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No. 67 October 1988

A Survey of the Economies of Scale

by Cliff Pratten *

Internal paper

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Section 1. Introduction

This paper surveys estimates of the economies of scale and analyses the implications of these estimates for the completion of the EC.

Section 2 of the paper gives an outline definition of the economies of scale. Section 3 provides a brief description of the alternative methods of measuring the economies of scale. The conclusion to Section 3 is that engineering estimates are the most reliable estimates of scale economies. Section 4 describes the characteristics of industries which predispose them to being industries with large or moderate economies of scale. Engineering estimates of economies of scale are surveyed in Section 5. Engineering estimates are a reliable source for assessing the economies of scale for development and production costs. They are far less satisfactory for evaluating the economies of scale for multi-plant and multi-product firms. The economies of scale for firms are analysed in Section 6. Other evidence bearing on the magnitude of economies of scale is reviewed in Section 7.

The emphasis on, and the apparently rapid growth of employment in, small businesses in some countries in recent years conflicts with the perception of generally large economies of scale. This conflict is the subject of Section 8. In Section 9 the pattern of the Community's exports is related to the estimates of the economies of scale. The purpose of this analysis is to test whether the community's exports are concentrated on trades subject to large economies of scale.

Most of the material in the earlier sections focusses on manufacturing industries. The economies of scale for services are considered in Section 10. Finally the impact of the completion of the EC via the economies of scale is assessed in Section 11.

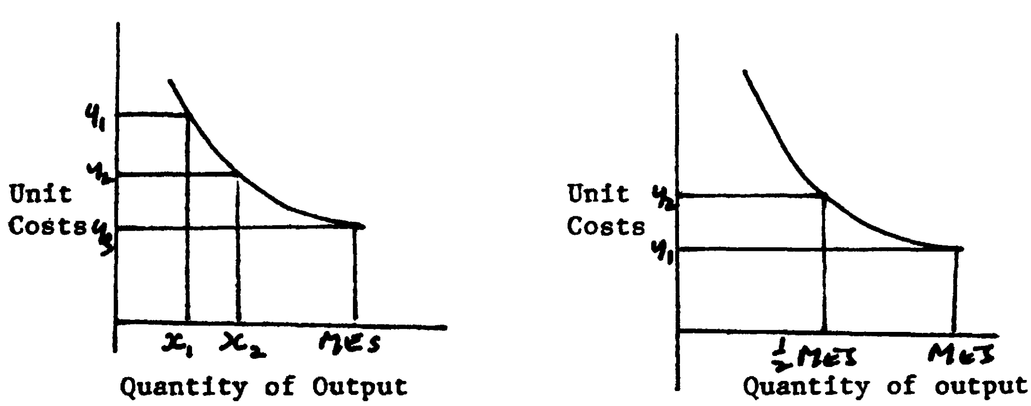
Section 2. Definition of the Economies of Scale

Definitions

Economies of scale (EOS) are reductions in average unit costs attributable to increases in the scale of output. Diagram 1 illustrates the point. As output increases from x_1 to x_2, unit costs fall from y_1 to y_2. The scale at which unit costs cease to fall is labelled the MES - the minimum efficient scale. In practice, the MES is usually defined in terms of the scale above which costs cease to fall rapidly, rather than the level at which they cease to fall at all.

In this paper the principal measure of the extent to which costs rise below the MES level is the percentage increase in costs at a half the MES. In diagram 1(b) this is $(y_2 - y_1)$ as a percentage of y_1. Again, in practice, costs are often divided between the bought out element of costs, materials, components and services bought from other firms, and internal costs including profits, or value added. This distinction is made because for some industries relatively few economies of scale relate to the bought out component of costs.

Diagram 2.1. (a) Costs and Output (b) Costs at Output below the MES



The Dimensions of Scale

In the literature economies of scale are most often associated with the scale or output of establishments (alternatively termed plants or factories) or the size of firms (companies). Cement is a relatively homogenous product and cement plants are often used to illustrate the economies of scale. Also many cement plants produce a single product, portland cement. Economies of scale for these plants apply to an output capacity of more than a million tons of cement a year.

In practice, at most plants a range of products is made and there are many, often inter-related, dimensions of scale to which economies of scale apply. Increases in the size of establishments or the overall size of firms per se are not necessarily the principal sources of economies of scale to be reaped from completion of the internal EC market.

