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Empirical Analysis of Food Manufacturing Industry in the Philippines

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Abstract

The main objective of this study is to estimate a cost function for the Food Manufacturing Industry in the Philippines in order to investigate some important characteristics of the production technology. A transcendental logarithmic variable cost function and three share equations are jointly estimated for food manufacturing industry with annual panel data for the period from 1980 to 1998. The results of the estimation process are used to calculate substitution possibilities, input demand and technological biases for three inputs. The results show that labor and capital, labor and energy are substitutes while capital and energy are complements. However, the degree of substitutability between labor and energy is higher than between labor and capital in all subsectors in the food manufacturing. Technological change has been biased toward labor and energy using and factor capital saving.

Contents

1.0 Introduction

The main objective of this study is to estimate a cost function for the Food Manufacturing Industry in the Philippines in order to investigate some important characteristics of the production technology. The result of the estimation process is used to calculate substitution possibilities, input demand and technological biases for the inputs used in the food manufacturing industry.

The Food Manufacturing Industry in the Philippines is the largest subsector of the manufacturing sector. Its share in the manufacturing sector in 1992 was 37.7 percent from a high of 44.7 percent in 1980 (De Dios, 1994). By 2000, it had declined further to 36 percent (Martin, 2001). Despite this steady decline, substitution possibilities and other important characteristics remains inadequately studied.

The aspect of food manufacturing industry which has received a great deal of attention in the empirical literature is the degree of monopoly using the traditional structure-conduct-performance analysis. For instance, De Dios (1994) found that two firms dominate the meat processing industry. Purefoods' share of the market at the time was 50 percent; Republic Flour Mills (RFM) controls 37 percent and other firms divide the remaining 13 percent. The same trend was observed in the dairy processing where San Miguel Corporation (SMC) was the leader followed by RFM (De Dios, 1994).

Although there are indications of monopoly[1] in the food manufacturing industry, the pattern of input use and technological biases of inputs are important aspects that could contribute to a better understanding of the state of the food manufacturing industry.

Some scholars are of the belief that the energy disruptions in the Philippines especially in the early 1990s may have affected the relative shares of energy and non-energy factors and by so doing impact on the cost structure of food manufacturing industry. These changes may have also affected substitution possibilities between factor inputs. However, due to the dearth of empirical studies in the area of substitution possibilities in the food manufacturing industry, many important policy questions requiring information on production and cost structures[2]

[1] There are conflicting views on just how monopolistic the Philippine economy has been since the 1950s. Studies on concentration ratios include Lindsey (1976, 1979) and De Dios (1994). However, Yamagata (2000) estimation results using Hooley's 1985 data found that constant returns to scale are more plausible in the Philippines from 1956 to 1980 than increasing returns to scale. This implies that the Philippine economy from 1956 to 1980 may have been more competitive than is generally acknowledged.

[2] The study of Berndt and Wood (1975) established substitution possibilities between energy and nonenergy inputs in the US manufacturing and assumed constant returns to scale. Halvorsen (1977) estimated translog to investigate different forms of energy substitution and help to shed light on the demand elasticities of different energy forms in the US manufacturing. He found that aggregate demand for energy appeared to be highly price sensitive. Berndt and Morrison (1979), using Berndt and Wood (1975) data disaggregated labor into blue collar and white collar and studied substitution possibilities among energy, capital and materials in the US manufacturing sector using a translog model**.** McRae (1981) estimated a translog model to investigate substitution possibilities among capital, labor, energy and materials in Canadian manufacturing. McRae (1981) model assumed Hicks neutral technical change but constant returns to scale was not imposed unlike Berndt and Wood (1975). Halvorsen and Smith (1986) investigated substitution possibilities in Canadian Metal Mining Industry using translog model. They found the demands for energy and capital as the most price sensitive. In the

have not been sufficiently answered. Although earlier studies using transcendental logarithmic (translog) cost function has focused on the manufacturing sectors in the United States and Canada, their findings raises important questions for the Philippines. One of the most detailed attempts to investigate substitution possibilities in the manufacturing sector in the Philippines was carried out by Mendoza (1992).[3]

The food manufacturing industry in the Philippines is generally classified as a light industry and resource-based, making labor intensive technology a natural choice since labor is generally regarded as abundant relative to capital. Cost function estimation carried out within the framework of translog may help shed light on whether technological progress has encouraged the relative use of labor or discouraged its use. Equally relevant for policy decisions is whether energy prices has effect on the demand for labor and other factor inputs used in the production process.

This study uses the duality theory to estimate systems of demand functions and cost function using annual panel data for the period from 1980 to 1998. The estimation process uses the popular flexible functional form known as transcendental logarithmic cost function. The popularity of translog cost function stems from the fact that it does not place a prior restriction on the substitution possibilities among inputs, in fact, it allows the Cobb-Douglas production form to be tested empirically, and it permits the study of other forms of economic effects such as economies of scale (Hitt and Snir, 1999).

This paper is organized as follows. Section 2 provides some background on the food manufacturing industry within the context of the manufacturing sector and examines the performance of different subsectors. Section 3 explores theoretical issues and specifies the econometric model used. Section 4 discusses the estimation method and some econometric issues in dealing with system equations. Section 5 presents data and variables used. Section 6 discusses the result and gives interpretation. Section 7 summarizes important findings and gives recommendations.

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case of Taiwan, Kuroda's (1998) empirical investigation of rice production in Taiwan using translog established that labor and capital are good substitutes and explained the migration of labor from agricultural to non-agricultural as consistent with the technological bias toward labor saving. Binswanger (1974) using translog found that technical change in the US agriculture was labor saving after World War II and concludes that factor prices can have very strong influence on technical change. Although Baltagi and Rich (2002) reached the same conclusion on production labor in the US, their translog model used a General Index Approach.

[3] Although energy was not considered as an input in the variable translog cost function which she estimated, four categories of inputs (skilled labor, unskilled labor, building and machinery) were considered. For the five subsectors (rice and corn milling, sugar milling and refining, oils and fats, meat and meat products and flour and feed milling) included in the study, machinery and unskilled labor, machinery and skilled labor, building and unskilled labor, building and skilled labor were substitutes for all subsectors in the food manufacturing. Complementary relationship was found only in sugar milling and meat and meat products for capital inputs building and machineries.

2.0 Philippine Food Manufacturing

Manufacturing in the Philippines is divided into twenty major industry groups. Food manufacturing has ten subsectors, namely: Bakery products, Coconut Products, Milk and Dairy Products, Grain Mill Products, Processed Meat and Fish, Processed Fruits and Vegetables, Milled and Refined sugar, Vegetables/Animal Oils and Fats, Animal Feeds and Miscellaneous Food (Appendix A).

Although food manufacturing has linkages with the agricultural sector, it involves the processing of agricultural products into final stage for consumption. In some cases, these agricultural products may undergo an intermediate stage of processing before they are sold to the consumer market. For instance in the meat processing subsector, the intermediate stage may include activities such as slaughterhouse for beef, pork and poultry (Abanto, 1998).

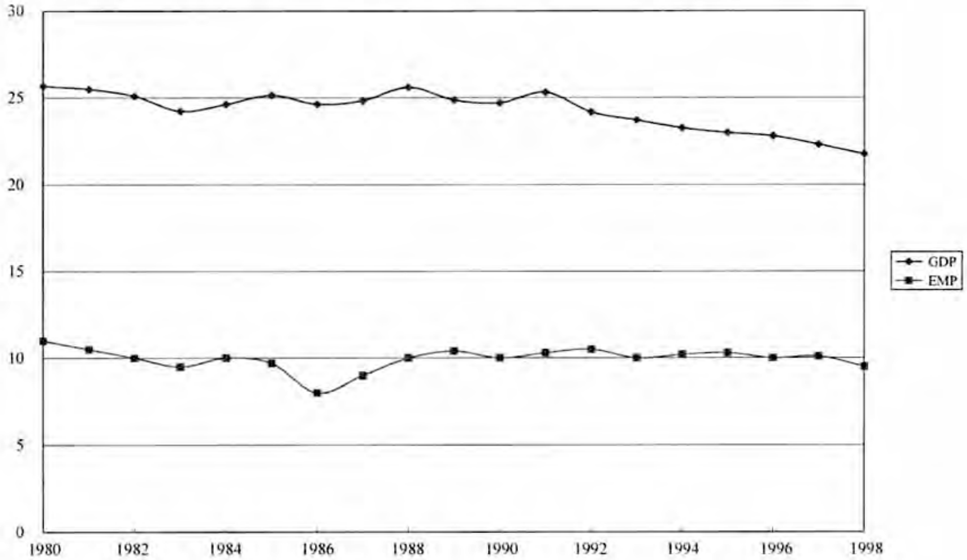
To shed some light on the performance of the food manufacturing industry, it is important to understand that except in cases of accelerated loss of comparative advantage, a sector's fortunes generally follow those of the economy in aggregate (Hill, 2003). Using several indicators such as census value added, employment and labor productivity, the food manufacturing industry mirrors the economy's performance. To get a better picture of the importance of the food manufacturing sector in the Philippine economy, a bit focus on the Gross Domestic Product (GDP) vis-à-vis manufacturing sector in general will provide some context. From the 1970s to the 1990s, the share of manufacturing was on average around 25 percent. It declined steadily during the 1990s to 21.76 percent by 1998 (NSO, 1998). In terms of employment, the share of manufacturing was a little over 10 percent in the early 1970s and leveled to about 10 percent in the 1990s (Figure 1).

Although the share of food manufacturing in the manufacturing value added has always been the highest, it has declined steadily from the 1980 levels. Its contribution on the average from 1989 to 1999 remained at 36 percent of Gross Value Added in manufacturing at constant 1985 prices.

In terms of employment, food manufacturing recorded the highest number of paid employees in the industry. It employed about 185,037 workers in 1997. In 1998, the total number of paid employees rose to 203,939. In terms of share of employment in the manufacturing industry, it registered 19.6 percent in 1975 and down to 17.1 percent in 1997 and rose to 17.9 percent in 1998. Although there was a marginal increase from 1997 to 1998, it is obvious that 1975 levels have not been reached (Figures 2 and 3).

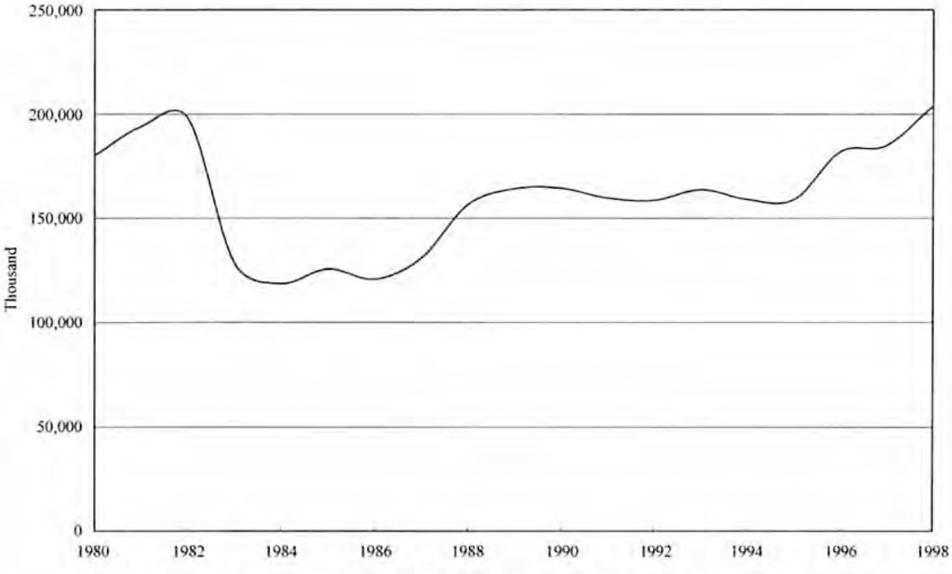
The decrease in the employment share of food manufacturing is not by itself a cause for alarm if the employment level in the manufacturing sector is increasing. It would have appeared that what is lost by food manufacturing is being absorbed by the other areas in manufacturing. This does not appear to be the case. The share of manufacturing in the total employment has decreased from 12 percent in 1970 to 11 percent in 1980 and dipped further

Figure 1 Share of Manufacturing in GDP and Total Employmemt (%)



Source:National Statistics Coordination Board (NSCB) in Bautista and Tecson (2003) Figure 7.1.

