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INPUT DEMAND IN THE NIGERIAN MANUFACTURING SECTOR

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ABSTRACT
This study investigates input substitution possibilities in a developing Nigerian manufacturing sector. It gives empirical evidence that the sector faces technological rigidities that constrain input substitutions, given the generally low input price elasticity coefficients and low Allen elasticity of substitution coefficients – which are largely less than unity. Even though the demands for inputs are generally inelastic in own price, the demand for energy inputs is relatively more elastic with respect to their own prices than any other input. Substitution opportunities among factor inputs are limited, which is depicted by low values of cross-elasticity coefficient estimates in this study. Few complementary relationships exist among different inputs across the sector, such relationships are generally not statistically significant, but their values confirm the existence of technological rigidities in input substitution. The disaggregated analysis brings out the possibilities of factor substitution, especially between capital and material in four out of the seven sub-sectors.

1. INTRODUCTION
Manufacturing sector is very crucial in economic development of any economy, especially for a developing economy. The importance of the manufacturing sector is due particularly to its intervening and linkage position in relation to other sectors in any economy. Development of the sector depends on a number of factors including availability of inputs, government incentive policies, and socio-economic environment. Government incentives are codified in different policies including industrial, fiscal and monetary, infrastructural, trade and international relations. These incentives may be appreciated by the economic producers as positive or negative, leading to expansion or decline in their economic activities in response. Similarly, congenial socio-economic environment – which comes as a result of levels of institutional factors like governance, inter-human relations, trust, cultural tolerance, etc, in an economy – grows well the component sectors of the economy. But these factors are generally external to the manufacturing sector's operations. The input usage by the sector is governed by both internal and external factors: while factors influencing the supply of inputs are mostly external to the sector, those regarding input demand are internal. The assemblage of inputs in a production plant is influenced by both the market prices of the inputs and technological requirement for the combination of those inputs.

Input demand is therefore an internal decision that the manufacturing sector takes continually at the firm level. It is necessary to investigate the demand for private inputs in the manufacturing process so as to offer some predictions on the pattern of demand for such inputs. The paper intends to use translog methodology to investigate some technological and economic effects within the manufacturing input demand functions. This entails computing the elasticities of price and of substitution and interpreting their values. Demand for different inputs within a production process is dependent on inter-factor substitution possibilities that a firm faces, besides the relative response of the firm to the changes in factor prices.

Many studies have been done on the factor demand among manufacturing firms in developed countries. However, fewer are studies on the subject with reference to the developing countries, with the major reason for the dearth of papers on developing economies often being the lack of data. This offers an opportunity for understanding some technical characteristics of a sector of the Nigerian economy. The study uses firm-level cross-sectional data of the Nigerian manufacturing sector.

The paper is divided into five sections in all. Section 2 deals with the theoretical framework and modelling, while section 3 is devoted to variable measurement and data sources and transformation. Due particularly to the problematic data situation common to developing economies, the section is meant for modest explanation on efforts to combat the data problems. Section 4, comprising two sub-sections, presents the results of estimation for both the sector as an aggregate whole, and at industry-level. The paper is concluded in section 5.

2. Theoretical Framework and Modelling of Input Demand

THE basic assumption is that input prices are not determined by forces under the control of any manufacturing firm and, indeed, these prices are not subject to any direct control by the manufacturing sector. The sector is taken to be too small to exert any reasonable influence on the prices of its inputs. This assumption is defensible, considering the small size of the manufacturing sub-sector in the economy: it currently accounts for about 8 per cent of the GDP. By the size of the manufacturing sector and the fact that the producers in the sector hire inputs from the same large input market from which all other sectors hire, it is reasonable to think of its having very little or no market power on the input side. Besides, the different inputs have markets that are different in their operations in terms of the timing of transactions, negotiation of prices, and changes of the quantities traded. There is, [illegible] relation between activities in the input

markets, making the prices of inputs to be unrelated, at last contemporaneously. This unrelatedness of input prices in the sector, therefore, offers some justification for choosing the "seemingly unrelated regression equations" (SURE) technique for the estimation of parameters in the model. Given that the value of the covariance matrix is unknown at the beginning of the parametric estimation, the maximum likelihood estimator (MLE) is derived using some iterative numerical procedure. The iteration procedure used here is referred to as Zellner's iterative efficient method (IZEF).

The choice of translog in the analysis of factor input demand is based on three reasons, as outlined by Moroney and Toevs (1979). First, it is a general log-quadratic local approximation of any arbitrary cost function. Second, it enables the direct estimation of elasticities of substitution and permits tests of their statistical significance. Third, it entails no *a priori* restrictions on parameters' values or constancy. These reasons appropriately explain why this study adopts translog modelling of energy input demands. The analysis of factor input demand requires information on factor prices and the technological characteristics of substitutability between the factors and output of the firm. These can be derived from translog production or cost analysis. For every variant of the model to be used, there is an assumption of the existence of an admissible (well-behaved) production function, Q, from which the admissible dual cost function, C, used for the analysis is derived. The use of translog cost model in this study derives from the dual relationship existing between production and cost functions. From duality we know that a well-behaved cost function can be used to represent the technological characteristics of the production function (Diewert, 1971). Thus, with the data on expenditure on factor inputs we can estimate the parameters of an optimal cost function, and, based on duality theory, information about the associated parameters of the production function.

Given the existence of duality, a total cost function can then be used to derive the technological characteristics of the dual production function. The total cost function for the sector to be estimated is represented below.

$$C = C(P_i, Q) =$$

$$\ln C = \alpha_0 + \sum_{i=1}^{n} \alpha_i \ln P_i + \alpha_q \ln Q + \tfrac{1}{2}\left[\sum_{i=1}^{n} \gamma_{ii}(\ln P_i)^2 + \gamma_{qq}(\ln Q)^2\right] +$$

$$\sum_{i=1}^{n}\sum_{j\neq 1}^{n} \gamma_{ij} \ln P_i \ln P_j + \sum_{i=1}^{n} \gamma_{iq} \ln P_i \ln Q \quad \ldots\ldots \quad (1)$$

where, C = total expenditure on all factor inputs;

P_i = *i*th factor input price (i,j = K, L, E, M)

With symmetry conditions, $\gamma_{ij} = \gamma_{ji}$, the total number of parameters in equation (1) is 21. There will be 28 parameters if technical progress variable is introduced.

If we differentiate equation (1) with respect to factor prices and get equation (2), it will yield the respective factor shares in the total costs.

$$\frac{\partial \ln C}{\partial \ln P_i} = \frac{\partial C}{\partial P_i}\frac{P_i}{C}$$

Applying Shephard's lemma to the differentials in equation (2), we get $\partial C/\partial P_i = X_i$. X_i is the actual physical input *i* required to cause an infinitesimally small change in total cost outlay given a very little change in *i*s price, P_i. Alternatively; X_i is the input *i* needed to produce some marginal physical output *q* that will offset the alteration in costs brought about by a change in the price of input *i*.

Thus, in

$$\frac{\partial \ln C}{\partial \ln P_i} = \frac{\partial C}{\partial P_i}\frac{P_i}{C} = \frac{P_i X_i}{C} = \frac{P_i X_i}{\sum_i P_i X_i} = S_i$$

S_i = cost share of input *i*.

the third ratio in the identity above defines the ratio of the costs ... which is the share of the *i*th input in

the total costs. The function, S_i, specifies the variables whose change will influence the quantity of input *i* required by the producer in combination with other factors for production at anytime. S_i is thus the demand function for input *i*.

By differentiating equation (1) partially with respect to P_i and using the Shephard's lemma, the following cost share functions can be derived.

$$S_i = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \ln P_j + \gamma_{iq} \ln Q \quad \ldots\ldots \quad (2)$$

Given four inputs (K,L,E,M), the model S_i contains four equations each having six parameters (1+4+1 for α_i, γ_{ij} and γ_{iq}, respectively), that is 24 parameters in all. When the symmetry assumption is imposed on factor price parameters, that is $\gamma_{ij} = \gamma_{ji}$, the number of parameters will drop to 18. The introduction of homogeneity of degree one in prices of factors on the cost function reduces the number of parameters to 12. The number can be further reduced to 9 if we assume constant returns to scale (Berndt 1991). In addition to these restrictions, since S_i is the cost share of the *i*th input, it follows that $\Sigma S_i = 1$. Therefore, once the parameters of (n-1) equations have been estimated, the parameters for the *n*th equation can be derived from the rest of the system, since the *n*th equation is linearly dependent on the parametric estimates of the other equations.

3. Variable Measurement and Sources of Data

The data used in this study are primarily those from the National Bureau of Statistics (NBS), especially the data for the model estimation. Cost shares of labour, energy and materials were derived directly from the cost data provided in the questionnaires. However, most of the firms surveyed did not supply any information on the cost of capital. There was scanty information on the depreciation of capital stock and amount of interests paid by firms on borrowed funds. But even if few firms gave data on interests payable, borrowed funds only account for an insignificant share of capital formation in the sector. This problematic situation was contained with the assumption of Euler's law of product exhaustion. Under the operation of this axiom, what is produced is completely attributed to the factors employed in production, a typical case of normal profit. Thus, the costs of production are exactly accounted for by sales proceeds (as assumed by Reister and Edmond, 1981). With this assumption, therefore, it is easy to derive the cost of capital as the residual of total costs,[1] after accounting for the costs of labour, materials and energy. Calculation for capital costs as residual costs in value added has been adopted by Moghimzadeh and Kymn (1986) and Woodland (1993). Accordingly, total costs data are equal to sales data by the same assumption. This means that the production is subject to normal profits. The sales data were supplied by the firms in the survey, in fact, sales data was the one of most available data supplied in the information source used.

