Size and Efficiency: the Case of the Irish Plastics Industry*

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I INTRODUCTION

INTERNATIONAL evidence has suggested that plant or firm size does not significantly affect efficiency in the plastics processing industry; this has led to the generalisation that small firms can be economically viable in the processing of plastics.[1] The aim of this paper is to examine such hypotheses within the context of the Irish Plastics Industry, i.e., to consider the effect of firm size on productive efficiency. The conclusion of our investigation is that output composition and factor mix are more important in explaining efficiency than the scale of output.

Irish plastics is essentially a processing industry, there being little, or no, production of polymers, and is for the most part organised on a small scale basis. Until recently, there has been no separate classification for plastics in the Irish industrial census. The information upon which this study is based had therefore to be gathered from questionnaires and interviews via a sample survey (described in the appendix). The sample consisted of 42 firms out of a total of 160 firms which comprised the Irish Plastics Industry in 1973. Nine of the sample firms had to be omitted because of inadequate data, so that the inter-firm efficiency comparison pertains to 33 firms. The results of the survey are set out in Table 1 for the individual firms.

The plan of the paper is as follows. Section II defines the concept of efficiency, the various indicators of efficiency, and the data used in their estimation. Section III analyses some principal characteristics of the sample firms, and in Section IV, single factor indicators of productivity are discussed. In Section V we turn to analysing the size-efficiency relationship by using the total factor productivity index as an indicator of overall efficiency; in Section VI a regression equation to test for internal economies of scale is fitted to the data for all 33 firms. A discussion concerning the identification of the more efficient size class of firm is to be found in Section VII; a concluding section then follows.

1. See, for example, OECD (1969), Pratten (1971), UNIDO (1969), Monographs 3 and 4.

Table 1: *Principal results of survey of 33 Irish firms in 1973*

L Employment force (number)	G Gross output (£'000)	M Cost of materials (£'000)	V Value added (£'000)	W Wages and salaries (£'000)	GP Gross profit (£'000)	TA Total assets (£'000)	FA Fixed assets (£'000)	S Stocks (£'000)
Small								
3	15·0	7·0	8·0	3·0	5·0	19·5	15·0	2·5
7	75·0	35·3	39·7	5·6	34·1	35·7	22·1	13·6
8	36·0	14·2	21·8	5·9	15·9	13·1	4·8	8·3
8*	40·0	18·8	21·2	12·0	9·2	27·0	20·0	6·0
10	22·0	10·3	11·7	9·0	2·7	23·7	22·0	1·7
11	28·0	1·6	26·4	7·0	19·4	9·8	5·8	1·5
12*	120·0	56·4	63·6	26·0	37·6	60·0	18·0	24·0
13	45·0	26·4	18·6	10·0	8·6	61·5	60·0	1·5
15	62·0	29·1	32·9	29·0	3·9	34·0	25·0	7·0
19*	150·0	70·5	79·5	51·0	28·5	114·0	92·0	20·0
Medium								
22	72·0	33·8	38·2	10·0	28·2	20·0	6·0	14·0
22*	240·0	112·8	127·2	52·0	75·2	200·0	170·0	30·0
25	176·0	87·1	88·9	43·0	45·9	36·8	20·5	15·0
25*	100·0	47·0	53·0	50·0	3·0	69·0	54·0	12·0
30	250·0	117·5	132·5	30·0	102·5	250·0	200·0	45.0
30	160·0	75·2	84·8	45·0	39·8	149·0	90·0	48·0
35*	850·0	399·5	450·5	70·0	380·5	250·0	90·0	160·0
35*	250·0	117·5	132·5	60·0	62·5	532·0	130·0	137·0
40	600·0	250·0	350·0	100·0	250·0	356·3	197·4	58·9
43	270·0	45·0	229·5	44·0	185·5	249·0	155·0	14·0
45	450·0	350·0	100·0	85·0	15·0	174·0	96·0	75·0
45	150·0	70·5	79·5	60·0	19·5	68·0	52·0	14·0
49*	254·0	119·4	134·6	87·0	47·6	138·0	76·0	60·0
Large								
55	96·0	34·6	61·4	35·0	26·4	150·0	18·4	75·3
62	700·0	371·0	329·0	70·0	259·0	368·9	125·5	81·1
65*	350·0	164·5	185·5	100·0	85·5	100·0	70·0	30·0
68	493·9	254·5	239·4	52·3	187·1	145·1	33·9	81·3
70*	1,000·0	470·0	530·0	120·0	410·0	823·0	370·0	350·0
75	500·0	275·0	225·0	100·0	125.0	640·0	384·0	65·0
105	1,150·0	690·0	460·0	183·0	277·0	726·6	667·0	59·6
110	1,200·0	533·0	667·0	178·7	488·3	516·7	284·8	122·3
120*	300	141·0	159·0	120·0	39·0	450·0	200·0	250·0
130	2,500·0	1,550·0	950·0	195·0	755·0	1,057·0	552·0	415·0

Source: Based on questionnaire replies from the individual firms. Each of the variables has been defined in the text.

*The value of the cost of materials as a percentage of Gross output for firms marked thus has been assumed as 47·0% (see Text).

II THE CONCEPT OF EFFICIENCY

1. ALTERNATE DEFINITIONS OF EFFICIENCY

A number of definitions of efficiency exist. For the shareholders, the firm is efficient if it yields a sufficiently high rate of return on their capital. To the production engineer, it is the actual level of output produced in relation to the maximum possible output of a given combination of resources. As R. J. Ball (1968) has stated, the search for a single index to measure success and efficiency of an enterprise is deficient in principle. Firms have multiple objectives. No single index is thus likely to reflect the extent to which a given firm is realising its objectives of maximising the rate of return on capital, productivity of labour and minimising the use of resources. Thus a set of alternative measures have been developed to facilitate inter-firm efficiency comparisons (see Dunning and Rowan (1968)) for a detailed discussion. In the present exercise we propose to measure the relative productive efficiency of different size groups of firms by the ratio of output of goods and services to the total input of resources used in their production.