Figure 2 Paid Employment



Source: Annual Survey of Establishments/Census of Manufacturing, 1980-1998.

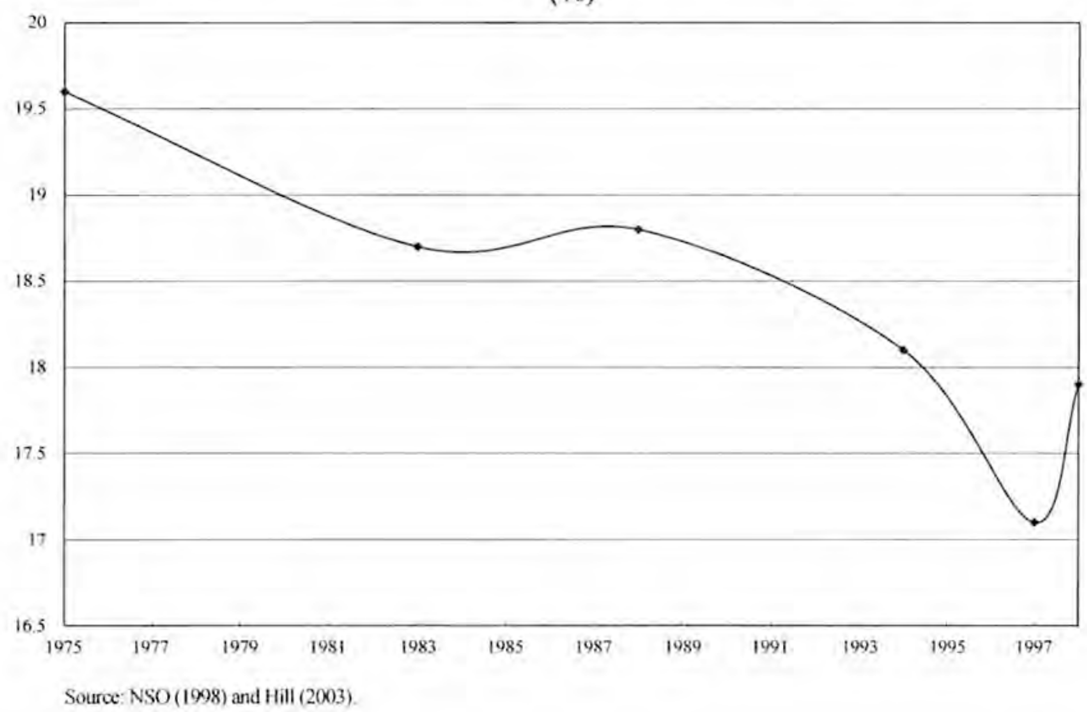
to 9.5 percent by 2000 (Herrin and Pernia, 2003).

It has been suggested that perhaps the declining share of manufacturing is a reflection of structural changes in the Philippine economy. However, Tecson (2001) noted that structural changes in the East Asian Economies occurred after they have reached high manufacturing sector shares of GDP.

Census Value Added (CVA) which follows the definition of Annual Survey of Establishment (ASE) is defined as the difference between the value of output and total costs of materials and supplies consumed, fuels purchased, electricity purchased, industrial services done by others and goods purchased and resold. In 1997 and 1998 CVA for the entire manufacturing was estimated at Php558.6 billion and Php669.3 billion, respectively. The percentage share of food manufacturing in 1997 and 1998 was 18.5 percent and 19.8, respectively (Appendix A.1).

The Census Value Added Ratio (CVAR) is defined as the ratio of CVA to Value of Output. Generally, the CVAR fluctuated for the food manufacturing for the period from 1980 to 1998. In 1990, the CVAR on the average for the manufacturing industry was 36.4 percent and decreased slightly in 1991 to 35.3 percent. For food manufacturing, CVAR was 37 percent and 29 percent, respectively, for the same period. In 1998, food manufacturing sector

Figure 3 Food Manufacturing Total Employment Share in the Manufacturing Industry (%)

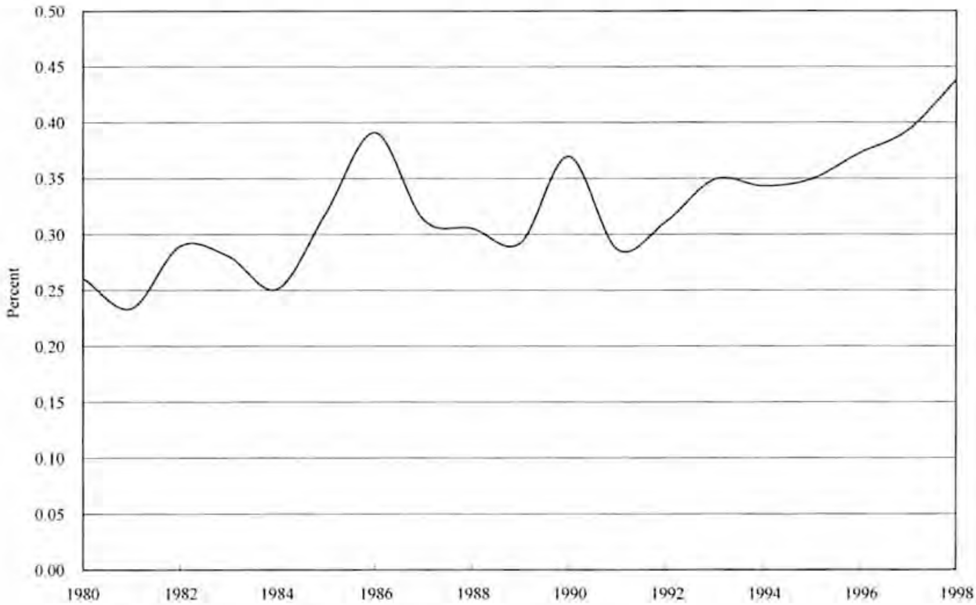


Source: NSO (1998) and Hill (2003).

registered a significant increase in its CVAR (Figure 4). This increase was considerably higher than for the entire manufacturing sectors' average.

Labor productivity defined as the ratio of CVA to the paid number of employees has been fairly on the increase during from 1980 to 1998 in the food manufacturing industry. Although it dropped by 20 percent from 1990 to 1991, it increased by 18 percent from 1991 to 1992 (Figure 5). The increase for the entire manufacturing sector from 1991 to 1992 was only 9.6 percent (NSO, 1992).

Figure 4 Food Manufacturing Census Value Added Ratio (1980-1998)



Source: Annual Survey Establishments / Census of Manufacturing 1980-1998.

Figure 5 Labor Productivity in Food Manufacturing (1980-1998)

Source: Annual Survey of Establishments / Census of Manufacturing 1980-1998.

2.1 Subsectors in Food Manufacturing

In terms of average annual paid employment from 1996 to 1998, three subsectors dominate: meat, fish, fruits and vegetables (33.5 percent), rice and corn milling (24.5 percent), and bakery products (20.5 percent). For the same period, coconut oil and copra was the least at 1 percent (Appendix A.2).

Census Value Added in 1996 was Php90.13 billion for the entire food manufacturing subsector, or an average of Php26.78 million per firm. For 1997 and 1998, CVA was recorded at Php103.62 billion or an average of Php27.87 million per firm, and Php163.22 billion or an average of Php41.64 million per firm, respectively. Two sectors dominate in terms of CVA using annual percentage share for the period 1996, 1997 and 1998: meat, fish, fruits and vegetables (34 percent), and rice and corn milling (34 percent). Coconut oil and copra cake was the least at 3 percent (Appendix A.3). The only subsector that recorded CVAR of over 50 percent from 1996 to 1998 was rice and corn milling which posted an average of 52 percent (Appendix A.4).

On the average, labor productivity in the food manufacturing grew by 28.6 percent from 1996 to 1997 and by 53 percent from 1997 to 1998. The more productive subsectors from

1996 to 1998 were: coconut oil and copra cake (Php1.5 million), dairy products (Php1.3 million), and rice and corn milling (Php853,000). Next was starch products (Php765,000), followed by meat, fish, fruits and vegetables (Php634,000). Bakery was the least productive subsector for the period with Php156,000 (Appendix A.5). According to De Dios (1994), meat processing was the most productive subsector in 1983. Productivity in the coconut oil and copra cake reflect a clear comparative advantage in the production of coconut oil. The Philippines' production accounts for about 50 percent of world production.

3.0 Theoretical Issues and Production Technologies

It is assumed that the food manufacturing industry consist of an aggregate of establishments (henceforth, firms) facing competitive markets, especially for inputs. However, if the input markets are not competitive, the input prices can be read as shadow imputed prices (Fuss, McFadden & Mundlak, 1978). It is further assumed that each firm follows a general production function,

$$Q = f(x, z, t) \qquad (1)$$

where Q is value added output, t is a time index, z is a vector of quasi-fixed inputs and x is a vector of variable inputs. The production function is assumed to be twice continuously differentiable, increasing and concave in x and thereby satisfy the regularity conditions (Baardsen, 2000). Cost minimization assumption is not violated even if the government intervenes in the market to control prices or quantities, as long as the governmental control concerns only prices or quantities and not both (Baardsen 2000, in Binswanger 1974).

This paper follows the basic assumption that firms faced with constraints on inputs will choose a combination of primary inputs which will produce a given level of output at minimum cost. In other words, this assumption identifies the total (variable) cost function of the given output level and input prices. Taking off from the work of Mendoza (1992), and assuming optimizing-producer behavior, a short-run cost for the industry can be written as:

$$C^V(q, w, z, t) \equiv \min_x \{\sum w_i x_i : F(q, x, z) = 0\} \qquad (2)$$

where $q > 0$ is the output quantity, $z > 0$ is the fixed input, $w > 0$ is the price vector for the industry's N variable inputs i.e. $w = (w_1, \ldots, w_N)$, and firms choose input bundle $x > 0$, and $x = (x_1, \ldots, x_N)$ variable inputs to minimize cost. The z is regarded as the subset of x factors which are difficult to adjust (Caves, Christensen & Swanson, 1981). The existence of fixed z is justified by the fact that short-run disequilibria were possible in the Philippines for the period under study (1980-1998). Generally, the 1980s were marked by economic crisis. Except from 1993 to 1996 when the economy grew consistently, the Philippines has been visited by one form of crisis after another. Alternatively, the fixed level of z can be interpreted as a level other than full equilibrium value (Lundmark & Soderholm, 2002). Modeling long-run cost functions assume that all inputs are fully-utilized and therefore reflect equilibrium usage. However, when inputs are not fully-utilized, one way to model this disequilibrium behavior is through restricted (short-run) cost function where a subset of inputs are treated as quasi-fixed inputs. The estimation of restricted cost function can provide as much information as would that of the total cost function (Halvorsen & Smith, 1986). It has been shown that models which presume an equilibrium usage of inputs typically shows larger reductions in technical change during adjustment periods than models that assume the possibility of disequilibrium behavior (Humphrey, 1990).

The variable cost function, C^v described above is dual to the production function in the sense that information about the firm's technology is embedded in the cost function making it easier to study the characteristics of the production function using the cost function (Binswanger, 1974; Alba, 1995)[4]. However, in designing the cost function, the question of validity of the cost is important. A valid cost function is one that is theoretically consistent with the characteristics of costs. Jorgensen (2000); Binswanger (1974), and Varian (1984) provide the following properties of the cost function:

(1) Positivity. The cost function is positive for positive input prices and a positive level of output. An increase in output will necessitate the use of inputs and an increase in total (variable) cost.
(2) Homogeneity. The cost function is homogeneous of degree one in the input prices. This means that when all factor prices double, the total variable cost will also double.
(3) Monotonicity. The cost function is increasing in the input prices and in the level of output. This implies that (given non-negative input prices and output) the value of the conditional factor demand function is positive.
(4) Concavity. The cost function is concave in the input prices. Concavity also implies that the matrix

$$\frac{\partial^2 C}{\partial w_i \partial w_j} \quad \text{must be negative semidefinite.}$$

The basic advantage of the cost function lies in the computational ease by which the cost minimizing input demand function can be derived. Using Shepard's (1953) lemma, the conditional factor demand can be derived by the partial derivative of the cost function with respect to the price of the i-th input. In mathematical form this can be shown as

$$\frac{\partial C^v(w,q,z,t)}{\partial w_i} = x_i \tag{3}$$

From equation 3**,** it is clear that the first derivative of the cost function gives the conditional factor function. Since the variable cost is assumed to be continuous, the second derivative of the cost function can be used to demonstrate the concavity condition as

$$\frac{\partial^2 C^v}{\partial w_i \partial w_j} < 0 \tag{4}$$

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[4] For instance, using the concept of duality theory, a production function (Baardsen, 2000) expressed as : $Q = f(X,T)$ can be represented by a minimum total cost of the type $C(w,Q,T)$, where w and T is vector of all input prices and technology index, respectively.