The prices of inputs required are derived from the questionnaires for labour and energy. Since there were data on total expenditure on these factors and the quantity of input used, the prices of the labour and energy are calculated by simply deflating the total expenditure on each factor (v_i) by the respective quantity employed (q_i) in production. Wage rates are denominated in naira per hour, just as the labour employed is calculated in hours of labour put into production. This involved adjustment of the labour employment figure to hours of labour time per year.[2] The wage rate is calculated as

[1] It can, however, be argued that capital costs under this assumption are grossly inflated as they are made to include profit earned by enterprises. This argument can be faulted or at least disparaged with two points. First, entrepreneurs are capitalists (owners of capital), therefore, they should earn the returns on capital and, therefore, the costs of capital are necessarily those returns. Second, all entrepreneurial efforts can be treated as labour and, therefore, all returns *not* earned by labour, materials or energy must be regarded the value of capital costs (returns on capital).

[2] Since each information given on the questionnaire is for a year, the magnitude of physical labour was changed to hours by multiplying or dividing through with average hours supplied per worker per week. A worker in the sector was assumed to supply an average of 2080 hours per year, which amounts to a daily labour time of 8 hours. Moroney and Toevs (1979) assumed some few minutes less daily and put the annual average at 2000 hours a year making allowance for losses in work-time by workers.

the total wage divided by total labour hours employed in a firm.

The average prices of energy are calculated in naira for tons of oil equivalent. This average price method has been widely used in the literature, including the studies by Pindyck (1979), Moroney and Toevs (1979), Halvorsen (1977), Woodland (1993) and Mlambo (1993), among others.

The prices of capital and materials could not be derived from the information provided by the firms directly. These prices are extraneously derived, just as they have been so computed in previous studies like Mlambo (1993) and Woodland (1993). The formula used for calculating the user's cost of capital (U_K), which is used as the proxy for the price of capital, is given as:

$$U_K = P_i(r + \sigma),$$

where: P_i = investment price index; r = interest rate; σ = depreciation rate.

Other studies used real interest rate, adjusting the nominal interest rate for the rate of inflation. In some of the post-SAP years in Nigeria, real interest rate is less than zero making the real price of capital negative. To avoid having an input evaluated as economic 'bad', the price of capital is computed with nominal lending (interest) rate. Alameda and Mann (1989) have used the nominal prime lending rate in a similar evaluation. The price-index of capital (investment) goods was not available so aggregate producer price index of the manufacturing sector for the years index under study were used. Concerning depreciation rates, since many firms did not report on depreciation, the average values of depreciation reported by firms in each of the sub-sectors were adopted for the rest in the group. Such average rates were general within the range of depreciation used in other studies, which is about 17 per cent of capital stock (Mlambo, 1993). Thus, as a way of getting variegated values across the sector, manufacturing activities were broken down into ten industries with two digit of ISIC (International Standard Industrial Classification) grouping of manufacturing activities.

The prices of materials are compiled as a weighted composite price of local materials and import price index and manufacturers' prices. As observed Akpan (2001) the utilisation of local materials has increased from 46 per cent in 1987 to about 58 per cent in 1996. However, surveys by the Central Bank of Nigeria and the NBS allude to the fact that small-scale manufacturing activities are more flexible in the use of domestic raw material than the large-scale firms. To this end, this study assumes that firms employing less than twenty workers and whose sales were less than ₦20 million are small-scale material-intensive firms, which use 60 per cent domestic raw material with the supplement of the remaining 40 per cent from imports. The large-scale firms are assumed to use the reverse ratios – 40 per cent domestic raw materials and 60 per cent imported raw and intermediate materials. For their prices of materials, therefore, the local price index from the domestic producer's price index are combined with the import price index at the ratio of 3:2 for small-scale and the reverse ratio for large-scale firms. However, in the actual estimation, coefficients estimates for material demand equation were derived from system given cost-share linearity assumptions in translog modelling.

The quantity index for firms was derived by a simple deflation of sales with composite consumer price indices for different manufactures. The food price index is used to deflate sales from food industry; price index for clothing and footwear is used on sales from those industries; and so on. Woodland (1993) adopted a method close to this, but his computation used aggregate (all items) composite consumer price index uniformly to deflate sales. The valuation here is weak in that apart from weighting factor imputed into the compilation of the price index no weighting factor is introduced. But since the price index used come from somewhat the same sector, the weight for price index compilation is adequate for transformation of output value into quantity.

With respect to energy, blank records were more common than any other input. Primarily, this is because energy has been regarded as materials in the accounting

process in the manufacturing sector. Besides, the request for energy data is still a very recent demand on the sector by the NBS.

Finally, some precautions have been taken in deriving data for this study. Although the number of firms surveyed by the NBS was 1005, after data entries, checking based on availability of minimum data on sales, labour, material cost or energy costs, the data points were reduced to 451 firms due to various reasons of inconsistent data and incomplete information cells. There are few cases among the final list where the averages for an industry were used as proxies for some missing data.

4. General Input Demand Functions

THIS section comprises two sub-sections, namely, 3.1 on Aggregate Input Demand Estimates and 3.2 on Industry-level General Input Demand. The essence is to observe whether the input demand pattern varies across industries that comprise the manufacturing sector.

4.1 Aggregate Input Demand Estimation *(KLEM Model)*

The demand functions for the four aggregate factors of production, namely, capital, labour, energy and materials have each been estimated. There are twenty-four parameters in the four cost share equations, of which only twelve were estimated, while the rest were recovered, from those estimated. With the deletion of one of the equations, by making its input price a numeraire to others, thus reducing its value to one, the number of estimable parameters is reduced from 24 to 15. The imposition of the symmetry condition makes three more parameters drop out, thus only 12 parameters were estimated. The numeraire equation can be anyone of the equations, so we decided to make the price of materials the numeraire because this price was derived as a proxy combining import and the producer's prices with some weights as explained previously in the section dealing data. There is evidence, however, that the parameters to be estimated are not completely insensitive to the particular equation dropped[3].

4.1.1 Factor Demand Elasticity of Output

THE response of the demand for inputs to change in the level of output is the factor demand elasticity of output. By substitution of the average values of S_i, Q, P_i and the estimated coefficients into the formula:

$$\eta_{iq} = \frac{d\log X_i}{d\log Q} = \frac{d\log X_i}{d\log C}\frac{\partial\log C}{\partial\log Q}$$

$$= \left[\frac{\partial\log S_i}{\partial\log Q}\frac{\partial\log Q}{\partial\log C} + 1\right]\frac{\partial\log C}{\partial\log Q}$$

$$= \frac{\partial\log S_i}{\partial\log Q} + \frac{\partial\log C}{\partial\log Q}$$

$$\Rightarrow \eta_{iq} = \frac{\gamma_{iq}}{S_i} + \alpha_q + \gamma_{qq}\log Q + \sum_{1}^{n}\gamma_{iq}\log P_i$$

the η_{iq} for the respective factors are derived. The η_{iq} (i = K, L, E, M) are as follows:

$\eta_{kq} = 0.1635$; $\eta_{lq} = -0.2748$; $\eta_{eq} = -0.0808$; $\eta_{mq} = 0.2204$.

The implication of η_{iq} is the reaction of the producer to the demand for input i as output level changes, holding the prices of inputs unchanged. That is, η_{iq} is the magnitude of shift in input demand function due change in the level of output in the input-using factory. In the manufacturing sector, increase in output will cause higher demand for capital and materials but by less than the proportionate the increase in output. This means that some other inputs would have been substituted for those directly considered to allow for the higher

[3] This evidence was obtained by dropping another equation and carrying out the estimation; the regression estimates were marginally different (from the third place of decimal, but in very few cases from the second place of the decimal of parameter estimates). There were series trial estimations to ascertain the level of relatedness of these prices. By far, the largest difference in sizes of estimates (but still within the above limits) occurred when the capital price equation was dropped: again, this is an influence (bias) that must be tolerated due to the process of derivation of the cost share of capital input.

output. The responses of labour and energy demands indicate negative relationship between output level and their respective demands. If this is possible, it may be due to the fact that increase in the manufacturing output will lead to the conservation of energy and higher efficiency in the use of labour, resulting in a fall in the demand. Such reduction in demands for energy and labour as output increases is also feasible if there is a possibility of higher substitution of other inputs for them. However, the coefficient of η_{iq} for energy and labour, though negative, are less than unity, showing that there is less than proportionate inverse relationship. This means that although an increase in scale of output will cause a reduction in these inputs, such conservation of inputs will be less than proportionate to the increase in output. Since manufacturing is an increasing returns (decreasing costs) sector[4], it is possible that input conservation and increasing efficiency can result in reduction in demand for some of the inputs as output (scale) increases.