2. INDICATORS OF PRODUCTIVE EFFICIENCY

The most commonly employed indicators of productive efficiency are labour productivity, capital productivity and total factor productivity. In addition, an index of capital intensity and an index of profitability are also estimated.

(a) Partial Measures of Efficiency

Utilising the code letters at the head of Table I, two indices of labour productivity, one in terms of value added per employee (V/L) and another in terms of value added per unit of total labour cost (V/W) are estimated. The use of the total wage bill (W) as a proxy for the number of employees is justified on several grounds. Dunning and Brown (1967) point out that employing the wage bill would be equivalent to using the number employed if the wage rates are invariant between firms. But wage rates do vary between firms within the same industry. If it is assumed that firms in general pay their employees a wage rate equivalent to their marginal product, then inter-firm wage differentials would reflect differences in the efficiency of the labour force. This may not always be true. One firm may pay an average wage per employee greater than the other for reasons unrelated to their efficiency. Further, as there are various constraints on the mobility of labour both between firms and areas some workers may be paid more than their opportunity costs and others may earn less than they could elsewhere. Nevertheless, the assumption that differences in wage rates reflect differences in labour efficiency may be accepted as a first approximation. Given this assumption the use of the wage bill, instead of numbers employed, may be preferable in analysing labour productivity differentials by size of firm.

The two indicators of capital productivity estimated in this exercise are the value added per unit of total assets (V/TA) and value added per unit of fixed assets (V/FA). The capital variable (TA) represents the sum of total fixed assets

(i.e., land, building, plant and machinery), gross of depreciation, and total working capital (i.e., stocks and inventories). The value of capital as reported in the balance sheet of the firms is the book value of assets. This measures capital at historic prices and not in terms of current replacement costs. Capital thus measured is unrepresentative of the real capital employed by the firms.

Three indicators of capital intensity are estimated, namely, (i) the ratio of total assets to number of employees (TA/L), (ii) the ratio of fixed assets to number of employees (FA/L) and (iii) the ratio of total assets to total wage bill (TA/W). The three indices represent respectively total capital per employee, fixed capital per employee, total capital per unit of labour cost.

The gross value added represented by (V) is defined here as the value of gross output less the cost of materials and fuels used. Eleven of the 33 sample firms did not give us the figures on value added. Thus we had to adopt a somewhat arbitrary procedure to estimate the value added figures for these firms. We calculated the value of cost of materials as a percentage of gross output for each of the 22 firms from different size groups who gave us both the figures. An average of these—47 per cent—was then used to arrive at the value added figures for the remaining 11 firms.

Though arbitrary, the above method is not altogether indefensible. The value of average material content of the products produced by the Irish plastics industry in 1973 was around 50 per cent (PIA, (1974)). The average of the percentages used also corresponded roughly with the value of cost of materials as a percent of gross output (46 per cent) in the US plastics products industry in 1972 (US Dept. of Commerce, (1972)). Thus given the type of products produced, the average used here appears to be broadly representative of the average material content in gross output of the plastics products industry in Ireland and elsewhere.

Our measure of value added being inclusive of depreciation is not ideal, but has a positive advantage. It avoids the problems involved in the calculation of depreciation that results from the differences in the accounting procedure between the large and the small-scale enterprises.

An index of gross profits per unit of gross total assets (i.e., GP/TA or $(V-W)/TA$) is estimated in order to assess the relative earning capacity of the firms of different sizes.

(b) Measure of Overall Efficiency

The efficiency indicators discussed above are partial measures and are, therefore, inadequate as measures of overall business performance. The use of any one of them in isolation may lead to misleading conclusions. To circumvent the problem, an index of total factor productivity (TFP) or overall efficiency is usually estimated.

The total factor productivity index estimated here is the gross value added per unit of total cost. The method followed in estimating the TFP index is that adopted by Dunning & Rowan (1968), Krishna & Mehta (1968) and Mukerji (1962). Dunning calls a variant of the TFP index an index of social efficiency and estimates it by using the reciprocal of an expression similar to the following:

$$z = \frac{wL + qK}{Q}$$

where z = index of social efficiency or total cost per unit of output
w = money wage rate
L = labour input
K = value of capital
Q = gross value added
and q = social cost of capital

q, the social cost of capital is defined as the opportunity cost of capital and is approximated by the minimum rate at which enterprises can borrow or the highest gross profits that can be earned on total assets.

In estimating the *TFP* for various size groups of firms we follow the above procedure. The average rate of return on capital, r, (15·5 per cent) earned by the firms in the Irish plastics industry in 1973 is employed to denote the opportunity cost of capital faced by the firms. This is the reported average rate of return earned on capital by the majority of the firms covered in the PIA survey of 1973 (PIA (1974) p. 44). The *TFP* index is estimated by using the following expression:

$$TFP = \frac{V}{wL + TAr}$$ or gross value added per unit of total cost.

(c) Measure of Size of Firms

A final problem encountered in the discussion of the size-efficiency relationship is that of finding a commonly agreed criterion for measuring the size of firms. Traditionally, size refers to scale of output and is defined in economic terminology as the scale of operation. As is well known, all available measures of size are deficient (see, Bates, 1965). Hence, admitting the obvious difficulties, "number of persons employed" is used as the measure of size in the present exercise.

