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## An analysis of industrial–agricultural interactions: a case study in Pakistan

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### Abstract

This paper empirically analyzes the relationship between Pakistan's industrial and agricultural sectors. Pakistan was chosen because of its status of a semi-industrialized country with heavy dependence on the agricultural sector. The relationship between cotton production and industrial growth is also evaluated due to the prominence of this crop in Pakistani agriculture. The results indicate that these sectors are complementary, yet industry tends to benefit more from agricultural growth than vice versa. The timing of this information is critical, as Pakistan's policy makers now face major agricultural policy reforms in their quest for continued industrial development. ©2000 Elsevier Science B.V. All rights reserved.

**Keywords:** Agricultural development; Economics of Pakistan's cotton production; Industrial and agricultural relationship

### 1. Introduction

In the early part of the nineteenth century, England experienced a phenomenon, which forever altered the world's economic conditions. This event, which swept through the western world transforming everything in its path, was the Industrial Revolution, and since its inception, economists and governmental policy makers alike have associated economic growth with industrialization. Indeed, according to many, economic development is not only aided by industrialization, but defined by it. In an early World Bank publication, development is defined as 'a new telephone exchange in Addis Ababa; a machine shop in Thailand; a pasteurization plant in Ceylon' (Heilbroner, 1966). This

association of growth and industry has not happened haphazardly. The development of large-scale industry not only increases the private sector's profitability, but also expands the productive capabilities of an entire nation by increasing the amount of goods that can be produced from a given set of resources. Not only does the process of industrialization allow a nation to better meet its domestic needs, but when excess manufactured goods are exported, the positive externalities created by trade are also increased (Khan, 1993). In addition, the industrial sector often serves to absorb excess labor, thus increasing the middle-income population base of a nation.

Industry is considered the next logical step to proceed to from the traditionally agriculture-based economy (Hunker, 1974). When this occurs, a relationship is formed between the established agricultural sector and the infant industrial sector. Agriculture provides food, fiber, and raw material for industry, and ben-

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efits in turn as industry helps modernize traditional production techniques by providing modern inputs, technology, and improved managerial skills. The end result is that both sectors benefit from each other, and the nation benefits from their growth and increased efficiency. This relationship between agricultural and industrial sectors is of great significance to the economies of Pakistan and other developing nations, and deserves a close analysis.

Industrialization has been the path of choice among many third-world nations in their attempt to follow in the economic footsteps of the Western world. It is a path that has been successful for many of the newly industrialized countries, such as Taiwan, South Korea, and Singapore. The correlation between GDP growth and industrial share of GDP for several low-income nations is demonstrated in Fig. 1.<sup>1</sup> With the obvious benefits that can be reaped from industrial growth, it can be easy for policy makers to overemphasize support for industry while neglecting the agricultural sector. Despite the high priority placed on industrialization by many third-world nations, there exists little attention from the government toward the exact relationship between the agricultural sector, which often dominates the economy, and industrial development.

Due to the wide variation among nations in their industrial bases, political atmospheres, and social and historical influences, it is important to examine this relationship for a single developing nation. Pakistan is used in this research as a case study. The overall objective of this study is to determine the relationship between growth rates of the agricultural and industrial sectors in Pakistan.

### *1.1. The Pakistan position*

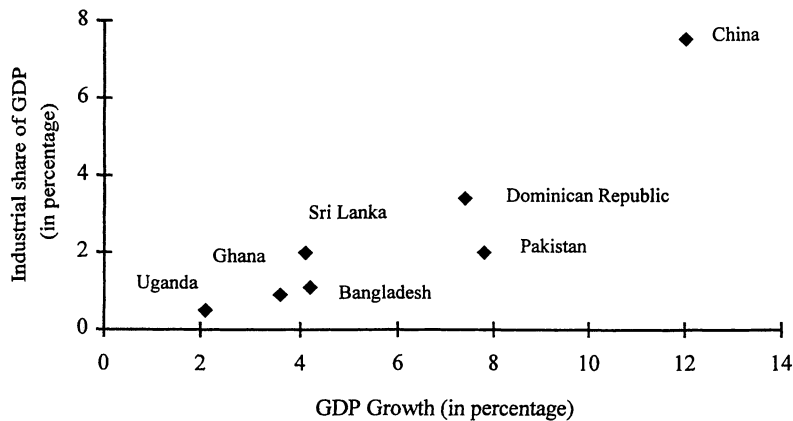
Located well within the bounds of the Asian poverty belt, with an estimated adult literacy rate of 34%, an infant mortality rate of approximately one out of ten (Finance Division, 1992), and only 32% of its population having access to safe drinking water (Burki, 1986), Pakistan can undoubtedly be classified as an underdeveloped nation despite its semi-industrial status. In 1995, Pakistan's per capita income was US \$460 (or 2,230 International dollars, converted using

the purchasing power parity), which classified it as a low-income nation by World Bank standards. Despite the relatively low level of per capita income, the GDP growth rate has been impressive. With an annual GDP growth rate of 4.6% during the 1990–1995 period, Pakistan optimistically hopes to surpass the GDP level of US \$766 (World Bank, 1997). A key source of GDP growth has been the agricultural sector (3.6% annually during the last 25 years), (Faruquee, 1994).