4.1.2 Sectoral-Level Demand and Factor Substitution Parameters

THE values of the regression coefficients are generally small, with serious lessening effect on the values of elasticity coefficients. Thus, the cross-effects of factor price changes on inputs substitution are generally low. The results depict that the Nigerian manufacturing sector has inelastic demand for factors. This means that increase in the prices of factors will easily be transmitted into the production system in the form high of costs. Such transmission is, however, less than proportionate since there is weak possibility for substitution, which will restrict some of the cost increases.

[4] The economies of scale index (ISE) has been calculated from the translog cost function (equation (1)) results: $\ln C = 5.93 + 0.093\ln K + 0.879\ln L + 0.077\ln E - 0.049\ln M + 0.596\ln Q + 0.5\{0.0526(\ln K)^2 - 0.0698(\ln L)^2 + 0.0065(\ln E)^2 - 0.071(\ln M)^2 - 0.025(\ln Q)^2\} - 0.0527\ln K\ln L - 0.0089\ln K\ln E + 0.002\ln L\ln E + 0.089\ln K\ln M - 0.019\ln L\ln M + 0.004\ln E\ln M + 0.029\ln K\ln Q - 0.064\ln L\ln Q - 0.006\ln E\ln Q + 0.041\ln M\ln Q$, using the formula, $ISE = 1 - \partial\log C/\partial\log Q$. If ISE >,<, or = 0, there is increasing, decreasing, or constant returns to scale, respectively. From the computation, ISE = 0.909, implying the existence of increasing returns to scale in the sector.

Accordingly, after the econometric estimation of the coefficients for the three cost share equations, the parameters for the numeraire input cost share equation were calculated and all the results are presented in Table 1. Of the 18 regression coefficients, 15 are statistically significant at between 1 and 10 per cent levels; 9 coefficients out of these are significant at 1 per cent level. Out of the remaining 6 coefficients, 5 are significant at 5 per cent level, while only one parameter is significant at 10 per cent level.

Indeed, since there is no 'Giffen effect' through the contrary working of the income effects (which in production input demand are non-existent), then, all the own-price coefficients should be positive, by theoretical expectation.

It is pertinent to observe that the values of the own and cross price coefficients in the input demand equations are generally low, but not surprising. This is because of the prevalence of structural rigidities that hinder factor substitution within a line of production and input switchings from one line of production to another. Nevertheless, the signs of these regression coefficients allude to the feasibility of long-run substitutability among inputs in the manufacturing sector.

Table 1: Input (KLEM) Demand Estimates

Coefficient symbol	Regression coefficient	t-value
α_k	0.1323	1.774 [c]
α_l	0.8687	21.612 [a]
α_e	0.0789	6.627 [a]
α_m	-0.0799	-2.099 [b]
γ_{kk}	0.0283	1.179
γ_{kl}	-0.0333	-3.332 [a]
γ_{ke}	-0.0068	-2.047 [b]
γ_{ll}	0.0756	10.448 [a]
γ_{le}	0.0028	1.521 [c]
γ_{ee}	0.0067	6.981 [a]
γ_{km}	0.0118	1.128
γ_{lm}	-0.0452	-2.365 [b]
γ_{em}	-0.0027	-1.164
γ_{mm}	0.0360	3.961 [a]
γ_{kq}	0.0343	5.579 [a]
γ_{lq}	-0.0672	-20.098 [a]
γ_{eq}	-0.0068	-6.133 [a]
γ_{mq}	0.0397	6.638 [a]
F-statistic	977.67	
LRT[1] statistic, $v = 3$	14.261	

Notes: Coefficient(s) whose t-statistics is(are) marked with:

a significant at one per cent level;
b significant at 5 per cent level; and
c significant at 10 per cent level.
1 LRT = likelihood ratio test; the theoretical $\chi^2_{v=3}$ =11.34 and 7.82 at 1 per cent and 5 per cent levels, respectively.

These definitions cover other Tables in the paper where they are used.

Source: Author's Computation Results

The degree of such substitution is measured by the elasticity of substitution, while the factor response to process of factors is captured by the partial price elasticity coefficients, which are presented in Table 2. From the coefficients of elasticities, the manufacturing has inelastic but substitutable technology for all inputs. Nevertheless, they are poor substitutes since the low cross-elasticity coefficients confer some idea of technological rigidities that impede any wide scope of substitution.

The own-price elasticity coefficients for all the factors are less than unity but conformably negative. Although these are long-run data (cross sectional), the structural rigidities still exist and make it difficult for factor prices to form crucial decision variables in hiring factors. The values cross-price elasticity coefficients (η_{ij}, η_{ji}) are, as expected, lower in magnitude than the values of the own-price elasticity coefficients, η_{ii}, but they are not statistically significant. Nevertheless, the cross price elasticity coefficients show that, in the long-run, all factor inputs are substitutes.

The γ_{ii} measures the direct impact of the change in prices of input *i* on the respective shares in the total costs. In the capital input demand equation, the own price coefficient γ_{kk} is correctly signed as positive. The γ_{kk} = 0.0283 in the capital demand equation. The implication of this is that if the prices of capital inputs are increased, by say 100 percent, then the direct impact on capital cost share will be a marginal increase of 2.83 per cent, if the desired level of output must be produced. Conversely, if the general price of capital falls by 10 per cent, the cost share of capital input will only fall by 0.283 (less than one) per cent. It will, however, be misleading to think that capital demand in the sector is inelastic with respect to its own price, just by observing the value of γ_{kk}, which is only a component of the own-price elasticity coefficient.

Table 2: Input Price and Substitution Elasticity Coefficients

Factor price elasticity	Factor price elasticity Coefficient, η_{ij}, η_{ji}	Standard error of η_{ij}, η_{ji}	t-value of η_{ij}, η_{ji}	Elasticity of substitution	Coefficient of elasticity of substitution, σ_{ij}	Standard error of σ_{ij}	t-value of σ_{ij}
η_{kk}	-0.600	0.0510	-11.766[a]	σ_{kk}	-1.276	0.1085	-11.766[a*]
η_{kl}	0.004	0.0212	0.180	σ_{kl}	0.021	0.1155	0.180
η_{ke}	0.00004	0.0071	0.006	σ_{ke}	0.001	0.1785	0.006
η_{ll}	-0.405	0.0393	-10.291[a]	σ_{ll}	-2.201	0.2138	-10.291[a]
η_{le}	0.002	0.0101	0.185	σ_{le}	0.047	0.2537	0.185
η_{ee}	-0.791	0.0243	-32.578[a]	σ_{ee}	-19.895	0.6107	-32.578[a]
η_{km}	0.031	0.0223	1.387[c]	σ_{km}	0.101	0.0730	1.387[c]
η_{lm}	0.006	0.1038	0.054	σ_{lm}	0.018	0.3393	0.054
η_{em}	0.022	0.0589	0.377	σ_{em}	0.073	0.1926	0.377
η_{mm}	-0.576	0.0298	-19.368[a]	σ_{mm}	-1.885	0.0973	-19.368[a]
η_{lk}	0.010	0.0543	0.180				
η_{ek}	0.00047	0.0840	0.006				
η_{el}	0.009	0.0467	0.185				
η_{mk}	0.048	0.0343	1.387[c]				
η_{ml}	0.0034	0.0624	0.054				
η_{me}	0.0029	0.0077	0.377				

Note: * The t-values for η_{ij} and σ_{ij} are equal even though their standard errors are different. This can be verified from the formula.

Source: Author's Computation Results

The size of γ_{kk} has direct effect on the own elasticity coefficients. The parameter, γ_{ii}, is also an elasticity coefficient measuring the responsiveness of cost share of the inputs to the change in their respective prices.

The cross-price regression coefficients γ_{ij} measure the direct impact of the change in the price of factor *j* on the demand and cost share of factor *i*, given that other prices do not change. The impacts of labour prices and energy prices on capital demand and cost share are measured by γ_{kl} = -0.0333 and γ_{ke} = -0.0068, respectively. They are both negative, implying that increases in the wage rates and energy prices will cause some fall in the demand for capital, resulting in a fall in the cost share of capital (but less proportionately). This does not wholly explain the response as does the cross-price elasticity, or the elasticity of substitution coefficients, of which γ_{ij} is only a part. The cross price effect of materials on the demand for capital reveals that increase in the prices of material will cause increase in the demand for capital and in the capital cost share. This shows a possibility of substitution between intermediate materials and capital, which can be well ascertained using their cross-elasticity of input demand or, better still, their elasticity of substitution.

The labour demand and cost share equation has an own price coefficient, γ_{ll}, of 0.0756. This means that if the wage rate increases by 10 percent, the cost share of labour will be affected upward but by less than 1 per cent. The cross factor price coefficients in the labour equation are negative except for the cross-effect of the prices of energy, meaning that the immediate impact of reduction in the prices of capital and materials will be increase in the demand for labour. That is because more labour has to be employed to operate the factors whose demands are rising due to decreases in their own prices. Ultimately, the cost share of labour will increase. In the case of materials, its cross-price effect on expenditure on labour is an inverse relationship. An increase in materials' prices will reduce the demand for intermediate raw materials and this can cause the manufacturers to reduce the number of shifts, lay off workers and retrench some. The effect of such curtailment of workforce will be a reduction on expenditure on labour and labour share in total costs.