III THE PRINCIPAL CHARACTERISTICS OF THE SAMPLE FIRMS

For analytical purposes, the firms are divided into three size categories: small (with 1 to 19 employees); medium (with 20 to 49 employees); and large (50 or more employees). While the Irish plastics industry had on average 50 employees per firm, nearly one-third of the total of 151 firms employed less than 10 people and only one-tenth had more than 100 persons in 1969 (McNamara & Sainsbury 1969). Such predominance of firms, with less than 50 employees in the plastics processing industry is, in fact, a world-wide phenomenon (McNamara & Sainsbury 1969, pp. 22–23, UNIDO, p. 10). Thus our classification of the firms with 20 to 49 people as medium-sized firms appears representative of the firms size in the Irish plastics industry. Table 2 shows the distribution of the sample firms by size.

Table 2: *Distribution of the sample firms by size*

Employees (No.)	No. of firms in each size	% of firm in each size	Average age of the firms
1 to 19	10	30·3	11·9
20 to 49	13	39·4	14·1
50 and more	10	30·3	18·8
Total Sample	33	100	14·9

Source: Author's Survey.

Strictly speaking, for an analysis of inter-firm efficiency, it is crucial that firms in various size groups be similar in terms of products produced, markets served and input prices they pay. In practice, differences between the firms in these respects are considerable.

Both intra-firm and inter-firm product heterogeneity is a marked characteristic of the sample firms. Only 9 of the 33 firms (Table 3) produce a single product and while the majority of firms produce more than two different products, some even manufacture more than eight products.

Table 3: *Firms classified by number of products produced*

Size Groups (No. of employees)	1	2	3	4 and more	All
1–19	5	3	1	1	10
20–49	4	6	1	2	13
50 and over	nil	1	2	7	10
Total Sample	9	10	4	10	33

Source: Author's Survey.

For example, firm A may produce beakers, trays, mats and plastic cocktail sticks, firm B may produce about 10 kinds of advertising signs and bicycle components, and so on. Not only do these products vary in kind, they also vary in colour, size and design both between firms and within the same firm.

However, our attempt to carry on the exercise can be defended on several grounds. First, product heterogeneity is a distinguishing feature of the plastics conversion industry. Research and development have been going on apace to substitute plastics for natural materials; and plastic being a highly adaptable material, the range of products and markets it has penetrated is bound to be high. There is thus no way of avoiding the problem of product heterogeneity.

Second, although there is an absence of product homogeneity, the firms in the

Table 4: *Distribution of the sample firms by size groups and by principal types of markets served*

Principal markets served	Firm size				Per cent of firms in each market
	Small	Medium	Large	Total	
Building and Construction	3	2	4	9	27·2
Packaging	2	3	1	6	18·2
Electrical	1	1	1	3	9·1
Household and Consumption	1	2	2	5	15·2
Furniture and Footwear	1	1	1	3	9·1
Textiles	1	2	—	3	9·1
Automobiles	1	2	1	4	12·1
Total	10	13	10	33	100

Source: Author's Survey.

sample share some important features. As shown by the data in Table 4, save in the case of textiles the market outlets are broadly similar for the firms in different size groups. The consumption of plastics by main markets as represented by the last column of the table is also broadly representative of that in the total industry. It is dominated by two main markets—building and packaging (PIA, 1974, p. 21).

Third, most firms in the sample use a limited range of processing techniques to convert plastics into end products, although a whole sheaf of such techniques are available. A majority of the firms are either injection moulders or extruders and fabricators and use a broadly similar range of plastic materials (i.e., mainly PVC, Polystyrene and Polyurethane).

Finally, all the firms in our sample are single plant and wholly independent concerns. They are not integrated with big firms and do not appear to enjoy economies of scale in input buying as sometimes occur with integrated small firms.

IV ANALYSIS OF SINGLE FACTOR INDICATORS OF PRODUCTIVITY

1. INDICATORS OF EFFICIENCY: THE RESULTS

The various indicators of efficiency are shown in Table 5. As measures of dispersion we have calculated the standard deviation for each of the efficiency indicators. The value of the estimated t statistic (for small samples) is also reported (whenever necessary) as a test for statistical significance (at 5 per cent level) of the difference in the means between different size groups.

2. LABOUR PRODUCTIVITY AND THE AVERAGE WAGE

The average labour productivity as represented by value added per unit of labour cost, (V/W), rises with size. But a different pattern emerges for the relationship of labour productivity (represented by V/L) to size. It declines at the top end of the size scale. This may reflect the relatively low employment of human

Table 5: *Efficiency indicators, by firm size*

Efficiency Indicators (Weighted)	Small (M)	(S)	Medium (M)	(S)	Large (M)	(S)	Total (M)	(S)
V/L*	3·20	1·53	4·49	3·38	4·43	2·42	4·35	2·83
V/W	2·42	1·82	2·81	1·75	3·21	1·39	3·02	1·61
V/TA	1·02	0·90	1·00	0·64	0·87	0·56	0·92	0·62
V/FA	1·86	1·67	1·99	1·84	2·09	2·42	2·04	1·94
GP/TA	0·55	0·62	0·54	0·51	0·57	0·38	0·56	0·43
TA/L*	3·76	1·94	5·59	4·08	5·79	3·27	5·57	3·27
FA/L*	2·69	1·69	2·98	2·25	3·14	2·19	3·06	1·96
TA/W	2·92	2·14	3·53	2·55	4·26	1·79	3·93	2·22
W/L*	1·49	0·74	1·65	0·59	1·34	0·36	1·45	0·56
S/V	0·22	—	0·39	—	0·57	—	0·48	—
TFP	1·67	1·01	1·81	1·02	1·96	0·82	1·89	0·91
STFP	1·67	0·64	2·05	1·15	1·99	0·83	1·98	0·92

M = Weighted Mean;
S = Standard Deviation;
*'000 Irish £; other rows in Irish £'s.
Source: Table 1.