In terms of economic development, both agricultural and industrial sectors have played major roles. In 1995 (the most recent year for which economic data are available), the industrial (includes manufacturing) and agricultural sectors accounted for 24 and 26% of the overall GDP, respectively (World Bank, 1997). However, while the industrial and manufacturing sectors accounted for 94.1% of export values, the agricultural sector had a share of only 5.2% (United Nations, 1974). In terms of employment, the industrial and manufacturing sectors accounted for 10.9% of total employment, while agricultural sector employed 46.5% (United Nations, 1997). Furthermore, both raw and processed cotton have been important to Pakistan's economic development. Not only is cotton a primary agricultural commodity, but it is also vital to Pakistan's industrial sector. Cotton production took 20% of the area under principle crops during the 1985–1995 period (United Nations, various issues). During the same period, the cotton industry (raw and processed cotton) accounted for more than 70% of the export value. Moreover, 15% of the manufacturing sector is composed of cotton-based enterprises, such as mills and power looms (Ender, 1990).

In spite of the importance of agriculture, Pakistan has pursued a consistent policy directed at industrial development in its attempts to increase its per capita income. Export restrictions have been levied on agricultural products, such as cotton, to increase domestic supplies. This has effectively subsidized these industrial inputs at the expense of the agricultural sector (Ender, 1990). The objective of this study is to bring about a fuller understanding of the relationship between the agricultural and industrial sectors of Pakistan's economy. Specific objectives include a simultaneous analysis of the impact of agricultural and industrial GDP on one another. A study, such as this, that evaluates the relationship between agriculture and industry, can be important for both Pakistani policy

<sup>1</sup> A similar figure was originally presented by Hewitt et al. (1992) for different countries and dates.



Source: Compiled from data gathered from World Bank, 1994 (Baltimore MA, John Hopkins University Press).

Fig. 1. Correlation between industrialization and growth in selected low-income nations.

makers and other developing nations in evaluating their policies in the past, and formulating strategies for the future. Without an understanding of the relationships between these major sectors, it is difficult to fully understand the complex dynamics of development and construct effective policies for sustainable economic growth.

### 1.2. Previous research

Previous research on interaction between agriculture and industry has been limited. In a theoretical analysis of agriculture's role in structural transformation of underdeveloped nations, Johnston and Kilby (1975) examined some of the traits of agricultural/industrial interaction. It was hypothesized that one of the major roadblocks to industrial expansion in underdeveloped nations relates directly to the relationship between agriculture and industry. According to this hypothesis, inequalities in agricultural income distribution concentrate a majority of the rural buying power in the hands of a few large landholders. This causes a disproportionate rural demand for high-value, capital-intensive goods. As underdeveloped nations possess the capabilities to produce labor-intensive products more efficiently than capital-intensive ones, a case such as this (where there exists a large rural demand for high-value products) results in the devel-

opment of inefficient industries for the production of capital-intensive manufactured goods for the domestic market. These goods have difficulty competing with imports, and are profitable only due to government policies which create favorable price distortions for the industry.

This inefficient allocation of resources not only slows the growth of the industrial sector, but also creates a vicious cycle by reducing the labor-absorption potential of industry. This reduces opportunities for expanding the middle-income population sector, and thus perpetuates the original income inequalities that first stimulated the development of an inefficient industrial sector. A situation such as this could hypothetically be altered through the development of the agricultural sector. This would effectively widen the middle-income population base and encourage the development of more efficient industries with lower capital per worker ratios.

A later work utilized empirical analysis to provide support for the hypothesis that a favorable relationship exists between the agricultural and industrial sectors. The study used a single-equation, non-linear model to test the significance of the agricultural/industrial relationship (Hwa, 1983). This model related industrial growth to per capita income and agricultural growth. The results indicated that agricultural growth had a significant impact on the industrial growth. Hwa's results also showed that the inclusion of the agricultural

growth variable raised the explanatory power of the model, and confirmed the hypothesis that countries with above-normal growth in their industrial sectors are the ones with above-normal growth in the agricultural sector. However, while this model acknowledged that industry benefits from agriculture, it did not take into account that agriculture also benefits from industry. It could be argued that, while industrial output is in part determined by agriculture, agricultural output is at the same time affected by industry.