In energy cost share equation, own-price coefficient is positive but less than those of the other three inputs. The cross-price effect of materials is negative, indicating that if the price of materials falls (causing the industrial demand for the materials to rise), then, more energy will be required to process the raw materials into finished goods. This will invariably lead to an increase in the demand for, and

expenditure on, energy and the energy cost share will increase. For the effects of other cross prices, since $\gamma_{ij} = \gamma_{ji}$, the argument above for γ_{ke} and γ_{le} can be adapted directly for energy, with the regressant changed to energy and capital prices and wage rate becoming explanatory variables. This holds analogously for the cross-price effect on the demand for intermediate materials. The material own price effect on its cost share is positive, conforming to the *a priori* expectation.

The Allen partial coefficients of substitution for the general input demand model are also presented in Table 2. The value of elasticity substitution can take any form negative infinity (showing the perfect complementary relationship between the factors), to positive infinity (indicating perfect substitutability between the factors). The relationship portrayed is weaker, as the value of elasticity of substitution approaches zero in absolute term. The own coefficient of elasticity of substitution shows the degree of substitution of the input, *i*, as it own price changes. The sign of own elasticity of substitution, σ_{ii}, is *a priori* negative, meaning that as the price of any input changes there will be substitution of that input for others in a direction opposite to the change in its price. The magnitude of the own elasticity of substitution shows the relative ease with which such substitution can take place in the process of production.

The own coefficient, σ_{ii}, describes the level of substitution of factor *i* for other inputs as *i*'s own price changes, with the prices of other inputs unchanged. The own elasticity of substitution coefficients for the four inputs range between σ_{kk} = -1.28 to the highly elastic σ_{ee} = -19.89. The implication is that the manufacturing sector cannot easily adjust to changes in the capital market situation, compared to the relative ease of technological adjustment to changes in material, labour and energy markets when their respective prices change. Undoubtedly, this own-elasticity of substitution coefficient reveals the structural problem brought on the sector by the associated output mix of Nigeria's manufacturing sector, which is dominantly consumer goods. Thus, the manufacturing sector is under the captivity of its capital inputs whose demand in the sector is mostly need-driven rather than price-centered. Although the demand for intermediate materials is a little more adjustable to changes in own-prices, similar conclusion can be adduced for the substitution of materials in manufacturing process.

The cross-elasticity of substitution coefficients give an impression that a weak possibility of substitutability exists generally among inputs. It is only the cross elasticity of substitution coefficient of material and capital that is up to 0.101. The rest lies between σ_{em} = 0.073 and σ_{ke} = 0.001. The cross elasticity of substitution coefficients are not statistically different from zero, that is, they are not statistically significant. But they show a tendency towards a long-run technological substitution. For material-capital substitution, it is curious and the explanation may lies in the fact that these two factors are virtually exogenous, so that the manufacturers have little technological influence over their utilisation in the production process. If the price of one of the two continues to increase such that long run profit is threatened, the firms will devise a long-term plan that will lead to factor substitution and improved performance. For instance, if the prices of intermediate materials persistently increase, the firms might decide to install new plants that can process cheaper raw materials. This means that in the long-run, new capital equipment can be installed so that lower priced material may be utilised, thus substituting the vintage capital stock for high-cost materials and increasing long-run profit.

4.2 Industry-level General Input Demand

THE manufacturing sector is disaggregated into seven industries based availability of data. The industries are: Food product Industry – 82 firms; Textile apparel, leather and leather products – 111 firms; Wood and wood products – 85 firms; Pulp, paper and paper products – 28 firms; Chemicals, pharmaceuticals and rubber products – 56 firms; Non-metallic products – 37 firms; and Iron, steel, machinery and Automobile – 52 firms. The firms are also classified along the scale of operation so as to unravel the effect of scale of operation on input demand.

The analysis of aggregate input demand is then carried out on each of the sub-sectors. The essence is to compare the size and signs of coefficients of the estimated coefficients across the sector. In this way the peculiar effects of sub-sectoral characteristics on their input demand can be verified.

The breaking down of the data reveals a few general facts about the input demand behaviour in the manufacturing sector. The shares of aggregate inputs (capital, labour, energy, and raw and intermediate materials) vary across the sub-sectors in magnitude terms but the relative share of remain comparably the same with capital share being the largest[5] followed by materials, labour and energy, in that order. The share of capital accounts for 57.8 per cent of total cost outlay in food product industry, 48.1 per cent chemical and pharmaceuticals, 48 per cent in non-metallic industry, with the least share of 42.5 per cent record in wood and wood product industry. The cost share of materials in iron, steel, machinery and automobile industries is the highest with 38.5 per cent, while food products industry with 20.3 per cent is the least cost shares of materials. Labour cost share is higher in wood and paper products industries that have 27 and 24 per cent, respectively.

Energy cost share is greater in paper products and wood products industries that spent 5.5 and 4.1 per cent their total costs on energy input, respectively. Textile and leather product group expending 2.9 per cent of their total cost has the lowest cost share for energy.

In comparative terms, the regression coefficients for aggregate input demand are generally low in sizes. Both the distributional share coefficients α_i's and the elasticity-

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[5] It appears that contradictory that the relative cost share of capital in our data set is higher than that of raw and intermediate materials, which would usually be higher in the manufacturing cost structure. But this relatively large cost share of capital is attributed to the assumptions that normal profit is earned by the firms and that Euler's law of product exhaustion holds. Since the costs of capital were not given directly, it was easier to derive them as the residual of the value-added less labour costs value, given those assumptions

associated regression coefficients, γ_{ij}, have low values. This, as observed earlier, portrays the inflexibility of manufacturing technology in Nigeria, which is the cause of low level of factor substitution in the sector. Across the industries, the values of regression coefficients lie between (–1.8) and 1.8 (that is, –1.8 < α_i, γ_{ij} < 1.8). If the values αi are not considered the value of γ_{ij} fall under zero in absolute terms (that is, $-1 < \gamma_{ij} < 1$). About 60 per cent of coefficient estimates (specifically 59.88%) are statistically significant as indicated in the respective tables below.

The values of price elasticity coefficient across the sub-sectors are generally lower than unity. The own-price elasticity coefficients are negative in consonant with economic *a priori* expectation, but are generally less than unity (in absolute term). Again, their sizes are not out of place given the technological rigidities associated with underdevelopment and inadequate supply of infrastructures to the manufacturing sector, which impair technological fungibility among factors of production. Notwithstanding their values, the t-values of price elasticity coefficients show that 63.2 per cent or 91 out of 144 coefficients estimates are statistically significant, most of them at one per cent level.

Similar position of weak substitution is reported with low values of elasticity of substitution coefficients across the industries in the sector. As with the sectoral results earlier reported, the four inputs are weakly substitutable for one another. There are three cases where labour is reported as a weak complement to other inputs and a case of capital-energy complementarity; but all these complementary relationships are not statistically significant, even at 10 per cent level. On the whole, 62.2 per cent of elasticity of substitution coefficients are significant.

Food Products Industry

THE result of input demand equations for the four aggregate factors of production used in food products industry are presented in Table 3. The estimates of autonomous factor share coefficients (or the distributional shares of factors), α_i,

are relatively larger than the elasticity component coefficients, γ_{ij}, in the all four share equations estimated. Given the logarithmic functional form of the translog model, the regression coefficient estimates are elasticity coefficients. Their sizes and signs are important in the interpretation of the responsiveness of both the cost share and the input demand to changes in prices of factors or output level.

In the food industry, the value of γ_{ij} in the input demand equations lies between (–0.119) for γ_{KL} and 0.174 for γ_{kk} while γ_{iq} have the value lying between $\gamma_{lq} = (-0.061)$ and $\gamma_{mq} = 0.04$. Since γ_{ij} measure price elasticity of cost shares of the respective inputs[6], the low magnitude of γ_{ij} means that change in prices of factors of production hardly has any significant effect on the alteration of cost shares of inputs. That is, a change in the price of an input will bring about less than proportionate change in the cost share of that input. This is due to technological rigidities that act as barriers to input substitution in the manufacturing sector generally. Factor intensify ratios do not change rapidly enough to cause any significant alternation in demand for inputs (and their cost shares) as the price of any input changes.

Analysis of price elasticity and elasticity of substitution confirms the inelastic response of technology in the food industry to factor price changes. For own price elasticity coefficients, demand for capital, labour and materials are inelastic to own price changes. However, it is only in this industry that demand for aggregate energy input is slight elastic, as its own price elasticity coefficient is (–1.048) and is statistically significant at one level. Capital input on the other hand has the lowest own price elasticity coefficient but it is statistically insignificant.

With respect to cross price responses to input demand in the food industry, all the pairs of inputs are revealed to have low substitutable relationship, except capital and labour, which have a weak but an insignificant

[6] This interpretation was adumbrated in Halvorsen (1977, pp 385-6).

complementary relationship. Most of the elasticity coefficients are significant but the capital-energy elasticity coefficients are not statistically significant.