capital (or less skilled labour) by the large size class. The average wage per employee *(W/L)* does, in fact, reflect this. Thus the lower average wage in the large firms may be explained by the fact that as the quality of the workers is relatively low, this low quality is compensated by the use of more sophisticated machinery. The substitution of physical capital for human skills by the large firms may, in part, be due to the shortage of such skills in Ireland. On the contrary, the higher wage bill reported by four of the sample firms from the medium size group seems to have pushed up the average wage labour ratio for the group. Excluding these 4 firms, the average wage per employee for the medium size group comes to be only (1·42) and thus falls below the average for the small size group. One possible factor explaining the higher *W/L* ratio (2·02) in the 4 firms appears to be the quality of products produced. As they are manufacturers of high precision and speciality products (i.e., plastic buttons for garments, cosmetic boxes, beakers, trays and plastic cocktail sticks) they may require greater worker dexterity and pay higher wages. As it was gathered from personal interviews with the chief executives of the small firms, the problem of shortage of labour with specific skills in plastics was further aggravated for the former through "poaching" from the large firms. Consequently, they might have no alternative but to pay higher than normal wages for recruiting such labour.

3. CAPITAL INTENSITY AND PRODUCTIVITY

As may be expected, capital intensity *(TA/L)* or total capital per employee rises with size. This also holds true for capital intensity as measured by capital per unit of labour cost *(TA/W)* and fixed assets per employee *(FA/L)*.

In contrast to the trend in labour productivity, capital productivity (V/TA) declines with size. However, the average capital productivity represented by value added per unit of fixed assets (V/FA) increases with size. The divergent trends exhibited by these indices of capital productivity need explanation. The difference between fixed assets and total assets consists primarily of inventories held by the firms in the form of raw materials and finished and semi-finished goods. Thus a higher V/FA compared to a corresponding lower V/TA for the large size groups indicates an excessive use of working capital and inventories by these firms. Further, both of the larger groups also exhibit a greater dispersion (indicated by the standard deviation) in their value added to fixed assets ratio compared to the small firms.

That a relatively greater amount of stocks (S) held by the large firms raises their capital-output ratio $(TA/V$, the reciprocal of $V/TA)$ can be demonstrated from the figures in Table 5.[2] As the final row of the table shows, the ratio of stocks to value added (S/V) rises consistently with size. This may be due to the relatively superior financial position of the large firms. The relatively greater access to sources of finance by the large firms particularly in the organised sector of the capital market is a common feature of the LDCs. For example, the easy availability of capital with lower interest rates in the organised industrial sector is cited as the most important reason for an excessive holding of inventories by Indian firms. (Krishnamurty & Shastry (1960)).

The differences in inventory holding by the large and small firms may also be explained by their relative market position and stage of growth. For example, large firms would tend to be under less competitive pressure to economise on the use of capital than the small firms especially in oligopolistic situations. This together with greater financial strength may make excessive inventory holdings (especially raw materials and intermediates) relatively inexpensive for the large firms. In contrast, the small firms being comparatively younger, as illustrated by the average age of the firms in Table 2, would have to get as much out of capital as possible to ensure their survival. Due to their weak financial standing, the small firms may sometimes have lower inventories of materials than they require. This appears to be an important reason for the lower stocks–value added ratio of the small firms in our sample. The lack of adequate finance to buy raw materials and other necessary intermediates was mentioned as an important problem by most respondents in the small size class. The problem was said to be further aggravated by the rise in the prices of plastic materials as a result of the increase in oil prices.

Further, the relatively small stocks-output ratio of the small firms may also be a result of their deliberate policy of producing mainly to order. As can be seen from Table 6, this argument must have considerable relevance in explaining much of the differences in the inventory-output ratio of the different size groups of firms. Half of the firms in the small size group produced totally according to

2. This has also been demonstrated as a significant reason for higher capital-output ratio of the large firms in US industries. cf. Davis, (1956).

Table 6: *Distribution of firms by sales networks and by size*

Principal cateogry of sales	Small		Medium		Large		Total	
	Number	per cent	Number	per cent	Number	per cent	Number	per cent
Direct to Customers	5	50	4	30·8	—	—	9	27·2
Retail (mainly to other manufacturers)	4	40	6	46·2	2	20	12	36·4
Wholesale (mainly to chain stores and industrial users)	1	10	3	23·0	8	80	12	36·4
Total	10	100	13	100	10	100	33	100

Source: Author's Survey.

order and sold direct to customers. The retail outlets for their products were also found to be confined to a very limited number of customers and work was done mostly on a cash and carry basis. The market outlets for the products of the medium size group were also found to be broadly similar with only 23 per cent of their total sales falling in the wholesale category. In contrast, the large firms produced on a much larger scale, sold in wider market areas and therefore required more selling on credit. For the same reason the latter also engage a larger sales staff, carry nationwide promotion of products to customers and incur more capital outlay per pound of sales than the small firms.

The relatively high labour productivity exhibited by the large firms seems to be a consequence of a high capital intensity of their operations. On all measures, a positive association between size and capital intensity appears as a regular feature of Table 5. Indeed the positive impact of capital intensity on labour productivity is well documented in the literature on productivity studies, Healy, (1968), Gouverneur, (1970), Diaz Alezandro, (1965).

Although the relatively high capital intensity of the large size groups may have contributed to higher labour productivity this appears not to have had any positive impact on their capital productivity.[3] Output per unit of total capital (V/TA) records a declining trend with increase in firm size. These divergent trends between capital intensity and capital productivity need further explanation.