In a more recent study, Yoa (1996) used the vector autoregressive (VAR) model to study the relationship among primary sectors in China. He indicated that the support of the farm production after economic reforms, has improved agricultural growth and industrial efficiency. Although the VAR model provides the linkage between agricultural and non-agricultural sectors, the model fails to present the contribution of capital growth to the sector.

In a study of the U.S. economy by Gopinath and Roe (1996), GDP is specified as a function of prices of each of the major sectors (agriculture, industry and services) and prices of inputs (capital and labor). From this study, it is concluded that the industrial and agricultural sectors are complementary. It is further explained that food processing and non-durable marketing sectors of industry benefit from agriculture products as a source of input. Moreover, the agricultural sector benefits from chemical and machinery output of the industry.

### 1.3. The model

In order to analyze the impacts of agricultural and industrial sectors on one another, a GDP growth model is developed and estimated in this study. In several of the past studies (Robinson, 1971; Gopinath and Roe, 1996; Humphries and Knowles, 1998), gross domestic product ( $Y$ ) is defined as a function of primary inputs, mainly, capital ( $K$ ) and labor ( $L$ ). Therefore, the output of any sector is defined as a function of capital and labor input employed in that sector at the time:

$$Y_j = F(K_j, L_j) \quad j = \text{agriculture (a), industry (i)} \quad (1)$$

In these models, capital and labor are assumed to be mobile among sectors, and this mobility causes a dif-

ferential growth rate across sectors (Robinson, 1971). This is shown by taking the total derivative of Eq. (1):

$$dY_j = \frac{\partial F}{\partial K_j} dK_j + \frac{\partial F}{\partial L_j} dL_j, \quad (2)$$

$$\frac{dY_j}{Y_j} = \frac{\partial F}{\partial K_j} \frac{K_j}{Y_j} \frac{dK_j}{K_j} + \frac{\partial F}{\partial L_j} \frac{L_j}{Y_j} \frac{dL_j}{L_j} \quad (3)$$

Or, in terms of parameter estimates:

$$\dot{y}_j = \beta_k \dot{k}_j + \beta_l \dot{l}_j,$$

where  $\dot{y}_j$ ,  $\dot{k}_j$  and  $\dot{l}_j$  are the output growth rates of sector  $j$  and the growth rates of capital and labor used in sector  $j$ .  $\beta$ s are elasticities with respect to input factors. Similar to Chenery and Syrquin (1975), Cobb–Douglas type functions are used to represent production in this study. The assumption of homogeneity of degree one (or linearly homogeneous production functions) implies that the total percentage change in output with respect to the percentage change in the quantities of all inputs, or the sum of  $\beta$ s, is equal to one. Using the Wald test, we failed to reject the null hypothesis of homogeneity of degree one of the production functions (industrial and agricultural) at 95% confidence level. Therefore, the production functions estimated in this study are assumed to be linearly homogeneous.

The model used in this study recognizes that the interaction between agriculture and industry may occur in both directions, with each sector affecting the other. Therefore, the equations of agricultural and industrial output are estimated by both a single-equation approach and a systems approach. More specifically, two equations were developed to evaluate the interaction between the agricultural and industrial sectors. The first equation determines the growth of the agricultural sector's GDP, thus evaluating the factors that are expected to impact the growth of this sector. And, likewise, the second equation determines the growth of the industrial sector's GDP. Given the importance of cotton to both agricultural and industrial sectors, the relationship between the growth of the industrial and cotton sectors is examined through two equations. One equation examines the factors impacting the growth of cotton production and the other specifies the growth of industrial GDP as a function of the growth of cotton output among other variables

(cotton-dependent industrial GDP equation). Therefore, the model consists of a total of four equations to be estimated.

### 1.3.1. Agricultural and industrial GDP equations

In order to capture the linkages between agriculture and industry, the growth in the industrial sector ( $\dot{y}_i$ ) and the growth in the GDP, generated by the transportation sector, ( $\dot{y}_t$ ) are added as independent variables to the agricultural sector's output growth model in addition to the capital and labor growth rates ( $\dot{k}_a$  and  $\dot{l}_a$ ). The GDP generated by the transport sector is added, as constraints in transportation infrastructure often limit sales. Included in transportation infrastructure and activities are railroads, roads, shipping, civil aviation, and communication (United Nations, 1974). The equation determining the growth rate of agricultural GDP is specified as

$$\dot{y}_a = \beta_0 + \beta_k \dot{k}_a + \beta_l \dot{l}_a + \beta_i \dot{y}_i + \beta_t \dot{y}_t + e \quad (4)$$

where  $\beta_0$  is the intercept or constant term, and other  $\beta$ s represent elasticities to be estimated.

