-0.67%***
l_Vsoja	0.00%	-0.42%**	-0.01%*	-0.93%***	-0.01%	-0.86%***
l_Vsc	-0.54%***	0.36%	-1.46%*	-2.90%***	-7.03%***	-3.25%***
l_Vso	0.15%***	0.12%	-0.50%***	-0.62%*	-0.18%	-1.42%***
l_Vmi	-0.10%	-0.41%*	-0.70%***	-1.25%***	-0.01%	-0.22%
l_Vb	-0.54%	-1.58%***	-2.75%***	-5.33%***	-11.19%***	-5.34%***
dum_66_79		0.14%		0.72%		0.25%
dum_91_92	-0.16%		-1.10%*		3.98%***	
dum_91_01		0.71%***		-0.60%		1.65%**
dum_93_01	-0.93%***		0.30%		3.11%***	
dum_99_01		-0.36%		-0.36%		1.57%*
dum_02_08	-0.94%***	0.22%	0.59%	-2.63%***	1.88%	3.31%***
Trend		0.04%**		0.03%		-0.20%***
R^2	0.887	0.887	0.788	0.957	0.797	0.926
R^2 ajust	0.842	0.825	0.703	0.934	0.715	0.884

Source = results from analysis

Table-1(b). Value and significance of equations coefficients.

	Corn	**Corn**	**Soybean**	**Soybean**	**Sugar cane**	**Sugar cane**
	Pakistan	India	Pakistan	India	Pakistan	India
Const.	5.87%***	5.60%***	0.02%	0.75%	0.24%	2.96%***
l_Vc	0.07%	-0.32%*	0.00%	-0.42%**	-0.54%***	0.36%
l_Vr	-0.52%***	-0.67%***	-0.01%*	-0.93%***	-1.46%*	-2.90%***
l-Vdb		-0.02%		-0.43%***		-0.30%***
l_Vco	-1.29%***	-0.67%***	-0.01%	-0.86%***	-7.03%***	-3.25%***
l_Vm	2.43%***	2.81%***	0.01%**	-0.03%	-0.41%***	-0.20%***
l_Vsoja	0.01%**	-0.03%	0.01%***	1.21%***	0.00%	0.79%***
l_Vsc	-0.41%***	-0.20%***	0.00%	0.79%***	15.26%***	7.11%***
l_Vso	0.01%	-0.19%	-0.01%*	0.28%**	-0.24%**	-0.18%
l_Vmi	-0.16%***	0.21%**	0.00%	-0.04%	-0.60%**	-0.24%*
l_Vb	-0.14%	-0.91%***	0.00%	0.42%	-4.98%***	-1.16%***
dum_66_79		-0.05%		-0.31%*		0.22%

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dum_91_92	-0.16%**		0.00%		-0.33%	
dum_91_01		0.07%		0.54%***		0.22%
dum_93_01	-0.13%		0.00%		1.96%**	
dum_99_01		0.06%		0.31%*		-0.09%
dum_02_08	-0.15%	0.50%***	-0.02%***	1.02%***	3.86%***	0.67%
Trend		-0.01%*		0.05%***		0.06%**
R^2	0.976	0.972	0.595	0.966	0.838	0.927
R^2 ajust	0.967	0.956	0.433	0.947	0.773	0.887

Source = results from analysis

Table-1(c). Value and significance of equations coefficients.

	Millet	**Millet**	**Dry bean**	**Dry bean**	**Wheat**	**Wheat**
	Pakistan	India	Pakistan	India	Pakistan	India
Constant.	3.54%***	9.59%***		4.65%***	54.82%	19.30%
l_Vc	-0.10%	-0.41%*		-0.21%	-0.54%	-1.58%
l_Vr	-0.70%***	-1.25%***		-0.44%**	-2.75%	-5.33%
l-Vdb		-0.05%		2.02%***	0.00%	-0.47%
l_Vco	-0.01%	-0.22%		-0.16%	-11.19%	-5.34%
l_Vm	-0.16%***	0.21%**		-0.02%	-0.14%	-0.91%
l_Vsoja	0.00%	-0.04%		-0.43%***	0.00%	0.42%
l_Vsc	-0.60%**	-0.24%*		-0.30%***	-4.98%	-1.16%
l_Vso	0.11%***	-0.76%***		0.07%	-0.05%	-1.82%
l_Vmi	0.94%***	3.47%***		-0.05%	0.52%	-0.70%
l_Vb	0.52%**	-0.70%***		-0.47%**	19.13%	16.89%
dum_66_79		-0.37%***		-0.01%		-0.03%
dum_91_92	-0.45%***				-1.56%	
dum_91_01		-0.05%		-0.35%***		-1.90%
dum_93_01	-0.97%***				-2.79%	
dum_99_01		0.08%		-0.74%***		-1.02%
dum_02_08	-0.95%***	0.16%		-0.62%***	-3.75%	-3.75%
Trend		-0.08%***		0.01%		0.20%
R^2	0.697	0.984		0.936		
R^2 ajust	0.575	0.975		0.9		

Source = results from analysis

Table-2. Matrix of calculated gross products elasticities for India and Pakistan.