4. CAPITAL INTENSITY AND FOREIGN OWNERSHIP

The high capital intensity of the large firms may also partly reflect the relatively greater use of foreign technical know-how by these firms compared to small firms. The greater incidence of foreign technology in the former is quite conceivable in the light of the fact that most of them are either subsidiaries of foreign companies

3. This corroborates J. C. Sandesra's (1966) findings for Indian industries. Though he did not find any positive association between capital intensity and labour productivity for all the industries analysed, the overall trend indicated a positive association between size and capital intensity, size and labour productivity and a clear negative association between capital intensity and capital productivity.

Table 7: *Distribution of the sample firms by subsidiary* and other status*

(1)	(2) Subsidiary of a foreign parent		(3) Associated with a foreign parent		(4) Wholly Irish		(5) Total	
Size groups								
	Number	per cent	Number	per cent	Number	per cent	Number	per cent
Small	—	—	3	30	7	70	10	100
Medium	3	23	1	7·7	9	69·2	13	100
Large	8	80	1	10	1	10	10	100
Sample total	11	33·3	5	15·2	17	51·2	33	100

Source: Author's Survey.

*Contrary to usual expectation, both the subsidiaries and the associates were found to be abso-lutely independent in decision-making in all the size groups. Thus the relationship was one of dividend sharing rather than policy-sharing.

or are associated with them. As Table 7 shows, the larger the firms the more they tend to have a subsidiary status.[4] The information gathered revealed that the relationship between the foreign parents and their subsidiaries and associates operating in Ireland consisted primarily of technical and financial links between them. Except one firm in the large size class, the foreign parent provided more than 60 per cent of the total capital requirement needed after receiving the IDA grants. The technical assistance provided consisted mainly of machinery, parts and skilled technicians. In contrast, the extent of equity participation by the foreign parent in the subsidiaries and associates of the medium size group ranged from 30 to 40 per cent on average. The form of technical assistance provided comprised mainly training of personnel, advertising the products and other sales service. In the small size class all the three associates received only marketing assistance or supply of raw materials from their foreign associates.

Thus it is the type of assistance received rather than the degree of dependence on foreign parents which is more important in explaining the impact on capital intensities of the firms of different size groups. It can therefore be argued that capital deepening in the large firms has resulted from their greater access to foreign technical know-how and easy availability of capital.[5] Another reason for high capital intensity of the large firms may be the non–availability of skilled domestic labour to operate imported technology. The general shortage of skilled labour appears to be a widespread phenomenon in Ireland. But the large firms appear to have had acute problems in obtaining such labour. The percentage of the respon-

4. Indeed, as shown by Gorman, et al. (1974) this is not a specific case with our sample or the Irish Plastics Industry, but a general phenomenon characterising the Irish industry.

5. For evidence on the association between foreign technology and high capital intensity in Indian firms, see, V. N. Balasubramanyam, (1973). Capital deepening in the Irish industry in general is also reported to be a consequence of the combined influence of easy access to capital and foreign technology, cf. Kennedy (1974).

dents identifying skill shortage as one of the serious problems confronting expan-
sion of their businesses was 50 per cent for the small and medium size groups and
over 90 per cent for the large-size class. This may have forced the large firms to
substitute capital for labour skills. This is equivalent to what Gouverneur (1971)
calls the "progress" effect which refers to the possible occurrence of capital-using
or labour-saving technological change.

5. CAPITAL PRODUCTIVITY AND PRODUCT DIVERSIFICATION

   The increase in the ratio of assets to value added with increase in firm size may
also have to do with differences in the degree of product diversification and vertical
integration among firms. A firm may diversify in various directions (i.e., increasing
the number of products produced, or moving into new fields, or both) for
attaining various objectives.[6] The main argument for diversification is that only
a diversified firm can adequately ensure the stability of its earnings in the face of
market and demand fluctuations. Similarly, vertical integration (a special form of
diversification) also stabilises the firms' markets. Such integration may either be
forward, involving expansion of the existing distribution (sales) channels, or
backward, involving a firm in producing instead of buying materials in order to
ensure its sources of supply.

   As a technically progressive industry the rate of product and process obsoles-
cence is higher in plastics compared to other industries. Given this, diversification
seems to be an obvious course of action for an individual firm to maintain market
competitiveness in the industry. Referring back to Table 3 it can be seen that
diversification is an important feature of the sample firms. It increases with the
size of firms and becomes more pronounced in the large size group. Though this
is the size group with the highest labour productivity (V/W) and profitability
(GP/TA) it also has the highest capital intensity.

   Five firms in the large size group have also integrated forward. They operate
retail stores, which means investing in store property. Three of the sample firms
from this size group have also integrated backward. Besides manufacturing final
plastic products these firms produce special kind of plastic polymers to meet part
of their raw material requirements. Commensurately, the ratio of fixed assets,
total assets and of inventories to value added in all these firms were found to be
almost two to three times higher than the averages for these for the large size
group. Thus, though diversification may have had some positive impact on the
labour productivity, this must have exerted considerable upward pressure on the
capital-output ratios.

6. THE RELATIONSHIP BETWEEN SIZE AND EFFICIENCY

   In sum, none of the productivity indicators discussed earlier allow us to
generalise on the relationship between size and efficiency. Only the index of

   6. For an elaborate discussion of the directions and objectives for diversification, see, Penrose
(1968).

profitability *(GP/TA)* appears to increase with size (Table 5). However, the difference in the average profitability between the medium and the large size groups is not very large. Similarly, a divergent trend is exhibited by the two indices of labour productivity. While V/W increases with size V/L falls for the large size group. This holds true for capital productivity also. Further the standard deviations around the mean calculated for various indicators also precludes any generalisation. For the majority of indices the dispersion around the mean is, contrary to expectation, higher for the large than for the small size class.