Textile, Wearing Apparels, Woven and Leather Products Industry

THIS group of manufacturing firms has regression coefficients that are so much comparable to those in food industry. For instance, from the results presented in Table 4, labour distributional share (α_l) also remain the highest coefficient here with the value of 1.176. The value of γ_{ij} for the four equations range between γ_{kl} = (– 0.077) to γ_{kk} = 0.144. Similarly, γ_{lq} = (– 0.082) is the lowest, while γ_{kq} = 0.062 is the highest values of output elasticity parameters.

Price elasticity coefficients for all input demands indicate that both the own- and cross-price effects on input demand are inelastic since all coefficients of price elasticities are less than one (in absolute term, in case of own-price elasticity). Remarkably, this is the only industry where the relationship between capital and energy is complementary although it is statistically insignificant. But even in all other industries where the relationship between the two factors is substitutable, none is statistically significant.

Wood and Wood Products Industry

PARAMETER estimates for input demands in wood and wood products industry are presented in Table 5. Apart from the distributional parameter for labour α_l whose value is 1.143, no other regression parameter is above γ_{km} = 0.257. Of the 18 parameters in the 4 input demand equations, 12 are statistically significant. Some of the estimates of γ_{ij} are negative, meaning that a change in the price of input *j* will inversely affect the cost share of input *i* in the total cost outlay. For instance, 100 per cent increase in the price of energy will cause less than one per cent (specifically, 0.091 per cent) decrease in cost share of capital. This cross effect of in price of input *j* on cost share of input *i* will work through the change in factor combination ratio in the production process caused by change in relative price of inputs. The cost share of a factor

can only fall with an increase in the price of another input if there is some complementary relationship that will cause a reduction in expenditure on the input whose price has not changed.

There is need to emphasise the note of caution that although the negative sign of γ_{ij} means inverse relationship between the cost share of input *i* and the price of input *j*, this might not necessarily confer a complementary relationship on the two commodities. Whether the commodities are definite complement or not depends on the size of the product of S_iS_j, in addition to the negative sign of γ_{ij}. If $\gamma_{ij} < 0$ is greater in absolute term than the product of S_iS_j (where $S_iS_j \geq 0$), then, input will be complements. Thus, γ_{ij} may have "apparent" complementary effect but it turns out that when the cross elasticity of demand as well as the elasticity of substitution is calculated, these inputs may be substitutes due to the magnitude of the products of their relative cost shares, S_iS_j.

In this sub-sector, the own price elasticity of materials is (–1.644) indicating that demand for logs, timber and plank, which are the basic raw materials in the sector, is elastic with respect to their prices. The cross effect of the price of material on the demand for capital (η_{mk} = 1.396) also reveals that these two factors are not only substitutes but they have elastic cross price effects. Thus, a fall in the price of raw and intermediate materials will lead to a higher than proportionate increase in the demand for capital required for the processing of the wood. However, although this substitutable relationship still exists, if the effect of price of capital is assessed on the demand for materials, the coefficient is less than unity (i.e., η_{km} = 0.848). This is realistic because production activities in the sector are more material-related than they are dependent on capital. Therefore, a change in capital price cannot have as much effect on the demand for materials in the sector as does a change in the price of materials on demand for capital.

Pulp, paper and Paper products Industry

IN comparative terms, the input demand equations in this sub-sector are similar to those in the wood and wood products industries. There are two differences between the estimates here and those in the wood product sub-sector. First, complementary relationship is revealed here between labour and capital. But this relationship is weak given the value of (–0.122) and it is not significant. The second is the high level of own elasticity coefficient for capital (–1.339) but again it is statistically insignificant. The results are presented in Table 6.

Chemicals, Pharmaceuticals and Rubber Plants

COEFFICIENT estimates of the share equations here are peculiarly different. In addition to being small in magnitude, none of the estimated coefficients is up one in absolute value. The results are presented in Table 7. The statistical test for the coefficients shows that only 8 out of the 18 parameters are significant. But the F-statistic for the estimated system of equations is 109.78, which is significant at one per cent level. This may be explained by the fact that 7 of the 8 significant parameters are among the twelve parameters estimated directly, while only one of the six recovered parameters is significant.

On the contrary, majority of estimates of price elasticity and elasticity of substitution coefficients were significant. For price elasticity coefficients, 12 out of 16 were significant at various levels, while 8 out of 10 estimates of elasticity of substitution coefficients were significant. Again cross analysis of inputs in this sub-sector shows they are all substitutable. However, the response to factor price changes shows that the sub-sector faces inelastic demand for all input (all $/\eta_{ij}/ < 0$).

Non-Metallic Products

AGAIN, as with the chemicals, pharmaceuticals and rubber products sub-sector, non metallic products industry has low values of cost share equation coefficients indicating that these sub-sectors are, more than others, facing greater rigidities in factor adjustment with respect to factor prices. This is in consonance with the earlier observation that capital producing industries have more technical adjustment problems than the more mature consumer goods sub-sector.

The statistical reliability of the individual parameter estimates is worst in this sub-sector, as only 7 parameters of the regression coefficients are statistically significant. But then, there is a large and significant F-statistic, which indicates that the parameters estimated are most likely the ones for the sub-sector. These results are shown in Table 8. As a result of the rigidities and relative fixity of factor intensity ratios, there are cases of complementarity between capital and labour and labour and energy. These relationships, though not statistically reliable, have to do with special skill required by labour to man the machines and equipment, which makes certain labour to be hired as new equipment is acquired. Complementary of labour and energy may be due to heavy dependence of the sub-sectors on self-generated energy, which requires specialised labour to handle the generation and distribution. Nevertheless, these complementary relationships are not significant statistically, meaning that it is not a reliable relationship and that there is a tendency for a change in this relationship.

Metallic Products, machinery and Automobile

THE estimated regression coefficients, as can be observed in Table 9, are generally lower than unity in absolute term. Like the non-metallic product group, the price elasticity coefficients show that the industries here face inelastic demand for factor inputs. Labour and capital are reported as complements but their elasticity coefficients are not statistically significant.

Large Scale group of industries

ESTIMATES of parameters for the large-scale firms are presented in Table 10. The results show that all the regression coefficients are less than unity in absolute term, which is an indication the general problem of technological rigidities that impair alteration in factor intensity ratios. The regression estimate for γ_{lm} is (– 0.043), meaning that an increase in the price of materials will bring about decrease in the cost share of labour but by less than the proportion of the increase in the price of materials. Conversely, if there is an increase in the wage rate, the cost share of material will fall but less than proportionately. This shows that labour and materials are apparently complements, which by computing the cross elasticity coefficients (η_{lm} = – 0.11, η_{ml} = – 0.029), the complemtarity is made manifest. The own price elasticity coefficients are large than the cross elasticity coefficients. Indeed, own price elasticity of energy demand is larger than the demand responsiveness to own prices in other factors. Nevertheless, the helplessness of the manufacturing sector in adjusting to changes in input prices is still evident in the inelasticity of their factor demand to changes in input prices.

Small-Scale group of industries

RESULTS from small-scale firms presented in Table 11 are, in many respects, similar to those from the large-scale firms. The signs of parameters that are negative in large-scale group are also maintained among small-scale firms. For instance, γ_{ke} = (– 0.014), which alludes to the possibility complementary effect of change in price of capital or energy. Again, the γ_{lm} = (– 0.085), γ_{kl} = (– 0.098) which reflects the results in the large-scale group. However, when the elasticity coefficients are calculated, the results show that complementary relationship only exists between labour and materials. Evaluation of own-price elasticity also shows that small-scale manufacturing enterprises are more responsive to change in energy prices than they do to movement in prices of other inputs.

Across the manufacturing sector, the results of these sub-sectoral analyses show that:

(a) Even though the demand for inputs are generally inelastic in own price, the demand for energy inputs is relatively more elastic with respect to their own prices than any other input.

(b) Substitution opportunities among factor inputs are limited and this is demonstrated by low values of cross-elasticity coefficients throughout the study.

(c) Although few complementary relationships exist among different inputs across the sector, these relationships are generally not statistically significant, which may allude to the long-run expectation of substitution possibilities rather complementarity. The presence of such complementarity also confirms implicitly the existence of technological rigidities that constricts substitution possibilities in the sector.

5. Conclusion

THE estimated price elasticity and Allen elasticity of substitution coefficients for the Nigerian manufacturing sector confirm the fragile nature of a developing economy, where the possibilities for factor substitution are very limited. This is because, considering the aggregate results of elasticities presented in Table 2, the price elasticity as well as Allen elasticity coefficients are generally lower than unity meaning that the firms in the sector scarcely alter the structure of their input combination in response to change in input prices. These technological rigidities are expected for a developing economy where, due to the limitation imposed on factor substitution by inadequacy of technological knowledge, there are constraints to technological switch-over to cheaper factors as the relative factor prices change.

Among firms in four out of the seven sub-sectors, the disaggregated analysis brings out the possibilities of factor substitution between capital and raw materials. In some other sparing cases, portrayed by the industry-level results (see elasticity of substitution coefficients columns), raw materials are found to be substitutable for labour or energy. This indicative trend of possible factor substitution is alluding to the importance of raw materials in the manufacturing plan. The weak possibilities of input substitution proved by this study are responsible for low capacity utilization and frequent shut-downs experienced in the Nigerian manufacturing sector.

