Arab Journal of Administrative Sciences

2008, Vol. 15, No. 2, 309 - 328

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FACTOR SUBSTITUTION IN MANUFACTURING INDUSTRIES IN KUWAIT

Key Words

Manufacturing Industries; Factor Substitution; Kuwait.

Abstract

The production structure of manufacturing industries in Kuwait has been examined, with specific focus on factor substitution. This has been done by estimating trans-logarithmic cost functions using annual time-series data. The results indicate that the implied production structure is non-homothetic, and the pattern of scale effect is labor and capital saving but material using. The evidence also supports the presence of induced exogenous technical change, which is non-neutral (labor and capital saving). For the majority of the industries, the elasticity of substitution between capital and labor is positive, implying that the two inputs are substitutes.

Introduction

Kuwait's economy is characterized by heavy dependence on one sector, i.e., mining and quarrying (mainly oil), for its sustenance. In terms of contribution to the country's real gross domestic product (GDP) and government revenues, the average shares of this sector during 2000 and 2004 were approximately 45% and 90%, respectively. To reduce dependence on hydrocarbon resources, the authorities have adopted policies to diversify the economy and encourage the development of the manufacturing sector for its importance in increasing the value-added of the national resources, employment generation, investment, and forward and backward linkages with other sectors of the economy. As a result of those policies, during the last more than two decades, the share of the manufacturing sector in gross domestic product in these countries has increased. Despite the growth, the manufacturing sector in Kuwait remains relatively small, faces a number of challenges, and continues to depend on support from the gov-

Submitted January 2007, accepted May 2007.

ernment in the form of subsidy on inputs. Also, its performance in terms of employment generation and contributions to the economy has been below expectations. Between 2000 and 2004, the manufacturing sector (including petroleum refining), on average, accounted for approximately 8% of the country's real GDP.

While Kuwait is rich in hydrocarbon resources, it lacks other natural resources and has a relatively small population base. This makes it dependent on foreign workers for the maintenance of industrial and physical infrastructure. For Kuwait to have a growing manufacturing sector, it is important to look into the underlying factors that may have affected its growth. Given the resource endowment, if the manufacturing sector in Kuwait is to play its due role in the development of the country, then the manufacturing industries must be cost effective. In this context, and to deal with the challenges posed by technological advances effectively, it is imperative that the cost structure of the manufacturing industries must be examined. This study examines the cost structure of manufacturing industries in Kuwait and provides empirical evidence on different production and efficiency parameters, such as substitution elasticity, and input demand elasticities. The cost structure of the industry is examined by analysing the production structure through estimating translog flexible cost functions. The estimated parameters of the cost function are then used to study the demand for factors of production in the industries and the nature of technical change experienced by the different industries. The analysis in the paper is based on annual time-series data.

The Manufacturing Sector in Kuwait

The size and structure of Kuwait's economy differs from that of other countries of the world in many respects. On the one hand, in terms of size, it is one of the smaller countries of the world, but it is rich in oil reserves and has one of the highest per capita incomes in the world. At the same time, the country has a relatively open economy that depends heavily on international trade and expatriate labor to maintain its industrial and physical infrastructure. In terms of social and economic development, the country shares many characteristics with developing countries. The philosophy underlying Kuwait's development strategy is influenced by the country's heavy dependence on one sector, i.e., its exhaustible resource, oil. For instance, the mining of oil accounts for approximately 45% of country's GDP. The domestic non-mining production base is limited, with agriculture and manufacturing (including petroleum refineries, which constitute 67% of manufacturing value-added) accounting for 0.4% and 12% of the country's GDP, respectively.

Over the years, while the dominance of oil has been reduced somewhat, oil still remains the main source of economic activity in the country, and both directly as well as indirectly, it contributes significantly towards the country's economic development. The share of the manufacturing sector in the GDP has increased from 4.2% in 1970 to 7.6% in 2004. In the year 2004, there was a total of 5446 establishments, of which the textile group accounted for the largest number (2838 or 52%). In terms of value-added, however, approximately 85% of the total manufacturing value-added is attributable to the petroleum and chemical group. Whereas, in terms of number of establishments, except for a small number of establishments (i.e., 13), all the other establishments are under complete private ownership; in terms of value-added, approximately 93% of the value-added in the manufacturing sector originates in the public sector. Furthermore, in the year 2004, approximately 102,602 (93,618 expatriates) persons were employed in the manufacturing sector, of whom around 82% were in privately owned establishments. This is in sharp contrast with the shares in the total value-added of the manufacturing industries, and it suggests that the publicly owned manufacturing industries are relatively more capital intensive than the privately owned industries.

Over the years, while the manufacturing sector in Kuwait has expanded, it has lacked the necessary depth and diversity to ensure smooth expansion and be a significant source of investment and employment generation. First, the manufacturing sector is dominated by large public corporations that are restricted to a single industry. Second, there are a large number of small establishments across most industries that account for the bulk of the employment in the manufacturing sector. Third, each industrial group is dominated by one or two industries.(1) Given the importance of a dynamic manufacturing sector, a number of studies have examined different issues related to the performance of the manufacturing industries.(2) In this context, one of the important issues has been utilization of industrial capacity. While evidence

(1) For a detailed overview of manufacturing sector in Kuwait, see Burney and Al-Musallam (2002).

(2) Some of the important studies are Burney and Al-Musallam (2002), Mahmood *et al.* (2000), Salama *et al.* (1996), and Al-Matrouk and Hajeeh (1995).

on industry-specific utilization rates is not available, most of the manufacturing industries in Kuwait operate far below their capacities.(3) In other words, at any particular point in time, there exists excess capacity in most of the manufacturing industries.

