A PRODUCTION COST INDEX FOR THE BARBADOS MANUFACTURING SECTOR

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1 INTRODUCTION

Previous studies of the manufacturing sector in Barbados indicate that this sector has made a significant contribution to output, employment and foreign exchange earnings [see Cox, 1982; Downes, 1985; Howard, 1991]. In 1970, the sector accounted for 10.1 percent of gross domestic product (GDP) at factor costs; 13.4 percent of total employment as measured in the population census and 34.6 percent of total domestic exports. By 1993, the sector's contribution to output and employment had dropped to 7.6 percent and 10.4 percent, respectively. The sector's contribution to domestic exports has however increased significantly, reaching a peak in the mid-1980s due to the growth of the electronic components sub-sector. After a dramatic decline in exports of electronic components in 1987, the exports of the sector recovered to contribute 81.4 percent of total domestic exports in 1993 [see Table 1].

Although a significant percentage of total sales of manufacturing output occurs in the domestic market, there has been a gradual increase in export-oriented manufacturing production. In the 1960s and 1970s, fiscal incentives to manufacturers resulted in manufacturing growth being propelled by domestic demand expansion and import substitution [see Downes, 1985]. Studies showed that there was a high rate of effective protection in the manufacturing sector resulting in an anti-export bias [see Whitehall, 1984; Maxwell Stamp Report, 1991]. Over the past decade, the government has made some attempt to encourage manufacturers to export to both regional and extra-regional markets. Trade missions have been organised and tax concessions have been granted to export-oriented companies.

In targeting the export markets, manufacturers must be able to monitor their cost of production since this factor has an important bearing on the degree of price competitiveness. For example, one indicator of price competitiveness is real unit labour cost (RULC) which can be specified as the ratio of the real product wage to labour productivity. This indicator has become a popular index of competitiveness primarily because labour cost (basic wage/salary plus other labour related payments) has been perceived as the key component of total production cost. Policy implications usually involve increasing labour productivity and/or restraining nominal wage/salary increases, so that the RULC of a country can keep in line with its competitors. There are several dimensions of the competitiveness issue, with price being only one factor. Furthermore, there are other components of cost other than labour cost which have a bearing on price. For example, a study on manufacturing cost in Barbados in 1985 indicates that the cost of raw materials accounted for 46.4 percent of total cost, while direct labour cost accounted for 17.2 percent [see BIDC, 1985].

Since the cost of production is an integral part of the competitiveness equation, it is desirable to develop a system whereby the components of the cost of production can be monitored over time. One way of monitoring the cost of production is through the development of a production cost index.

The purpose of this paper is to examine the principles underlying the development of a production cost index for the manufacturing sector of Barbados. This paper forms part of an ongoing study which involves the calculation of such an index. In section 2, the principles underlying a production cost index are examined. These principles not only guide the construction of the index but also aid in its interpretation. In section 3, some preliminary data on produciton cost in the manufacturing sector are provided. The final section outlines the future development of the research project.

2 THEORETICAL BACKGROUND

There is now a vast literature on the construction of index numbers [see, for example, Samuelson and Swamy, 1974; Diewert, 1981]. Although Court and Lewis (1942/43) have outlined the theoretical principles governing the construction of production cost indices, there has been little empirical work on these indices. Researchers and statisticians have focussed on the construction of employment cost indices rather than broader production cost indices.

A production cost index measures the relative change in the average or unit cost of production over time. There are several different approaches to the construction of production cost indices. First, there is the statistical approach associated with Jevons and Edgeworth. Production cost indices are considered as one kind of average of an universe of cost changes over time. Therefore, the average level of production cost in period 2 relative to period 1 can be given as the arithmetic average of period 2 cost relative to the arithmetic average of period 1 cost.

Second, the axiomatic or test approach associated with Fisher posits a number of properties or tests which an index number formula should satisfy. There are nine tests which a formula should satisfy; identity, proportionality, invariance to changes in scale, invariance to changes in units (commensurability), symmetric treatment of countries or time (reversal), symmetric treatment of commodities (commodity reversal), monontonicity, mean value and circularity.