Table 3: Food Product Sub-sector: Regression and Elasticity Coefficients

Regression Coefficient Symbol	Regression Coefficient α_i, γ_{ij}	t-value of α_i, γ_{ij}	Factor Price Elasticity Symbol	Price Elasticity Coefficient, η_{ii}, η_{ij}	Standard Error of η_{ii}, η_{ij}	t-value of η_{ii}, η_{ij}	Elasticity of Substitution Symbol	Elasticity of Substitution Coefficient, σ_{ij}	Standard Error of σ_{ij}	t-value of σ_{ij}
α_k	-0.0368	-0.167	η_{kk}	-0.1252	0.1333	-0.939	σ_{kk}	-0.2201	0.2343	-0.939
α_l	1.0152	8.439[a]	η_{kl}	-0.0162	0.0582	-0.278	σ_{kl}	-0.0840	0.3018	-0.278
α_e	0.1217	4.918[a]	η_{ke}	0.0012	0.0141	0.087	σ_{ke}	0.0357	0.4099	0.087
α_m	-0.1001	-0.624	η_{km}	-0.2485	0.1189	-2.090[b]	σ_{km}	-1.2889	0.6165	-2.090[b]
γ_{kk}	0.1740	2.294[b]	η_{lk}	0.0729	0.0213	3.419[a]	σ_{lk}	2.1240	0.6213	3.419[a]
γ_{kl}	-0.1189	-3.591[a]	η_{ll}	-1.0485	0.0523	-20.038[a]	σ_{ll}	-30.5570	1.5249	-20.038[a]
γ_{ke}	-0.0188	-2.352[b]	η_{le}	0.1402	0.1014	1.382[c]	σ_{le}	0.6876	0.4975	1.382[c]
γ_{km}	0.1077	4.699[a]	η_{lm}	0.2234	0.0154	14.535[a]	σ_{lm}	1.0958	0.0754	14.535[a]
γ_{ll}	0.0074	1.809[c]	η_{em}	0.4531	0.1943	2.332[b]	σ_{em}	2.2222	0.9529	2.332[b]
γ_{le}	0.0028	1.582[c]	η_{mm}	-0.6787	0.2560	-2.652[a]	σ_{mm}	-0.3290	1.2654	-2.652[a]
γ_{lm}	0.0269	1.902[c]	η_{ek}	-0.0478	0.1717	-0.278				
γ_{le}	-0.0606	-6.983[a]	η_{el}	0.0203	0.2332	0.087				
γ_{ee}	-0.0060	-3.386[a]	η_{ee}	0.4095	0.1198	3.419[a]				
γ_{me}	0.0397	3.455[a]	η_{mk}	0.3912	0.2831	1.382[c]				
γ_{km}	-0.0362	-0.628	η_{ml}	0.2113	0.0145	14.535[a]				
γ_{lm}	0.0038	1.270	η_{me}	0.0762	0.0327	2.332[b]				
γ_{em}	0.0086	1.283[c]								
γ_{mm}	0.0239	0.459								
F-statistic	191.849									
LRT statistic v=3	3.669									

Source: Author's Computation Results

Table 4: Textile and Wearing Apparels Product Sub-sector: Regression and Elasticity Coefficients

Regression Coefficient Symbol	Regression Coefficient α_i, γ_{ij}	t-value of α_i, γ_{ij}	Factor Price Elasticity Symbol	Price Elasticity Coefficient, η_{ii}, η_{ij}	Standard Error of η_{ii}, η_{ij}	t-value of η_{ii}, η_{ij}	Elasticity of Substitution Symbol	Elasticity of Substitution Coefficient, σ_{ij}	Standard Error of σ_{ij}	t-value of σ_{ij}
α_k	-0.3684	-0.579	η_{kk}	-0.2371	0.5686	-0.417	σ_{kk}	-0.5585	1.3394	-0.417
α_l	1.1756	11.221[a]	η_{kl}	0.0885	0.0685	1.292[c]	σ_{kl}	0.3270	0.2531	1.292[c]
α_e	0.0710	2.533[b]	η_{ke}	-0.0194	0.0233	-0.830	σ_{ke}	-0.7184	0.8660	-0.830
α_m	0.1218	0.196	η_{lk}	-0.3302	0.0567	-5.822[a]	σ_{lk}	-1.2209	0.2097	-5.922[a]
γ_{kk}	0.1437	0.595	η_{le}	0.0137	0.0091	1.504[c]	σ_{le}	0.5080	0.3377	1.504[c]
γ_{kl}	-0.0773	-2.659[a]	η_{ee}	-0.7887	0.0380	-20.745[a]	σ_{ee}	-29.2739	1.4111	-20.745[a]
γ_{ke}	-0.0197	-1.984[c]	η_{km}	0.1680	0.5622	0.299	σ_{km}	0.6041	2.0221	0.299
γ_{l}	0.1080	7.039[a]	η_{lm}	0.8639	0.0936	9.232[a]	σ_{lm}	3.1071	0.3365	9.232[a]
γ_{le}	-0.0036	-1.457[c]	η_{em}	0.9562	0.3638	2.628[a]	σ_{em}	3.4391	1.3085	2.628[a]
γ_{lm}	0.0050	4.850[a]	η_{mm}	-0.5220	0.8627	-0.605	σ_{mm}	-1.8775	3.1026	-0.605
γ_{ke}	0.0617	4.201[a]	η_{lk}	0.1388	0.1074	1.292[c]				
γ_{le}	-0.0819	-11.839[a]	η_{ek}	-0.3050	0.3676	-0.830				
γ_{ee}	-0.0026	-2.007[b]	η_{el}	0.1374	0.0913	1.504[c]				
γ_{me}	0.0228	1.609[c]	η_{mk}	0.2565	0.8584	0.299				
γ_{km}	-0.0467	-0.196	η_{ml}	0.8404	0.0910	9.232[a]				
γ_{lm}	-0.0271	-1.072	η_{me}	0.0927	0.0353	2.628[a]				
γ_{em}	0.0183	1.864[c]								
γ_{mm}	0.0556	0.232								
F-statistic	330.565									
LRT statistic v=3	2.481									

Source: Author's Computation Results

Table 5: Wood Product Sub-sector: Regression and Elasticity Coefficients

Regression Coefficient Symbol	Regression Coefficient α_i, γ_{ij}	t-value of α_i, γ_{ij}	Factor Price Elasticity Symbol	Price Elasticity Coefficient, η_{ii}, η_{ij}	Standard Error of η_{ii}, η_{ij}	t-value of η_{ii}, η_{ij}	Elasticity of Substitution Symbol	Elasticity of Substitution Coefficient, σ_{ij}	Standard Error of σ_{ij}	t-value of σ_{ij}
α_k	0.2302	0.798	η_{kk}	-0.9308	0.3468	-2.684ᵃ	σ_{kl}	-2.0977	0.7815	-2.684ᵃ
α_l	1.1425	12.431ᵃ	η_{kl}	0.0441	0.0523	0.843	σ_{ke}	0.1793	0.2127	0.843
α_e	0.1099	3.251ᵃ	η_{ke}	0.0391	0.0236	1.660ᶜ	σ_{km}	0.9501	0.5724	1.660ᶜ
α_m	-0.4825	-1.687ᶜ	η_{km}	-0.4056	0.0558	-7.264ᵃ	σ_{le}	-1.6505	0.2272	-7.264ᵃ
γ_{kk}	-0.1662	-1.080	η_{lk}	0.0619	0.0165	3.763ᵃ	σ_{lm}	1.5046	0.3999	3.763ᵃ
γ_{kl}	-0.0895	-3.859ᵃ	η_{ll}	-0.8365	0.0588	-14.232ᵃ	σ_{em}	-20.3296	1.4284	-14.232ᵃ
γ_{ke}	-0.0009	-0.087	η_{le}	0.8476	0.3561	2.381ᵇ	σ_{kk}	3.1468	1.3219	2.381ᵇ
γ_{km}	0.0857	6.242ᵃ	η_{lm}	0.2642	0.0054	48.979ᵃ	σ_{ll}	0.9808	0.0200	48.979ᵃ
γ_{ll}	0.0051	1.252	η_{ek}	0.0452	0.2586	0.175	σ_{ee}	0.1678	0.9600	0.175
γ_{le}	0.0050	2.081ᵇ	η_{el}	-1.6442	0.6157	-2.670ᵃ	σ_{mm}	-6.1041	2.2858	-2.670ᵃ
γ_{lm}	0.0461	2.613ᵃ	η_{ee}	0.0795	0.0944	0.843				
γ_{ee}	-0.0915	-9.206ᵃ	η_{em}	0.4216	0.2540	1.660ᶜ				
γ_{em}	-0.0110	-2.912ᵃ	η_{mk}	0.3698	0.0983	3.763ᵃ				
γ_{mm}	0.0564	3.247ᵃ	η_{ml}	1.3963	0.5865	2.381ᵇ				
γ_{kt}	0.2566	1.624ᶜ	η_{me}	0.2410	0.0049	48.979ᵃ				
γ_{lt}	-0.0013	-0.960	η_{mm}	0.2115	1.2086	0.175				
γ_{et}	-0.0092	-0.867								
γ_{mt}	-0.2461	-1.434ᶜ								
F-statistic	203.137									
LRT statistic $v=3$	2.504									