The main dimensions of scale are:

a) Dimensions affecting the efficiency of production

1) The total output of particular products through time
2) the duration of production runs - the period during which a distinct product is made or produced before switching to the processing of another product.
3) The rate of production of particular products per unit of time (The size of batches is determined by the duration of production and the rate of production)
4) The extent of standardization of components and products.
5) The capacity of units of plant, machines and production lines within plants
6) The total capacity of individual plants

7) The overall size of a complex of plants at one site

8) The extent of vertical integration - the range of operations and stages of production performed at plants and by firms

b) Dimensions affecting selling and distribution costs

9) Sales to each customer

10) The geographic concentration of customers

11) The size of consignments to customers

c) Overall dimensions of scale

12) The size of firms

13) The scale of an industry

14) The scale of a national economy

Scale economies are reductions in unit costs attributable to different positions along dimensions of scale. In the same way that there are scale economies attributable to the size of plants, scale economies may relate to the size of batches, the size of firms or industries, etc. However a noteworthy distinction has been introduced into the literature. Where the production of two or more products reduces costs compared to the position where each product is produced separately in similar quantities, the economies are termed the economies of scope.

The Sources of Economies of Scale

The forces making for economies of scale are:

a) Indivisibilities

There are many costs which are at least partly independent of scale over certain ranges of output i.e. costs which are wholly or partly indivisible with respect to output. The following are examples:

Type of cost:	Partly or wholly indivisible with respect to:
The initial development and design costs for a new car	The output of the car
First copy costs of books, newspapers, etc.	The number of copies produced
Obtaining tenders and studying sources of supply for a component	The size of orders placed for the component
Items of capital equipment	The total output for which the equipment is required
Office records for a batch of a product	The size of the batch
Preparation of advertisements	The area of the country in which the advertisements are shown

As the relevant dimensions of scale are increased, indivisible costs can be spread over a larger throughput and the cost per unit is therefore reduced.

b) <u>The economies of increased dimensions</u>[1]

For many types of capital equipment both initial and operating costs increase less rapidly than capacity. A typical example of such economies occurs in the construction of tanks, pressure vessels and road and sea tankers which are used in the chemical and oil industries. If the thickness of the walls of a tank are not affected by its size, then the cost of increasing capacity increases approximately in proportion to the surface area, while the capacity of the tank rises in proportion to its cubic capacity. Another reason for large units being relatively less costly is that there are proportionately fewer parts to make and fabricate. Operating costs may also be affected by the size of units. In the processing industries the total direct labour costs of operating units of equipment are not much affected by their size, and maintenance costs are usually assumed to be proportional to the capital costs of equipment.

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(1) The economies of increased dimensions and the economies of specialisation which are considered in the following sub-section, may be considered as examples of indivisibilities. If labour and capital equipment were divisible in the same way, as say, a bucket of sand, then there would be no economies from these sources. Many types of equipment and labour are divisible in the sense that it is possible to build units with smaller capacity and employ less expensive labour, or to employ staff on a part-time basis, but the cost per unit of capacity may be higher because of the economies of increased dimensions and of specialisation, i.e. if the factors are purchased in small quantities, they may be less efficient. This distinction was made by E.H. Chamberlin in 'Proportionality, Divisibility and Economies of Scale'. Q. Jnl. of Econ., 1948.

One possible source of diseconomies for using larger units of capital equipment is that they may take longer to design, build and run in, particularly if the size is outside the manufacturer's existing experience. If large plants take longer to construct this will increase the cost of equipment because of the cost of capital tied up while the plant is built and run in.

c) The economies of specialisation

The larger the output of a product, plant or firm, the greater will be the opportunities for, and advantages of, specialisation of both the labour force and the capital equipment. Increased output may enable a firm to employ staff with special skills, or staff with more highly developed skills. Also it may be economic for firms with a large throughput to use special purpose machinery.

Increased output will provide greater opportunities for specialisation not only within a plant, but also for suppliers of materials and services bought out.

d) The economies of massed resources(1)

The operation of the law of large numbers may result in economies of massed resources. For example, a firm using several identical machines will have to stock proportionately fewer spare parts than a firm with only one machine, because the firm with several machines can assume that its machines are unlikely to develop the same faults at the

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(1) If all factors of production and all products were infinitely divisible, there would be no economies of massed resources i.e. the economies of massed resources may also be regarded as a type of economy caused by indivisibilities.

same time. There may be similar economies for stocks of raw materials, and intermediate and final products, part of which may be held to meet interruptions to the supply of raw materials, a temporary breakdown of intermediate plants, and the uncertain flow of orders from customers. Similar economies for certain types of labour and monetary resources may be achieved by a large firm.

A large company's ability to spread risk may enable it to take greater risks. Large concerns have a greater opportunity for experimenting with new methods and introducing new products without jeopardising the future of the business if particular new methods or products are unsuccessful. Similarly if a firm operates in a number of national markets it can experiment with different policies in individual markets.