Equation 4 implies that the conditional input demand function is non-decreasing in its own price. It also demonstrates that the Hessian matrix be negative semi-definite (Caves, Christensen & Swanson, 1981). Following Fuss, McFadden and Mundlak (1978), equation 4 can be written to show the symmetry and cross price effects as

$$\frac{\partial^2 C^v}{\partial w_i \partial w_j} = \frac{\partial^2 C^v}{\partial w_j \partial w_i} \quad \text{Or} \quad \frac{\partial x_i}{\partial w_j} = \frac{\partial x_j}{\partial w_i} \tag{5}$$

Equation 5 can be of use in reducing the number of parameters to be estimated, conserving degrees of freedom and possibly eliminating multicollinearity in the estimation process (Fuss, McFadden & Mundlak, 1978). Additionally, the cost function plays an important role in describing the substitution possibility that the technology permits. The Allen partial elasticity of substitution for inputs i and j (Berndt and Wood, 1975) is defined as:

$$\sigma_{ij} = \frac{CC_{ij}}{C_i C_j} \tag{6}$$

where

$$C_i = \frac{\partial C}{\partial w_i} \; ; \qquad C_{ij} = \frac{\partial^2 C}{\partial w_i \partial w_j}$$

from equation (6) by symmetry $\sigma_{ij} = \sigma_{ji}$. The term C_{ij} is simply the second order partial derivative of the cost function with respect to w_i and w_j. Equation (6) can be used to explain Allen-Uzawa elasticity of substitution. For instance, $\sigma_{ij} > 0$ implies that inputs i and j are substitutes while they are complements otherwise. Allen (1938) defined the price elasticities of conditional factor demand as $\eta_{ij} = S_j \sigma_{ij}$ [5], where S_j is the cost share of input j used in the production process. According to Binswanger (1974), technical change bias occurs due to the influence of change in technology on factor shares, holding output and relative factor prices constant. Kohli (1991), on the other hand describes the rate of technological change as the weighted average of the rates of increase in output components due to time for given factor endowments and output prices. The reference to output components incorporates the concept of GNP share of output.

[5] Kohli (1991) noted that substitution possibilities can be described by ordinary price elasticities as :

$$\eta_{ij} \equiv \partial \ln\left[x_i(q,w)\right] / \partial \ln(w_j) = (\partial x_i / \partial w_j)(w_j / x_i)$$

where η_{ij} is the elasticity of the demand for input i with respect to the price of input j.

Using Shepard's Lemma, he demonstrated that derivation is straight forward as:

$$\begin{aligned} \eta_{ij} &= c_{ij} w_j / c_i \\ &= \left[cc_{ij} / (c_i c_j)\right](w_j c_j / c) \\ &= \sigma_{ij} s_j \end{aligned}$$

According to Humphrey (1990), when output expands but inputs are held constant, the effects on costs of the output expansion should be isolated leaving only the effect on costs of the change in technology.

The idea that technological change could be completely unbiased (Hicks neutrality)[6] means that output components and factor rewards expand at the same rate (Kohli, 1991). According to Kohli (1991), when Hicks neutrality is assumed, it simply means that the time index is no longer considered as an explanatory variable in the estimation process. The assumption of neutrality essentially defeats the argument that technology is shifting over time or that the quality of inputs and outputs is changing with time.

Technological biases following Binswanger (1974)[7] can be written as

$$B_i = \frac{\partial S_i^*}{\partial T}\frac{1}{S_i} \tag{7}$$

where S_i^* denotes the share of the relative factor prices held constant and S_i is the share of factor i. Technological change is factor i saving if $B_i < 0$, neutral if $B_i = 0$ and factor i using if $B_i > 0$.

3.1 Model Specifications

This study follows closely the translog cost function of Christensen, Jorgenson and Lau (1971, 1973) which has been used extensively in modeling producer behavior by Andrade (2000) and Baardsen (2000). It is a logarithmic Taylor's series expansion to the second term around the mean input prices of an arbitrary twice differentiable variable cost function and can be written as:

$$\begin{aligned} \ln C^v &= \alpha_0 + \sum_{i=1}^{N}\alpha_i \ln W_i + \alpha_z \ln Z + \alpha_q \ln Q + \alpha_t \ln T \frac{1}{2}\sum_{i=1}^{N}\sum_{j=1}^{N}\alpha_{ij}\ln W_i \ln W_j + \frac{1}{2}\alpha_{zz}(\ln Z)^2 \\ &+ \frac{1}{2}\alpha_{qq}(\ln Q)^2 + \frac{1}{2}\alpha_{tt}(\ln T)^2 + \sum_{i=1}^{N}\alpha_{iz}\ln W_i \ln Z_z + \sum_{i=1}^{N}\alpha_{iq}\ln W_i \ln Q_q + \sum_{i=1}^{N}\alpha_{it}\ln W_i \ln T_t \\ &+ \alpha_{qz}\ln Z \ln Q + \ln Z \ln T + \alpha_{qt}\ln Q \ln T + \sum_{i=1}^{N} d_{si} D_{si} \end{aligned} \tag{8}$$

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[6] Lau (1978) observed that a production which could be described as Hicks neutral may be expressed as $Q = F(f(X), t)$. Neutrality in the practical sense implies that the marginal product of any two inputs, say K and L are independent of time. On the other hand, nonneutral technical change yields a change in the marginal rate of substitution between inputs for a ratio of input use (Baltagi and Rich, 2002). Recent econometric studies have taken issues with a simple time trend t preferring instead the general index of technical change, $A(t)$. Details can be found in Lundmark and Soderholm (2002) and Baltagi and Rich (2002).

[7] Binswanger (1974) described neutrality as homothetic inward shift of the unit isoquant. He observed that the challenge is to determine the extent share changes are caused by biased technical change or change in prices.

where C^v is variable cost, W is a vector of input prices (i.e. variable input prices for labor, capital and energy), Z is fixed asset, Q is value added quantity, T is time trend to capture technological change, and $\ln$ represents natural logarithm. Seven dummies account for heterogeneous intercepts with respect to the 7 subsectors in the food manufacturing industry, D_{si} (i = 1, 2…., 7)[8].

A cost function must be homogeneous with degree one in input prices. From equation (1), this condition implies the following restrictions:

$$\sum_{i=1}^{N} \alpha_i = 1,$$

$$\sum_{i=1}^{N} \alpha_{ij} = 0,$$

$$\sum_{i=1}^{N} \alpha_{iq} = 0,$$

$$\sum_{i=1}^{N} \alpha_{it} = 0. \tag{9}$$

Additionally, to ensure symmetric Hessian, the following is implied

$$\alpha_{ij} = \alpha_{ji}, \quad i \neq j$$

By Shepard's lemma, the variable cost can be differentiated with respect to input prices yielding the corresponding share equations:

$$\frac{\partial \ln C^v}{\partial \ln w_i} = \frac{\partial C^v}{\partial w_i} \frac{w_i}{C^v} = \frac{w_i x_i}{C^v} = S_i \tag{10}$$

where S_i is the share of the i - th input in the total variable cost. For the translog variable cost function the input demand function can be shown as

$$S_i = \alpha_i + \sum_{j=1}^{N} \alpha_{ij} \ln W_j + \alpha_{iz} \ln Z_z + \alpha_{iq} \ln Q_q + \alpha_{it} \ln T_t \qquad i = 1,2,3 \tag{11}$$

The concept of cost exhaustion implies that $\sum_{i=1}^{N} S_i = 1$. As long as C^v and w_i are

[8] The seven dummies correspond to the seven subsectors : D151 (Meat, Fish and Vegetable) ; D152 (Dairy Products) ; D154 (Starch) ; D156 (Bakery) ; D157 (Sugar) ; D158 (Copra); and D153, 159 (Rice and corn milling).

greater than zero, monotonicity of the variable cost function is assured. Monotonicity simply implies that the estimated cost share of the translog variable cost must be nondecreasing (non-negative) in factor prices. Or put differently, the variable cost should be an increasing function of input prices. The translog variable cost function is also required to be monotonically nondecreasing in output. Expressed in equation form, this condition is met when

$$\frac{\partial \ln C^v}{\partial \ln Q} = \alpha_q + \sum_{i=1}^{N} \alpha_{iq} \ln w_i + \alpha_{qq} \ln Q + \alpha_{qz} \ln Z_z + \alpha_{qt} \ln T \qquad (12)$$

Equation (12) implies that $\alpha_q > 0$ corresponds to a necessary and sufficient condition for monotonicity in output.

Concavity in factor prices (w_i) requires that the bordered Hessian matrix of cross price derivatives of the factor demand functions be negative semi-definite. For the translog cost function, the diagonal elements of the bordered Hessian matrix should be negative at the point of approximation. This condition, following Antler and Capalbo (1988) and Alba (1995), can easily be shown for the diagonal elements as

$$\frac{\partial^2 C^v}{\partial w_i^2} = \frac{C^{v*}}{w_i^{*2}} (\alpha_{ii} - \alpha_i \left(1 - \alpha_i\right) \quad \text{for } i = 1, \ldots, \text{N} \qquad (13)$$

and for the off-diagonal elements as

$$\frac{\partial^2 C^v}{\partial w_i \partial w_j} = \frac{C^{v*}}{w_i^* w_j^*} (\alpha_{ij} + \alpha_i \alpha_j) \quad \text{for } i \neq j \qquad (14)$$

$$H_{ww}^* \begin{pmatrix} \alpha_{11} - \alpha_1 \left(1 - \alpha_1\right) & \alpha_{12} + \alpha_1 \alpha_2 & \ldots\ldots & \alpha_{1l} \alpha_1 \alpha_l \\ \alpha_{12} + \alpha_1 \alpha_2 & \alpha_{22} - \alpha_1 \left(1 - \alpha_1\right) & \ldots\ldots & \alpha_{2l} \alpha_2 \alpha_l \\ \vdots & \vdots \ddots & & \vdots \\ \alpha_{1l} + \alpha_1 \alpha_2 & \alpha_{2l} + \alpha_2 \alpha_l & \ldots\ldots & \alpha_{ll} - \alpha_l \left(1 - \alpha_l\right) \end{pmatrix}$$

Given the signs in the parenthesis of equations (13) and (14), H_{ww}^* is negative semi-definite. It also follows that the principal minor determinants of order k alternate in sign as -, +, -, +, for k = 1, 2, 3.

To get a sense of the response of demand patterns to changes in input prices and substitution possibilities between inputs, the elasticity of substitution concept was used. The elasticity of substitution is defined as the proportional change in the ratio of two inputs with respect to a proportional change in their relative prices. Substitutability of two inputs was measured on the basis of whether substitution measure is greater than unity, equal or less than unity. The commonly used measure of substitution is the Allen partial elasticity of substitution (AES). Following Binswanger (1974) and Christensen and Greene (1976), AES can be computed as

$$\sigma_{ij} = \frac{\alpha_{ij} + S_i S_j}{S_i S_j} = \frac{\alpha_{ij}}{S_i S_j} + 1, \quad i \neq j \text{; and} \tag{15}$$

$$\sigma_{ii} = \frac{\alpha_{ii} + S_i(S_i - 1)}{S_i^2} = \frac{\alpha_{ii}}{S_i^2} - \frac{1}{S_i} + 1, \quad i = j, \tag{16}$$

If $\sigma_{ij} > 0$, inputs i and j are substitutes, while $\sigma_{ij} < 0$ implies that inputs i and j are complements.

Own and cross price elasticities can be obtained as

$$\begin{aligned} \eta_{ii} &= S_i \sigma_{ii} \quad i = j \\ \eta_{ij} &= S_j \sigma_{ij} \quad i \neq j \end{aligned} \tag{17}$$

Following Jensen, Kristensen and Nielsen (1999) and Andrade (2000), disaggregating elasticities into subsectors may be necessary when firms have different production lines. In the case of food manufacturing, deriving specific subsectoral elasticities can be done by using coefficients from the estimated translog cost function and weights of each subsector's share of the firm's total demand for a given input (Jensen, Kristensen & Nielsen, 1999).