Source: Author's Computation Results

Table 6: Pulp, Paper and Paper Product Sub-sector: Regression and Elasticity Coefficients

Regression Coefficient Symbol	Regression Coefficient α_i, γ_{ij}	t-value of α_i, γ_{ij}	Factor Price Elasticity Symbol	Price Elasticity Coefficient, η_{ii}, η_{ij}	Standard Error of η_{ii}, η_{ij}	t-value of η_{ii}, η_{ij}	Elasticity of Substitution Symbol	Elasticity of Substitution Coefficient, σ_{ij}	Standard Error of σ_{ij}	t-value of σ_{ij}
α_k	1.1700	0.533	η_{kk}	-1.3390	1.3918	-0.962	σ_{kl}	-2.9712	3.0884	-0.962
α_l	1.2258	4.078ᵃ	η_{kl}	-0.1222	0.1806	-0.677	σ_{ke}	-0.7457	1.1017	-0.677
α_e	0.4026	4.057ᵃ	η_{ke}	0.0084	0.0473	0.177	σ_{km}	0.1512	0.8526	0.177
α_m	-1.7984	-0.849	η_{km}	-0.2412	0.1579	-1.527ᶜ	σ_{le}	-1.4712	0.9633	-1.527ᵇ
γ_{kk}	-0.3559	-0.567	η_{lk}	0.0232	0.0348	0.667	σ_{lm}	0.4133	0.6276	0.667
γ_{kl}	-0.1290	-1.585ᶜ	η_{ll}	-0.6847	0.0705	-9.719ᵃ	σ_{em}	-12.3494	1.2707	-9.719ᵃ
γ_{ke}	-0.0212	-0.996	η_{lm}	1.4529	1.3452	1.080	σ_{kk}	4.4029	4.0767	1.080
γ_{km}	0.0975	3.768ᵃ	η_{le}	0.5540	0.2431	2.279ᵇ	σ_{ll}	1.6790	0.7368	2.279ᵇ
γ_{ll}	-0.0053	-0.926	η_{em}	0.5479	0.3734	1.467ᶜ	σ_{ee}	1.6603	1.1315	1.467ᶜ
γ_{le}	0.0144	3.689ᵇ	η_{mm}	-2.3515	1.8047	-1.303ᶜ	σ_{mm}	-7.1261	5.4692	-1.303ᶜ
γ_{lm}	0.0662	1.903ᶜ	η_{ek}	-0.3361	0.4965	-0.677				
γ_{ee}	-0.0631	-6.071ᵃ	η_{el}	-0.0682	0.3842	0.177				
γ_{em}	-0.0343	-5.154ᵃ	η_{ee}	0.0686	0.1029	0.667				
γ_{mm}	0.0312	0.936	η_{mk}	1.9842	1.8372	1.080				
γ_{km}	0.5060	0.835	η_{ml}	0.2752	0.1208	2.279ᵇ				
γ_{lm}	0.0367	0.921	η_{me}	0.0921	0.0627	1.467ᶜ				
γ_{em}	0.0121	0.584								
γ_{mm}	-0.5548	-0.932								
F-statistic	75.371									
LRT statistic $v=3$	3.320									

Source: Author's Computation Results

Table 7: Chemicals, Pharmaceuticals and Rubber Sub-sector: Regression and Elasticity Coefficients

Regression Coefficient Symbol	Regression Coefficient α_i, γ_{ij}	t-value of α_i, γ_{ij}	Factor Price Elasticity Symbol	Price Elasticity Coefficient, η_{ii}, η_{ij}	Standard Error of η_{ii}, η_{ij}	t-value of η_{ii}, η_{ij}	Elasticity of Substitution Symbol	Elasticity of Substitution Coefficient, σ_{ij}	Standard Error of σ_{ij}	t-value of σ_{ij}
α_k	0.4158	1.397^c	η_{kk}	-0.5350	0.1262	-4.241^a	σ_{kk}	-1.1112	0.2620	-4.241^a
α_l	0.5929	7.105^a	η_{kl}	0.0677	0.0366	1.843^c	σ_{kl}	0.7539	0.4078	1.848^c
α_e	0.1316	2.561^b	η_{ke}	0.0311	0.0194	1.600^c	σ_{ke}	0.8713	0.5447	1.600^c
α_m	-0.1403	-0.489	η_{ll}	-0.4690	0.1226	-3.825^a	σ_{ll}	-5.2226	1.3652	-3.825^a
γ_{kk}	-0.0080	-0.131	η_{le}	0.0795	0.0411	1.934^c	σ_{le}	2.2297	1.1529	1.934^c
γ_{kl}	-0.0106	-0.604	η_{ee}	-0.7848	0.0817	-9.605^a	σ_{ee}	-21.9979	2.2902	-9.605^a
γ_{ke}	-0.0022	-0.236	η_{km}	0.4363	0.1132	3.852^a	σ_{km}	1.1100	0.2882	3.852^a
γ_{ll}	0.0396	3.599^a	η_{lm}	0.0265	0.4460	0.059	σ_{lm}	0.0674	1.1349	0.059
γ_{le}	0.0039	1.067	η_{em}	0.1650	0.2341	0.705	σ_{em}	0.4199	0.5957	0.705
γ_{ee}	0.0064	2.197^b	η_{mm}	-0.5555	0.1389	-3.999^a	σ_{mm}	-1.4135	0.3535	-3.999^a
γ_{kq}	0.0097	0.358	η_{lk}	0.3630	0.1964	1.848^c				
γ_{lq}	-0.0492	-6.937^a	η_{ek}	0.4195	0.2623	1.600^c				
γ_{eq}	-0.0126	-2.568^b	η_{el}	0.2002	0.1035	1.934^c				
γ_{mq}	0.0522	1.944^c	η_{mk}	0.5345	0.1387	3.852^a				
γ_{km}	0.0208	0.382	η_{ml}	0.0060	0.1019	0.059				
γ_{lm}	-0.0329	-0.822	η_{me}	0.0691	0.9803	0.705				
γ_{em}	-0.0061	-0.974								
γ_{mm}	0.0202	0.370								
F-statistic	139.569									
LRT statistic v=3	7.516									

Source: Author's Computation Results

Table 8: Non-Metallic Product Sub-sector: Regression and Elasticity Coefficients

Regression Coefficient Symbol	Regression Coefficient α_i, γ_{ij}	t-value of α_i, γ_{ij}	Factor Price Elasticity Symbol	Price Elasticity Coefficient, η_{ii}, η_{ij}	Standard Error of η_{ii}, η_{ij}	t-value of η_{ii}, η_{ij}	Elasticity of Substitution Symbol	Elasticity of Substitution Coefficient, σ_{ij}	Standard Error of σ_{ij}	t-value of σ_{ij}
α_k	-0.4966	-0.943	η_{kk}	-0.0431	0.6935	-0.062	σ_{kk}	-0.0898	1.4437	-0.062
α_l	0.7023	5.651^a	η_{kl}	-0.0642	0.1158	-0.555	σ_{kl}	-0.4236	0.7632	-0.555
α_e	-0.0186	-0.371	η_{ke}	0.0289	0.0381	0.758	σ_{ke}	0.7583	1.0006	0.758
α_m	0.8130	1.602^c	η_{ll}	-0.5737	0.1496	-3.835^a	σ_{ll}	-3.7827	0.9863	-3.835^a
γ_{kk}	0.2239	0.687	η_{le}	-0.0005	0.0397	-0.011	σ_{le}	-0.0120	1.0417	-0.011
γ_{kl}	-0.1037	-1.865^c	η_{ee}	-0.5993	0.1067	-5.615^a	σ_{ee}	-15.7445	2.8042	-5.615^a
γ_{ke}	-0.0044	-0.242	η_{km}	0.0785	0.7023	0.112	σ_{km}	0.2380	2.1287	0.112
γ_{ll}	0.0417	1.836^c	η_{lm}	0.7777	0.4785	1.625^c	σ_{lm}	2.3573	1.4503	1.625^c
γ_{le}	-0.0058	-0.971	η_{em}	0.2369	0.4770	0.497	σ_{em}	0.7181	1.4461	0.497
γ_{ee}	0.0138	3.397^a	η_{mm}	-0.4992	1.0685	-0.467	σ_{mm}	-1.5132	3.2391	-0.467
γ_{kq}	0.0735	2.591^a	η_{lk}	-0.2035	0.3667	-0.555				
γ_{lq}	-0.0438	-4.245^a	η_{ek}	0.3643	0.4807	0.758				
γ_{eq}	0.0000	0.012	η_{el}	-0.0018	0.1580	-0.011				
γ_{mq}	-0.0298	-1.046	η_{mk}	0.1143	1.0226	0.112				
γ_{km}	-0.1208	-0.358	η_{ml}	0.3575	0.2200	1.625^c				
γ_{lm}	0.0679	0.936	η_{me}	0.0273	0.0550	0.497				
γ_{em}	-0.0035	-0.195								
γ_{mm}	0.0564	0.160								
F-statistic	59.613									
LRT statistic v=3	2.826									