Third, the economic theory approach associated with Konus, Malmquist, Leontief and Theil. This approach is based on the assumption that the economic unit (firm, household) seeks to optimize an objective function subject to a set of constraints. The economic approach to index number construction permits a closer integration of economic theory and statistical analysis. For example, Court and Lewis (1942/43) define a production cost index as "the ratio of the minimum cost of maintaining a given production level complex under a final (altered) price regime, advantage being taken of every economy permitted by the entrepreneur's unchanging production-function constraint, to the minimum cost of maintaining the same production level complex under the initial price regime" (p. 30). The final index can be calculated in either ratio or difference form. In addition, the index can be measured over discrete time or continuous time (i.e., the Divisia approach).

The economic theory approach to index number construction permits the derivation of specific index number formulae from different functional forms of the objective (aggregator) function. In such cases, the index number is said to be exact, that is, the approximation error is zero. For example, the commonly used Laspeyres index is exact for a Leontief (fixed coefficients) objective function [see Table 2]. This means that the use of a Laspeyres production cost index assumes that the Leontief fixed technical coefficients production function adequately reflects the production technology in the manufacturing sector. This index, however, suffers from a 'substitution bias' in that the use of constant (base period) weights does not take into consideration the increase in production obtained by substituting inputs which have become relatively cheap in the current period for those which have become relative more expensive. In effect, it overestimates production cost changes. Diewert (1976) has introduced a class of superlative index number formulae. An index number functional form is said to be superlative if it is exact or consistent with a 'flexible' aggregator or objective function form which approximate to the second order of an arbitrary functional form (i.e., via a Taylor expansion). The Tornqvist and Fisher 'ideal' indices are regarded as superlative.

Superlative index numbers such as the Tornqvist and Fisher 'ideal' indices are preferable to Laspeyres and Paasche indices since the latter indices are derived from a restrictive fixed coefficients (Leontief) functional form, while the former indices are exact for more flexible functional forms (i.e., a second order approximation to an arbitrary functional form - translog function form).

The formal derivation of a production cost index can be shown using a single output-multi input firm which seeks to minimize the production cost associated with reaching a production (output) target.

Let the production function of the firm be

$$q = q(x) \quad (1)$$

where q is a single valued output and x is a vector of inputs.

The cost function can be specified as

$$C(q, R) = R.X \quad (2)$$

where R is a vector of input prices or unit costs and X is a vector of inputs.

The producer's problem is to minimize the cost of producing a target output level, q*. The solution to this problem defines the cost function, C

$$C(q, R) = \min_{X} \left[R.X;\ q(X) \geq q^*,\ X \geq 0\right] \quad (3)$$

If q(x) if continuous, increasing, concave and linearly homogeneous, then the cost function is given as

$$C(q, R) = q.c(R) \quad (4)$$

where c(R) is the unit (average) cost function corresponding to the aggregator (production) function q(X).

The general formulation can be used to develop various index number formulae. For example, the Konus production cost index, K, is given as

$$K(R^0, R^1, X) = C[q(X), R^1] / c[q(X), R^0] \ldots \quad (5)$$

where R^0 and R^1 are vectors of input prices or unit costs in period 0 and period 1, respectively. [The two input case is given in the appendix]. Equation (5) shows the minimum cost of producing q(X) given an input price (unit costs) vector in period one, R^1, relative to the miminum cost of producing the same quantity when input prices are R^0, that is, on the same isoquant [see Figure 1].

The properties of the production cost index are therefore determined by the properties of the aggregator (objective) production and cost functions.

The Laspeyres type production cost index is given as

$$L(R^0, R^1, X^0) = R^1.X^0 / R^0.X^0 \quad (6)$$

Alternatively, it can be specified in more familiar terms as

$$L(r_{io}, r_{it}, X^o) = \sum_i w_{io} \frac{r_{it}}{r_{io}} \times 100 \quad (7)$$

where $w_{io} = \frac{r_{io}X_{io}}{\sum r_{io}X_{io}}$, that is, the cost share associated with a production level q* in the base period and r_{io} and r_{it} are the unit cost of the ith input in the base period and the current period, respectively and x_{io} is the quantity of the ith input purchased and used in the base period.

The Paasche type production cost index is given as

$$P(R^0, R^1, X^1) = R^1.X^1 / R^0.X^1 \quad (8)$$

where current period input quantities, X^1, are used as weights.

As indicated earlier, the underlying aggregator (production) function for these index number formulae is the Leontief (fixed coefficients) functional form which may be a weak reflection of the production technology in the manufacturing sector.