A Translog Cost Model

It is assumed that there exists a twice-differentiable aggregate production function for the manufacturing industries. If factor prices and output levels are exogenously determined, then the theory of duality between cost and production implies that the production function can be uniquely represented by a cost function. Using a flexible functional form, the long-run cost function can be approximated by a transcendental logarithmic (translog) second-order, twice-differentiable, non-homothetic, and non-neutral technical change cost function of the following form:(4)

$$\begin{aligned} LnC = \; & \theta + \sum_{i}^{n} \alpha_i LnP_i + \beta_q LnQ \\ & + \gamma_t T + \frac{1}{2}\sum_{i}^{n}\sum_{j}^{n} \alpha_{ij} LnP_i LnP_j \\ & + \frac{1}{2}\beta_{qq}(LnQ)^2 + \frac{1}{2}\gamma_{tt}T^2 \\ & + \sum_{i}^{n} \beta_{iq} LnQ LnP_i + \gamma_{tq} T LnQ \\ & + \sum_{i}^{n} \gamma_{it} T LnP_i \qquad (1) \end{aligned}$$

where i,j = labour (L), capital (K), energy (E), and material inputs (M); C is total cost of production; P_i is price of ith input; Q is quantity of output; T is time trend (added to allow shifts in the cost function due to exogenous technical change); and $\alpha, \beta, \gamma, \theta$ are parameters to be estimated.(5)

By partially differentiating equations (1) logarithmically with respect to factor prices separately and using Shephard's lemma, the following corresponding cost-minimizing factor cost-share equation can be derived:

$$\begin{aligned} S_i = \; & \alpha_i + \beta_{iq} LnQ + \gamma_{it} T + \sum_{j}^{n} \alpha_{ij} P_j \\ & (i,j = L, K, E, M) \qquad (2) \end{aligned}$$

(3) It is estimated that, on average, the capacity utilization rate among the manufacturing industries is approximately 34%, implying that at any given time 66% of the installed capacity remains unutilized. For more on capacity utilization in the manufacturing industries, see Jamal (1999).

(4) The translog cost function has been introduced by Christensen *et al.* (1973). In the empirical literature, it has been extensively used to analyse characteristics of production structures in different sectors, particularly manufacturing.

(5) Equation 1 is most general and flexible form of production specification that can be used to test various restrictions on the structure of production such as functional separability, substitution possibilities, homotheticity, homogeneity, and technical change bias. As in general an unrestricted form, such as equation 1, has been found to approximate the production structure better than the restricted forms. In this paper no attempt is made to test the restrictions.

where S_i is the share of i^{th} input in the total cost of production.

There are a number of restrictions that must hold if the translog function is to represent a well-behaved cost function. The two most important of those restrictions are linear homogeneity in factor prices, output, and trend; and symmetry in factor prices. The linear homogeneity implies following the restrictions on the parameters:

$$\sum_{i}^{n} \alpha_i = 1 \tag{3}$$

$$\sum_{i}^{n} \alpha_{ij} = \sum_{j}^{n} \alpha_{ji} = \sum_{i}^{n}\sum_{j}^{n} \alpha_{ij} = 0 \tag{4}$$

$$\sum_{i}^{n} \beta_{iq} = 0 \tag{5}$$

$$\sum_{i}^{n} \gamma_{it} = 0 \tag{6}$$

where $i,j = L, K, E, M$. The symmetry restrictions require that $\alpha_{ij} = \alpha_{ji}$, where $i,j = L, K, E, M$ for $i \neq j$. The other conditions that the cost function must satisfy in order to conform to a well-behaved production structure are monotonicity and concavity. Monotonicity requires that fitted shares be non-negative at all points. Concavity requires that the Hessian matrix of second derivatives of the cost function be negative, semi-definite at each point. This will be true if the first n - 1 estimated principal minors alternate in sign. However, since the matrix is not determined if any principal minors are statistically significant, this procedure does not constitute a statistical test of concavity.

Because all the cost-share equations have identical explanatory variables, and total cost is the sum of all the factor costs, the n cost-share equations constitute a system of seemingly unrelated regression equations, and simultaneous estimation of $n-1$ of them yields the desired parameters of the entire production system. The set of coefficients obtained by estimating the systems defined by equation 2 facilitates examining various issues relating to production structure of the industry in question. For instance, to examine the substitution/complementarity possibilities between different pairs of factors, and demand for factors, the Allen partial elasticities of substitution (σ) and partial price elasticities of demand for factors (η) can be obtained from estimated coefficients with respect to factor price variables (i.e., α_{ij}) as follows:(6)

$$\sigma_{ii} = \left(\alpha_{ii} + S_i^2 - S_i\right)/S_i^2 \tag{7}$$

$$\sigma_{ij} = \left(\alpha_{ij} + S_i S_j\right)/S_i S_j \tag{8}$$

$$\eta_{ii} = \sigma_{ii} * S_i \tag{9}$$

$$\eta_{ij} = \sigma_{ij} * S_j \tag{10}$$

Two factors are termed as substitutes

(6) For more details, see Uzawa (1962).

(complements) to each other as σ_{ij} is positive/negative.

A production structure is characterized to have non-homothetic specification if the estimated coefficients with respect to output (i.e., β_{iq}) are found to be statistically different from zero. The scale bias in the production structure is termed as factor saving (using) as β_{iq} is negative/positive. Also, a production structure is characterized to exhibit induced technical change if the estimated coefficients with respect to trend (i.e., γ_{it}) are found to be non-zero statistically. The induced technical change is termed as non-neutral and referred to as factor saving (using) as γ_{it} is negative/positive.

Empirical Results

In order to study the production structure of manufacturing industries in Kuwait, the logarithmic cost model was estimated for 35 of the 41 industries based on time-series data covering the period from 1980 to 1997 (18 yrs).[7] Initially, four factor inputs (or cost components) were taken into consideration, namely, labor (L), capital (K), energy (E), and raw materials (M). They were subsequently reduced to three by lumping energy (which includes electricity) and raw materials components together. This was because, in Kuwait, electricity consumption is highly subsidized and electricity prices have remained unchanged since the mid-1960s. As a result, not only is there no variability in electricity prices, but the share of electricity in the total cost of production is also negligible.

To save degrees of freedom, it has been customary to estimate the system of factor cost-share equations. The estimated coefficients are subsequently used to obtain the different production parameters, such as elasticities of substitution and factor demand. As the factor cost shares must necessarily sum to unity, in the estimation, one of the cost-share equations is dropped from the system to prevent the disturbance covariance matrix from being singular. This approach yields all the coefficients in the cost

(7) The data range is restricted to 1980 to 1997 due to lag in the availability of recent data and lack of consistent time series resulting from changes in industrial classification and base of the price indices. Except for the prices of capital and raw materials, the requisite data on cost components, employment, and output were obtained from various issues of *Annual Survey of Establishments: Industry*, published by the Ministry of Planning, Kuwait. The price of labor was taken to be the average annual earnings of the workers, which were obtained by dividing the total wage-bill of the industry by the total number of persons employed in the industry. As for the price of capital and raw materials, the study used raw material and capital goods price indices, compiled by the Ministry of Planning and reported in each issue of the *Annual Statistical Abstract*. All the prices were converted into indices, and the base year was taken to be 1980. Finally, the measure of output was taken to be real value-added, which is nominal value-added divided by the relevant product price index obtained from the *Annual Statistical Abstract*.

functions except β_y, β_{yy}, γ_t, γ_{tq}, γ_{tt}, and θ. As such, when only factor cost-share equations are estimated, it is not possible to directly infer the impact of output (i.e., economies of scale) and technology on cost.

