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Capital Labour Substitution in the Large-scale Food-processing Industry in Pakistan: Some Recent Evidence

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1. INTRODUCTION

Food-processing is one of the first industries developed by man. Most agricultural commodities require some sort of processing for them to be edible. In primitive societies man processed his own food using the simple mortar and pestle. With the advent of industrialisation there emerged important implications for food-processing technologies. The workers in the industrial and commercial sectors of urban areas required greater supplies of food. This encouraged the establishment of processing plants supplemented by storage facilities to ensure that the urban population received the food that they required. Food-processing, therefore, began to occupy a fairly predominant position in the overall industrial sector. Its importance was heightened by its strong backward and forward linkages with the rest of the economy.

In a labour-surplus developing economy, where most of the labour is unemployed or underemployed, the absorption of this surplus labour force in the industrial sector is an important issue. In recent decades, there has been significant growth in the industrial sector in most developing countries, in terms of both investment and output. This has not resulted in a similar rate of increase in labour absorption. This is often attributed to the adoption of inappropriate technologies see, for example, Malik and Battese (1986) or to the lack of technological alternatives. In this paper we seek to determine whether capital-labour substitution is possible in the large-scale food-processing sector in Pakistan.

The elasticity of substitution is a measure which determines the rate at which the two inputs, capital and labour, can be substituted for each other without altering the level of production. The existence of a positive elasticity of substitution in the industrial sector is a pre-requisite for policy-makers to successfully implement

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policies which will result in the greater absorption of labour in the production process. Other things being equal, if the elasticity of substitution between capital and labour is high then efficient production can still be achieved by substituting the relatively abundant labour for the relatively scarce capital [Behrman (1972)]. The estimation of the elasticity of substitution is thus of considerable practical importance for the formulation of appropriate policies for the economic development of Pakistan.

The remainder of this paper consists of three sections. The second section discusses the importance of the large-scale food-processing industry and its sub-sectors in Pakistan. The third section presents a brief description of the methodology for estimating the elasticity of substitution and includes empirical results obtained by using data from the fourteen most recent Censuses of Manufacturing Industries in Pakistan. The concluding section indicates the major policy implications for employment generation in the large-scale, food-processing industry in Pakistan.

2. THE FOOD-PROCESSING INDUSTRY IN PAKISTAN

Data from the Census of Manufacturing Industries, 1986-87 [Government of Pakistan (1991)], which is the latest available indicate that the food-processing industry is a significant part of the industrial sector in Pakistan because it comprises about fifteen percent of the total value-added in all large-scale industries combined (about 15 percent and 16 percent in Punjab and Sindh, respectively). The value of fixed assets in this industry relative to the total fixed assets in the large-scale industries is approximately thirteen percent in Punjab and six percent in Sindh. Labour èmployed in the large-scale, food-processing industry relative to the total labour force in large-scale manufacturing is thirteen percent and twelve percent for Punjab and Sindh, respectively. However, the cost of employment of labour in food-processing industries, relative to the total cost of employment for large-scale manufacturing is about fourteen percent in Punjab and twelve percent in Sindh. The relationship between value-added and wage per worker in an industry is of great importance in explaining employment. The data on the relationship between value-added and wage per worker in the large-scale, food-processing industry from 1970 to 1987 show that while average productivity per labourer (V/L) has increased remarkably, the wage rate has risen much more slowly. Moreover, the gap between the two continued to increase from 1971 to 1986. There is, however, a narrowing of this gap in the last year covered by this study.

Food-processing industries include such diverse components as sugar refining, edible oil, fats, hydrogenated oil, cotton seed oil, wheat and grain milling, rice milling, dairy products, canning of fish and sea food, manufacturing of tea and others.

In Table 1 we present the average percentage shares of the different sub-sectors in the food-processing industry for 1986-87. These shares are computed for value-added, number of workers employed and employment cost. Growth rates are also presented for the period 1969-70 to 1986-87.[1]

Table 1

Average Relative Shares of the Different Sub-sectors of the Food-processing Industry for 1986-87