Divisia type indices are obtained by cumulating the rate of change in the values of an index of unit cost changes, that is, it is based on a line integral such that the change in the value of the unit cost of production between any two points is dependent on the path of integration. This path dependence requirement means that the Divisia integral index

(i) makes use of the information between the base period and the given period

(ii) considers the path of the unit cost of production and quantity of inputs purchased and used.

Since Divisia index numbers are based on continuous time, approximations for discrete time are needed. One such approximation is the Tornqvist-Theil index formula which is given as:

$$T.T.D.(r_{io}, r_{it}) = \ln C_t - \ln C_{t-1} = \sum_i w^*_{it}(\ln r_{it} - \ln r_{i,t-1}) \quad (9)$$

where the weighting factor, $w^*_{it} = \frac{1}{2}[w_{it} + w_{i,t-1}]$, that is, the arithmetic average of the cost shares of each input in each of the two period for which the rate of change is computed.

Divisia type indices (eg, Tornqvist-Theil approximation) have the following features:

(i) weights can be adjusted continuously over the time period

(ii) they provide the justification of chain index numbers so that they can be related to the Laspeyres and Paasche indices by using first difference approximations (i.e., the chain Laspeyres and Paasche index numbers)

(iii) they possess the property of 'invariance' or accurancy, that is, the reduction of errors of approximation as one moves from one state to another as the weights are changed continuously

(iv) if the underlying aggregator (production) function is homothetic (i.e., a monotonically increasing function of a linear homogenous function), then these indices will be independent of the path of integration

(v) where the path is non-homothetic, then 'superlative' index numbers can be developed and are consistent with a second-order approximation to a linear homogeneous function.

Although the data demands for the construction of Divisia indices are slightly greater than Laspeyres and Paasche indices, the flexible production technology underlying Divisia indices make them 'superior' to fixed weighted indices.

The analysis in this paper has been undertaken using a single output-multi input situation. It can easily be extended to the multi output - multi input case using Hall's aggregation approach (Hall, 1973).

3 AN ANALYSIS OF PRODUCTION COST

In producing and selling a good, a manufacturer normally faces the following costs:

(i) overheads

(ii) raw materials

(iii) direct labour (production workers)

(iv) general and administrative

(v) selling and distribution

Overhead costs usually consist of rent, electricity and other utilities, depreciation, supplies and miscellaneous expenditures. General and administrative costs are made up of executive and office salaries, interest and financial charges, research and development and related expenditure.

The scale of the impact of changes in a specific cost element on overall production cost may vary from firm to firm and from sub-sector to sub-sector in the manufacturing sector. In a study undertaken by the Barbados Industrial Development Corporation (BIDC, 1985), raw material costs were the single most significant factor in the production process [see Table 3]. Raw material costs accounted for 46.4 percent of overall production costs followed by direct labour costs which accounted for 17.2 percent. Selling and distribution costs were the smallest component of overall production costs.

The findings of this 1985 survey provided an important insight into the nature of manufacturing costs in Barbados. The results give some idea of the relative importance of various cost components in overall production costs. Data from the annual Survey of Industrial Establishments also proivide additional evidence on the distribution of production costs since 1985. Raw material costs accounted for over 40 percent of total production costs during the period 1985-1993. Direct labour costs varied between 11.1 and 13.6 percent of production costs, while indirect labour accounted for approximately 5 percent of total costs
[see Table 4]. The data indicate a general increase in the general and administrative cost component, from 18.8 percent in 1985 to 28.1 percent in 1993. Both the contributions of total labour costs and overhead costs declined during the period. In general, the data would suggest that the manufacturing sector in Barbados is highly import dependent since most of the raw materials used in the production process is imported (i.e., non-competing imports).

There is some intra-sectoral variation in the distribution of costs. Food products, wearing apparel, industrial chemicals, metal products, machinery and miscellaneous sub-sectors have high proportions of direct materials costs. Labour costs are relatively important in textiles, wearing apparel, wood products and furniture, equipment and machinery [see table 5]. Overhead costs are significant in the industrial chemicals and non-metallic mineral products.

The data suggest that a fixed base year weighted index such as the Laspeyres production cost index may be inappropriate for monitoring production costs in the manufacturing sector given the intertemporal changes in the relative importance of different cost components. In addition, econometric results on the nature of the production function over the 1970-1977 period suggest that the Leontief production function, with a zero elasticity of input substitution, does not hold for the manufacturing sector (see Downes, 1987; Table 2). The elasticity of input substitution lay between zero and unity, suggesting a more flexible production functional form is appropriate. The Tornqvist-Theil approximation of the Divisia index may therefore form the basis of a more appropriate production cost index.