The input cost-share regressions were estimated jointly as a multivariate regression system using Zellner's iterative seemingly unrelated regression equation (SURE) technique, which yields maximum likelihood estimates.(8) In the estimation, the cost-share regression for the raw materials was dropped. In this context, Barten (1969) has shown that the maximum likelihood estimates of a system of cost-share regressions are invariant to the equation dropped.

The estimated regression coefficients and related statistics are reported in Table 1. Except for a few regressions, the R^2 values for a majority of the estimated regressions are reasonably high. A well-defined cost function should be increasing in input prices and output, and be concave in input prices. The majority of the coefficients have the expected signs, but not all are necessarily statistically significant.

Table 1
Estimated Coefficients of the Translogarithmic Cost Model

	Industry							
	Dairy Products		Bakery Products		Food Products		Animal Feeds	
	ISIC-3112		ISIC-3117		ISIC-3121		ISIC-3122	
	S_L	S_K	S_L	S_K	S_L	S_K	S_L	S_K
Intercept	0.1595+	2.2816*	1.6910*	-0.8785*	0.1848+	0.3690*	0.5681*	0.4232*
	(1.787)	(12.690)	(6.719)	(-3.416)	(1.992)	(3.281)	(2.703)	(2.773)
LY	0.0056	-0.2278*	-0.1423*	0.0952*	-0.0017	-0.0275**	-0.0661+	-0.0561**
	(0.598)	(-12.160)	(-5.567)	(3.650)	(-0.189)	(-2.495)	(-2.064)	(-2.421)
LPL	0.0708*	0.1329*	0.1149*	-0.0343**	0.0168	0.0472	0.0423	0.0299
	(2.624)	(3.326)	(7.218)	(-2.217)	(1.326)	(3.255)	(0.948)	(0.934)
LPK	0.1329*	-0.0149	-0.0343**	0.1756*	0.0472*	0.1136*	0.0299	0.0621
	(3.326)	(-0.134)	(-2.217)	(5.714)	(3.255)	(3.647)	(0.934)	(0.881)
LPM	-0.2036	-0.1180	-0.0807*	-0.1414*	-0.0641**	-0.1608*	-0.0722	-0.092
	(-4.604)	(-1.073)	(-4.346)	(-4.285)	(-2.548)	(-3.959)	(-1.006)	(-1.098)
T	-0.0082*	-0.0048	0.0022**	-0.0046*	-0.0018**	-0.0062*	-0.0084**	-0.0059+
	(-5.531)	(-1.340)	(2.477)	(-4.030)	(-2.393)	(-5.794)	(-2.289)	(-1.912)
R^2	0.6254	0.8969	0.7781	0.7226	0.2468	0.6667	0.2567	0.3167
Log-L	74.139		107.301		111.210		65.408	
LRT	3.263		3.622		11.861		14.072	

(8) For details, see Zellner (1962).

	Industry							
	Soft Drinks		Made-Up Textiles		Wearing Apparel		Sawmill	
	ISIC-3134		ISIC-3212		ISIC-3220		ISIC-3311	
	S_L	S_K	S_L	S_K	S_L	S_K	S_L	S_K
Intercept	0.0433	1.6515*	0.1895	-0.0793	1.7024	0.3008*	1.4841*	0.4764*
	(0.423)	(12.490)	(0.513)	(-0.321)	(1.540)	(3.546)	(8.590)	(3.519)
LY	0.0150	-0.1578*	0.0020	0.0140	-0.1131	-0.0285**	-0.1265*	-0.0433*
	(1.355)	(-11.110)	(0.045)	(0.476)	(-1.041)	(-3.411)	(-6.990)	(-3.071)
LPL	0.0664*	0.0202	0.0278	-0.0139	0.2101*	-0.0003	0.1223	-0.0324
	(2.721)	(0.699)	(0.789)	(-0.617)	(3.089)	(-0.052)	(3.903)	(1.410)
LPK	0.0202	-0.2108*	-0.0139	-0.0050	-0.0003	0.0330*	-0.0324	-0.0231
	(0.699)	(-3.976)	(-0.617)	(-0.142)	(-0.052)	(3.599)	(-1.410)	(-0.484)
LPM	-0.0866*	0.1906*	-0.0139	0.0188	-0.2099*	-0.0327*	-0.0899+	0.0555
	(-3.875)	(4.370)	(-0.380)	(0.415)	(-3.025)	(-2.759)	(-1.885)	(0.961)
T	-0.0017	0.0054*	0.0049*	0.0002	-0.0070**	-0.0005	-0.0050*	-0.0044*
	(-1.408)	(2.872)	(3.507)	(0.142)	(-2.519)	(-1.485)	(-2.849)	(-2.790)
R^2	0.5519	0.9083	0.5020	0.0171	0.7225	0.8811	0.7035	0.5363
Log-L	93.847		95.356		105.362		87.505	
LRT	11.364		4.3531		40.649		5.582	