Crop	Country	Corn	Cotton	Dry bean	Millet	Rapeseed	Rice	Sorghum	Soybean	Sugar cane	Wheat
Corn	India	5.7%	2.7%	1%	10%	-9%	10%	-3.9%	0.2%	0.1%	-17%
Corn	Pakistan	0.8%	-6.9%		-5%	3%	-9%	1%	0.4%	-1.5%	17.2%
Cotton	India	0.3%	14.7%	1.3%	2.0%	0.9%	-6.9%	-2.2%	-2%	-4.4%	-3.6%
Cotton	Pakistan	-.4%	2.1%		0.8%	-0.3%	-0.2%	0.1%	0.0%	-0.5%	-1.8%
Dry bean	Pakistan										
Dry bean	India	1.8%	18.7%	8.8%	0.1%	-8.6%	11.3%	6.8%	-21%	-8.4%	-8.8%
Millet	India	10%	19.4%	0%	24.9%	-12%	-9%	-24%	-0.3%	-1%	-8.5%
Millet	Pakistan	-16%	44%		12%	-10%	-70%	13%	-0.2%	-56%	84%
Rapeseed	India	-9%	8.3%	-5.7%	-12%	27%	16%	7%	-14%	20%	-39%
Rapeseed	Pakistan	9%	-11%		-8.8%	61.2%	2.3%	15.0%	0.2%	-37%	-29%
Rice	India	0.8%	-5.4%	0.6%	-0.7%	1.3%	3.7%	1.3%	-1.6%	-0.8%	0.7%
Rice	Pakistan	-2%	-0.6%		-5.0%	0.2%	8.9%	-3.7%	-0.1%	2.7%	-0.3%
Sorghum	India	-3%	-19.0%	4.2%	-22%	6.6%	14.5%	50.3%	10.4%	1.6%	-43%
Sorghum	Pakistan	5%	9.9%		23%	30.5%	-88%	39.9%	-2.0%	-32%	13.7%
Soybean	India	0.5%	-50%	-37%	-0.9%	-34.6%	-48%	28.6%	9.6%	78.1%	53.6%
Soybean	Pakistan	149.7 %	-53%		-23.4%	35.4%	-182%	-165%	94.4%	73.7%	71.0%
Sugar cane	India	0.0%	-16%	-2.1%	-0.4%	7.5%	-3.7%	0.6%	11.5%	1.8%	0.6%
Sugar cane	Pakistan	-0.2%	-1.5%		-3.2%	-2.6%	2.1%	-1.1%	0.0%	16.9%	-10%
Wheat	India	-3.0%	-6.2%	-1.0%	-1.5%	-7.0%	1.6%	-8.3%	3.7%	0.3%	21.4%
Wheat	Pakistan	1.9%	-3.5%		3.1%	-1.3%	-0.2%	0.3%	0.0%	-6.8%	6.6%

Source = results from analysis

Interpretation of coefficients: by example for Pakistan, when gross product of corn increases by 10% (all other gross products being unchanged) area of corn increases by 10%*0.8%=0.08% and when gross product of rice increases by 10% area of corn decreases by 10%*9%= 0.9%

Table-3. Substitute and complementary crops in Pakistan and India.

Crop	Country	Corn	Cotton	Dry bean	Millet	Rapeseed	Rice	Sorghum	Soybean	Sugar cane	Wheat
Corn	India			C	C	S	C	S			S
Corn	Pakistan			NA	S	C	S	C	C		C
Cotton	India			C	C	C		S	S	S	
Cotton	Pakistan			NA	C	S			S		
Dry bean	India	C	C			S	C	C	S	S	S
Dry bean	Pakistan	NA	NA		NA	NA	NA	NA	NA	NA	NA
Millet	India	C	C			S	S	S	S		S
Millet	Pakistan	S	C	NA		S	S	C	S	S	C
Rapeseed	India	S	C	S	S		C	C	S	C	S
Rapeseed	Pakistan	C	S	NA	S			C	C	S	S
Rice	India	C			S	C		C	S		

Rice	Pakistan	S		NA	S			S	S		
Sorghum	India	S	S	C	S	C	C		C		S
Sorghum	Pakistan	C		NA	C	C	S		S	S	C
Soybean	India		S	S	S	S	S	C		C	C
Soybean	Pakistan	C	S	NA	S	C	S	S		C	C
Sugar cane	India		S	S		C			C		
Sugar cane	Pakistan			NA	S	S		S	C		S
Wheat	India	S		S	S	S		C	C		
Wheat	Pakistan	C		NA	C	S		S	C	S	

C = complement. S = substitute. NA = not available
Green = same relationship in India and Pakistan. Orange = diagonal term no signification
Source = results from analysis

Table-4. Comparison of own elasticities of Pakistan and India with elasticities cited by FAPRI Khan (2003) and developed countries.