Economies of Scale (ES) is defined as the proportional increase in cost as a result of small proportional increase in the level of output or put differently, it is the elasticity of cost with respect to output (William & Laumas, 1984; and Christensen & Greene 1976):

$$\text{ES} = 1 - \frac{\partial \ln C^v}{\partial \ln Q} \tag{18}$$

From equation 18, positive numbers implies scale economies while negative numbers implies scale diseconomies.

Cost neutrality as noted by Baardsen (2000) implies that $\alpha_{T_i} = 0$ for all i.
For the translog variable cost function the rate of technical bias can be shown as (Binswanger, 1974 ;and Andrade, 2000):

$$B_i = \frac{\partial S_i^*}{\partial T} \frac{1}{S_i} = \frac{\alpha_{T_i}}{S_i} \tag{19}$$

4.0 Estimation Method

The optimal method of estimating all the parameters is to jointly estimate the translog cost function (equation 8) and the share equations (equation 11). Estimating the translog cost function and the share equations as a system substantially improves the efficiency of the parameter estimates. The reason for this gain in efficiency is attributed to the fact that additional degrees of freedom can be obtained without imposing any new restrictions (Christensen & Greene, 1976). The translog variable cost function and the share equations are converted into a multivariate regression system by appending a random disturbance term ε .

Following Andrade (2000) the disturbance term is assumed to be normally distributed with mean zero and constant covariance matrix[99]. The following estimable equations were used:

$$\ln C_{nt}{}^{v} = \alpha_0 + \sum_{i=1}^{N} \alpha_i \ln W_{\text{int}} + \alpha_z \ln Z_{nt} + \alpha_q \ln Q_{nt} + \alpha_t \ln T \frac{1}{2} \sum_{i=1}^{N} \sum_{j=1}^{N} \alpha_{ij} \ln W_{int} \ln W_{j_{nt}} + \frac{1}{2} \alpha_{zz} (\ln Z_{nt})^2$$

$$+ \frac{1}{2} \alpha_{qq} (\ln Q_{nt})^2 + \frac{1}{2} \alpha_{tt} (\ln T)^2 + \sum_{i=1}^{N} \alpha_{iz} \ln W_{int} \ln Z_{znt} + \sum_{i=1}^{N} \alpha_{iq} \ln W_{int} \ln Q_{qnt} + \sum_{i=1}^{N} \alpha_{it} \ln W_{\text{int}} \ln T_t$$

$$+ \alpha_{qz} \ln Z_{nt} \ln Q_{nt} + \ln Z_{nt} \ln T + \alpha_{qt} \ln Q_{nt} \ln T + \sum_{i=1}^{N} d_{si} D_{si} + \varepsilon_t^{c^v}$$

$$S_{pnt} = \alpha_P + \sum_{j=1}^{N} \alpha_{Pj} \ln W_{jnt} + \alpha_{Pz} \ln Z_{znt} + \alpha_{Pq} \ln Q_{qnt} + \alpha_{Pt} \ln T_t + \varepsilon_t^P$$

$$S_{Ont} = \alpha_O + \sum_{j=1}^{N} \alpha_{Oj} \ln W_{jnt} + \alpha_{Oz} \ln Z_{znt} + \alpha_{Oq} \ln Q_{qnt} + \alpha_{Ot} \ln T_t + \varepsilon_t^O$$

i, j = Labor, capital n=1... N (subsector dimension)

t = 1…, TT (time dimension).

The t – bar test for heterogeneous panel unit roots proposed by Im, Pesaran and Shin (1995) was used to test the null hypothesis of panel unit root for all the variables used in the estimation process. The null hypothesis which is based on Dickey-Fuller statistics rejected unit root in all cases. Results are shown in Appendixes B.6, B.7, B.8, B.9, B.10 and B.11.

[9] Since the adding up restriction requires that the cost shares of the three equations sum to unity, the disturbances on the share equations must sum to zero at each observation and thus, the system is singular (Berndt and Wood, 1975; and Christensen and Greene, 1976). To avoid this singularity problem, one share equation must be deleted and then estimate the remaining n-1 share equations. For this study, the energy share equation was dropped. All parameter estimates relating to energy was retrieved using the restrictions imposed on (equation 9). Though dropping one share equation is good procedural step in solving the singularity problem, it raises the question of whether the parameter estimates so obtained is invariant to which equation that is dropped. Maximum-Likelihood estimates has been shown to be invariant to the equation dropped (Barten, 1969). However, iterated seemingly unrelated regression can also produce invariant estimates as it is asymptotically equivalent to maximum likelihood estimates.

5.0 Data and Variables

The data sources for the estimation of the Food Manufacturing translog cost function comes from the Annual Survey of Establishments (ASE), a nation-wide sample survey of manufacturing industries, and the Census of Establishments (conducted in principle every five years or for a reference period). Both are administered by the National Statistics Office (NSO). Large establishments with average total employment (ATE) of 10 or more were included in this study. There are seven subsectors classified as (151) Production, Processing and Preservation of Meat, Fish and other Seafood, Fruits, Vegetable Oils and Slaughtering and Meat Packing; (152) Manufacture of Dairy Products; (154) Manufacture of Starches and Starch Products; (156) Manufacture of Bakery Products; (157) Manufacture of Sugar; (158) Production of Crude Coconut Oil, Copra Cake, Meals and Pellets; and (153, 159) Rice and Corn Milling and Other Food Products. The seven subsectors over the period 1980 to 1998 resulted in a sample of 133 panel data observations (i.e. N x TT = 7x19 = 133).

The survey reports the following data in each subsector: total number of establishments, average total employment, total wages and salaries, total compensation, total revenue, total cost, book value of assets and capital assets. The data needed for the estimation of the variable cost function are the variable cost of production, cost shares of variable inputs, fixed assets and value added quantity. All cost has been deflated using consumer price index (CPI, 1994=100).

Variable cost is defined as the sum of expenditures on labor, capital and energy (electricity consumption). The average annual wages for the firms were calculated as total compensation accruing to labor divided by number of workers. The price of energy was taken directly from published reports of Meralco on industrial cost of electricity per kilowatt-hour. Alternative method to calculate unit price of energy may involve dividing values of energy consumed by quantities (Baardsen, 2000). The price of capital is defined as the ratio between gross quasi rent and quantity of capital input. Gross quasi rent is defined as the difference between value added and the total compensation accruing to labor. To obtain the cost share of labor, the total compensation to labor was divided by the total variable cost. Cost shares for capital and energy were obtained analogously. The value added quantity was used as a proxy for physical quantity. Value added quantity was calculated (following Mendoza, 1992) as total revenue minus total intermediate cost deflated by the food manufacturing index. Since this study considered variable cost function, land and materials cost were fixed inputs (Z). Aggregation of quasi fixed asset had been used in the literature by some authors including Humphrey (1990). The variable cost is a summation of capital, labor and energy costs as $VC = P_L X_L + P_E X_E + P_K X_K$, where VC=variable cost; $P_L X_L$=Price of labor multiplied by the quantity of labor; $P_E X_E$=Price of energy multiplied by the quantity of energy and $P_K X_K$=Price of capital is multiplied by the quantity of capital.

This paper basically analyzed industry totals rather than firm level data. Caves, Christensen and Swanson (1981) found little difference in the cost structures of firm level and industry totals, but noted that industry totals show little output growth and hence little effect of scale. Although industry totals were used, in pooling the data number of establishments was used as weights to correct for the averaging done on the data. Details of data description and construction are provided in the Appendix B.

6.0 Empirical Results

The estimated coefficients and their associated standard errors of the seemingly unrelated regression for translog cost and share equations are presented in Table 1. The first order terms (α_l, α_k, α_e, and α_q) can be interpreted as cost elasticities evaluated at the sample mean. They all have the expected signs and are highly significant. The input price coefficients i.e., α_l, α_k and α_e are the intercepts of the cost share equations and represent the percentage of variable costs that each input factor accounts for in the total variable cost over the sample period. The positive input prices which are interpreted as share elasticities implies that value shares increase with an increase in price (Jorgenson, 2000). Among the variable inputs, capital (α_k) accounts for the highest share (60.41 percent), followed by labor (α_l) 27.84 percent and energy (α_e) at 12 percent. Output coefficient (α_q) can be interpreted as output elasticity of the variable cost. The output elasticity when positive implies that increase in output will bring about increase in total variable cost. Alba (1995) described output elasticity as monotonic transforms of marginal cost when the evaluation is performed at the sample means of the variables.

The parameters α_{lt}, α_{kt} and α_{et} are simply the estimated biases of technical change with respect to the input prices of labor, capital and energy, respectively. A positive value indicates that technological change is biased toward using the input while a negative value implies input saving.

Technological change in the food manufacturing industry over the period 1980 to 1998 has been biased towards the use of two factors (labor and energy), and factor capital saving (see Appendixes B.2,B.3, and B.4).

Are the requirements of a well behaved cost function met?

The estimated variable cost function satisfied the conditions for monotonicity in factor prices and output since the coefficients of the input prices and output are positive and highly significant. The cost function fits the model well since the *R* square for the cost function and the share equations are positive. Positivity of the cost function is satisfied if the fitted cost shares are positive (Berndt & Wood, 1975; Andrade, 2000). Concavity in input prices is satisfied in this study. Concavity requires that the Hessian matrix is negative semi-definite (see Appendix B.5). Negative semi-definite can be further observed in the negative own price elasticities of the factor inputs. Although the cost function does not satisfy these conditions globally, satisfying the monotonicity and concavity locally can provide a good representation of production possibilities (Berndt & Christensen, 1973).

Table 1 Estimates of the Variable Cost System

Parameter	Coefficient	Std. Error	Parameter	Coefficient	Std. Error
α_0	-0.0905	0.0599	α_{kq}	-0.1566	0.0018
α_l	0.2784	0.0053	α_{kz}	0.0946	0.0016
α_k	0.6041	0.0077	α_{eq}	-0.0413	0.0019
α_e	0.1174	0.0072	α_{ez}	0.1225	0.0016
α_q	2.193	0.0286	α_{qz}	-0.9071	0.0032
α_z	-1.262	0.0246	α_t	-0.1181	0.0017
α_{ll}	-0.6486	0.0032	α_{tt}	0.0015	0.00005
α_{kk}	0.0745	0.001	α_{lt}	0.0927	0.00056
α_{ee}	-0.4591	0.0033	α_{kt}	-0.0277	0.00013
α_{zz}	0.9929	0.0036	α_{et}	0.0123	0.00078
α_{qq}	0.8354	0.004	d_{151}	0.499	0.004399
α_{lk}	0.0575	0.001	d_{154}	-0.321	0.00462
α_{le}	0.5911	0.0033	d_{156}	-0.219	0.0046
α_{lq}	0.1979	0.0027	d_{157}	0.797	0.00501
α_{lz}	-0.2171	0.0024	d_{158}	-0.198	0.006
α_{ke}	-0.132	0.0009	$d_{153,159}$	-0.674	0.0044
α_{kq}					

Estimation Equations	R- square	R m se
Cost function	0.6778	0.5682
Labor	0.4138	0.089
Capital	0.2173	0.139

Parameter estimates based on ISURE estimation of variable cost and share equations.
Note: l, labor; k, capital; e, energy; t, time index of technological change; and the dummies (151 to 159) refer to the seven subsectors.

Is there evidence of Economies (diseconomies) of scale?

The parameter estimate α_q can be viewed as average scale elasticity or cost flexibility. Cost flexibility is simply the elasticity of cost with respect to output. The value 2.193 can be interpreted as average cost flexibility over the sample period. It implies that on the average the firms in the food manufacturing exhibit diseconomies of scale. Another way to view this is in terms of the cost curve is that the firms in the sample are operating on the increasing section of their average cost curves. This situation when viewed in terms of elasticity implies that on the average, 1 percent increase in output would increase total variable cost by 2 percent. Although diseconomies of scale are possible due to reasons such as over investment, it is less believable in economics. However, the extent of diseconomies of scale in this study is by no means conclusive. Estimation exercise using industry totals tend to show little output growth and hence little effect on scale (Caves, Christensen & Swanson, 1981). Certainly, more work needs to be done on this topic using plant level or firm level data.

Does the cost function have a Cobb-Douglas form?

The translog cost function can degenerate to a Cobb-Douglas function when the coefficients of the second order terms are found to be jointly not significant from zero (Alba, 1995). The second order terms of the translog were significantly different form zero (F=1790; p <0.0001). This implies that the use of more general functional form in this study is justified.