	Industry							
	Wood Products		Wood Furniture		Paper Containers		Paper Articles	
	ISIC-3319		ISIC-3320		ISIC-3412		ISIC-3419	
	S_L	S_K	S_L	S_K	S_L	S_K	S_L	S_K
Intercept	-0.0119	0.0293	0.1619	0.8448*	0.3944*	0.8828**	0.3702*	-0.2130
	(-0.052)	(0.998)	(0.756)	(6.331)	(3.556)	(2.184)	(4.365)	(-1.147)
LY	0.0384	-0.0024	0.0202	-0.0836*	-0.0248+	-0.0876**	-0.0158	0.0398
	(0.961)	(-0.470)	(0.917)	(-6.087)	(-1.885)	(-1.833)	(-1.415)	(1.644)
LPL	-0.0216	-0.0047	-0.0594*	0.0222+	0.0439*	-0.0528	0.0712*	-0.1145*
	(-0.332)	(-0.576)	(-2.822)	(1.729)	(3.179)	(-1.363)	(3.176)	(-3.366)
LPK	-0.0047	0.0412*	0.0222+	0.0538*	-0.0528	0.1959	-0.1145*	-0.0393
	(-0.576)	(2.932)	(1.729)	(2.697)	(-1.363)	(1.219)	(-3.366)	(-0.400)
LPM	0.0263	-0.0364**	0.0371**	-0.0760*	0.0089	-0.1413	0.0433	0.1538
	(0.364)	(-2.150)	(2.207)	(-3.614)	(0.182)	(-0.745)	(0.894)	(1.413)
T	0.0083+	0.00004	-0.0077*	-0.0001	-0.0026**	-0.0111**	-0.0008	-0.0035
	(1.954)	(0.068)	(-7.134)	(-0.087)	(-2.326)	(-2.432)	(-0.633)	(-1.078)
R^2	0.2373	0.3255	0.7833	0.7755	0.7734	0.3496	0.8939	-0.1121
Log-L	86.090		111.181		82.375		78.915	
LRT	25.513		8.880		16.894		4.867	

	Industry							
	Printing & Pub.		**Industrial Chemic**		**Fertilizers & Pesti**		**Paint & Varnish**	
	ISIC-3420		**ISIC-3511**		**ISIC-3512**		**ISIC-3521**	
	S_L	S_K	S_L	S_K	S_L	S_K	S_L	S_K
Intercept	0.8715^{+}	0.2423	0.9378*	0.2948	0.8232	0.5819**	0.5993*	0.0371
	(1.799)	(1.554)	(2.698)	(1.440)	(1.495)	(2.279)	(2.851)	(0.451)
LY	-0.0484	-0.0182	-0.0846**	-0.0090	-0.0246	-0.0471^{+}	-0.0484^{+}	-0.0014
	(-0.983)	(-1.153)	(-2.009)	(-0.361)	(-0.458)	(-1.905)	(-2.074)	(-0.151)
LPL	0.1471*	0.0019	0.0482	-0.1123*	0.2196**	-0.0967^{+}	0.0822*	-0.0008
	(2.662)	(0.106)	(1.406)	(-5.882)	(2.139)	(-1.978)	(3.145)	(-0.085)
LPK	0.0019	0.0676*	-0.1123*	0.1654**	-0.0967^{+}	0.2217*	-0.0008	0.0481*
	(0.106)	(3.459)	(-5.882)	(2.256)	(-1.978)	(2.994)	(-0.085)	(3.427)
LPM	-0.1490**	-0.0694*	0.0641	-0.0532	-0.1229	-0.1252	-0.0814*	-0.0473*
	(-2.240)	(-2.605)	(1.698)	(-0.703)	(-0.973)	(-1.676)	(-3.301)	(-3.934)
T	-0.0054*	-0.0007	0.0021	-0.0024	-0.0114*	0.0018	-0.0017**	-0.0008^{+}
	(-3.070)	(-0.957)	(0.883)	(-1.016)	(-3.038)	(0.773)	(-2.467)	(-1.916)
R^2	0.6649	0.6084	0.3683	0.6928	0.5131	0.6107	0.5285	0.5499
Log-L	100.494		67.437		62.840		123.778	
LRT	9.392		0.342		7.177		6.338	

	Industry							
	Chemical Product		**Petroleum Refinin**		**Rubber Products**		**Plastic Products**	
	ISIC-3529		**ISIC-3530**		**ISIC-3559**		**ISIC-3560**	
	S_L	S_K	S_L	S_K	S_L	S_K	S_L	S_K
Intercept	0.5382*	0.7128*	0.8834*	1.7331*	0.1567	-0.1598	0.6071*	0.7753*
	(6.657)	(8.928)	(27.950)	(17.240)	(0.694)	(-0.797)	(4.159)	(5.319)
LY	-0.0380*	-0.0803*	-0.0615*	-0.1220*	0.0048	0.0247	-0.0423*	-0.0689*
	(-3.586)	(-8.018)	(-27.200)	(-17.070)	(0.167)	(0.973)	(-2.684)	(-4.409)
LPL	0.0449^{+}	0.0201	0.0613*	-0.0037	0.0149	-0.0211	0.0833*	0.0582*
	(1.754)	(0.791)	(8.996)	(-0.323)	(0.449)	(-0.739)	(4.174)	(3.165)
LPK	0.0201	-0.0899	-0.0037	0.0659^{+}	-0.0211	-0.0098	0.0582*	-0.1019**
	(0.791)	(-1.478)	(-0.323)	(1.798)	(-0.739)	(-0.154)	(3.165)	(-2.328)
LPM	-0.0650	0.0699	-0.0576*	-0.0622	0.0062	0.0309	-0.1414*	0.0437
	(-1.472)	(1.208)	(-4.523)	(-1.470)	(0.129)	(0.427)	(-6.305)	(1.096)
T	-0.0097*	-0.0032	0.0015*	0.0034**	-0.0047*	0.0039^{+}	-0.00834*	0.0033^{+}
	(-5.096)	(-1.572)	(3.790)	(2.582)	(-3.167)	(1.949)	(-2.680)	(1.867)
R^2	0.6705	0.8687	0.9818	0.9550	0.5626	0.3261	0.7574	0.6571
Log-L	73.948		122.623		80.404		98.568	
LRT	13.984		13.396		0.854		0.317	