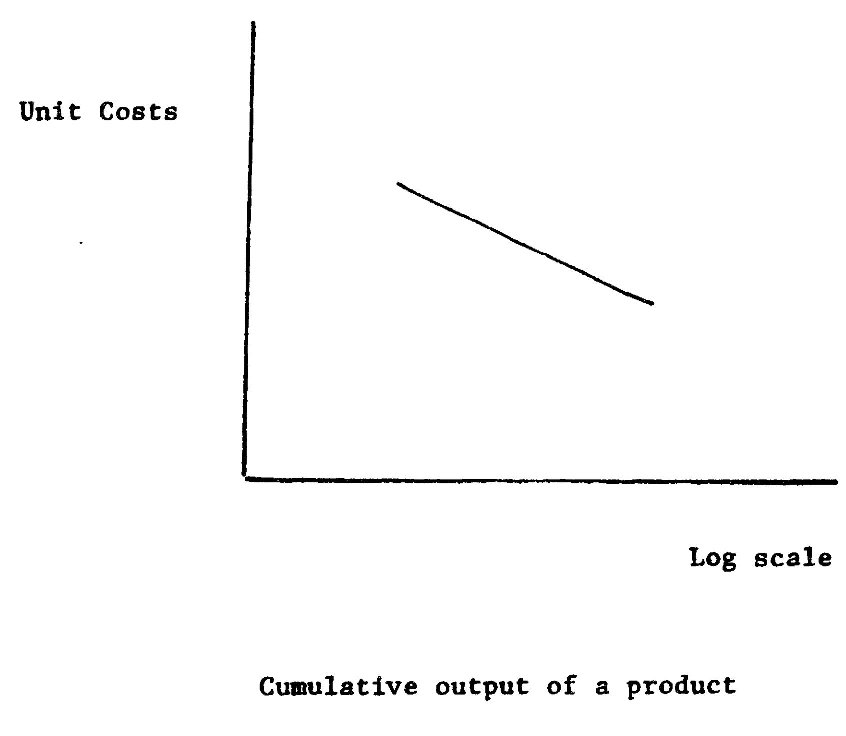
e) Superior techniques of organising production

Increased scale may make it possible to use more efficient techniques or methods of organising production; for example, as scale is increased automatic machinery may be used instead of manually operated machinery, or it may be possible to substitute methods of flow production for batch production. If high rates of output enable a firm to substitute flow for batch production, this usually results in a faster rate of production i.e. the time taken between work commencing on a product and its completion is reduced, and this should reduce unit costs for stocks and work in progress.

f) <u>The learning effect</u>

Learning is a source of economies which relates to movements along some dimensions of scale, particularly the cumulative output of products and the length of production runs. Diagram 2.2 illustrates the relationship. Unit costs are shown to decline as the cumulative output of a product increases. In theory the effects of learning (or experience) can be divided between the invention and introduction of new techniques - technical progress - during a production run, and the other cost-reducing effects of sustained production of a good. Examples of the latter are greater manual dexterity brought about by experience of production and machining successive batches of components more exactly as experience of assembly is obtained.

Diagram 2.2 <u>The Learning Curve</u>



g) Economies through control of markets

A vertically integrated concern may be able to achieve economies by evening out the flow of output. If the operation of two consecutive processes required to produce a product are under independent ownership, a conflict of interest may arise and result in fluctuating output. For example, an independent retailer when reducing his stocks will not take into account the losses to be incurred by a manufacturer due to lost production. The price system, operating through reductions in prices by manufacturers at times of slack capacity, may not counter this tendency because retailers may assume that the slackness of demand on manufacturers will continue for some time, and that prices will fall still further, and so price cuts may not stimulate orders.

Control of a market by a manufacturer may reduce the uncertainty he faces - he will know that customers cannot switch their custom to competitors - and so enable him to invest more heavily in capital intensive methods of production. The possible economies a firm can achieve through the control of its markets which have been outlined so far are advantages attributable to a monopoly situation - the supplier controls the customer. Also they only occur because there are changes through time in market conditions.

Apart from the scale economies which may be achieved by vertical expansion there are also other economies - such as reductions in buying and selling costs, reduced need for checking the quality of consignments and control of the timing of deliveries and quality - which are attributable to the control of suppliers.

This completes the outline of the sources of economies of scale. We now turn to the sources of diseconomies of scale.

The Sources of Diseconomies of Scale

Increases in unit costs may occur as scale increases for two groups of reasons:

(a) The supply of a factor of production is fixed or the cost of a factor increases as demand for the factor rises.