Similarly, the growth in the industrial GDP is specified as a function of the growth rates of capital used in industry ( $\dot{k}_i$ ), industrial labor force ( $\dot{l}_i$ ), agricultural GDP ( $\dot{y}_a$ ), and GDP generated by the transportation sector ( $\dot{y}_t$ ):

$$\dot{y}_i = \alpha_0 + \alpha_k \dot{k}_i + \alpha_l \dot{l}_i + \alpha_a \dot{y}_a + \alpha_t \dot{y}_t + e \quad (5)$$

where the intercept or constant term is  $\alpha_0$ , and  $\alpha$ s represent elasticities to be estimated.

Despite the fact that much of Pakistan's industry is capital intensive (as opposed to labor intensive), it is expected that the industrial sector's GDP will respond positively to the availability of qualified labor. This is expected in light of the shortage of technical knowledge and ability among the traditional labor force. While Pakistan may not be suffering from an absolute shortage of labor, the percentage of the labor force that is qualified labor may not be sufficient to meet the needs of industry. The coefficient of capital is expected to be positive, as the growth in the capital formation in each sector is expected to impact positively the growth of that sector. Moreover, the inclusion of agricultural and industrial GDPs as independent variables in Eqs. (4) and (5) will help determine

the relationship between the industrial and agricultural sectors.

### 1.3.2. Cotton related equations

In order to determine more accurately the relationship between Pakistan's large cotton sector and the industrial sector, two recursive equations consisting of a cotton equation, which analyzes the growth in the real value of total cotton production, and a cotton-dependent industrial GDP equation were specified. The factors that are expected to impact the growth of cotton production ( $\dot{c}$ ) are the growth rates in capital used in agriculture ( $\dot{k}_a$ ), agricultural labor force ( $\dot{l}_a$ ), the amount of cotton textile processed (metric tons) in the country ( $\dot{m}$ ), and previous year wholesale real price of cotton ( $\dot{p}$ ). These factors are reflected in the following function:

$$\dot{c} = \gamma_0 + \gamma_k \dot{k}_a + \gamma_l \dot{l}_a + \gamma_m \dot{m} + \gamma_p \dot{p} + e \quad (6)$$

where  $\gamma_0$  is intercept, and  $\gamma$ s represent elasticities to be estimated. The amount of cotton textile processed in Pakistan is used as an indication of industrial growth in the cotton sector.

This cotton-dependent GDP equation determining the size of the industrial sector is a modification of Eq. (5), as described in the previous section. Here, it is assumed that the growth of industrial GDP ( $\dot{y}_i$ ) is a function of growth rates in capital used in industry ( $\dot{k}_i$ ), industrial labor ( $\dot{l}_i$ ), and the real value of cotton output ( $\dot{c}$ ). The resulting function is written as follows:

$$\dot{y}_i = \delta_0 + \delta_k \dot{k}_i + \delta_l \dot{l}_i + \delta_c \dot{c} + e \quad (7)$$

where the intercept or constant term is  $\delta_0$ , and  $\delta$ s represent elasticities to be estimated.

## 2. Data and estimation methods

The primary source of data was United Nations (1977–1994). The monetary data was deflated by a GDP deflator using the data from the International Monetary Fund (1996) and using 1990 as the base year. The data used in this study cover the period 1970–1994. Financial data are measured in real rupees. The natural logarithm of the variable were used to represent the growth rates of variables.

Eqs. (4–7) were estimated using the ordinary least squares (OLS) method and two-stage least squares (2SLS), with the constant returns to scale restriction imposed. OLS is one of the most popular single-equation methods, but estimating each equation separately may lead to biased results. Despite its suffering from asymptotic bias, OLS can be a very effective tool for small samples since it minimizes the variance and is less susceptible to estimation errors such as misspecifications and multicollinearity (Kennedy, 1998).

The 2SLS uses an instrumental variable approach. It yields consistent and fully efficient (in cases where disturbances are normally distributed) estimators. In the just-identified equations, 2SLS estimators are identical to those of Limited Information Maximum Likelihood and Indirect Least Squares (Green, 1997). The alternative method is three-stage least squares (3SLS), which can be more efficient than 2SLS. The disadvantage of 3SLS is its sensitiveness to misspecification errors. Also, it is difficult to prove superiority of 3SLS over 2SLS. Due to its preferred small sample properties than most other methods, insensitiveness to misspecification errors or multicollinearity, as shown in monte carlo studies, and due to inexpensive cost of estimation, 2SLS is recommended for general use (Kennedy, 1998).

The misspecification test suggested by McGuirk et al. (1995) was used to verify the assumption of normality, independence, homoskedasticity, stability and linear form. All assumptions held at 95% confidence level. Though the model has a problem of multicollinearity, imposing the restriction (constant return to scale in this study) is expected to reduce variance of parameter estimates (Kennedy, 1998).