	India	**India**	**Pakistan**	**Pakistan**	**Pakistan**	**Australia**	**UE 15**
	Present study	FAPRI	Present study	FAPRI	Khan (2003)	FAPRI	FAPRI
Corn	0.057	0.210	0.008	0.280	0.11	0.23	0.08
Cotton	0.147		0.021				
Dry bean	0.088						
Millet	0.249		0.123		1.71		
Rapeseed	0.273	0.340	0.612			0.26	0.28
Rice	0.037	0.110	0.089	0.290		0.17	
Sorghum	0.503	0.300	0.399	0.200	0.11	0.35	
Soybean	0.096	0.360	0.944				0.19
Sugar cane	0.018	0.210	0.169	0.070		0.14	0.31
Wheat	0.214	0.290	0.066	0.230	0.31	0.33	0.12

CONCLUSIONS

The study delineates a model to estimate the gross product per hectare elasticities of different crops and empirically applies the model to estimate own and cross gross product per hectare elasticity of major and minor crops which cover more than 80 percent of the total cropped area in Pakistan and India. The data used in this study are collected from FAO database and, in some cases, are corrected by data from economic survey of Pakistan 2010. After a general description of main evolutions of the supply side for these products (areas and yields), prices received by farmers which appeared in some cases to be correlated with some international prices when the evolution of conversion rate between Indian and Pakistan rupees to dollar are taken in account.

After parameters estimation of a translog share model concerning 9 crops in Pakistan and 10 crops in India, we calculated short run own and cross gross product elasticities for these products. According to our empirical estimations, it appears that in the two countries farmers are more or less responsive to gross product per hectare modifications, but contrary to the situation in many developed countries where the response is quick, in India and Pakistan farmers are influenced by the average product of last years' yields and prices (or consider as anticipated gross product), though in developed countries the data concerning the last crop (year t-1) are much more important than those of proceeding years. The parameters of the different share equations have generally good significance when some dummy variables are introduced to take into account some apparent discontinuities in data (mainly prices).

Globally own gross product elasticities for main crops are weaker in Pakistan as compared to India and are lower than those indicated in FAPRI database for these countries and some other representing more modern and "free" agriculture (developed countries). It means that farmers in developed countries like Australia and European Union are more responsive to gross product as compared to developing countries like Pakistan and India.

In our analysis, Pakistan is lowest developed country so it has also lowest values of gross product elasticities.

Short run cross revenue elasticities and partial Allen-Uzawa substitution elasticities have also been calculated, the latter parameters indicate the “ease of change” between two products areas. On this basis it is possible to distinguish the influence of a crop on another in three possible ways: competitive, complementary and unrelated. The classification of crops is compared for Pakistan and India, but some unexplained differences can be observed. In fact it is important to stress on the fact that some data used in estimations could be biased, and, on a methodological point of view, due to lack of data we only introduce the output prices and yields in our estimation. But it is well known that the prices and availabilities of some input factors (water, irrigation, fertilizer, machine, labor, etc.) are also very important in farmer’s decisions.

Therefore a careful analysis of gross product per hectare (and when possible of gross profit) change for any crop is necessary because this can not only affect the production (acreage) of that particular crop but also change composition of other crops. This indicates that there is a need to develop a systematic and comprehensive approach on which agro-policy reflecting government priorities for certain crops should be based. In Pakistan, low magnitude of elasticity reflects more traditional agricultural practices compared to India due to the lack of improved production technology, credits, marketing system, farmer linkages, weak research and incentive for support price for feed crops excluding wheat. The analysis could be extended in different directions. Firstly, the cost of production and non price factors should be included and data should be desegregated for different crop zones to obtain better values of elasticity, by a panel data approach, for each zone that may be different according to climatic, agronomic and social parameters. Secondly, it should be analyzed if the anticipated gross product is the effective parameter taken into account by farmers or if the prices and yields (and eventually public subventions) have different roles. Finally, our objective is to use these matrixes of supply prices elasticities simultaneously with matrixes of food and feed demand to analyze economic impact on producers, consumers and public finance of some possible public policies (subvention, taxations, etc.) or some modifications in international prices.

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