Are there differences in the cost structures of the subsectors?

Seven dummies corresponding to the seven subsectors were introduced to capture differences in the intercepts of the subsectors. The joint null hypothesis that there are no differences in the intercept (Ho: $d_{si} = 0$, si for *D151, D152, D154, D156, D158, D153, 159)* was tested and strongly rejected. All were significantly different from zero (F=41728; p<0.000). Considering the period under this study, the subsectors which experienced lower variable costs were 154 (Starch); 158 (Copra); 156 (Bakery) and 153, 159 (Rice and Corn) while 151 (Meat, Fish, Vegetable) and 157 (Sugar) experienced cost increases.

Is technological change Hicks neutral?

Following Andrade (2000) and Kuroda (1998), the test for Hicks neutrality implies that $\alpha_{Ti} = 0$ (for i = labor, capital and energy). The hypothesis of Hicks neutrality was strongly rejected (F=19805; p<0.000). Berndt & Wood (1975) assume that production characteristics can be described by constant returns to scale and that technical change affecting inputs is Hicks neutral. When constant returns to scale is assumed, the Cobb-Douglas form is not tested as a hypothesis. Hick's neutrality assumption implies that technical progress does not alter relative factor shares in cost (Hicks, 1963).

6.1 Substitution Elasticities and Factor Demand

To measure elasticity estimates for each subsector included in the data set, Allen partial elasticities of substitution and price elasticities were computed using estimated coefficients in table 1; subsector specific shares in Appendix B.1 and expressions in equations 15, 16 and 17. In table 2 the average subsector specific elasticities of substitution are quite high for all subsectors. The elasticities of substitution of labor and capital (σ_{LK}) and labor and energy (σ_{LE}) are positive for all subsectors. Capital and energy (σ_{KE}) turned out to be complements for all subsectors. Energy and capital complementarity is consistent with Berndt & Wood (1975). Mendoza (1992) found skilled and unskilled labor to be complements in the following subsectors in the Philippine Food Industry: rice and corn milling, sugar milling, meat and meat products, and oils and fats. Substitutability between labor and energy is higher than between labor and capital for all subsectors. Complementarity between labor and energy is generally less than one in absolute value in all subsectors except in 157 (Sugar) where it is greater than one.

Own and cross price elasticities reported in Tables 3 and 4 were computed using equation (16), estimated coefficients in Table 2 and subsector specific shares.

Table 3 shows that all inputs have the correct negative signs as required by theory. Negative own price elasticities implies that as the price of an input goes up, the conditional demand for that input goes down (Mendoza, 1992). In essence, the negative signs verify the concavity condition of the variable cost. The demand for the three inputs (labor, capital and energy) are responsive to a change in their respective own prices.

Table 2 Elasticities of Substitution

Average elasticities of substitution between labor, capital and energy inputs in the subsectors of food manufacturing, 1980-1998.

Subsector	σ_{LL}	σ_{KK}	σ_{EE}	σ_{LK}	σ_{LE}	σ_{KE}
151	-10.55	-0.48	-34.66	1.28	17.04	-0.64
152	-13.34	-0.39	-41.33	1.29	21.03	-0.67
154	-24.08	-2..09	-22.76	1.39	20.88	-0.16
156	-6.31	-4.10	-26.39	1.26	11.51	-0.74
157	-23.98	-1.59	-84.44	1.34	41.34	-1.10
158	-19.60	-2.21	-24.09	1.36	19.36	-0.23
153,159	-25.71	-2.09	-21.10	1.41	20.75	-0.11

The own price elasticities are generally greater than one for all inputs except for capital in subsectors 151 (Meat, Fish and Vegetables) and 152 (Dairy Product) where the demand for capital appears very inelastic. The own price elasticities of labor (η_{LL}) is highest in subsector 153, 159 (Rice and Corn Mill). Mendoza (1992) found own price elasticities greater than one in the rice and corn milling subsector for capital factors. On the average, the demand for energy (η_{EE}) is the most responsive to changes in its own price. Although the degree of responsiveness differ across subsectors, the own price elasticity of energy is on the average substantial in subsector 157 (Sugar).

In the case of cross price elasticities shown in Table 4 conditional input demands are found to be less than one in absolute value on the average for all subsectors except for the cross-price elasticities of labor and energy (η_{LE}) and energy and labor (η_{EL}) for all subsectors. Additionally, substitutability among variable inputs dominates (except for capital and energy) in all subsectors.

Table 3 Own Price Elasticities

Average elasticities of substitution between labor, capital and energy inputs in the subsectors of food manufacturing, 1980 – 1998.

Subsector	η_{LL}	η_{KK}	η_{EE}
151	-3.02	-0.28	-4.51
152	-3.37	-0.24	-4.89
154	-4.42	-1.36	-3.73
156	-2.38	-1.93	-3.98
157	-4.41	-1.16	-6.81
158	-4.02	-1.41	-3.83
153, 159	-4.56	-1.36	-3.61

Table 4 Cross Price Elasticities

Average elasticities of substitution between labor, capital and energy inputs in the subsectors of food manufacturing, 1980-1998.

Subsector	η_{KL}	η_{EL}	η_{EK}	η_{LK}	η_{LE}	η_{KE}
151	0.75	2.21	-0.08	0.36	4.88	-0.37
152	0.81	2.48	-0.07	0.33	5.31	-0.42
154	0.91	3.42	-0.03	0.25	3.83	-0.11
156	0.59	1.73	-0.11	0.47	4.34	-0.35
157	0.99	3.33	-0.09	0.24	7.61	-0.81
158	0.86	3.07	-0.03	0.27	3.97	-0.15
153,159	0.91	3.54	-0.02	0.25	3.68	-0.08

Rates of Technological Bias

Generally, technological change in the food manufacturing has been biased toward labor and energy using and factor capital saving for all subsectors. In the case of labor, the extent of bias differed only slightly among subsectors. The extent of labor using is shown in Figure 6 (see also Appendix B.2) as positive rates from 1980 to 1998. Although the extent of labor using increased for subsectors 158; 153, 159; 152; 156; and 154 in the early 1980s, for the most part the entire subsectors behaved similarly. The extent of labor bias reached a substantial level for subsector 151 in 1998 which corresponds to the period directly after the Asian crisis. That technical change was biased toward labor using for the period 1980 to 1998 in the Philippines is not surprising. Some economists have strong prior that in a resource based and relatively light industry like food manufacturing, labor use should be encouraged.

Technological change has been biased toward capital saving as indicated by the negative rates from the period 1980 to 1998 in all subsectors. The extent of bias is shown in Figure 7 (see also Appendix B.3). Except in the early 1980s when substantial increases were registered for almost all subsectors especially for subsectors 158 and 157. The manner of bias toward capital saving was essentially the same for all subsectors.

Figure 6 Rates of Technological Bias for Labor Using

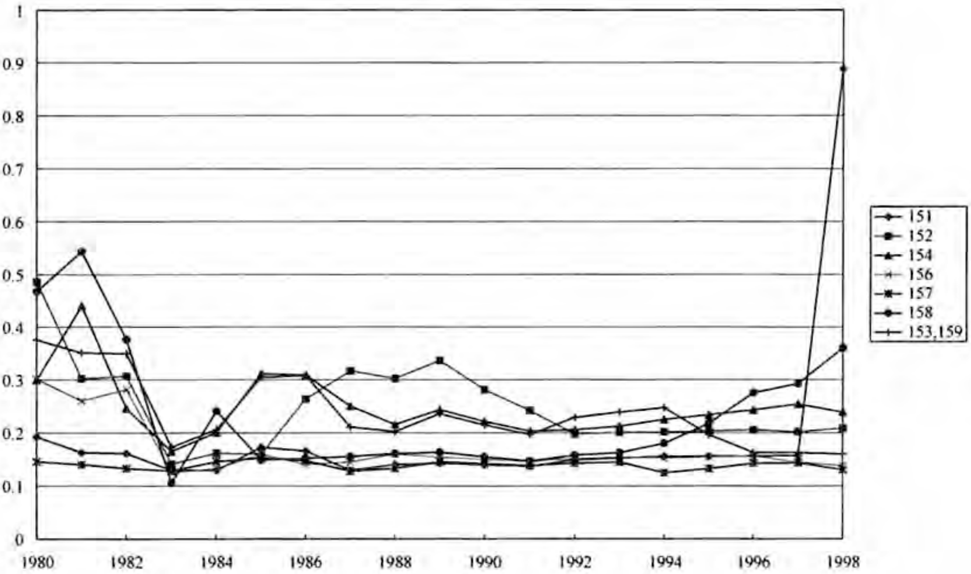
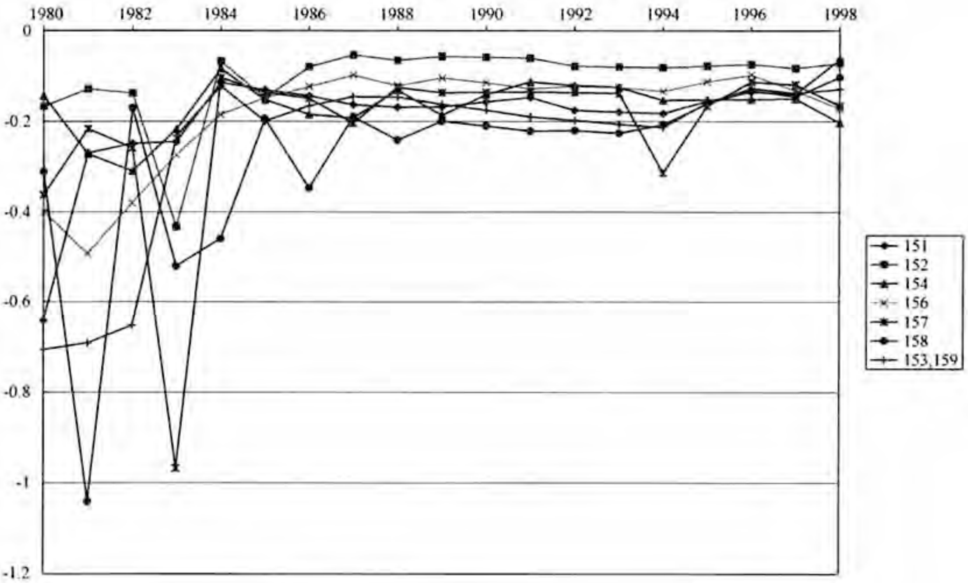


Figure 7 Rates of Technological Bias for Capital Saving

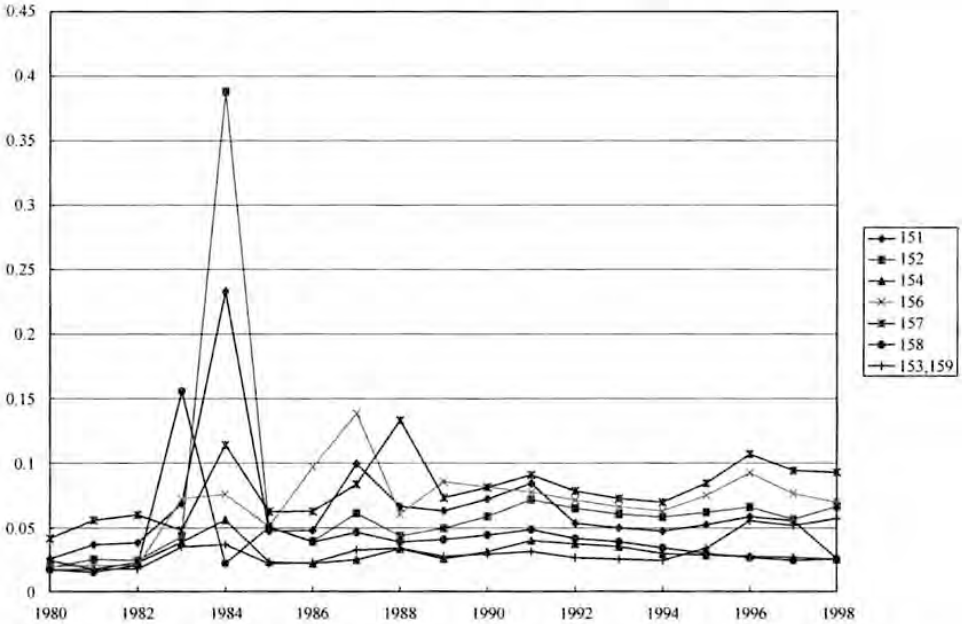


Technological change has been biased toward energy using in all subsectors from 1980 to 1998 as shown in Figure 8 (see also Appendix B.4). However, the extent of energy using has on the average been lower than both capital saving and labor using. The extent of bias for all subsectors behaved similarly except for subsectors 151 (Meat, Fish and Vegetable) and 152 (Dairy Products) which experienced sharp increases from 1983 to 1984. It is not clear why the two subsectors that deal with perishable foods experienced sharp increases in energy use from 1983 to 1984.