Sub-Sectors	No. of Firms	Value-added	Labour	Employment-Cost
1. Sugar Refining	4.69	50.16	45.89	44.31
	(6.03)	(8.15)	(4.89)	(10.85)
2. Edible Oil, Fats and Hydrogenated Oil	17.93	23.13	23.29	27.98
	(4.60)	(4.97)	(4.31)	(10.34)
3. Tea Blending	0.72	7.64	3.05	5.93
	(1.05)	(5.59)	(0.43)	(7.77)
4. Fruit and Vegetable Canning	1.32	0.69	0.83	0.68
	(0.14)	(5.34)	(–1.84)	(2.84)
5. Wheat and Grain Milling	25.39	2.65	7.52	4.12
	(9.97)	(4.62)	(5.42)	(6.86)
6. Canning of Fish and Sea Food	1.32	0.68	0.70	0.62
	(–3.29)	(1.11)	(–9.87)	(–8.01)
7. Rice Milling	20.46	1.18	2.61	1.82
	(14.01)	(13.75)	(9.20)	(14.57)
8 Others	28.17	13.87	16.11	14.54
	(7.23)	(8.42)	(8.59)	(13.45)
9. All Food Manufacturing	100.00	100.00	100.00	100.00
	(6.70)	(9.33)	(5.01)	(10.34)

Note: 1. Figures in parenthesis are growth rates for the period 1969-70 to 1986-87.
2. Growth rates of value-added and employment cost are based on deflated data with base year 1975-76.
3. Value-added deflated by General Price Indicator, employment cost deflated by the consumer price ndicator obtained from the *Economic Survey* of the Government of Pakistan.

The relative importance of different sub-sectors of the food-processing industry are significant for an analysis of the whole food-processing industry. We present only a descriptive analysis of the value-added, size of the labour force and its associated employment costs. We avoid emphasising the analysis of the capital involved because of the severe aggregation problems in the capital variable which make comparisons across sub-sectors difficult and because of the unavailability of appropriate capital deflators.

In terms of the shares of value-added, labour and employment cost, the most important sub-sector is sugar refining. However, this sub-sector has a proportionately smaller number of firms, which implies a larger scale of operation as

[1]The growth rates are computed from the following regressions:
$Log\ (Y) = \alpha + \beta T$, where β is the trend coefficient, and T denotes time. The growth rates are based upon the available Census of Manufacturing Industries data for the period 1969-70 to 1986-87.

compared with, say, the edible oils, fats and hydrogenated oils sub-sector. Although sugar refining employs 45.89 percent of the labour, its employment cost is 44.31 percent of the total. This indicates that wages paid are relatively lower than those for say the edible oils, fats and hydrogenated oils sub-sector.

In terms of the share of value-added, the fastest growing sub-sector (excluding the non-specified 'others' category) is rice milling. The relatively slowest growing sub-sector is canning of fish and sea food where the growth rate of the share of value-added is 1.11 percent. The growth rate of labour for the rice milling sub-sector is the highest. Canning of fish and sea food have declining shares in terms of the growth of number of firms, labour and employment cost. This decreasing importance suggests a relative stagnation in this sub-sector. The non-specified 'other' category appears to be composed of a relatively large number of small-sized firms.

The foregoing description brings out not only the relative importance of the different sub-sectors, but also the diversity of the different activities that make up the large-scale, food-processing industry in Pakistan. The non-homogenous nature of the outputs involved needs to be borne in mind in any analysis of aggregate data of the food-processing industry.

3. ESTIMATION OF ELASTICITIES OF SUBSTITUTION

Data on different aspects of large-scale manufacturing firms in Pakistan were obtained from the Censuses of Large-Scale Manufacturing Industries. The Census of Manufacturing Industries (CMI) is undertaken with the collaborative effort of the Central Statistics Office and the Provincial Statistics Departments. The Censuses provide the core information regarding the manufacturing sector of Pakistan. The data on the number of reporting establishments, the value of production, assets, inventories and value-added are all covered in the Census. Kemal (1976) has discussed aspects of the nature of these data. We use the original published data on the food-processing industry for the fourteen most recent years for which data are available in published form. These are 1969-70, 1970-71, 1975-76, 1976-77, 1977-78, 1978-79, 1979-80, 1980-81, 1981-82, 1982-83, 1983-1984, 1984-85, 1985-1986 and 1986-87 see Government of Pakistan (1991) and earlier issues. These data are available in aggregative form in cross tabulations across asset-size categories for the provinces of Punjab and Sindh.