### 3. Estimation results

The results of 2SLS and OLS estimation for agricultural (Eq. (4)) and industrial GDPs (Eq. (5)) are reported in Table 1. Likewise, the parameters estimates for cotton production (Eq. (6)) and cotton-dependent industrial GDP (Eq. (7)) are reported in Table 2. Note that Eqs. (4) and (5) were estimated in a separate model than Eqs. (6) and (7).

The  $R^2$ s for the four equations, estimated using OLS, are 0.97, 0.95, 0.84, and 0.97 for agricul-

tural GDP, industrial GDP, cotton production, and cotton-dependent industrial GDP equations, respectively. Moreover, the  $R^2$ s for each equation, when estimated with 2SLS, are similar to the  $R^2$ s from the OLS method of estimation. Likewise, the magnitude of the coefficients of capital and labor in the industrial GDP (Eq. (5)) and cotton-dependent industrial GDP (Eq. (7)) equations were very similar, indicating robust results. Note that the estimated parameters for Eq. (6) using the OLS method of estimation are identical to those obtained from the 2SLS.<sup>2</sup>

#### 3.1. The interactions of industry and agriculture

In the agricultural GDP equation (Eq. (4)), the coefficient for industrial sector's GDP ( $\beta_i$ ) represents the benefit that agriculture receives from the industrial sector (Table 1). In the 2SLS model for this equation,  $\beta_i$  is positive, but not statistically significant. When the same relationship is examined by the single equation OLS, we find that the coefficient of the industrial GDP variable is positive and statistically significant. From the OLS results, it can be concluded that the agricultural sector is benefiting from the manufacturing sector. This may be due to the fact that the industry began reciprocating benefits by supplying the agricultural sector with modern technology since the early eighties. In addition, Pakistan has recently become self-sufficient in certain chemical fertilizers.

The sign on the coefficient for the agricultural sector's GDP ( $\alpha_a$ ) in the industrial equation (Eq. (5)) was expected to be positive, as a large portion of the industrial sector has been dependent upon agriculture for raw materials since Pakistan's independence in 1947. The agricultural GDP parameter estimates from both 2SLS and OLS models were consistent with this expectation. This coefficient was statistically significant at a level of 5% in 2SLS and at 1% in OLS. However, the magnitude of the industrial GDP parameter in the agricultural GDP equation (Eq. (4)) is much smaller than the size of the agricultural GDP parameter in the

<sup>2</sup> The reason for identical coefficients is that the dependent variable in Eq. (7), industrial GDP, is not included as an independent variable in Eq. (6), cotton production equation. Instead, the variable indicating cotton textile processed is included as an independent variable in Eq. (6) to represent industrial growth in the cotton sector.

Table 1  
Estimated elasticities, agricultural and industrial GDP equations, Pakistan, 1970–94<sup>a</sup>

Parameter estimates of	Model estimated with 2SLS	Model estimated with OLS
Agricultural GDP equation (Eq. (4))		
Capital ( $\beta_k$ )	0.048 (0.670)	−0.025 (−0.292)
Agricultural labor force ( $\beta_l$ )	0.952*** (13.222)	1.025*** (11.986)
Industrial GDP ( $\beta_i$ )	0.064 (0.416)	0.322** (2.990)
Transportation GDP ( $\beta_t$ )	0.217* (2.114)	0.060 (0.679)
Intercept ( $\beta_0$ )	−2.321*** (−7.666)	−2.717*** (−8.707)
	$R^2 = 0.97$	$R^2 = 0.97$
Industrial GDP equation (Eq. (5))		
Capital ( $\alpha_k$ )	0.246 (1.454)	0.314 (1.738)
Industrial labour force ( $\alpha_l$ )	0.754*** (4.448)	0.686*** (3.788)
Agricultural GDP ( $\alpha_a$ )	1.729* (2.013)	1.301** (2.914)
Transport GDP ( $\alpha_t$ )	−0.530 (−1.427)	−0.348 (−1.557)
Intercept ( $\alpha_0$ )	−4.121** (−2.725)	−3.379*** (−3.786)
	$R^2 = 0.97$	$R^2 = 0.95$

<sup>a</sup>Figures in parentheses are *t*-statistics; \*, significance at 5% level; \*\*, significance at 1% level; and \*\*\*, significance at 0.1% level.