	Industry							
	Glass Products		Cement		Mineral Products		Iron & Steel	
	ISIC-3620		ISIC-3692		ISIC-3699		ISIC-3710	
	S_L	S_K	S_L	S_K	S_L	S_K	S_L	S_K
Intercept	1.0666*	-0.5771+	0.7262*	1.4895*	0.5359+	1.0213*	1.0795*	0.2986
	(5.932)	(-1.743)	(6.394)	(4.109)	(1.812)	(4.176)	(7.597)	(0.919)
LY	-0.1102*	0.1018**	-0.0664*	-0.1353*	-0.0282	-0.0836*	-0.0952*	-0.0097
	(-4.303)	(2.117)	(-6.116)	(-3.872)	(-1.032)	(-3.710)	(-5.595)	(-0.253)
LPL	0.0989*	0.0910*	0.0947*	-0.0441	0.1410*	0.0595**	0.1629*	-0.1248*
	(3.610)	(2.900)	(6.111)	(-1.255)	(4.354)	(2.311)	(6.117)	(-2.689)
LPK	0.0910*	-0.2220	-0.0441	-0.4420	0.0595**	-0.0309	-0.1248*	0.0538
	(2.900)	(-1.219)	(-1.255)	(-0.321)	(2.311)	(-0.619)	(-2.689)	(0.341)
LPM	-0.1900*	0.1310	-0.0505	0.0883	-0.2005*	-0.0286	-0.0381	0.0710
	(-3.989)	(0.688)	(-1.663)	(0.716)	(-6.542)	(-0.560)	(-0.675)	(0.433)
T	0.0066+	-0.0034	0.0001	-0.0027	-0.0057*	0.0023	-0.0032+	-0.0054
	(1.798)	(-0.795)	(0.071)	(-0.700)	(-3.539)	(1.322)	(-1.997)	(-1.046)
R^2	0.6873	0.524	0.8584	0.4919	0.7203	0.4880	0.8910	0.3095
Log-L	65.079		84.338		85.339		67.644	
LRT	1.448		4.744		2.801		1.305	

	Industry							
	Metal Furniture		Metal Structures		Metal Products		Industrial Machin	
	ISIC-3812		ISIC-3813		ISIC-3819		ISIC-3824	
	S_L	S_K	S_L	S_K	S_L	S_K	S_L	S_K
Intercept	1.1010*	0.1523	2.2551*	0.1642	1.6131*	0.2300	-0.5792	0.1127+
	(3.753)	(1.286)	(5.921)	(0.700)	(6.080)	(1.125)	(1.592)	(1.819)
LY	-0.0974*	-0.0094	-0.1872*	-0.0100	-0.1484*	-0.0200	0.1427*	-0.0141
	(2.730)	(-0.652)	(-5.176)	(-0.452)	(-5.094)	(-0.898)	(2.864)	(-1.621)
LPL	0.1540*	-0.0002	0.1187*	-0.0203	0.1874*	-0.0310	0.1170+	0.0211+
	(5.457)	(-0.015)	(3.648)	(-1.120)	(4.677)	(-1.063)	(1.990)	(2.069)
LPK	-0.0002	-0.0318	-0.0203	-0.0154	-0.0310	0.0099	0.0211+	-0.0171
	(-0.015)	(-0.980)	(-1.120)	(-0.380)	(-1.063)	(0.175)	(2.069)	(-0.379)
LPM	-0.1538*	0.0319	-0.0983**	0.0358	-0.1564*	0.0210	-0.1381**	-0.0039
	(-5.456)	(0.886)	(-2.263)	(0.829)	(-3.878)	(0.427)	(-2.259)	(-0.078)
T	-0.0012	-0.0006	-0.0080*	-0.0015	-0.0016	0.0030	-0.0057	0.0074*
	(-0.634)	(-0.531)	(-4.342)	(-1.210)	(-1.014)	(1.644)	(-0.607)	(4.802)
R^2	0.7082	0.2484	0.6622	0.1987	0.6778	0.6153	0.5331	0.6726
Log-L	89.025		88.871		85.188		65.019	
LRT	1.535		4.805		0.972		2.418	

	Industry							
	Non-Elect. Machi		Elect. Indust. Mac		Elect. Appliances		Shipbuilding	
	ISIC-3829		ISIC-3831		ISIC-3839		ISIC-3841	
	S_L	S_K	S_L	S_K	S_L	S_K	S_L	S_K
Intercept	0.3453$^+$	0.5369*	-0.5797*	0.0404	1.0509*	0.8645$^+$	-0.2732	1.3011*
	(1.831)	(3.034)	(-2.640)	(1.535)	(4.411)	(1.801)	(-0.306)	(8.002)
LY	-0.0022	-0.0533**	0.1434*	0.0011	-0.0974*	-0.0814	0.0832	-0.1223*
	(-0.099)	(-2.591)	(4.669)	(0.304)	(-3.932)	(-1.653)	(0.769)	(-6.217)
LPL	-0.0246	0.1734*	-0.0731	-0.0016	-0.0522	0.1035$^+$	-0.0376	0.0097
	(-0.497)	(3.922)	(-1.121)	(-0.210)	(-1.435)	(2.028)	(-0.480)	(0.701)
LPK	0.1734*	0.0168	-0.0016	-0.0097	0.1035$^+$	-0.0385	0.0097	-0.0462
	(3.922)	(0.233)	(-0.210)	(-0.545)	(2.028)	(-0.272)	(0.701)	(-0.868)
LPM	-0.1488**	-0.1901*	0.0747	0.0113	-0.0513	-0.0650	0.0279	0.0365
	(-2.398)	(-2.817)	(1.103)	(0.573)	(-1.180)	(-0.555)	(0.333)	(0.662)
T	-0.0109*	0.0002	-0.0353*	-0.0005	-0.0070*	-0.0035	-0.0100	-0.0059*
	(-5.769)	(0.084)	(-7.189)	(-0.708)	(-4.899)	(-903)	(-1.208)	(-2.760)
R^2	0.6094	0.4591	0.8046	0.1733	0.8564	-0.2222	0.0799	0.9343
Log-L	78.427		80.994		70.624		58.072	
LRT	1.759		4.576		5.879		2.005	