What can explain these observations?

While it is difficult to explain definitively the pattern of biases for the three inputs, some general facts can help us gain insight. A close look at the biases for the industry's inputs reveals that sharp increases occurred in the early 1980s which corresponds to when the Philippine economy was virtually on its knees due to both political and economic downturn. It was a period characterized by lack of investment both foreign and domestic ones. It can also be seen that the pattern of biases for capital input saving and energy using is consistent with capital-energy complementarity found in this study.

Figure 8 Rates of Technological Bias for Energy Saving



Although the Philippines experienced severe energy disruptions in the early 1990s there was no unusual technological biases towards energy during the early 1990s. Another point that is noteworthy is that the impact of technological bias toward energy using was no less energy using in the 1990s when energy prices were high (see Appendix A.6). However, Appendix A.7 shows that on the average industrial consumption of energy in the Philippines decreased during the energy crisis in the early 1990s. From Appendix A.8, it is clear that labor using technological bias cannot be explained by the presence of Hicks Induced Innovation Theory explained very clearly in Ruttan (1977). This theory states that "a change in the prices of factors of production is itself a spur to innovation and to inventions of a particular kind which will result in economizing the use of a factor which has become relatively expensive". The explanation for the extent of labor using could lie elsewhere in the structure of the economywide conditions.

7.0 Summary and Conclusions

In this paper, the production technology of the food manufacturing industry in the Philippines for the period 1980-1998 was estimated using a variable translog cost function. It would have been ideal to estimate a variable cost for each subsector but performing estimation runs on small subsector samples proved to be difficult. The initial attempt to estimate a cost function for each subsector cut deep into the degrees of freedom and made the parameters unstable to produce meaningful results. The price index used to derive wage of labor and capital are not generally precise though they remain the dominate methods used in the literature. The annual wage of labor is derived as the total compensation divided by the number of workers. The price of capital is derived as the ratio between quasi rent and the quantity of capital input, where quasi rent is simply defined as the difference between value added and total labor compensation. However, the regression results show that the estimated cost function satisfies the regularity conditions as required by theory. The first order terms have the expected signs and are highly significant. The non-negative values of the first order terms satisfy the monotonicity conditions in both factor prices and quantity. The concavity condition is also satisfied. The Hessian matrix is negative semi-definite. Conforming to these theoretical requirements implies that the cost function is well behaved and offers a reasonable representation of the production technology prevalent in the food manufacturing industry. Other notable findings are summarized as follows:

(1) The substitution elasticities of labor and capital, labor and energy are positive which indicates that they are substitutes in the production process. However, the degree of substitutability between labor and energy is higher than between labor and capital in all subsectors in the food manufacturing. Capital and energy are complements. This is consistent with the study of Wood & Berndt (1975). In the case of substitution relationship, this study is consistent with the study of Mendoza (1992) of food manufacturing subsectors. Although in her study labor was disaggregated into skilled and unskilled labor while capital was disaggregated into building and machineries. However, different categories of labor and capital were found to be substitutes.

(2) Labor can be substituted for all inputs. The possibility of substituting labor for energy may be of interest in the Philippines where labor is considered abundant and energy scare.

(3) The own price elasticities of demand for labor, capital and energy for all subsectors are negative for all subsectors, in effect verifying the concavity conditions. On the average, the demand for energy (η_{EE}) is the most responsive to changes in its own price. Although the degree of responsiveness differ across subsectors, the own price elasticity of energy is on the average substantial in subsector 157 (Sugar).

(4) The output elasticity of variable cost (overall measure of scale economy) indicates

evidence of diseconomies of scale. What are we to make of this evidence in the food manufacturing? At best, it could be regarded as inconclusive. Caves, Christensen & Swanson (1981) found little difference in the cost structures of firm level data and industry level data (i.e. industry total), but noted that industry totals show little output growth and hence little effect of scale. This implies that the use of industry total data tend to hide the extent of economies of scale.

(5) Technological change has been biased toward labor and energy using and capital saving. However, the technological bias toward labor and energy using and capital saving is not explained by the Hicks induced innovation. Explanation for the biases may lie else in the structure of the economy. Another point that is noteworthy is that the impact of technological bias toward energy using was no less energy using in the early 1990s due to severe power disruptions and high energy prices.

(6) Among the variable inputs, capital accounts for the highest cost share at 60.41 percent, followed by labor at 27.84 percent and energy at 12 percent.

(7) Cobb-Douglas production function and Hicks neutral technological change are both rejected. So is the joint null hypothesis that there are no differences in the intercepts of the subsectors.

In concluding, it is important to note that this study has its own share of limitations. The use of aggregate data may have introduced aggregation bias. It is recommended that the use of firm level data with big sample size will permit the use of more disaggregated inputs. These limitations notwithstanding, the cost function behaved reasonably well as required by theory and has uncovered two potentially strong areas for future research: the possibility of substituting labor for energy may be of interest in the Philippines where labor is considered abundant and energy scare. Another obvious implication is that since capital and energy are complements and labor and energy are substitutes, energy price increase (common occurrence in the Philippines) will tend to encourage labor intensiveness in the production process.

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Appendix A: 20 Major Industry Groups in the Philippines

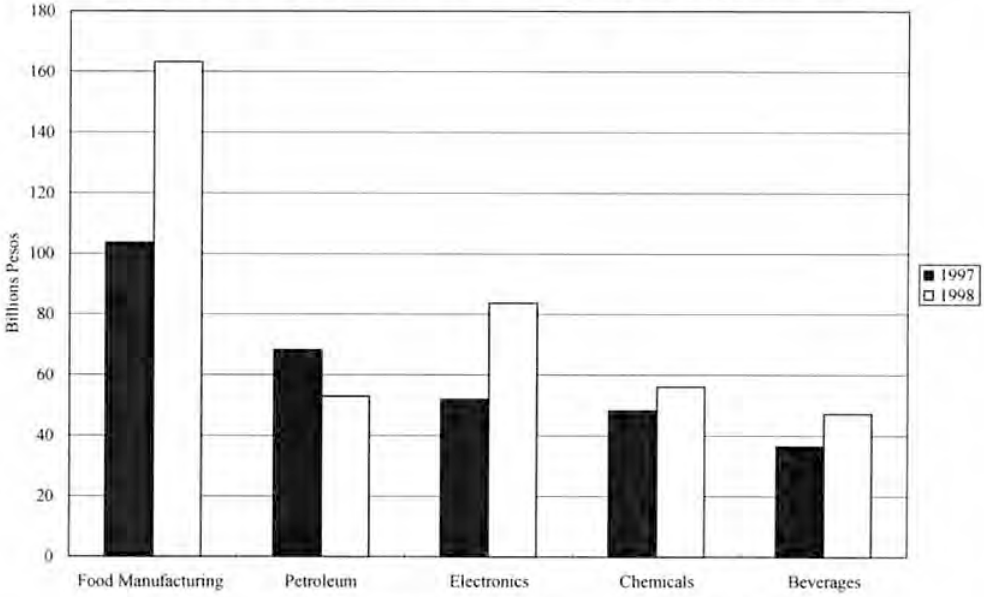
1. Food
2. Beverages
3. Tobacco
4. Textile
5. Foot wear and Wearing Apparel
6. Wood and Wood Products
7. Furniture and Fixtures
8. Paper and Paper Products
9. Printing and Publishing
10. Leather and Leather Products
11. Rubber and Rubber Products
12. Chemical and Chemical Products
13. Products of Petroleum Coal
14. Non-Metallic Mineral Products
15. Basic Metal Products
16. Fabricated Metal Products
17. Machinery except electrical
18. Electrical Machinery
19. Transport Equipment
20. Miscellaneous Manufactured Products

Food Manufacturing

1. Bakery Products
2. Coconut Products
3. Milk and Dairy Products
4. Grain Mill Products
5. Processed Meat and Fish
6. Processed Fruits and Vegetables
7. Milled and Refined Sugar
8. Vegetables/ Animal Oil and Fats
9. Animal Feeds
10. Miscellaneous Foods

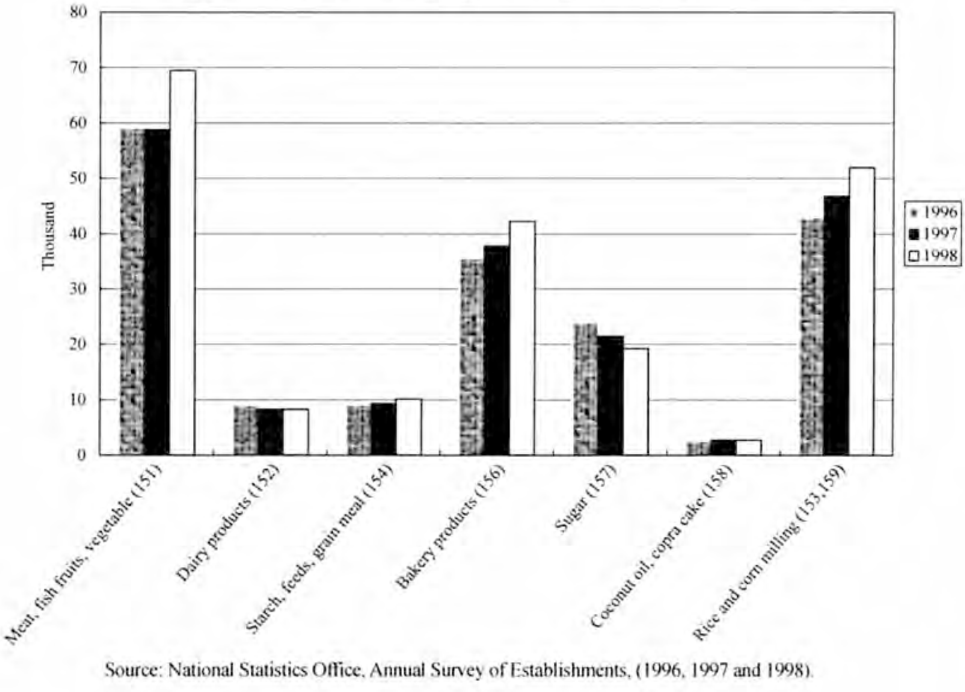
Source: NSCB (2001. Martin p.3)

Appendix A.1. Top Grossers in Census Value Added: ATE 10 or More



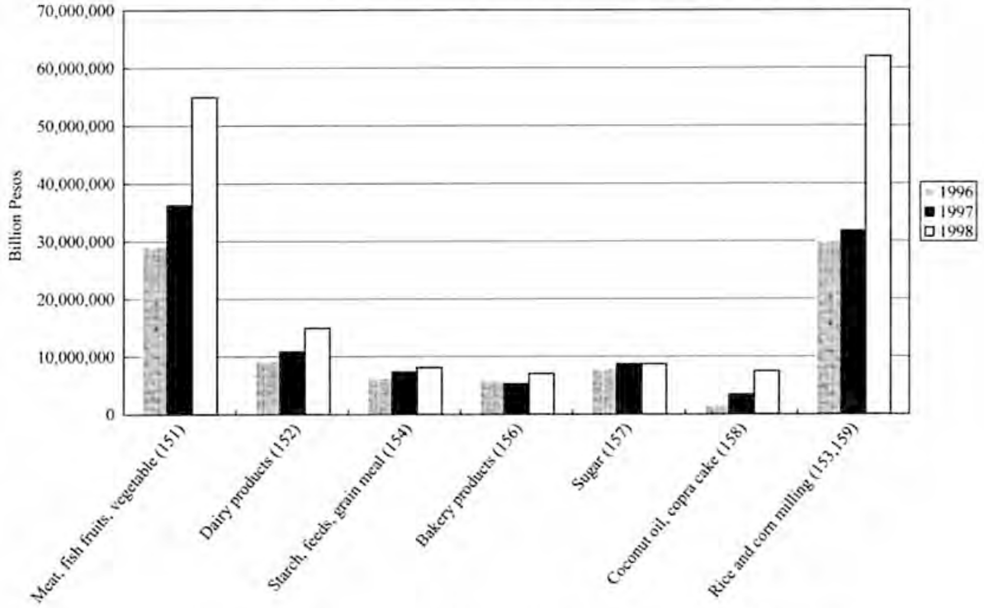
Source: National Statistics Office, Annual Survey of Establishments (1997 and 1998).