Examples of factor limitations are:

(i) the labour supply in an area available to a firm

(ii) the space available at one site for a factory

(iii) the supply of water which can be taken from a river for purposes of cooling a plant

(iv) the supply of a material produced as a by-product of another process

(v) the size of ship which can dock at a port.

(b) The efficiency in use of a factor of production declines as the quantity of the factor of production used by a firm increases.

The first source of increases in costs caused by the supply of factors of production being fixed or the costs of factors increasing as demand rises is not a source of diseconomies of scale. For the purpose of measuring the economies of scale, it is assumed that there is a perfectly elastic supply of factors of production available to firms - the quantity of factors they buy does not affect the price. In practice factor costs may rise with increasing scale and offset the economies of scale.

The efficiency in use of factors of production may decline with increases in scale for the following reasons:

(a) Technical forces

There are some technical forces which cause diseconomies of scale. As the capacity of individual units of plant is increased, increased stresses and strains[1] and friction may result, and to combat these, wider gauge walls etc., may have to be used, different, and more expensive materials employed, cooling systems, or improved cooling systems be introduced, or more elaborate foundations may have to be built. It is usually technically possible to overcome the problems caused by increasing stresses and strains etc., in large plants, but in certain cases, and over certain ranges of capacity, the costs of overcoming them increase faster than the increase in scale. There are in practice two types of costs required to overcome these problems - it may be necessary to use more expensive (and stronger) materials etc. and/or there may be initial costs required to invent new techniques to overcome the technical limitations when the first of a larger scale of plant is built. A way of avoiding any net diseconomies because of increased stresses and strains in many cases is to duplicate units of plant. Thus stresses, etc. are a limitation on the sources of economies of scale rather than a source of diseconomies.

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(1) An example of stresses and strains increasing more than proportionately over a range of output is provided by turbines. If very large turbines are built the ends of the blades travel at a speed near to that of sound. At this speed the strains and stresses increase more than proportionately with the capacity of the turbines.

(b) Management

It has been argued that the costs of management may increase more than proportionately with scale or the effectiveness of management may decline as scale is increased. If so, this could set a limit to the optimum scale for plants and firms(1). Given a changing environment, and evolving firms, as scale increases, the costs of coordinating and organising production may rise more than proportionately. The effectiveness of management may decline as the chain of management is extended because of delays in taking decisions brought about by the length of the management chain and/or the tendency for those ultimately taking decisions to get out of touch with events affecting the decisions. Scale may also affect the motivation of managers. Whether or not the management and ownership of a large firm are separated, the determination to maximise profits at the expense of other objectives may decline as scale is increased. Within a large organisation it may be difficult to focus financial incentives as accurately as in a small concern. In some cases the management of large firms may be able to shelter behind the technical economies of scale achieved by their firms. Small firms may face the choice between economising and achieving a higher level of efficiency, or being forced out of business and this may spur the managers to achieve relatively greater efficiency and to avoid mistakes(2).

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(1) If the effectiveness of management falls as scale is increased, the costs of production are increased, but not necessarily the cost of management itself.

(2) Small firms may operate nearer to the bounds of their production possibility surface (p.p.s.). For a discussion of X-efficiency (the degree to which firms operate within the bounds of their p.p.s.) see Harvey Leibenstein, Am. Econ. Rv. LVI (June, 1966) and Q. Jnl of Econ. (Nov. 1969).

On the other hand a large firm can employ more management specialists, and increasing scale may result in a less than proportionate demand for decision taking and management expertise. For example the problems of managing some types of large plant may not increase proportionately because of the economies of scale for direct labour costs.

(c) Labour relations

As scale is increased people may simply work less well. The possibility that the performance of employees declines with scale could apply to more than one dimension of scale. As the length of production runs increases this may result in specialized and/or repetitive work, as the size of factories is increased it may be difficult to retain a 'family spirit', and similarly in a large firm labour relations may be inherently worse. The larger the factory or firm the greater the hierarchical chain must be - employees tend to be further away from the 'boss', and he is less likely to understand them. Also it may be easier for the employees of a large firm, or at a large factory, to oppose the management and to organise restrictive practices. This could be because the management of a small firm can spot sooner, and remove, employees who might create diversions, or because in a large organisation it is easier to whip up feelings in the same way that it is easier to whip up mass hysteria at a football match watched by a great many spectators, compared to a match watched by very few spectators, or simply because a large organisation breeds more dissatisfaction.