Table 2  
Estimated elasticities, cotton production and cotton-dependent industrial GDP equations, Pakistan, 1970–1994<sup>a</sup>

Parameter estimates of	Model estimated with 2SLS	Model estimated with OLS
Cotton production equation (Eq. (6))		
Capital ( $\gamma_k$ )	−0.264 (−0.904)	−0.264 (−0.861)
Agricultural labor force ( $\gamma_l$ )	1.264*** (4.320)	1.264*** (4.116)
Cotton textile processed ( $\gamma_m$ )	0.878*** (5.091)	0.878*** (4.852)
Cotton price ( $\gamma_p$ )	0.410* (2.250)	0.410* (2.144)
Intercept ( $\gamma_0$ )	−8.027*** (−3.456)	−8.027** (−3.293)
	$R^2 = 0.77$	$R^2 = 0.84$
Cotton-dependent industrial GDP equation (Eq. (7))		
Capital ( $\delta_k$ )	0.424*** (6.312)	0.455*** (6.603)
Industrial labour force ( $\delta_l$ )	0.576*** (8.573)	0.545*** (7.908)
Cotton production ( $\delta_c$ )	0.356*** (5.984)	0.323*** (5.644)
Intercept ( $\delta_0$ )	−5.678*** (−7.159)	−5.248*** (−6.830)
	$R^2 = 0.95$	$R^2 = 0.97$

<sup>a</sup>Figures in parentheses are *t*-statistics; \*, significance at 5% level; \*\*, significance at 1% level; and \*\*\*, significance at 0.1% level.

industrial GDP equation (Eq. (5)). This may suggest that industry has benefited more from the relationship than has agriculture.

The impact on the industrial sector was also evaluated in terms of cotton production. This allows us to examine how Pakistan's industrialization process interacts with one specific crop. This is especially pertinent to Pakistan's economy due to cotton's large share of overall agricultural production. The estimations of the 2SLS and OLS methods for both cotton production equation (Eq. (6)) and cotton-dependent industrial GDP equation (Eq. (7)) are reported in Table 2. In the

cotton-dependent industrial GDP equation, the coefficient of the value of cotton production ( $\delta_c$ ) is positive. This indicates that cotton production has been a favorable factor in Pakistan's industrial growth. These results are statistically significant at a 0.1% significance level using both 2SLS and OLS estimation methods. According to 2SLS, a 10% increase in the value of cotton production has resulted in an increase of almost 3.5% in the value of total industrial output. The results obtained by the OLS single-equation model, in column 2, confirm the findings reported by 2SLS.



While cotton production is not directly dependent on industrial development in our model, it is dependent on the amount of cotton textile processed, a somewhat related variable. In Table 2, the estimation results of cotton production equation (Eq. (6)) show a positive and statistically significant sign for the coefficient of cotton textile processed ( $\gamma_m$ ). This may indicate that production is demand driven. Increases in the amount of cotton textile processed are expected to increase the demand for cotton, which, in a free market situation, will encourage its production. It is interesting to note that these results occurred despite price fixing mechanisms present in the Pakistani economy intended to provide a cheap supply of cotton to encourage the development of the textile industry. The size of this coefficient implies that a 10% increase in the amount of cotton textile processed has led to an increase of approximately 9% in cotton production.

This study recognizes the fact that agriculture and industry are also indirectly bound together in their relationship by many factors. In determining proper policy priorities, it is important to understand how a nation's many limited resources are shared between these sectors, and how they each benefit from these resources. The results for the capital parameters are examined first, and the labor force, next.

### 3.1.1. *The impact of capital*

In the agricultural GDP equation (Eq. (4)), the estimated capital parameter is positive, but non-statistically significant from the 2SLS method, and negative and statistically insignificant from the OLS method of estimation. Two explanations may be given for these results. The first explanation relates to factor intensity in each sector. It is expected that the more capital-, or labor-, intensive a sector is, the larger is the growth of the sectoral output with respect to increases in capital or labor (Gopinath and Roe, 1996). Since the industrial sector in Pakistan is more capital intensive than the agricultural sector, a smaller capital coefficient is expected in the agricultural GDP equation than the industrial GDP equation. Second, the data on the capital variable measures total capital formation (domestic and imported), and does not distinguish as to which sector (agriculture or industry) it is being invested in. If the investments are not made in agriculture, a non-significant impact of the

change in capital formation may be observed for the agricultural GDP. In the past, government policies in Pakistan have encouraged industrial development by diverting resources to the industrial sector and away from the agricultural sector (Faruquee, 1995).