4 FURTHER RESEARCH

The proposed production cost index for the Barbadian manufacturing sector will include the following costs:

(i) raw materials and other supplies

(ii) wages, salaries and other labour costs

(iii) fuel, electricity, water and sewerage, telephones and telefax

(iv) rental of buildings

(v) selected components of general and administrative costs

Unit cost data will be collected bi-annually, while the weights for the index will be based on data from the Survey of Industrial Establishments. Both Laspeyres and Tornqvist-Theil-Divisia indices will be calculated. The use of the former index involves the identification of a 'normal' period (year).

Although the index is based on accounting data, there will be a need to examine the economic costs of production' at a later stage. Several enterprises in the manufacturing sector benefit from duty-free and other fiscal concessions which tend to depress production costs. It might therefore be necessary to make adjustments to such cost components (i.e., shadow costing) to obtain an idea of the underlying production costs. Some enterprises in the sector are housed in BIDC-provided space at subsidized rates. Of special interest in this class would be foreign-owned enclave firms whose production cost structures are, to a large extent, determined by the head office. Many of these enterprises receive raw materials and supplies and other inputs on transfer from parent or sister establishment. Such transfer pricing tends to distort the underlying economic costs of production. A specific index may have to be calculated for this class of enterprises or adjustments made to the index for these enterprises.

The proposed production cost index can be taken as an indicator or the 'cost of doing business' in the manufacturing sector of Barbados. The calculation of a Divisia type index (or a chain Laspeyres index) would accommodate changes in the relative importance of cost components and hence changes in the 'cost of doing business' as the business environment and production technology changes over time.

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APPENDIX 1

PRODUCTION COST INDEX: ONE OUTPUT-TWO INPUT CASE

Let the total cost function of the production unit be

$$C = r_1X_1 + r_2X_2 \quad (1)$$

where r_1 and r_2 are the unit cost (price) of inputs, X1 and X2, respectively.

The production function for a single-output producer is given as

$$q = q(X_1, X_2) \quad (2)$$

Assuming that the production unit seeks to minimize production cost, equation (1), subject to the production target given as q^*, then the first order conditions are

$$r_1 = \lambda q_1(X_1, X_2) \quad (3)$$

$$r_2 = \lambda q_2(X_1, X_2) \quad (4)$$

$$q^* = q(X_1, X_2) \quad (5)$$

where λ is the Lagrangean multiplier and q1 and q2 are the marginal productivities associated with inputs X_1 and X_2, respectively.

Solving for X_1, X_2, λ (i.e., the marginal cost of production), we have the following functions (i.e., input demand for X_1 and X_2):

$$X_1^* = X_1^* (r_1, r_2, q^o) \quad (6)$$

$$X_2^* = X_2^* (r_1, r_2, q^o) \quad (7)$$

$$\lambda^* = \lambda^* (r_1, r_2, q^o) \quad (8)$$

Substituting the optimal values of X_1 and X_2 into the cost equation (1), we obtain the cost function

$$C^* = r_1 X_1^*(r_1, r_2, q^o) + r_2, X_2^* (r_1, r_2, q^o) \quad (9)$$

that is,

$$C^* = C^*(r_1, r_2, q^o) \quad (10)$$

that is, the minimum cost associated with the production target, q^o.

If the cost function (10) is linear homogeneous with respect to $u = 1/q^o$, then we have a unit (average) cost of production function associated with the production target, that is,

$$c^* = C^*/q^o = c^*(r_1, r_2) \quad (11)$$

The production cost index is given as

$$c_t^* / c_o^* = c^*(r_{1t}, r_{2t}) / c^*(r_{10}, r_{20}) \quad (12)$$

The cost function (10) depends on the underlying production function (2), hence the production cost index (12) also depends on the nature of the production technology.