V ANALYSIS OF TOTAL FACTOR PRODUCTIVITY

The important factor that precludes any firm conclusion between size and efficiency is the contradictory trends exhibited by the labour and capital productivity indices. As Krishna and Mehta (1968) note, such contradictions only emphasize the undesirability of arbitrarily selecting the average product of any factor as an index of overall efficiency. We therefore, turn to analysing the size efficiency relationship by using the total factor productivity index as an indicator of overall efficiency.

The total factor productivity represented by (TFP) shows an upward trend (Table 5) with increase in size. However, if we measure total factor productivity in terms of a "new" index of social efficiency, STFP, this does not hold true. It is necessary to clarify what is meant by this new index.

As is well known, factor price distortion is a widespread phenomenon in the developing countries (See Khan (1970)). For example, due to trade union pressure and minimum wage legislation the market wage rate is often in excess of the opportunity cost of labour. Indeed, given the high levels of unemployment the opportunity cost of labour in the extreme may be even zero. Similarly, due to government subsidies the cost of capital is often much lower than its true social opportunity cost. This appears to be especially true of Ireland which has a policy of providing capital subsidies to foreign firms. Therefore, if ruling market prices are used estimates of social efficiency may be misleading.

Thus in estimating the "new" index of social efficiency STFP we have used a shadow wage rate for the labour variable and an approximated maximum interest rate for the capital variable. The shadow wage rate used here is the Minimum Legal Wages in agriculture estimated to be £1,029 in 1973 (ILO (1974)). The use of the agriculture wage rate as the shadow wage rate may be appropriate in the presence of considerable unemployment and under-employment in the Irish economy. This may also be justified on the ground that agriculture happens to be a significant source of employment (24·8 per cent of total employment in 1973) for the unemployed labour force in Ireland. Instead of the 15·5 per cent average rate of return earned on capital (used earlier) we now use a shadow interest rate of 20 per cent to arrive at the total capital costs. This may approximate to the

real capital costs the large firms ought to pay. Our "new" TFP index is thus estimated by using the following expression:

$$STFP = \frac{V}{w^*L + TAr^*}$$

where V = gross value added; L = employment force
         w^* = Minimum Legal Wages per adult agricultural employee reported
                 to be £1,029 in 1973
         TA = total assets
         r^* = A shadow rate of interest on borrowed capital assumed to be
                 20 per cent

As we see in Table 5, although STFP shows a higher value for the medium size class, it registers a decline for the large size class. This result appears to substantiate further the *a priori* thesis that size does not significantly affect efficiency in the plastics processing industry. Though GP/TA, V/W and TFP show a tendency to rise with increase in the size of firms, the differences between the indicators for different size groups are not statistically significant. On the basis of both Chi-Square and t tests difference between the means for any two size groups was found to be statistically insignificant at the 95 per cent confidence level.

VI ECONOMIES OF SCALE: A REGRESSION ANALYSIS

The above findings are largely indicative of the absence of significant internal economies of scale[7] in the Irish plastics industry. Indeed, the absence of scale economies is advanced as another *prima facie* argument in support of the economic viability of the small scale units in the plastics processing industry. To assess the validity of this presumption and also to test the consistency of our earlier findings a regression equation is fitted to the data for all 33 firms.

The procedure followed is that adopted by Joel Bergsman (1970) in determining the relative influence of capital intensity, size of establishment (internal economies) and externalities on productivity in Brazilian manufacturing. In his analysis, Bergsman followed C. A. Roca (1967) and proposed a relationship of the form

$$\left(\frac{V}{L}\right)_i = f\left[\left(\frac{K}{L}\right)_i, (I)_i, (\Sigma V)_i\right]$$

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7. We define economies of scale as the reduction in costs of production per unit of output that can be achieved as a consequence of increasing the scale of output in a firm, an industry, or in the market in general. Scale economies that arise in a firm or a plant as a consequence of increase in its own scale of production are referred to as internal economies of scale. Unless otherwise stated we shall be concerned here with internal technical economies of scale that are realised when a large scale of output permits a lesser input per unit of output.

where f denotes an unrestricted Cobb-Douglas function, the subscripts indicate various regions and

$$\frac{V}{L} = \text{value added per worker (or output)}$$

$$\frac{K}{L} = \text{capital per employee (or capital intensity)}$$

$$L = \text{average number of workers per firm (or size of establishment)}$$

$$\Sigma V = \text{value added in all manufacturing sectors (or externalities)}$$

In adopting the above model to the present exercise, we have used as dependant variables two alternative measures of labour productivity V/L and V/W. While capital per employee, TA/L, and capital per unit of total labour cost, TA/W, represent capital intensity, size of firms are measured by the number of employees (L), value of labour costs (W) and also by total (TA) and fixed assets (FA). As we have two variants of labour productivity, two alternative measures of labour input (L) and (W) had to be tried. However, due to the lack of regional data on the total value added in the Irish plastics industry we could not introduce a third independent variable to account for externalities. Thus, the basic function estimated in our case relates to a regression of the dependent variable, the logarithm of the measure of labour productivity on the independent variables, the logarithms of the measures of capital intensity and the size of firm.

$$\log (V/L) = 0.6304 + 0.5156^{**} \log TA/L + 0.0038 \log L \quad \bar{R}^2 = 0.41$$
$$(0.1146) \qquad\qquad (0.0803)$$

$$\log (V/L) = 0.6300 + 0.5116^{**} \log TA/L + 0.0039 \log TA \quad \bar{R}^2 = 0.40$$
$$(0.1606) \qquad\qquad (0.0803)$$

$$\log (V/L) = 0.7499 + 0.5605^{**} \log TA/L - 0.0329 \log FA \quad \bar{R}^2 = 0.67$$
$$(0.1462) \qquad\qquad (0.0768)$$

$$\log (V/W) = 0.7764 + 0.4971^{**} \log TA/W - 0.06484 \log W \quad \bar{R}^2 = 0.32$$
$$(0.1228) \qquad\qquad (0.0669)$$

$$\log (V/W) = 0.9059 + 0.5782^{**} \log TA/W - 0.1021 \log FA \quad \bar{R}^2 = 0.64$$
$$(0.1302) \qquad\qquad (0.0614)$$

$$\log (V/W) = 0.7763 + 0.5619^{**} \log TA/W - 0.0648 \log TA \quad \bar{R}^2 = 0.31$$
$$(0.1480) \qquad\qquad (0.0664)$$

Notes: Figures in parentheses represent standard errors of the estimates.