Appendix A.2. Paid Employment by Sector: ATE 10 or More



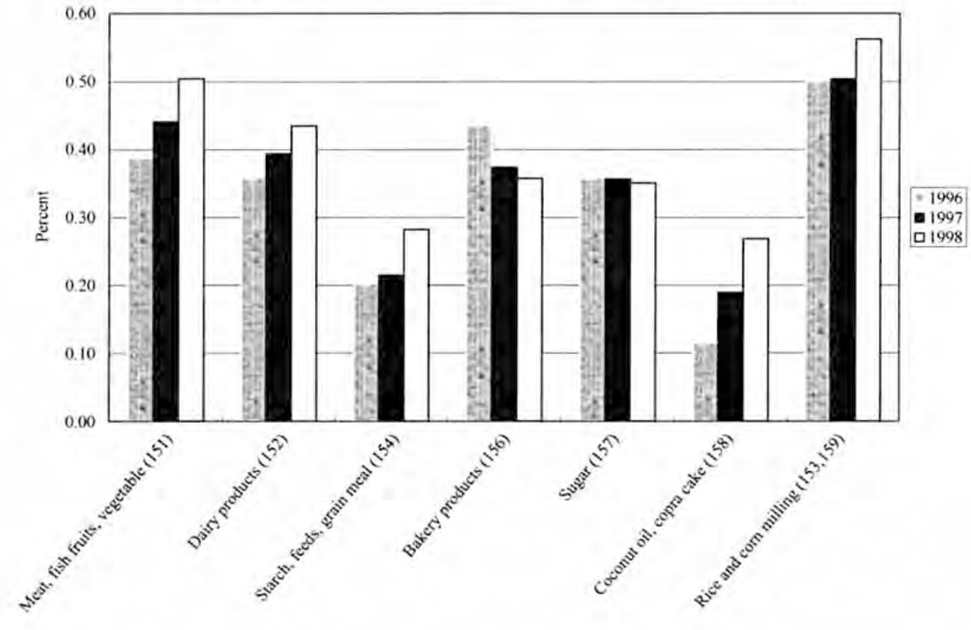
Source: National Statistics Office, Annual Survey of Establishments, (1996, 1997 and 1998).

Appendix A.3. Census Value Added:ATE 10 or More



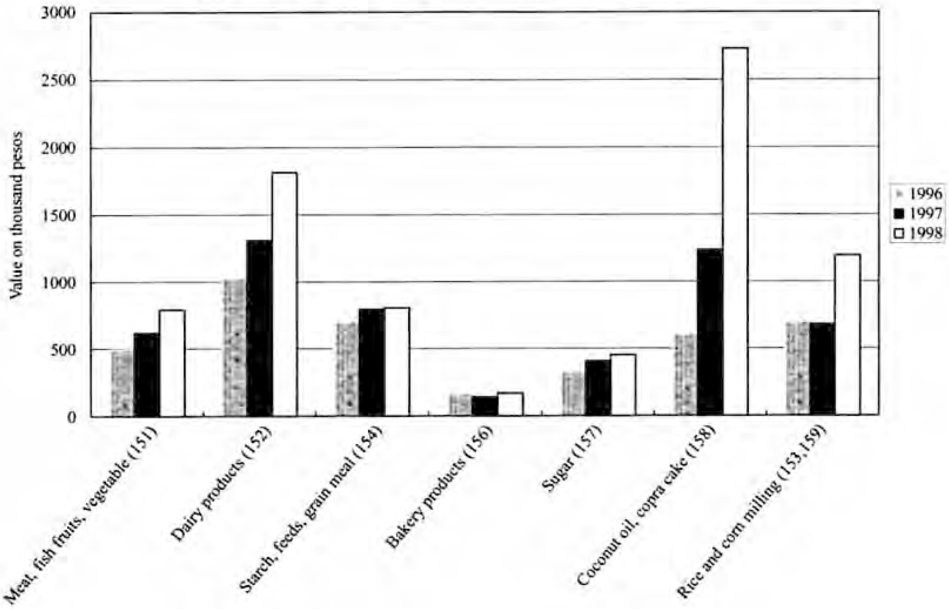
Source:National Statistics Office, Annual Survey of Establishments, (1996, 1997 and 1998).

Appendix A.4. Census Value Added Ratio: ATE 10 or More



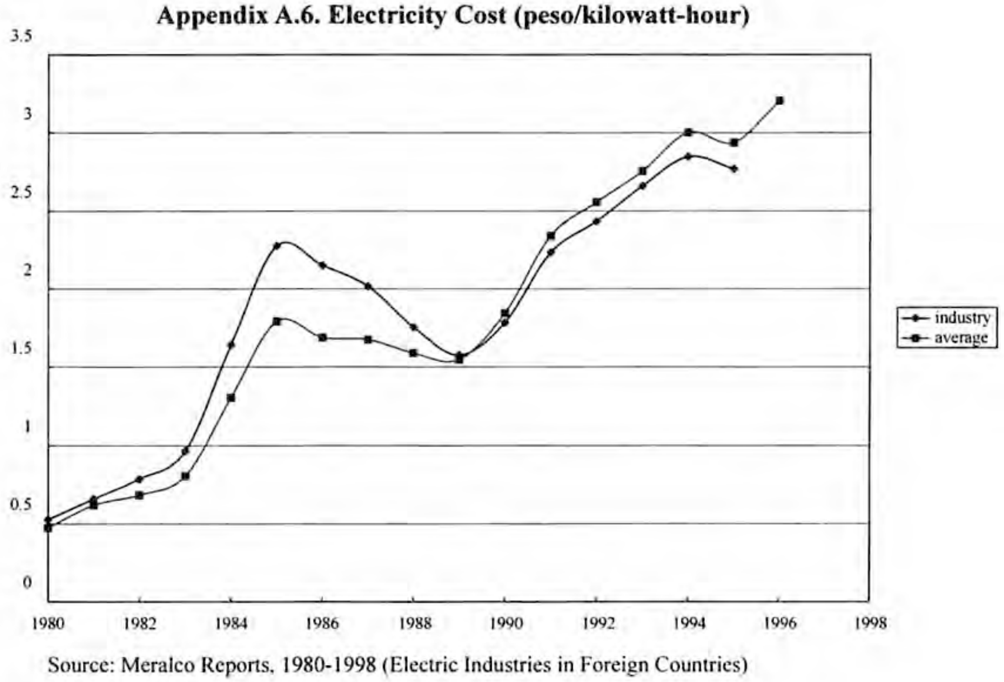
Source:National Statistics Office, Annual Survey of Establishments, (1996, 1997 and 1998).

Appendix A.5. Labor Productivity: ATE 10 or More



Source:National Statistics Office, Annual Survey of Establishments, (1996, 1997 and 1998).

Appendix A.6. Electricity Cost (peso/kilowatt-hour)

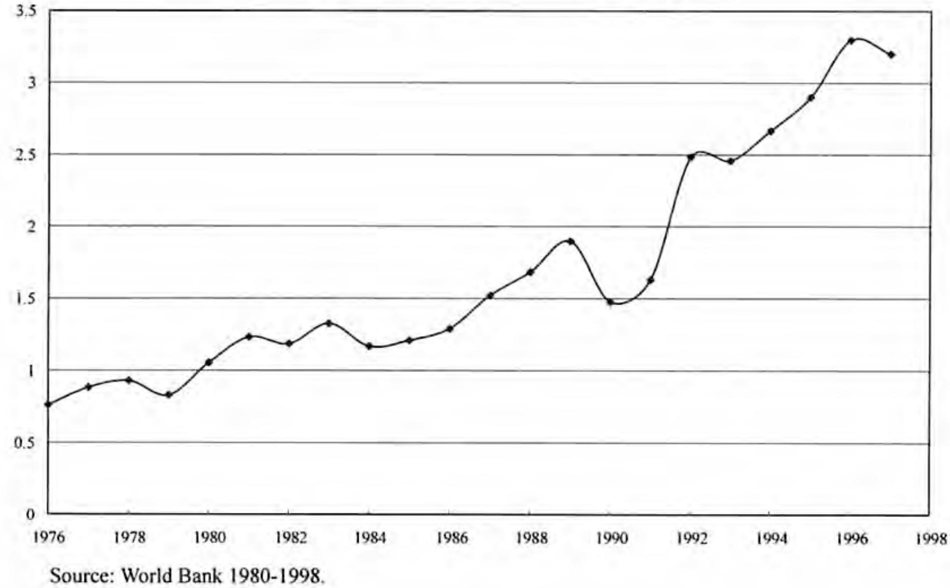


Source: Meralco Reports, 1980-1998 (Electric Industries in Foreign Countries)

Appendix A.7. Industrial Energy Consumption in the Philippines (million kilowatt-hours)

Source: Department of Energy and World Bank Reports 1981-2001.

Appendix A.8. Food Manufacturing Wage Index



Source: World Bank 1980-1998.

Appendix B Variable Description and Data Construction

The description in this section is taken from the Annual Survey of Establishments (ASE) conducted by the National Statistics Office. ASE has the following data items for each subsector:

1. Number of establishments
2. Average total employment defined as the sum of the number of persons who worked for the establishment for a given number of months in one year.
   - 2.1 Categories of employees
     - 2.1.1 Paid employees :
       - 2.1.1.1 Managers, executive and supervisors (include directors and paid owners.
       - 2.1.1.2 Production workers (include working foremen and production workers directly engaged in the production process).
       - 2.1.1.3 Other paid employees or nonproduction workers (include workers doing jobs such as accounting, administrative, personnel, apprentices and learners).
     - 2.1.2 Unpaid employees (include working owners who do not receive regular pay, apprentices and learners without regular pay, etc.).
3. Total number of hours worked by production workers
   - 3.1 Male
   - 3.2 Female
4. Compensation of paid employees
   - 4.1 Salaries and wages (include basic pay and overtime pay).
   - 4.2 Other benefits (include bonuses, food, housing, cost of living allowances, retirement pay, gratuities, etc).
   - 4.3 Employer’s contribution to Social Security System (SSS) / Government Service Insurance System (GSIS).
5. Revenue
   - 5.1 Value of products
   - 5.2 Value of industrial services done for others
   - 5.3 Value of non-industrial services done for other
6. Cost
   - 6.1 Materials and supplies purchased
   - 6.2 Fuels purchased
   - 6.3 Electricity purchased
   - 6.4 Industrial services done by others
   - 6.5 Non-industrial services done by others

6.6 Goods for resale

6.7 Indirect taxes

7. Book value of asset

7.1 Land

7.2 Buildings, other structures and land improvements

7.3 Transport equipment

7.4 Machinery and other equipment

Reconstructing paid employees and unpaid employees in the data set

The Annual Survey of Establishments classified labor into two, namely, paid employees and unpaid employees. The paid employees include managers and supervisors, production workers and other labor. The unpaid workers are simply listed as average total unpaid workers. However, only the salaries and wages data for paid workers are given. To ensure that the number of unpaid workers was not thrown away, the total number of unpaid workers was divided by three and this average was added to each of the paid workers. In other words, it was assumed that an equal number of workers were unpaid among three subgroups paid employee subgroups.

Salaries and wage data are reported in the ASE for only the three categories of paid employees. To obtain adjusted annual average firm salaries and wages for each subsector, the salaries and wages data reported for the three categories of labor was divided by the adjusted number of paid employees for each category of labor (which include the unpaid workers). Mendoza (1992) distributed the unpaid workers in such a manner that preserved the relative proportions of the three categories of paid workers.

Published ASE data on other benefits and SSS/GSIS does not indicate the value accruing to each category of labor. In order to distribute other benefits and SSS/ GSIS among the three categories of labor, a simple weight was assigned to each category of labor. The weight for each category was obtained by dividing the share of salaries and wages for each category of worker by the sum of the salaries and wages of the three categories of workers.

Appendix B.1.Average Share of Inputs in Food Manufacturing

SUBSECTOR	LABOR	CAPITAL	ENERGY
151	0.287	0.583	0.130
152	0.253	0.629	0.118
154	0.184	0.652	0.164
156	0.377	0.472	0.151
157	0.184	0.735	0.081
158	0.205	0.636	0.159
159	0.178	0.652	0.171

Appendix B.2 Annual Rates of Technological Bias for Labor Using for All Sectors in Food Manufacturing, 1980-1998.