Econometric Methodology

Parameters of the constant- and variable-elasticity-of-substitution production functions are estimated by considering their indirect forms which are derived under the assumption that the marginal productivity of labour is equal to the wage rate. These functions are specified for firms in different asset-size categories. Given that the input levels of firms within these different asset-size categories are the same see Battese and Malik (1986), the appropriate indirect form of the variable-returns-to-scale, constant-elasticity-of-substitution (CES) production function is

$$Log\left[\frac{\overline{Y}_i}{L_i}\right] = \beta_0 + \beta_1 \, Log\, W_i + \beta_2 \, Log\, L_i + \; Log\, \overline{V}_i,$$

$$i = 1, 2, \ldots, n; \qquad \ldots \qquad \ldots \qquad (1)$$

Where $\beta_1 \equiv \nu(\nu+\rho)^{-1}$ and $\beta_2 \equiv \rho(\nu-1)^{-1}(\nu+\rho)^{-1} = (\nu-1)(1-\beta_1)$;

based on the CES Production function:

$$Y_i = \gamma \left[\delta k_i^{-p} + (1-\delta)\, L^{-p}\right]^{-\nu/p} e^{u_i}$$

$$i = 1, 2, \ldots, n$$

- ν is the homogeneity (return-to-scale) parameter;
- ρ is the substitution parameter;
- $\overline{Y}_i$ represents the sample mean of value-added for the firms in the ith asset-size category;
- L_i represents the number of labourers employed by a firm in the ith asset-size category;
- W_i represents the wage rate for labourers in firms within the ith asset-size category;
- $Log\,\overline{V}_i$ is assumed to have normal distribution with mean zero and variance inversely proportional to the number of firms within the ith asset-size category, represented by r_i; and
- n represents the number of asset-size categories for which data are available.

The assumption that the random errors, $Log\,\overline{V}_i$, $i = 1, 2, \ldots, n$, in the indirect form (1) are heteroscedastic with variance inversely proportional to the numbers of reporting firms in the corresponding asset-size categories is consistent with the assumption that the CES production function, which defines value-added for individual firms in terms of labour and capital inputs, has multiplicative errors which are homoscedastic. If the random errors in the firm-level CES production function are assumed to have log normal distribution, then the errors, $Log\,\overline{V}_i$, in the indirect form (1) have approximately normal distribution, provided the number of firms in the ith asset-size category is sufficiently large [cf. Battese and Malik (1986, 1987)].

It is readily verified that the elasticity of substitution, σ, is expressed in terms of the coefficients of the logarithms of wages and labour in (1) by

$$\sigma = \beta_1 (1 + \beta_2)^{-1}.$$

Thus, if the constant-returns-to-scale CES production function applies (i.e., $\nu = 1$), then the coefficient of the logarithm of labour, β_2, is zero and so the coefficient of the logarithm of wages, β_1, in the indirect form (1) is equal to the elasticity of substitution. In this case the estimable indirect form is

$$Log\left[\frac{\overline{Y}_i}{L_i}\right] = \beta_0 + \beta_1 Log\, W_i + Log\, \overline{V}_i, \quad i = 1, 2, \ldots, n. \qquad \ldots \quad \ldots \quad \ldots \quad (2)$$

We also consider the stochastic variable-returns-to-scale VES production function, derived by Yeung and Tsang (1972). The associated indirect form of this VES production function with variable returns to scale is defined by

$$log\, (Y_i/L_i) = \beta_0 + \beta_1\, log\, W_i + \beta_2\, log\, L_i + \beta_3\, log\, (K_i/L_i) + log\, \overline{V}\, -i, \qquad \ldots \quad (3)$$

where $\beta_1 = \nu\, (\nu{+}\rho)^{-1}$; $\beta_2 = (\nu{-}1)\,(1{-}\beta_1)$; and $\beta_3 = c.$; based on the VES production function:

$$Y_i = \gamma[\delta K_i^{-\rho}\, (1{-}\delta)\eta L^{-\rho}{}_i (K_i/L_i)^{-c\,(1+\rho)}]^{-\nu/\rho}\, e^{u_i}$$
$$i - 1, 2, \ldots, n.$$

It is evident that the variable-returns-to-scale VES production function is equivalent to the constant-returns-to-scale CES production function (2) if the parameters, β_2 and β_3, in the indirect form (3), are both zero. Under the assumptions of the VES production function (3), it follows that if these two parameters are zero, then the F-statistic associated with the weighted least-squares estimators for β_2 and β_3 has F-distribution with degrees of freedom 2 and n-4.

We also consider that the stochastic constant-returns-to-scale VES production function [Lu and Fletcher (1968)]. The indirect form of this VES production function with constant-returns-to-scale, i.e., $\nu = 1$, is defined by:

$$log\, (\overline{Y}_i/L_i) = \beta_0 + \beta_1\, log\, W_i + \beta_3\, log\, (K_i/L_i) + \overline{V}_i, \qquad \ldots \quad (4)$$
$$i = 1, 2, \ldots, n,$$

where $\beta_1 = (1{+}\rho)^{-1}$; and $\beta_3 = c$.