APPENDIX 2

COMPONENTS OF MANUFACTURING COST

Group Cost	Items included from SIE Questionnaire
Direct Materials	Purchases of Raw Materials Plus (Closing Stock less Opening Stock) of Raw Materials and other supplies
Manufacturing Overheads	Electricity, water, Fuel, Rent, Insurance, Technical/Consultancy fees, Depreciation, Purchases of other supplies
Selling and Distribution	Commissions, Advertising and Sales Promotion, Freight, Local and Overseas Travel
General and Administrative	Repairs and Maintenance, Payments for Contract Work, Staff Training, Stationery and Office Supplies, Telephones, Interest and Bank Charges, Audit Services, Management/Head Office expenses, Bad debts, Indirect Taxes, Other operating costs
Direct Labour	A proportion of total labour cost. The proportion used is the ratio of the number of production workers to the number of total employees.
Indirect Labour	The difference between the total labour cost and the estimate for direct labour. This should have been added to the General and Administrative Costs.

[Extracted from surveys of Industrial Establishments (SIE)]

Table 1

THE CONTRIBUTION OF THE MANUFACTURING SECTOR TO GDP, EMPLOYMENT AND DOMESTIC EXPORTS 1970 - 1993 (%)

	Contribution To		
Year	**GDP at Factor Cost**	**Employment**	**Domestic Exports**[b]
1970	10.1	13.4	34.6
1975	10.3	15.2[a]	37.9
1980	11.9	15.0	64.6
1985	10.6	13.0	87.4
1990	8.0	11.3	75.9
1993	7.6	10.4	81.4

Notes: [a] This figure is for the period October-December 1976
[b] includes rum exports

Sources: (i) Barbados Economic Report 1979, 1983
(ii) Central Bank of Barbados: Annual Statistical Digest 1994
(iii) Downes (1985)

Table 2

INDEX NUMBER FORMULAE AND ALTERNATIVE PRODUCTION FUNCTIONS

INDEX NUMBER FORMULA	EXACT PRODUCTION FUNCTION
1. Laspeyres Index	Leontief (Fixed Coefficients)
2. Paasche Index	Leontief (Fixed Coefficients)
3. Fisher's Ideal Index	The Square Root of a Quadratic Functional Form
4. Geometric Index	Cobb Douglas function
5. Tornqvist-Therl-Divisia Index	Linear Homogeneous (homothetic) Translog functional form
6. Sato-Vartia Index	Homothetic Constant Elasticity of Substitution Functional Form

Table 3

THE DISTRIBUTION OF PRODUCTION COSTS (1985)

COST COMPONENT	PERCENT (%)
Raw Material	46.4
Direct Labour	17.2
Overheads	14.1
Selling and Distribution	7.3
General and Administrative	15.0
TOTAL	100

Source: BIDC (1985)

Table 4

THE DISTRIBUTION OF PRODUCTION COSTS 1985 - 1993*
(%)

Year	Raw Materials	Total Labour Costs	Over-heads	Selling & Distribu-tion	General & Administra-tive	Total
1985	42.8	19.1	16.1	3.2	18.8	100
1986	41.3	19.3	17.6	3.0	18.8	100
1987	43.5	19.3	15.4	2.8	19.1	100
1988	41.9	19.5	16.7	2.9	19.1	100
1989	44.5	17.9	14.3	2.6	20.6	100
1990	49.6	16.8	10.5	2.8	20.4	100
1991	45.7	17.0	11.4	2.7	3.2	100
1992	41.5	16.6	10.8	3.5	27.6	100
1993	43.3	15.2	10.5	2.8	28.1	100

Source: Barbados Statistical Service: Survey of Industrial Establishments

*The definition of different cost components is given in Appendix 2.

FIGURE 1.