Years	*151*	*152*	*154*	*156*	*157*	*158*	*153, 159*
1980	0.192	0.485	0.299	0.301	0.145	0.467	0.375
1981	0.162	0.302	0.439	0.259	0.140324	0.543	0.351
1982	0.161	0.307	0.245	0.281	0.133	0.376	0.34971
1983	0.129	0.141	0.164	0.125	0.128	0.105	0.172
1984	0.129	0.161	0.200	0.132	0.145	0.240	0.206
1985	0.172	0.159	0.311	0.159	0.152	0.148	0.304
1986	0.165	0.263	0.309	0.140	0.147	0.152	0.308
1987	0.129	0.317	0.250	0.144	0.127	0.155	0.210
1988	0.140	0.302	0.215	0.160	0.133	0.160	0.202
1989	0.142	0.336	0.243	0.154	0.145	0.163	0.235
1990	0.139	0.281	0.221	0.150	0.141	0.154	0.214
1991	0.137	0.241	0.203	0.146	0.138	0.147	0.196
1992	0.149	0.197	0.205	0.151	0.142	0.157	0.228
1993	0.152	0.201	0.212	0.153	0.144	0.162	0.238
1994	0.155	0.201	0.224	0.152	0.124	0.179	0.246
1995	0.155	0.203	0.233	0.154	0.133	0.217	0.196
1996	0.156	0.205	0.243	0.156	0.142	0.275	0.162
1997	0.157	0.201	0.253	0.144	0.143	0.292	0.162
1998	0.888	0.208	0.238	0.137	0.130	0.360	0.159
Average	0.190	0.248	0.248	0.168	0.139	0.234	0.238

Appendix B.3. Annual Rates of Technological Bias for Capital Saving for All Sectors in Food Manufacturing, 1980-1998.

Years	151	152	154	156	157	158	153,159
1980	-0.641	-0.167	-0.143	-0.400	-0.362	-0.311	-0.706
1981	-0.269	-0.128	-0.271	-0.492	-0.216	-1.040	-0.691
1982	-0.249	-0.137	-0.309	-0.379	-0.258	-0.170	-0.651
1983	-0.245	-0.433	-0.217	-0.273	-0.967	-0.520	-0.232
1984	-0.113	-0.067	-0.083	-0.184	-0.103	-0.459	-0.122
1985	-0.130	-0.147	-0.152	-0.147	-0.135	-0.194	-0.199
1986	-0.143	-0.079	-0.184	-0.123	-0.148	-0.346	-0.165
1987	-0.162	-0.053	-0.192	-0.097	-0.204	-0.189	-0.144
1988	-0.168	-0.065	-0.130	-0.121	-0.124	-0.241	-0.145
1989	-0.167	-0.056	-0.187	-0.103	-0.135	-0.199	-0.161
1990	-0.156	-0.058	-0.140	-0.114	-0.135	-0.209	-0.174
1991	-0.146	-0.060	-0.112	-0.127	-0.134	-0.221	-0.189
1992	-0.175	-0.078	-0.120	-0.122	-0.135	-0.219	-0.197
1993	-0.179	-0.079	-0.124	-0.124	-0.137	-0.226	-0.205
1994	-0.182	-0.081	-0.152	-0.132	-0.313	-0.207	-0.213
1995	-0.154	-0.077	-0.151	-0.112	-0.165	-0.160	-0.158
1996	-0.134	-0.073	-0.150	-0.097	-0.112	-0.131	-0.126
1997	-0.139	-0.082	-0.149	-0.131	-0.118	-0.144	-0.137
1998	-0.063	-0.072	-0.202	-0.171	-0.165	-0.102	-0.128
Average	-0.190	-0.105	-0.167	-0.182	-0.214	-0.278	-0.250

Appendix B.4.Annual Rates of Technological Bias for Energy Using for All Sectors in Food Manufacturing, 1980-1998.

Years	151	152	154	156	157	158	153, 159
1980	0.025	0.018	0.024	0.019	0.041	0.017	0.017
1981	0.036	0.025	0.017	0.020	0.055	0.015	0.017
1982	0.038	0.024	0.022	0.020	0.060	0.020	0.017
1983	0.068	0.042	0.038	0.072	0.048	0.155	0.035
1984	0.233	0.387	0.056	0.075	0.114	0.022	0.036
1985	0.047	0.050	0.023	0.050	0.062	0.050	0.021
1986	0.047	0.039	0.022	0.096	0.062	0.038	0.022
1987	0.099	0.061	0.025	0.138	0.083	0.046	0.032
1988	0.066	0.043	0.033	0.060	0.133	0.038	0.034
1989	0.063	0.049	0.025	0.085	0.073	0.040	0.027
1990	0.072	0.058	0.031	0.081	0.081	0.044	0.029
1991	0.084	0.071	0.040	0.077	0.090	0.048	0.031
1992	0.053	0.065	0.037	0.071	0.078	0.041	0.026
1993	0.049	0.060	0.035	0.066	0.072	0.039	0.025
1994	0.047	0.058	0.029	0.063	0.069	0.034	0.024
1995	0.052	0.061	0.028	0.075	0.084	0.030	0.034
1996	0.058	0.066	0.027	0.092	0.107	0.026	0.055
1997	0.055	0.056	0.026	0.076	0.094	0.024	0.051
1998	0.026	0.066	0.025	0.069	0.092	0.025	0.057
Average	0.064	0.068	0.030	0.069	0.079	0.040	0.031

Appendix B.5 Hessian Matrix

-0.265	0.225	0.623
0.225	**-0.164**	-0.061
0.623	-0.061	**-0.562**

Appendix B.6

Im, Pesaran and Shin unit root test on value added quantity (VC)

Method	Statistic	Prob.**
Im, Pesaran and Shin W-stat	-5.19865	0.0000

** Probabilities are computed assuming asympotic normality

Intermediate ADF test results

Cross section	t-Stat	Prob.	E(t)	E(Var)	Lag	Max Lag	Obs
1	-3.3074	0.0300	-1.519	0.880	0	3	18
2	-1.8018	0.3669	-1.508	0.973	1	3	17
3	-2.6777	0.0970	-1.519	0.880	0	3	18
4	-4.0823	0.0063	-1.519	0.880	0	3	18
5	-3.2005	0.0369	-1.519	0.880	0	3	18
6	-4.3778	0.0035	-1.519	0.880	0	3	18
7	-4.1715	0.0053	-1.519	0.880	0	3	18
Average	-3.3742		-1.517	0.893			

Appendix B.7

Im, Pesaran and Shin unit root test on value added quantity (Q)

Method	Statistic	Prob.**
Im, Pesaran and Shin W-stat	-3.04773	0.0012

** Probabilities are computed assuming asympotic normality

Intermediate ADF test results

Cross section	t-Stat	Prob.	E(t)	E(Var)	Lag	Max Lag	Obs
1	-2.3619	0.1653	-1.519	0.880	0	3	18
2	-1.8193	0.3592	-1.508	0.973	1	3	17
3	-1.3523	0.5815	-1.519	0.880	0	3	18
4	-2.4517	0.1428	-1.519	0.880	0	3	18
5	-3.5868	0.0172	-1.519	0.880	0	3	18
6	-3.0175	0.0522	-1.519	0.880	0	3	18
7	-3.6517	0.0151	-1.519	0.880	0	3	18
Average	-2.6059		-1.517	0.893			

Appendix B.8

Im, Pesaran and Shin unit root test on quasi fixed asset (Z)

Method	Statistic	Prob.**
Im, Pesaran and Shin W-stat	-2.58775	0.0048

** Probabilities are computed assuming asympotic normality

Intermediate ADF test results

Cross section	t-Stat	Prob.	E(t)	E(Var)	Lag	Max Lag	Obs
1	-1.7864	0.3738	-1.508	0.973	1	3	17
2	-1.2400	0.6296	-1.395	1.056	2	3	16
3	-2.3287	0.1742	-1.519	0.880	0	3	18
4	-2.5010	0.1315	-1.519	0.880	0	3	18
5	-2.8344	0.0733	-1.519	0.880	0	3	18
6	-3.9426	0.0084	-1.519	0.880	0	3	18
7	-2.4616	0.1413	-1.508	0.973	1	3	17
Average	-2.4421		-1.498	0.932			

Appendix B.9

Im, Pesaran and Shin unit root test on capital price (k)

Method	Statistic	Prob.**
Im, Pesaran and Shin W-stat	-2.84341	0.0022

** Probabilities are computed assuming asympotic normality

Intermediate ADF test results

Cross section	t-Stat	Prob.	E(t)	E(Var)	Lag	Max Lag	Obs
1	-2.2512	0.1967	-1.519	0.880	0	3	18
2	-2.3881	0.1599	-1.395	1.056	2	3	16
3	-1.8674	0.3387	-1.519	0.880	0	3	18
4	-2.7694	0.0824	-1.519	0.880	0	3	18
5	-2.8952	0.0667	-1.508	0.973	1	3	17
6	-2.5014	0.1315	-1.519	0.880	0	3	18
7	-3.0336	0.0506	-1.519	0.880	0	3	18
Average	-2.5295		-1.500	0.918			

Appendix B.10
Im, Pesaran and Shin unit root test on labor price (L)

Method		Statistic	Prob.**
Im, Pesaran and Shin W-stat		-3.39850	0.0003
Im, Pesaran and Shin t-bar		-2.72364	
T-bar critical values ***:	1% level	-2.35000	
	5% level	-2.09800	
	10% level	-1.96800	

** Probabilities are computed assuming asympotic normality
*** Critical values from original paper

Intermediate ADF test results

Cross section	t-Stat	Prob.	E(t)	E(Var)	Lag	Max Lag	Obs
1	-2.7236	0.0894	-1.519	0.880	0	3	18
2	-2.7236	0.0894	-1.519	0.880	0	3	18
3	-2.7236	0.0894	-1.519	0.880	0	3	18
4	-2.7236	0.0894	-1.519	0.880	0	3	18
5	-2.7236	0.0894	-1.519	0.880	0	3	18
6	-2.7236	0.0894	-1.519	0.880	0	3	18
7	-2.7236	0.0894	-1.519	0.880	0	3	18
Average	-2.7236		-1.519	0.880			

Appendix B.11
Im, Pesaran and Shin unit root test on energy price (E)

Method	Statistic	Prob.**
Im, Pesaran and Shin W-stat	-4.72381	0.0000

** Probabilities are computed assuming asympotic normality

Intermediate ADF test results

Cross section	t-Stat	Prob.	E(t)	E(Var)	Lag	Max Lag	Obs
1	-2.4912	0.1337	-1.519	0.880	0	3	18
2	-3.6653	0.0173	-1.366	1.181	3	3	15
3	-2.2575	0.1948	-1.519	0.880	0	3	18
4	-3.1620	0.0397	-1.519	0.880	0	3	18
5	-3.7138	0.0134	-1.519	0.880	0	3	18
6	-3.7509	0.0124	-1.519	0.880	0	3	18
7	-3.4442	0.0229	-1.519	0.880	0	3	18
Average	-3.2121		-1.497	0.923			

Appendix C Sector Classification 1977 PSIC to 1994 PSIC

1994 PSIC CLASSIFICATION		1977 PSIC CLASSIFICATION	
(151)	Production, Processing and Preservation of Meat, Fish and Other Seafood, Fruits, Vegetable Oils and Slaughtering and Meat Packing	3111	Slaughtering, preparing and preserving meat
		3114	Canning and preserving of food and vegetables
		3115	Canning, preserving and of fish and other sea foods
		3117	Processing of vegetables and animal Oils and fats
(152)	Manufacturing of Dairy Products	3112	Processed milk and dairy products
(154)	Manufacture of Starches and Starch products, Prepared Animal Feeds and Grain Mill	3121	Processing of grain mill and products
(156)	Manufacture of Bakery Products	3122	Processing of bakery products, cocoa, Chocolate and sugar confectionary, Dry ice and coffee roasting and Processing
(157)	Manufacture of Sugar	3123	Sugar milling and refining
(158)	Production of Crude Coconut oil, Copra Cake, Meals and Pellets	3116	Production of crude coconut oil including cake
(153,159)	Rice and Corn Milling, Manufacture of Other Food Products	3118	Rice and corn milling

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