**Indicates that the coefficient is significant at 1% level. Otherwise they are not significant at the 5% level.

Capital per worker turns out to be a highly significant explanatory variable in all the equations. In four cases the value of the capital coefficient implies that a per cent change in capital per worker is associated with more than 50 per cent change in labour productivity. This is as expected and in conformity not only with theoretical expectations but also with the results obtained from our inter-

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firm comparisons of labour productivity and capital intensity. In contrast, the size variable does not suggest the presence of scale economies. In fact, in the case of all the equations save two the size cofficient bears signs which are at variance with the hypothesis of scale economies. Even in the two cases where it is positive it is statistically insignificant suggesting the possibility of diseconomies of scale.

Apart from the small size of the sample other deficiencies associated with the variables may have biased the estimates. For example, the value of capital measured by the book value of assets may not represent the real capital employed by the firms; nor take into account differences in capacity utilisation. Labour being an aggregate concept introduces further bias in the estimated coefficients. It is possible therefore that the aggregate nature of our data conceals scale economies that may exist.

However, the absence of internal technical economies indicated by the negative signs in the scale coefficient seems to be real rather than apparent. The empirical findings concerning economies of scale in the plastics processing industry elsewhere also suggest this. As C. F. Pratten (1971) shows, in terms of physical output, the minimum optimum scale for firms in the plastics processing industry of UK is less than 1 per cent of the industry's capacity. Any firm producing at only 50 per cent of the minimum efficient scale experiences very small increases in operating costs. This suggests that economies of large scale production are not significant determinants of operative efficiency in the British plastics processing industry. Similar evidence is also presented by Haldi and Whitcomb (1967). Analysing plant data for several North American and European countries, they found that plastics products industry generally experience constant or decreasing returns to scale. Given these shreds of evidence, it can be concluded that inter-firm variability in the average costs of production in the plastics processing industry is attributable to composition of output and factor mix rather than to the scale or level of output. This possibility derives further support from two other facts. Production in the plastics processing industry is generally organised on a batch process rather than on a continuous flow basis. Extreme diversity in the product range in kind, colour, shape and design seriously restricts the introduction of higher process speeds or longer production runs. This prohibits realisation of static internal economies in the form of specialisation of labour and equipment and saving in workers' time lost and so on. Further, the hypothetical scale curve of the text book theory drawn on the assumption of non-existence of "X-inefficiency" has little to do with real-world situations. It is possible that though potentially well placed to take advantage of economies of scale, many large firms may not in practice do so. They may not seek sufficient standardisation of their products and may neglect proper maintenance of plant and equipment needed to benefit fully from scale. (See, for empirical evidence Kilby (1961), (1962)). Given this, the lack of any positive association between size and efficiency or the absence of scale economies in the Irish plastics industry may also be attributed to such "X— inefficiencies" in the large firms.

VII THE EFFICIENT SIZE

In the light of the preceding analysis, can we say anything about the identification of the most efficient size class of firms? Again we are faced with certain ambiguities. For example, large firms exhibit both a relatively high labour productivity (V/W) and profitability (GP/TA). But their high labour productivity, as argued earlier, is mainly a result of their relatively high capital intensity. Furthermore, they exhibit a relatively low capital productivity. However, these partial measures cannot be taken as an indicator of overall efficiency without reference to total factor productivity. In fact, the large firms do exhibit relatively high total factor productivity (TFP). Even though efficient from the point of view of the firms themselves the large firms may be socially inefficient. Given the market prices they may be efficient allocators and utilisers of the factors of production, but market prices being distorted may not reflect real scarcities in the economy. When this fact is taken into account and the factor inputs evaluated at their scarcity prices, the overall efficiency measured by ($STFP$) exhibits a decline for the large size class. Thus the large firms which are facing the distorted market prices may, in themselves, not be inefficient, but from the society's point of view they may be wasting resources. As Farrell (1957) would argue, their promotion might do the economy serious harm through overcapitalising it. The appropriate policy measure in this case is to correct the distorted factor prices and force the firms to make use of them.

On the above considerations, the firms in the medium size group appear to be relatively more efficient than their small and large counterparts. Besides showing higher overall efficiency on the basis of the recalculated total factor productivity index ($STFP$), they record the highest productivity per labourer (V/L). Though their productivity per unit of total assets (V/TA) falls marginally below that of the small size group, it remains higher than that for the large size group. It is also noteworthy that the medium sized firms not only exhibit a high degree of labour productivity but also a relatively low degree of capital intensity. This broadly indicates that the optimum units in the Irish plastics industry may lie in the medium size group. Those in the very small and large size groups appear to be less viable productive units.

VIII SUMMARY AND CONCLUSIONS

Limitations of data preclude firm generalisations. But it is hoped that the tentative conclusions listed below will stimulate further study and analysis.

(i) Labour productivity is, on the whole, higher the larger the size of firms. But the trend of increase in one of the two indices of labour productivity with increase in the size of firms is not persistent.

(ii) The large firms are more capital intensive than the small and the medium sized firms. The higher capital intensity of the former may be due to their rela-

tively greater inventory holdings, higher incidence of foreign technical know-how and greater diversification of production.