Source: Author's Computation Results

Table 9: Metallic, Machine and Transport Product Sub-sector: Regression and Elasticity Coefficients

Regression Coefficient Symbol	Regression Coefficient α_i, γ_{ij}	t-value of α_i, γ_{ij}	Factor Price Elasticity Symbol	Price Elasticity Coefficient, η_{ii}, η_{ij}	Standard Error of η_{ii}, η_{ij}	t-value of η_{ii}, η_{ij}	Elasticity of Substitution Symbol	Elasticity of Substitution Coefficient, σ_{ij}	Standard Error of σ_{ij}	t-value of σ_{ij}
α_k	0.2320	0.773	η_{kk}	-0.7276	0.2752	-2.644^a	σ_{kk}	-1.5514	0.5868	-2.644^a
α_l	0.6257	6.838^a	η_{kl}	0.0413	0.0669	0.617	σ_{kl}	0.3822	0.6195	0.617
α_e	0.1708	4.589^a	η_{ke}	0.0141	0.0296	0.477	σ_{ke}	0.3730	0.7819	0.477
α_m	-0.0286	-0.104	η_{ll}	-0.3691	0.1367	-2.699^a	σ_{ll}	-3.4165	1.2658	-2.699^a
γ_{kk}	-0.0922	-0.714	η_{le}	0.1435	0.0423	3.393^a	σ_{le}	3.7913	1.1174	3.393^a
γ_{kl}	-0.0313	-0.997	η_{ee}	-0.7590	0.0711	-10.669^a	σ_{ee}	-20.0565	1.8799	-10.669^a
γ_{ke}	-0.0111	-0.802	η_{km}	0.6722	0.2564	2.622^a	σ_{km}	1.7452	0.6656	2.622^a
γ_{ll}	0.0565	3.824^a	η_{lm}	0.0464	0.3278	0.141	σ_{lm}	0.1204	0.8511	0.141
γ_{le}	0.0114	2.498^b	η_{em}	0.1745	0.3468	0.503	σ_{em}	0.4530	0.9004	0.503
γ_{ee}	0.0077	2.856^a	η_{mm}	-0.8486	0.3157	-2.688^a	σ_{mm}	-2.2033	0.8197	-2.638^a
γ_{kq}	0.0464	2.436^a	η_{lk}	0.1793	0.2905	0.617				
γ_{lq}	-0.0512	-7.412^a	η_{ek}	0.1749	0.3667	0.477				
γ_{eq}	-0.0153	-5.060^a	η_{el}	0.4096	0.1207	3.393^a				
γ_{mq}	0.0201	1.059	η_{mk}	0.8185	0.3122	2.622^a				
γ_{km}	0.1346	1.120	η_{ml}	0.0130	0.0919	0.141				
γ_{lm}	-0.0366	-1.034	η_{me}	0.0873	0.1756	0.503				
γ_{em}	-0.0080	-0.608								
γ_{mm}	-0.0900	-0.740								
F-statistic	136.893									
LRT statistic v=3	3.377									

Source: Author's Computation Results

Table 10: Large-Scale Manufacturing Group of Firms: Regression and Elasticity Coefficients

Regression Coefficient Symbol	Regression Coefficient α_i, γ_{ij}	t-value of α_i, γ_{ij}	Factor Price Elasticity Symbol	Price Elasticity Coefficient, η_{ii}, η_{ij}	Standard Error of η_{ii}, η_{ij}	t-value of η_{ii}, η_{ij}	Elasticity of Substitution Symbol	Elasticity of Substitution Coefficient, σ_{ij}	Standard Error of σ_{ij}	t-value of σ_{ij}
α_k	0.4830	3.761^a	η_{kk}	-0.4745	0.0593	-8.002^a	σ_{kk}	-0.9052	0.1131	-8.002^a
α_l	0.3663	9.213^a	η_{kl}	0.0909	0.0173	5.252^a	σ_{kl}	0.9674	0.1842	5.252^a
α_e	0.0565	3.091^a	η_{ke}	0.0252	0.0076	3.323^a	σ_{ke}	0.8693	0.2618	3.323^a
α_m	0.0942	0.790	η_{ll}	-0.4500	0.0610	-7.377^a	σ_{ll}	-4.7912	0.6495	-7.377^a
γ_{kk}	0.0007	0.021	η_{le}	0.0525	0.0188	2.787^a	σ_{le}	1.8107	0.6497	2.787^a
γ_{kl}	-0.0016	-0.177	η_{ee}	-0.7643	0.0387	-19.772^a	σ_{ee}	-26.3575	1.3331	-19.772^a
γ_{ke}	-0.0020	-0.497	η_{km}	0.3584	0.0528	6.793^a	σ_{km}	1.0158	0.1495	6.793^a
γ_{ll}	0.0428	7.478^a	η_{lm}	-0.1097	0.3929	-0.279	σ_{lm}	-0.3108	1.1133	-0.279
γ_{le}	0.0022	1.248	η_{em}	0.1383	0.1229	1.126	σ_{em}	0.3920	0.3482	1.126
γ_{ee}	0.0060	5.346^a	η_{mm}	-0.5146	0.0767	-6.707^a	σ_{mm}	-1.4584	0.2174	-6.707^a
γ_{kq}	0.0050	0.426	η_{lk}	0.5071	0.0966	5.252^a				
γ_{lq}	-0.0270	-7.925^a	η_{ek}	0.4559	0.1372	3.323^a				
γ_{eq}	-0.0055	-3.158^a	η_{el}	0.1700	0.0610	2.787^a				
γ_{mq}	0.0275	2.449^b	η_{mk}	0.5325	0.0784	6.793^a				
γ_{km}	0.0029	0.105	η_{ml}	-0.0292	0.1046	-0.279				
γ_{lm}	-0.0434	-1.177	η_{me}	0.0114	0.0101	1.125				
γ_{em}	-0.0062	-1.746^c								
γ_{mm}	0.0467	1.727^c								
F-statistic	649.434									
LRT statistic v=3	12.083									

Source: Author's Computation Results

Table 11: Small-Scale Manufacturing Group of Firms: Regression and Elasticity Coefficients

Regression Coefficient Symbol	Regression Coefficient α_i, γ_{ij}	t-value of α_i, γ_{ij}	Factor Price Elasticity Symbol	Price Elasticity Coefficient, η_{ii}, η_{ij}	Standard Error of η_{ii}, η_{ij}	t-value of η_{ii}, η_{ij}	Elasticity of Substitution Symbol	Elasticity of Substitution Coefficient, σ_{ij}	Standard Error of σ_{ij}	t-value of σ_{ij}
α_k	-0.5539	-3.330[a]	η_{kk}	-0.4360	0.0820	-5.315[a]	σ_{kl}	-1.0678	0.2009	-5.315[a]
α_l	1.8782	17.551[a]	η_{kl}	0.0805	0.0375	2.150[b]	σ_{ke}	0.2517	0.1171	2.150[b]
α_e	0.0787	2.345[b]	η_{ke}	0.0115	0.0134	0.856	σ_{km}	0.2560	0.2990	0.856
α_m	-0.4031	-2.587[a]	η_{km}	-0.1183	0.0395	-2.994[a]	σ_{le}	-0.3698	0.1235	-2.994[a]
γ_{kk}	0.1636	1.898[c]	η_{lk}	0.0528	0.0103	5.111[a]	σ_{lm}	1.1808	0.2311	5.111[a]
γ_{kl}	-0.0975	-6.392[a]	η_{ll}	-0.7764	0.0388	-20.004[a]	σ_{em}	-17.3516	0.8674	-20.004[a]
γ_{ke}	-0.0136	-2.488[b]	η_{le}	0.3440	0.0718	4.789[a]	σ_{em}	1.5160	0.3166	4.789[a]
γ_{km}	[illegible]	[illegible]	η_{lm}	-0.0373	0.2132	-0.175	σ_{m}	-0.1642	0.9396	-0.175
γ_{ll}	[illegible]	0.783	η_{ek}	0.2940	0.1173	2.506[b]	σ_{em}	1.2957	0.5170	2.506[b]
γ_{le}	0.0086	-4.607[a]	η_{el}	-0.6244	0.1405	-4.444[a]	σ_{mm}	-2.7516	0.6192	-4.444[a]
γ_{lm}	0.1216	5.931[a]	η_{ee}	0.1028	0.0478	2.150[b]				
γ_{ee}	-0.1833	-13.527[a]	η_{em}	0.1045	0.1221	0.856				
γ_{em}	-0.0051	-1.136	η_{mk}	0.3779	0.0739	5.111[a]				
γ_{mm}	0.0666	3.278[a]	η_{ml}	0.6190	0.1293	4.789[a]				
γ_{km}	0.0478	1.630[c]	η_{me}	-0.0525	0.3007	-0.175				
γ_{m}	-0.0845	-1.239	η_{mm}	0.3332	0.1330	2.506[b]				
γ_{am}	0.0030	0.572								
γ_{mm}	0.0337	1.058								
F-statistic	459.673									
LRT statistic v=3	9.797									

Source: Author's Computation Results

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