	Industry					
	Motor Vehicles		Jewelry Articles		Misc. Products	
	ISIC-3843		ISIC-3901		ISIC-3909	
	S_L	S_K	S_L	S_K	S_L	S_K
Intercept	1.0521*	0.2880$^+$	2.1071*	0.1305*	0.5784*	0.1230
	(3.706)	(2.101)	(4.838)	(4.224)	(9.815)	(1.457)
LY	-0.0878*	-0.0247	-0.2255*	-0.0146*	-0.0187$^+$	-0.0029
	(-2.893)	(-1.707)	(-3.769)	(-3.439)	(-1.794)	(-0.193)
LPL	0.0681	0.0441**	-0.2404$^+$	-0.0347*	-0.0666*	-0.0264
	(1.494)	(2.328)	(-1.923)	(-3.899)	(-3.221)	(-1.443)
LPK	0.0441**	-0.0025	-0.0347*	0.0493*	-0.0264	-0.0379
	(2.328)	(-0.049)	(-3.899)	(2.732)	(-1.443)	(-0.376)
LPM	-0.1122$^+$	-0.0416	0.2751	-0.0146	0.0929*	0.0643
	(-2.084)	(-0.804)	(2.165)	(-0.769)	(2.899)	(0.642)
T	-0.0094$^+$	-0.0056**	0.0108	-0.0001	-0.0113*	-0.0010
	(-1.760)	(-2.569)	(1.188)	(-0.145)	(-6.876)	(-0.464)
R^2	0.5143	0.5988	0.6553	0.6701	0.8513	0.2250
Log-L	78.682		78.885		83.151	
LRT	1.848		12.014		2.986	

Note: Figures within the parenthesis are estimated t-ratios. Also, *, and $^+$ indicate that the coefficient is statistically significant at 99%, 95%, and 90% level of significance, **,respectively.
S_L is share of labor in total cost; S_K is share of capital in total cost; LY is logarithm of industrial value-added; LPL is logarithm of price of labor; LPK is logarithm of price of capital; LPM is logarithm of price of raw material; T is time trend; Log-L is logarithm of likelihood function; and LRT is likelihood ratio test.

It can be observed from the tables above that for the majority of the industries, the intercept term in factor cost-share regressions is positive and statistically significant. This implies that the cost functions for Kuwait's manufacturing industries are increasing in input prices. In general, the estimated coefficients with respect to factor prices (labor, capital, and material inputs) have positive signs and are not necessarily equivalent to zero. For instance, out of the 35 manufacturing industries for which factor cost-share regressions have been estimated, the coefficient with respect to the price of labor in the labor cost-share regression is positive for 27 (of which it is statistically significant in 21 cases), and negative for 8 (of which it is statistically significant in 3 cases). Similarly, the coefficient with respect to the price of capital in the labor cost-share regression is positive for 15 (of which it is statistically significant in 9 cases), and negative in 20 (of which it is statistically significant in 6 cases). The coefficient with respect to the price of raw materials in the labor cost-share regression is positive in 10 regressions (of which it is statistically significant in 3 cases), and negative in 25 regressions (of which it is statistically significant in 17 cases). In the case of capital cost-share regressions, the coefficient with respect to price of capital is positive in 16 (of which it is statistically significant in 11 cases), and negative in 19 (of which it is statistically significant in 2 cases). Similarly, the coefficient with respect to the price of raw materials in the capital cost-share regression is positive in 16 (of which it is statistically significant in 1 case), and negative in 19 (of which it is statistically significant in 8 cases). The implied coefficient with respect to the price of raw materials in the case of the materials cost-share equation (not estimated) is positive in 27 cases and negative in 8 cases.

All the estimated coefficients with respect to factor prices are less than unity, and are not necessarily equivalent to zero. This implies that, in general, the Cobb-Douglas specification is not suitable for studying the production structure of manufacturing industries in Kuwait. The partial elasticities of substitution, computed at mean factor cost-shares, are reported in Table 2. The own-price substitution elasticities (σ_{ii}) for labor, capital, and raw materials are generally negative, implying that the inputs are normal, and an increase in their prices would lead to reduction in their demand. The magnitudes of the estimated elasticities for labor and capital are generally greater than unity, which indicates that the two inputs are sensitive to changes in their respective prices.

As for the nature of the relationship between the factors of production, the computed Allen partial elasticities of substitution (σ_{ij}) for labor and capital are positive for 22 industries, implying that in those industries the two factors are substitutes to each other. In other words, a rise

Table 2
Estimates of Production Parameters for Kuwait's Manufacturing Industries

	3112	3117	3121	3122	3134	3212	3220	3311	3319	3320	3412	3419	3420	3511	3512	3521	3529	3530
σ_{ll}	-2.34	-1.09	-4.37	-4.63	-2.76	-2.58	536.9	-1.03	-2.84	-2.93	-3.81	-2.33	13.8	-2.20	-0.14	-2.02	-2.96	0.77
σ_{kk}	-6.45	15.58	5.59	4.70	-9.42	-27.7	-0.86	-27.4	20.5	6.53	12.4	-12.6	-1.21	0.15	2.75	19.26	-23.8	-1.07
σ_{mm}	-0.34	-0.29	-0.30	-0.13	-0.33	-0.35	-0.17	-0.21	-0.49	-0.67	-0.24	-0.26	-0.33	-0.66	-0.11	-0.10	-0.30	-0.08
σ_{lk}	5.87	-0.49	4.41	6.31	1.81	-0.43	0.97	-1.36	0.38	2.68	-2.85	-5.09	1.07	-1.23	-0.25	0.83	2.24	0.24
σ_{lm}	-0.65	0.55	0.49	0.20	-0.01	0.92	-22.2	0.51	1.14	1.19	1.08	1.33	-2.58	1.46	0.28	0.35	0.54	-0.08
σ_{km}	-0.20	-1.76	-1.60	-1.10	2.42	1.67	0.86	2.60	-0.95	-1.68	-0.99	3.11	0.66	0.51	-0.94	-0.88	2.16	0.08
η_{ll}	-0.43	-0.31	-0.73	-0.50	-0.35	-0.64	10.14	-0.28	-0.80	-0.89	-0.55	-0.43	1.04	-0.56	-0.06	-0.31	-0.57	0.05
η_{kk}	-0.95	1.26	0.46	0.24	-1.87	-1.09	-0.43	-1.40	0.55	0.28	1.17	-1.28	-0.45	0.03	0.47	0.59	-1.99	-0.08
η_{mm}	-0.23	-0.18	-0.23	-0.11	-0.23	-0.25	-0.08	-0.14	-0.34	-0.44	-0.18	-0.19	-0.18	-0.36	-0.04	-0.08	-0.22	-0.07
η_{lk}	0.87	-0.04	0.36	0.33	0.36	-0.02	0.49	-0.07	0.01	0.12	-0.27	-0.52	0.40	-0.25	-0.04	0.03	0.19	0.02
η_{lm}	-0.44	0.35	0.37	0.17	-0.01	0.66	-10.6	0.35	0.79	0.77	0.82	0.95	-1.43	0.80	0.11	0.28	0.39	-0.07
η_{km}	-0.13	-1.12	-1.20	-0.93	1.64	1.19	0.41	1.77	-0.66	-1.10	-0.75	2.22	0.37	0.28	-0.36	-0.72	1.56	0.07
η_{ly}	1.03	0.50	0.99	0.39	1.12	1.01	-4.99	0.53	1.14	1.07	0.83	0.91	0.35	0.67	0.95	0.68	0.80	0.01
η_{ky}	-0.54	2.18	0.67	-0.08	0.20	1.36	0.94	0.15	0.91	-0.93	0.07	1.39	0.95	0.95	0.72	0.95	0.04	-0.55
η_{my}	1.33	1.07	1.04	1.15	1.21	0.98	1.30	1.25	0.95	1.10	1.15	0.97	1.12	1.17	1.19	1.06	1.16	1.21