(iii) The relatively high labour productivity exhibited by the large firms is, however, not matched by relatively higher productivity of capital. In fact, capital productivity is lower the larger the size of firms. This finding of increasing capital intensity coupled with falling productivity of capital with increase in the size of firms implies that though capital deepening may have a positive impact on labour productivity its effect on capital productivity may go either way.

(iv) Though profitability appears to increase with size, the difference in gross profits per unit of total assets between the large and the medium sized firms is not very large.

(v) When the factor inputs are evaluated at their true scarcity prices rather than in terms of their market prices, the overall social efficiency measured by total factor productivity also records a decline for the large firms. This shows that although the large firms are efficient from the private point of view they are inefficient from the society's point of view and their operations may have led to the waste of scarce capital resources.

(vi) The regression analysis shows results that are in conformity with those derived from the comparison of productivity indicators. While the value of the capital coefficient picks up most of the explanation for labour productivity that for the scale variable denotes diseconomies of scale. This confirms the hypothesis that inter-firm variability in efficiency in the Irish plastics industry is attributable to output composition and factor mix rather than to the scale or the level of output.

(vii) The high labour productivity and a relatively low capital intensity exhibited by the medium sized firms indicates that the firms employing 20 to 49 workers may be the optimum productive units in the Irish plastics industry. The relatively high overall efficiency represented by the recalculated total factor productivity index, $STFP$, of the medium sized firms further substantiates the finding that they are more efficient than the firms in the very small and the large size groups. The implication is that processing of plastics is a type of industry which can realise economies of scale only up to a point.

The above findings have at least three implications. Firstly, they support the general proposition that processors of plastics can become efficient operating on a reasonably small scale basis.

Secondly, the results seem to contradict the general tendency to think that "largeness and efficiency are synonymous". Of course, more industries need to be analysed to prove that this is true for all manufacturing.

Finally, the relatively high capital intensity of the large firms and their failure to exhibit greater overall social efficiency may be the result of the distorted factor prices they face. If these distortions are corrected and the market prices made to reflect true scarcities in the economy it may go a long way towards encouraging efficiency in the utilisation of resources, especially capital.

APPENDIX: THE METHODOLOGY OF THE SURVEY

In this appendix we give a brief outline of the random sample survey of 42 firms in the Irish plastics industry on which the above analysis is based. It describes the build-up of the sample, nature and scope of the interviews and data collection procedure.

(a) DRAWING THE SAMPLE

In planning the field study the initial task was to specify the population to be surveyed. It was necessary to obtain a list of all firms comprising the Irish plastics industry. The only source available for the purpose during the time of the field study was the "Directory of Plastics Firms" published as an appendix to the survey of the industry carried out by the Institute for Industrial Research and Standards in 1969. The total numbers of firms included in the Directory were 154 with complete addresses of each of the firms. Consistent with the objective of the inquiry, a sample of three-quarters (108) of the firms was drawn from this list and a copy of the survey questionaire was mailed to each of them on the 11th of July 1974. Excluding cases of firms which went public after 1969, merged with other firms, changed addresses, went out of business or diversified out of plastics, we were left with 82 relevant firms which were approached. Of these, 15 firms expressed willingness to co-operate through mail and 27 were convinced through direct contact over the telephone. The remaining 40 firms which did not co-operate refused to do so mainly because of company policy not to divulge any information to private researchers. Thus the response rate, 51 per cent, can be considered reasonably satisfactory for a survey of this strictly private nature; we may note that in many such studies a response rate of 30 to 40 per cent has been usual. (See, e.g., Lund and Minor (1971)).

The firms analysed are reasonably representative of the total industry in terms of products produced, type of processes used, markets served and other demographic characteristics.

(b) DATA COLLECTION PROCEDURE AND INTERVIEWS

The data needed to conduct the statistical analysis of inter-firm efficiency was collected by visiting the firms and arranging for the completion of the pre-posted questionaire both before and after the interviews.

In the case of nearly two-thirds of the firms, the statistical data were provided by the accountant of the company from its internal records. The author himself had access to books of the companies for three cases, whilst such data for others were provided by the managing directors from their books. Accordingly, the author believes that the statistical data are reasonably accurate.

Data on gross output were asked for in the original mailed questionnaire. However, to arrive at the value added figures, all the 42 firms were contacted again, requesting information on the cost of materials. As mentioned in the text, only 22 firms provided such figures at the second approach, the value added

figures for the remaining 11 of the 33 firms analysed had to be deduced via an indirect method. The other problem encountered in the exercise was the low average wage rate found for some of the firms. The most plausible reason explaining lower average wage rates in these firms appeared to be the mode of employment prevailing in the areas where the firms are located. These firms being located in rural areas could obtain labour at relatively lower wage rates than those situated in urban locations and had also a relatively higher incidence of part-time workers. The maintenance of close ties with traditional homes, avoidance of long distance commuting problems between home and the place of work by the labourers and above all the relatively low incidence of industrial disputes such as strikes, might have been the main factors contributing to the low supply price of labour for these rural based firms.

However, the average wage rate per worker (1·45) in the total sample approximates closely to that in the Miscellaneous Manufacturing Section (1·34) including plastics in 1972 and also for the annual average wage rate (1·13) in the Irish plastics industry itself in 1971.[8]

In 39 of the 42 sample firms, the respondent interviewed was the chief executive. In three cases, where the chief executive was not available a senior manager was interviewed. The total time spent in completing the interviews was spread over a period of 8 weeks between September and November 1974. Besides a short history of the company and its founders, information about legal status, sales networks, competitive position, marketing, management structure and future policies and plans of each company was also sought.

8. Calculated from figures collected by the author from the Irish Central Statistical Office during the time of the survey. All three wage rates reported are in thousand Irish pounds.

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