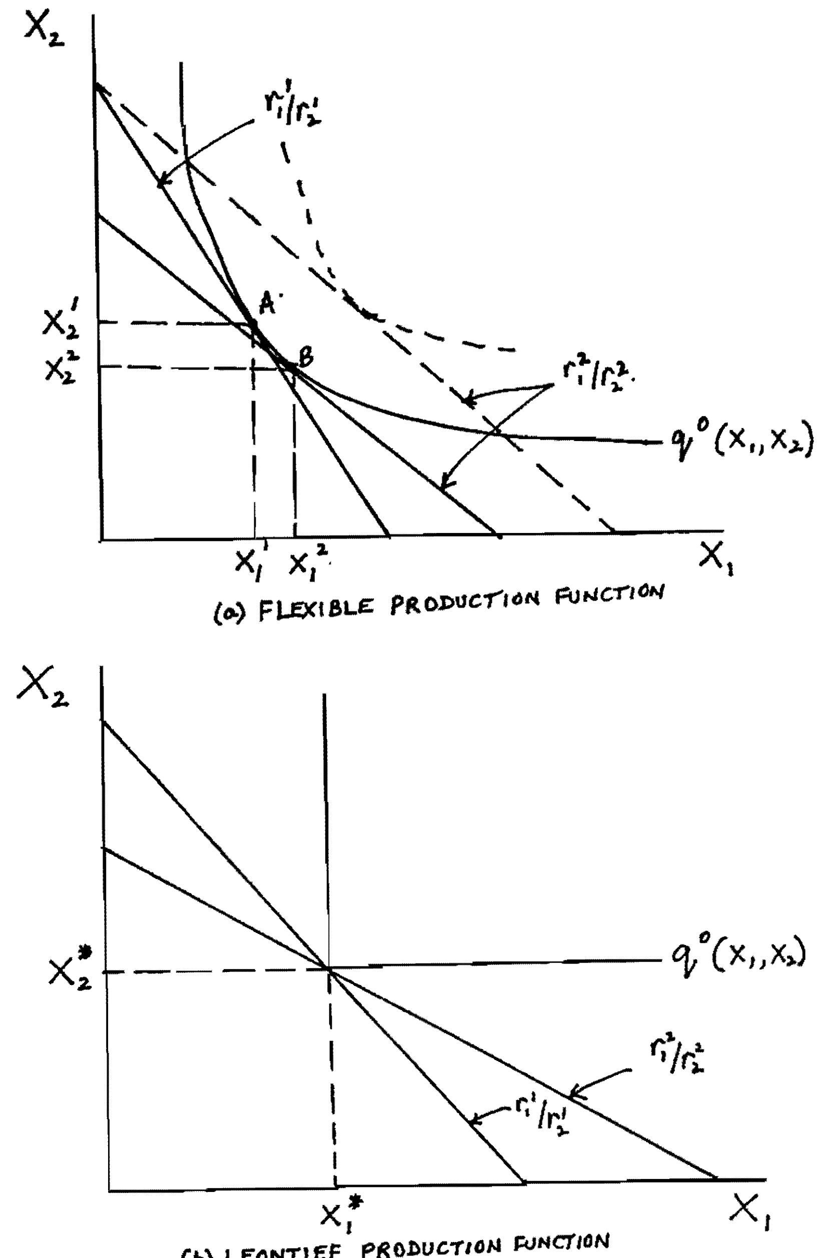

Table 5: THE DISTRIBUTION OF PRODUCTION COSTS BY SUB-SECTOR
1985, 1993 (%)

SUB-SECTOR	Raw Materials		Labour Costs		Overheads		Selling & Distribution		General & Administration	
	1985	1993	1985	1993	1985	1993	1985	1993	1985	1993
Food Products	49.9	57.3	17.3	15.7	19.5	13.0	1.7	2.4	11.6	11.5
Beverages/Tobacco	27.1	31.7	20.3	17.8	19.4	14.5	3.9	6.0	29.3	30.0
Textiles	30.8	52.4	32.3	26.1	18.1	7.2	4.9	2.3	13.9	12.1
Wearing Apparel	43.1	19.5	35.5	52.7	8.6	11.0	3.0	1.7	9.7	15.1
Furniture/Wood Products	37.4	58.3	31.0	16.8	12.2	7.5	4.1	1.5	15.3	15.8
Printing/Paper Products	36.4	27.8	29.2	40.3	11.9	14.1	4.8	4.2	17.6	13.6
Industrial Chemicals	61.3	37.4	5.3	5.6	5.3	4.8	1.3	0.9	26.8	51.3
Other Chemicals	43.7	47.9	16.0	8.8	20.3	22.3	6.7	7.3	13.3	13.7
Non-metallic Minerals	17.7	32.0	17.0	23.5	33.6	19.1	7.0	1.4	24.7	24.1
Metal Products	53.8	59.3	19.1	15.5	9.7	8.4	3.1	4.8	14.3	11.9
Equipment	17.2	41.8	44.1	24.4	23.9	9.3	4.2	3.1	10.5	21.4
Machinery	38.8	60.9	30.5	24.7	11.6	4.3	3.1	2.2	16.0	7.9
Other Products	54.6	39.5	19.0	17.3	9.8	17.6	3.0	5.0	13.7	20.6
Overall	42.8	43.3	19.1	15.2	16.1	10.5	3.2	2.8	18.8	28.1

Source: B.S.S.: Survey of Industrial Establishments 1985, 1993.