It is evident that if the coefficient of the logarithm of the capital-labour ratio, β_3, is zero, then the model reduces to the indirect form of the constant-returns-to-scale CES production function (2). Given the assumption of the VES production function (4), it follows that a test of the hypothesis that the production function has constant elasticity of substitution is obtained by a *t*-test on the least-squares estimator for the coefficient of the logarithm of the capital-labour ratio.

Initially we consider the possibility of the similarity of production functions in the two provinces, Punjab and Sindh. Two hypotheses are considered, namely:

(i) The two provinces have the same elasticities of substitution but different intercepts; and
(ii) The two provinces have the same production functions.

The first hypothesis is not as restrictive as the second. It permits the two provinces to have differences of production. This is reflected in the indirect form of the two provinces having different intercept (β_0) parameters. The hypotheses are tested by traditional regression methods after the variables of the corresponding indirect forms are transformed, as indicated above. The estimates of elasticity parameter, σ, based on the indirect form, are estimated through applying the weighted least-squares regression. The observations are weighted by the square root of the number of reporting firms in the corresponding asset-size category to account for heteroscedasticity due to the grouped nature of the data.

The similarity of production functions over time can also be tested, given that certain regularity conditions are satisfied see Malik (1985); Battese and Malik (1986). If the hypothesis of constant elasticity of substitution over time is rejected, then the use of aggregative time-series data, as suggested by some researchers [e.g., Kemal (1981)] to investigate the possibilities of capital-labour substitution is not a particularly meaningful exercise.

Empirical Results

The number of asset-size categories for which aggregate data are reported for the food-processing industries for the fourteen census years involved are generally seven for each of the provinces of Punjab and Sindh, implying a total of fourteen observations for each census year. However, in 1969-70 there were twenty four, in 1970-71 there were eighteen and in 1977-78 there were thirteen observations. These are presented in Table 2[2].

We consider the possibilities of the similarity of the province functions. Tests are conducted on the basis of three hypotheses for both the constant returns-to-scale and variable returns-to-scale versions of the CES production function.

The relevant test statistics have approximate *F*-distributions and are presented in Table 3 to 4[3]. A perusal of these tables show that Punjab and Sindh have CES production functions with the same elasticities of substitution in almost all years until 1982-83, for both the constant- and variable-returns-to-scale models.

[2]This table is not being presented here because of space constraint.
[3]These tables are not being presented here because of space constraints.

For the subsequent years, however, based on the tests, it is not possible to pool the provincial data. These results indicate that pooling of provincial data is valid for estimation of a common elasticity of substitution for the large-scale, food-processing industry in Pakistan only in the initial years.

Tests for the adequacy of the constant-returns-to-scale CES production function given the adequacy of variable-returns-to-scale CES and VES production functions, reveal that the constant-returns-to-scale CES production function adequately represents the underlying production structure. These test statistics are reported in the last column of Table 5 and in Table 6, respectively.

The estimated elasticities of substitution based on the assumption that the constant-returns-to-scale CES production function applies in each year are also presented in Table 5. The results show that all the estimated elasticities are significantly different from zero. The significant elasticity estimates for the constant-returns-to-scale CES production function range from 0.91 to 2.22. It may be noted that elasticity of substitution is highest for the year 1975-76 i.e. 2.22. It is 1.26 for the year 1969-70. For the pooled data from 1969-70 to 1986-87, the estimated elasticity is 1.31.

Since all the elasticity estimates are significantly different from and greater than zero, it is of interest to test whether the elasticities are different from one, which applies for the Cobb-Douglas production function.

It can be shown that the estimated elasticities are significantly different from one for only five of fourteen Census years, namely 1970-71, 1976-77, 1977-78, 1980-81 and 1981-82. Our results indicate that the elasticity of substitution of labour for capital in food-processing industries in Pakistan is not zero and, in fact, does not differ significantly from one in most years. So significant possibilities exist for the substitution of labour for capital in the food-processing industries.

4. CONCLUSIONS

An analysis of data from recent Censuses of Manufacturing Industries reveals that the possibilities of capital-labour substitution are far greater in the food-processing sector of Pakistan than earlier studies have indicated see Kazi, Khan and Khan (1976) and Kemal (1981). This implies that more labour-intensive techniques can be efficiently adopted without sacrificing output. This finding has important policy implications for Pakistan's economic development. Two possibilities exist for generating employment. One is through the adoption of techniques that are labour-intensive in sub-sectors and the other is through changes in the output mix, i.e., through increased production from those sub-sectors that are more labour intensive. Obviously, the processing of staple foods, such as wheat, rice and sugar, must continue. However, other sub-sector which employ larger numbers of labourers per unit of capital should also be encouraged.