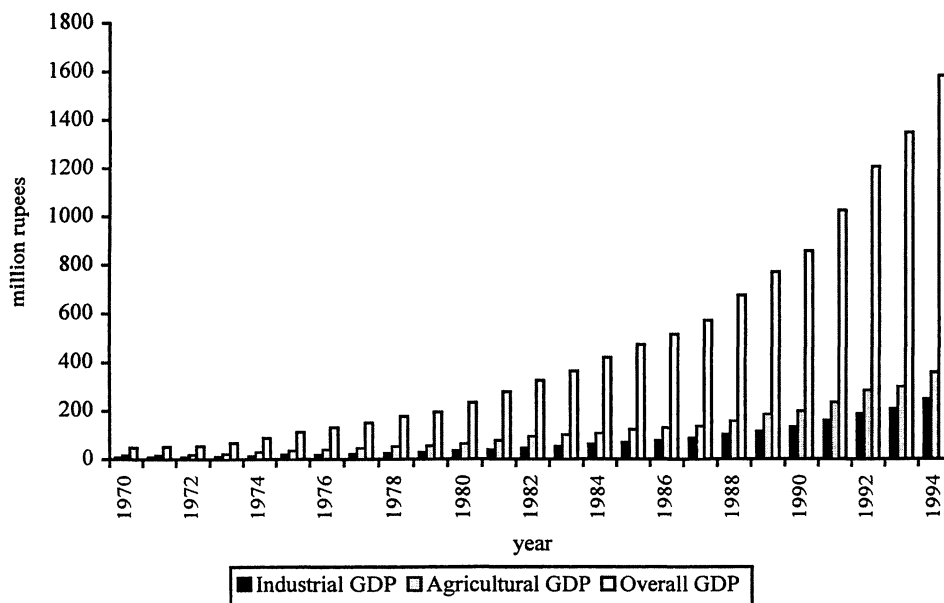
In the industrial GDP equation (Eq. (5)), the sign for capital coefficient ( $\alpha_k$ ), when estimated by both 2SLS and OLS estimation results, was positive, but also statistically insignificant and larger in magnitude than the coefficient of capital in the agricultural equation. This may be because the industrial sector is more capital intensive relative to the agriculture sector and, therefore, the industrial output is expected to be more responsive than the agricultural output to the growth in capital formation. Note that statistical insignificance does not always imply economic insignificance (McCloskey and Ziliak, 1996).

Total capital showed a statistically significant parameter, with a positive sign in the cotton-dependent industrial equation (Eq. (7)), but it showed statistical non-significance, with a negative sign in cotton equation (Eq. (6)). This is also consistent with the prior expectations. Again, government policies have emphasized diverting capital investments to the industry. Estimation results indicate that the elasticities of the industrial output with respect to capital are relatively low (0.3–0.4) in both industrial and cotton-dependent industrial equations (Eqs. (5) and (7)). This may be due to the overprotection of the industrial sector, which, according to past studies, results in inefficient performance of resources used in industry (Faruquee, 1995).

### 3.1.2. *The effect of labor*

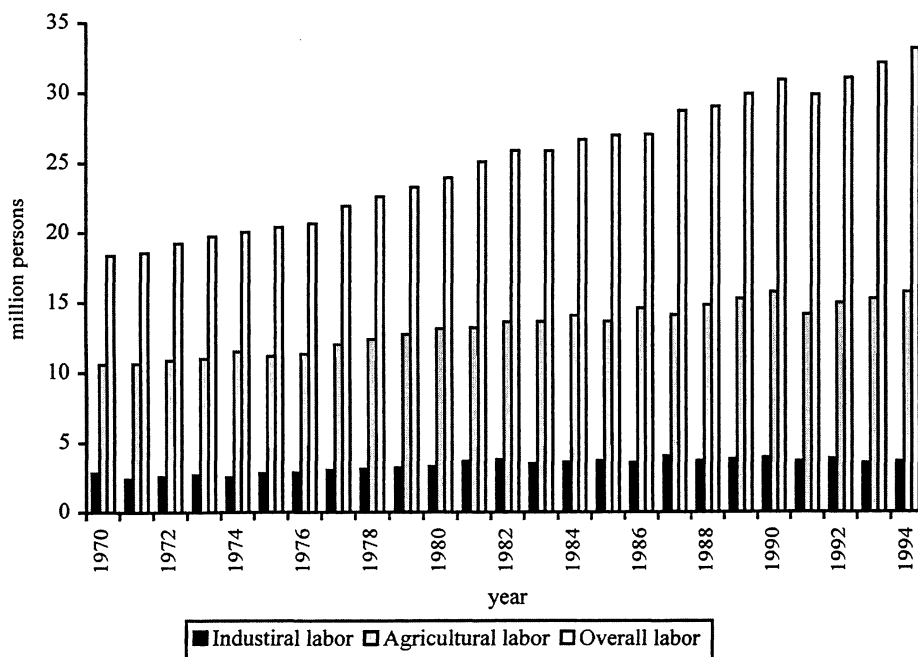
Capital is not the only resource that must be divided between agricultural and industrial sectors. Labor supply can have extensive effects on the growth of both agricultural and industrial sectors. The relative size of industrial GDP and industrial labor force is given in Figs. 2 and 3. As is shown in the figures, although the industrial sector accounted for 24% of GDP in 1994, it employed only 10.9% of the labor. Meanwhile, the agricultural sector, while accounting for 26% of the GDP, employed about 50% of the labor force in 1994.