	3559	3560	3620	3692	3699	3710	3812	3813	3819	3824	3829	3831	3839	3841	3843	3901	3909
σ_{ll}	-5.03	-1.95	-1.44	1.07	-0.42	-0.01	-0.62	-1.10	0.15	-0.36	-2.85	-3.25	-12.1	-2.00	-1.71	-5.54	-2.49
σ_{kk}	-17.4	-16.0	-15.0	-90.9	-9.55	-2.86	-23.0	-31.5	-11.5	-24.7	-9.46	-28.0	-22.9	-5.86	-21.5	91.0	-17.4
σ_{mm}	-0.24	-0.26	-0.39	-0.07	-0.16	-0.20	-0.19	-0.18	-0.05	-0.88	-0.61	-0.67	-0.29	-1.41	-0.34	-0.92	-0.93
σ_{lk}	-1.25	3.71	3.44	-5.25	3.56	-2.32	0.99	-0.91	-0.94	1.69	9.31	0.87	15.0	1.14	4.36	-5.63	0.04
σ_{lm}	1.05	-0.06	-0.29	0.35	-0.50	0.70	0.20	0.45	0.04	0.35	0.18	1.38	0.44	1.17	0.41	2.39	1.47
σ_{km}	1.62	1.56	2.42	2.42	0.65	1.63	1.80	2.21	1.44	0.79	-3.00	1.40	-0.19	1.44	-0.32	-0.13	2.39
η_{ll}	-0.75	-0.37	-0.35	0.10	-0.08	0.00	-0.19	-0.28	0.03	-0.21	-0.80	-0.95	-1.35	-0.73	-0.48	-1.57	-0.85
η_{kk}	-1.09	-1.80	-2.29	-6.82	-1.14	-0.52	-1.44	-1.32	-0.79	-1.28	-0.70	-1.19	-1.52	-1.07	-1.01	1.68	-1.39
η_{mm}	-0.19	-0.18	-0.23	-0.06	-0.11	-0.12	-0.12	-0.13	-0.03	-0.32	-0.39	-0.45	-0.24	-0.63	-0.23	-0.65	-0.54
η_{lk}	-0.08	0.42	0.53	-0.39	0.42	-0.42	0.06	-0.04	-0.06	0.09	0.69	0.04	0.99	0.21	0.20	-0.10	0.00
η_{lm}	0.83	-0.04	-0.18	0.29	-0.34	0.43	0.13	0.32	0.03	0.12	0.12	0.92	0.36	0.53	0.27	1.67	0.85
η_{km}	1.28	1.09	1.46	2.01	0.45	1.00	1.14	1.56	1.01	0.28	-1.93	0.93	-0.16	0.65	-0.22	-0.09	1.38
η_{ly}	1.03	0.78	0.55	0.29	0.86	0.54	0.68	0.26	0.37	1.24	0.99	1.49	0.13	1.23	0.69	0.20	0.95
η_{ky}	1.39	0.39	1.66	-0.80	0.30	0.95	0.85	0.76	0.71	0.73	0.28	1.03	-0.23	0.33	0.47	0.21	0.96
η_{my}	0.96	1.16	1.01	1.24	1.16	1.17	1.17	1.28	1.24	0.64	1.09	0.78	1.22	1.09	1.17	1.34	1.04

in the price of any of these factors will not only reduce its own demand, but will also lead to an increase in the demand for the other factor. In the case of the remaining 13 industries, the substitution elasticity between labor and capital is negative, implying that in those industries the two factors are complementary to each other. In other words, a rise in the price of any of these factors will not only reduce its own demand but will also reduce the demand for the other factor as well. The magnitude of the elasticity of substitution between factors determines the range of technologies that are available to produce a given output level. The higher the value of the elasticity of substitution, the greater the possibility for producing a given level of output with different factor combinations and vice versa. A high value of elasticity of substitution is taken as an indicator of the speed of economic growth.(9) Judging by the magnitude of the estimated substitution elasticities, it is evident that the size of the elasticity is reasonably high; implying that, in general, among the manufacturing industries in Kuwait, the possibilities for producing a given level of output with different factor combinations are extensive.

The computed price elasticities of factor demand (η_{ii} and η_{ij}), reported in Table 2, are generally negative and less than unity for all the factors. This implies that, in general, other things remaining unchanged, the demands for factors of production in Kuwait's manufacturing industries are inelastic with respect to changes in factor prices. Among the three inputs, the demand for capital is the most responsive to its own price, and that of material inputs is least responsive to its own price.

The estimated coefficients with respect to output show the impact of changes in the quantity of output on factor cost shares and is referred to as 'scale effect'. In general, the coefficients, with respect to output, are negative and statistically significant. Out of the 35 manufacturing industries for which the cost function was estimated, the coefficients with respect to output in the labor cost-share equation are negative in 26 equations (and statistically significant in 21 of them), and positive in 9 equations (and statistically significant in 2 of them). In the case of capital cost-share equations, the coefficients with respect to output are negative in 29 equations (and statistically significant in 18 of them), and positive in 6 equations (and statistically significant in 2 of them). The evidence indicates that, other things remaining unchanged,

(9) For more on this issue, see de la Grandville (1989) and Yuhn (1991).

the factor cost shares vary with changes in the quantity of industrial output. In other words, in general, the production structure in manufacturing industries in Kuwait is characterized by a non-homothetic functional specification. The pattern of scale biases, as revealed by the signs of the coefficients with respect to output level, indicate that, with factor prices remaining unchanged, a rise in the quantity of output (scale operation) is expected to reduce labor and capital intensities in the manufacturing industries. This implies that the scale-effect in the manufacturing industries in Kuwait is labor- and capital-saving.