Table 5

Test Statistics for the Adequacy of the CES Production Function with Constant Returns to Scale and the Corresponding Estimated Elasticities of Substitution

Years	Elasticity Estimates			Test Statistics for the Adequacy of Constant Returns to Scale for All Pakistan[1]
	All Pakistan	Punjab	Sindh	
1969-70	1.26* (.33)	–	–	0.63
1970-71	1.30* (.14)	–	–	1.137
1975-76	2.22* (.62)	–	–	–0.548
1976-77	1.66* (.16)	–	–	4.022*
1977-78	1.92* (0.15)	–	–	0.524
1978-79	1.79* (.44)	–	–	–0.747
1979-80	1.46* (.27)	–	–	0.418
1980-81	1.65* (.25)	1.97* (0.17)	1.33* (0.23)	0.354
1981-82	1.43* (.20)	–	–	2.197**
1982-83	1.18* (.17)	–	–	2.557**
1983-84	1.08* (.33)	1.44* (0.21)	0.30 (0.26)	0.428
1984-85	1.23* (.34)	1.57* (0.23)	0.66*** (0.29)	–0.309
1985-86	1.24* (.37)	1.79* (0.24)	0.67** (0.22)	–0.308
1986-87	0.91*** (.51)	1.39* (0.37)	0.02 (0.55)	–0.236
1969–1987	1.31* (.08)			0.633

[1]These test statistics have *t*-distribution if the hypothesis of constant-returns-to-scale applies, given the assumption that the CES production function with variable-returns-to-scale holds.
Figures in brackets are the standard errors of the elasticity estimators.
* Denotes significant at 1 percent level.
** Denotes significant at 5 percent level.
*** Denotes significant at 10 percent level.

Table 6

Test Statistics for the Adequacy of the Constant-Returns-to-Scale CES Production Function, Given the Assumption that the Constant-Returns-to-Scale or the Variable-Returns-to-Scale VES Production Function Holds

Years	t-Values[1]	F-Values[2]
1969-70	0.457	0.188
1970-71	1.857**	1.611
1975-76	–4.235*	14.745**
1976-77	2.283**	8.251
1977-78	–0.506	0.625
1978-79	–0.558	0.272
1979-80	–0.178	0.181
1980-81	–1.285	2.022
1981-82	0.967	2.398
1982-83	0.533	2.973
1983-84	0.181	0.083
1984-85	1.204	0.870
1985-86	–0.575	0.174
1986-87	0.333	0.147
1969-87	0.551	0.249

[1]These t-values are involved in testing the hypothesis of constant-returns-to-scale, given the assumption that the constant-return-to-scale VES production function holds.

[2]These F-values are involved in testing the hypothesis that the constant-returns-to-scale CES production function is an adequate representation, given the assumption that the variable-returns-to-scale VES production function holds.

* Denotes significant at 1 percent level.

** Denotes significant at 5 percent level.

It is difficult to discern whether these significant aggregate elasticity estimates also imply the possibilities of a shift from one output mix to another. There is thus also an urgent need for further analyses to be undertaken at more disaggregated levels to determine the possibilities of labour-capital substitution for well-defined products.

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Comments on[1]
"Capital Labour Substitution in the Large-scale Food-processing Industry in Pakistan: Some Recent Evidence"

Battese, Malik, and Sultana's paper is a good attempt to update elasticity estimates in Pakistan. However, a few points need some clarification.

First, the changes in wages are very slow. What is the reason for this? Is it due to the government policy freezing wages?

Second, Table 1 reports the growth rate on the basis of constant price data. However, it is not clear which price indices are used to deflate value-added and employment cost and which is the base year?

Third, in economic theory, under perfect competition, wage is equal to the marginal product of labour and when marginal product is rising, average product is below marginal product. But here we see the opposite. The authors do not discuss the causes and consequences of this reversal.

Fourth, the elasticity estimates are very important. However, when the number of observations is small the precision of the estimates is suspected. I would like to know if the authors have accounted for this aspect. Furthermore, wages are very low as compared to the productivity of labour. How far will the elasticity estimates reported in this paper hold if wages start rising faster.

Fifth, I would like to know if it is possible to disaggregate the food industry by product, i.e., sugar refining, edible oil, and others separately. The elasticity estimates for each commodity group may be different, which may result in different policy prescriptions.

Finally, the authors should report intercepts of provincial production functions. In a production function framework, the intercepts reflect technology and the effect of omitted variables. If the differences in intercepts across provinces reflect differences in technology across provinces, it will be important to discuss these technological differences in detail.

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[1]These comments were given on the original paper presented in the Ninth Annual General Meeting of the Pakistan Society of Development Economists.