Both the agricultural GDP (Eq. (4)) and the cotton production equations (Eq. (6)) showed a statistically significant and positive parameter for the agricultural labor force (Tables 1 and 2). The positive and statis-



Source: Compiled from data gathered from United Nations, various issues.

Fig. 2. The size of industrial, agricultural and overall GDP, Pakistan, 1970–1994.



Source: Compiled from data gathered from United Nations, various issues

Fig. 3. The size of industrial, agricultural and overall labor force, Pakistan, 1970–1994.

tically significant labor force parameter provides implicit support for the labor intensiveness of Pakistan's agricultural sector. Nevertheless, increased employment in agriculture can have only positive results on output if it is combined with increase in complementary factors of production, such as land and water.

Labor was also evaluated in the industrial GDP equation (Eq. (5)). In both 2SLS and OLS methods (Table 1), the estimated coefficient for industrial labor force ( $\alpha_1$ ) had a positive sign and was statistically significant. Positive and statistically significant results were also estimated by the cotton-dependent industrial equation (Table 2). Given that Pakistan's industrial sector is capital intensive, the quality of labor available to the industry may be more important than the quantity of labor available. Nevertheless, the industry suffers from shortage of high quality labor despite the high level of unemployment (Khan, 1993).

### 3.1.3. *The effect of transport sector's GDP*

The size of the transport sector's GDP was evaluated in both agricultural and industrial GDP equations (Eqs. (4) and (5)). This variable was expected to have a larger impact on the agricultural sector since agriculture is primarily located in lesser developed rural areas, where even slight improvements in transport can remove major obstacles in accessing the markets. In the agricultural equation, the coefficient of transport sector's GDP ( $\beta_1$ ) was estimated to be positive in both 2SLS and OLS models, but statistically significant only in the 2SLS model. This is consistent with prior expectation that growth in the transport sector has benefited agriculture. The better access to markets provided by growth in the transportation sector not only means that farmers have more incentives to produce, but also that more of the production is accounted for when calculating total output because marketable surplus can be delivered to the markets.

The transport sector's GDP is expected to have less impact on the industrial GDP than on the agricultural GDP due to the fact that industry tends to develop in areas that already have adequate infrastructure. The estimated coefficient of transport GDP in the industrial GDP equation ( $\alpha_1$ ) was statistically insignificant and negative in both 2SLS and OLS models (Table 1). As expected, the estimations of both models demonstrated that changes in the size of the transport sector's

GDP have had a larger impact on agriculture than on industry.

## 4. Conclusions

This study examines the interaction between the agricultural and industrial sectors of Pakistan's economy. As Pakistan's policy makers continue to pursue growth in the industrial sector with hopes of stimulating economic development, the prospects for agriculture retaining priority status seem slim. Much of Pakistan's industrial growth to present has been funded at the expense of the agricultural sector. The results of this study indicate that this may not be an entirely efficient approach. The positive coefficients associated with the interaction terms in both industrial and agricultural GDP equations indicate that both sectors benefit from their relationship. However, the difference in the sizes and statistical significance of the interaction parameters demonstrates that while both the sectors may have benefited from their relationship, the industrial sector has gained more. This tends to confirm the conclusions made by Adelman (1983), Hwa (1983), and Yoa (1996) that agricultural growth and rural development should be given top priority, since their growth helps the industrial sector grow even faster.

This study also indicates that some policies that have been implemented in Pakistan to encourage industrial development, may not be having the intended effects. For example, interest rate subsidies have been featured prominently to promote capital improvements in the industrial sector. However, it is interesting to note that the estimates for capital in the industrial sector (Eq. (5)) were statistically insignificant in 2SLS and OLS. These results indicate that government policies, which were designed to increase investment and stimulate industrial development, may not be achieving their goals.

While the implications of this study's results are widespread for Pakistan's development policy, the significance of these findings reaches beyond national boundaries. This study also indicates the need for similar studies to be conducted for other low-income nations which are pursuing a course of industrial development. These results are also significant from a social standpoint. They indicate that agricultural development does not have to be abandoned in order

to focus resources on industrial development. By encouraging industrial development through growth in agricultural sector, the position of rural poor can be bettered while simultaneously providing a solid backdrop for the nation's industrial development. On the other hand, developing country government attempts to industrialize the economies at such a high speed that agricultural growth is diminished, would result in poor agricultural performance and low industrial efficiency (Yoa, 1996). From 1987 to 1993, the total number of population living on less than \$1 a day in developing economies increased from 1227.1 million to 1331.9 million (World Bank, 1997). With the majority of this population dependent on agricultural incomes, an approach of this type promises potential for reducing large amounts of poverty while stimulating the type of industrial base vital to a nation's balanced economic growth.

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