A change in the quantity of output induces changes in the number of factors demanded. The output elasticity of the i^{th} factor demand can be computed as;

$$\eta_{iy} = \alpha_{iy}/S_i + \left(\alpha_y + \alpha_{yy} LnY + \sum_i^n \alpha_{iy} LnP_i + \gamma_{yt} T\right)$$

The second term in the above expression refers to economies of scale, and is equivalent to the ratio of the marginal cost (MC) to the average cost (AC) of production. The economies of scale cannot be determined because the total cost function has not been estimated. This, however, does not pose any problem as the output elasticities of factor demands can be computed by assuming the economies of scale to be either unity or whatever is considered appropriate. For the purposes of this study, the economies of scale have been assumed to be unity.

The output elasticities of factor demands (η_{iy}), computed at mean factor cost shares, are reported in Table 2. In general, the estimated elasticities for the three factors are positive; implying that, in the absence of changes in factor prices, increases in the industrial output levels will promote employment generation and capital formation in Kuwait's manufacturing sector. The magnitude of the estimated elasticities varies across industries. In the case of labor and capital, although the estimated elasticities are generally less than unity, they are reasonably high. As for raw materials, the estimated elasticities are, in general, greater than unity. This implies that in Kuwait the demand for labor, capital, and material inputs are relatively elastic with respect to changes in industrial output.

For a cost function to be well behaved, the coefficients with respect to the trend variable (T), included to allow shifts in the cost functions due to exogenous technical change, must be negative. In other words, the cost function should be non-increasing in T. In general, the estimated coefficients with respect to the variable T are neither necessarily positive nor statistically significant. In the case of labor cost-share regression, the coefficients with respect to T are negative for 27 industries (and statistically significant in 22 cases) and positive for the remaining 8 industries (and statistically significant in 4 cases). As for the capital cost-share regression, the estimated coefficients are negative for 24 industries (and statistically significant in 8 cases) and positive for 11 industries (and statistically significant in 4 cases). For all the industries, the estimated coefficients are less than unity. The non-zero estimated coefficients imply that the production structure in Kuwait's manufacturing industries exhibits the presence of induced exogenous technical change, which is non-neutral. For the majority of the industries, the induced technical change is labor- and capital-saving.

Concluding Remarks

This paper has examined the production structure of manufacturing industries in Kuwait. This has been done by estimating translog cost functions on the basis of annual time-series data. For the majority of the industries, the cost function was increasing in factor prices, implying that increases in factor prices result in higher factor cost-shares. The estimated coefficients with respect to factor prices were less than unity, suggesting that the CD specification was not suitable for studying the production structure of manufacturing industries in Kuwait. The computed input demand elasticities showed that, in general, factor inputs were normal, implying that an increase in their prices leads to reduction in their demand, and their demands are sensitive to changes in prices.

Overall, the findings of the paper suggest that the manufacturing industries in Kuwait have no inherent mechanism that would guarantee productivity growth through adoption of newer technologies. However, authorities can use factor prices as policy instruments to induce changes in the manufacturing industries. For 22 of the 35 industries, labor and capital were substitutes to each other, implying that a rise in the price of any one of the factors not only reduces its own demand but also increases demand for the other factor. This suggests that the authorities can use factor prices as policy instruments to bring about desired changes in the production structures of manufacturing industries in Kuwait. For instance, using price of labor as a policy instrument will not only help control expatriate demand, but will also induce more demand for new capital. As productivity gains are embodied in new capital, this will further lead to an increase in the rate of productivity growth.

The estimated coefficients with respect to output showed that, other things remaining unchanged, changes in industrial output levels affect factor cost-shares for the majority of the industries. In other words, the production structure of manufacturing industries in Kuwait is characterized by their scale of operation. The pattern of scale bias, as revealed by the sign of the coefficients, was labor- and capital-saving. In the absence of changes in factor prices, labor and capital intensities of the industries are expected to decline with increases in output over time. As decline in capital intensity is likely to adversely impact productivity gains, the authorities can use factor price instruments to offset such adverse effects.

The elasticities of factor (i.e., labor, capital, and raw materials) demand with respect to industrial output were generally positive and reasonably high, implying that, in the absence of changes in factor prices, increases in industrial output promote employment generation, capital formation, and create demand for output from other industries (raw materials) through backward and forward linkages. In other words, by promoting demand for industrial outputs the authorities can help create jobs and capital formation in the country. Finally, the evidence presented in this study showed that the production structure in Kuwait's manufacturing industries exhibits the presence of induced exogenous technical change, which is non-neutral. For the majority of the industries, the induced technical change was labor- and capital-saving. In other words, there appears to be no built-in mechanism in the industries to promote new capital investment, which is not good for the long-run growth and competitiveness. By using factor prices as policy instruments and providing appropriate incentives, the authorities can promote adoption of new technologies in the industries.

JEL Classification: D24 *

The author is Senior Research Scientist in the Techno-Economics Division at the Kuwait Institute for Scientific Research. This paper has benefited from helpful comments from anonymous referees of the journal. The author alone, however, is responsible for any remaining errors.

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الملخص

بدائل عوامل الإنتاج في الصناعات التحويلية في دولة الكويت

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تمت دراسة هيكل الإنتاج في الصناعات التحويلية في دولة الكويت مع التركيز على بدائل عوامل الإنتاج، وذلك عن طريق تقدير دراسة الإنتاج (trans-logarithmic) باستخدام سلسلة بيانات سنوية. وقد بينت النتائج أن هيكل الإنتاج غير متجانس وأن نمط تأثير الحجم هو توفير في العمالة ورأس المال ومزيد من استخدام المواد الأولية، كما تؤيد الأدلة وجود تغير تكنولوجي خارجي ضمني يكون له تأثير من خلال توفير العمالة ورأس المال. وقد أوضحت الدراسة أن مرونة الإبدال بين رأس المال والعمالة موجبة بالنسبة لمعظم الصناعات، وهو ما يعني أن رأس المال والعمالة بديلان.

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