In order to minimise the problems of managing large organisations and of labour relations, companies have adopted strategies of focussing their activities, of selling off peripheral lines of business, and of delegating responsibility to the managers of separate subsidiary companies and profit centres.

(d) Selling and distribution

Selling and distribution costs are possible sources of increased costs at higher scales of output. For example, if, as the scale of a plant is increased, the geographic spread of markets, and so the average length of haul, is increased, the average unit costs of transport will rise. If the additional sales are obtained from a new, less concentrated, market, the costs per unit of representation may be increased. On the other hand if the additional sales are made to existing customers and the size of consignments are increased, both selling and delivery costs per unit may be reduced. Whether there are increased unit costs at higher scales of output depends on which marketing dimensions of scale are increased.

Technical Progress

The inter-relationships between economies of scale and technical progress are important.

a) Development and other initial costs may, or may not, involve technical progress. Spreading these costs over the output to which they relate is often an important source of reductions in unit costs with increases in scale. In practice, it is not always possible to distinguish development costs which produce, or require, new knowledge or techniques and those which do not.

b) As noted above learning effects may include the invention and introduction of new techniques - technical progress.

c) In order to build plants with larger capacity than at present operated, it may be necessary to invent and use new techniques. It may not be technically possible to simply increase the dimensions of a plant or machine.

d) Firms have to adapt to changes in the techniques of production through time, and it is sometimes claimed that large firms have advantages in achieving and introducing technical progress.

Many but not all of the 'engineering' estimates of scale effects given in Section 5 of the paper include the effects of spreading development and other initial costs for products over varying outputs of the products, and the effects of learning for production runs of varying length. Some of the estimates therefore include an element of technical progress. The advantage of including development costs in analyses of the economies of scale is that it makes them more realistic. Firms in many industries have to develop a stream of new and improved products to remain competitive and development costs are a substantial proportion of total costs for many firms. But problems are introduced when development expenditure is included. The costs of developing many new products depends in part on the expected demand for the product, and a firm's expenditure on developing new products depends upon the development strategies adopted by its competitors. In an oligopolistic market if one firm introduces new products, its competitors may follow this lead and introduce similar new products.

The Economies of Rapid Growth

The concept of economies of scale for cement plants which was used earlier as an example is static, it measures differences in unit costs for positions along the dimension of scale measuring the sizes of plants. The estimates of costs and economies of scale are for plants built at one point in time or more realistically are estimates made for hypothetical plants for which blueprints are designed at one point in time. The important point is that the plants are designed to minimise costs for their scales of production and are based on the set of techniques of production known at one point in time. Otherwise unit costs for the plants would differ because of changes in technical knowledge through time as well as scale differences. When movements along some dimensions of scale, such as the cumulative output of products, are considered, the estimates of economies of scale can not relate to one point in time, though they can be based on a constant set of techniques.

A related concept is the economies related to rapid growth. In practice there are a number of forces (apart from the utilization of spare capacity) which may enable a firm which increases its output rapidly to achieve lower costs than a firm which expands less rapidly.

(1) There may be disequilibrium between the capacity for different operations - existing resources may not be in perfect balance - and by bottle-neck breaking it may be possible to achieve some increase in overall capacity without a proportionate increase in costs. The disequilibrium may occur because of indivisibilities, errors when the original plant was built or extended, the original plant was designed with the expectation that it would be expanded later, differential rates

of learning or technical progress for different operations, the freeing of resources, particularly management resources, engaged in previous expansion, etc. The rate of growth of output will determine the extent to which a firm takes up these economies in a given period.

(2) There may be scope for taking advantage of the economies of scale, by, for example, spreading first copy costs for a periodical over a larger circulation, by building larger units of plant, and by extending existing plants. The rate of growth is a factor determining the total output of products through time, and hence the extent to which the economies for spreading initial costs are achieved. It is also an important influence on the size of new plants and extensions to existing plants.

(3) New techniques which were not available, or were not used, when existing plants were built may be incorporated in new capacity: growth may enable a firm to take advantage of technical progress. The rate of growth of a firm may affect, or depend upon, technical progress. For example, a firm which is expanding rapidly may have more incentive to invest in developing new techniques of production which it can incorporate in its new capacity.

The following are the main sources of increased unit costs and diseconomies of rapid growth.

(1) Existing capacity will have been built when price levels were lower, and, other things being equal, in book value terms, but not in real terms, capital costs will be lower than for new plants. Also, in practice, much of the capital equipment employed in old plants will have been written off against previous profits and capital costs may be low. The rate of growth will determine the proportion of 'high cost' new plant operated by a firm.

(2) The costs per unit of some factors may increase if scale is increased. Examples of limitations on the supply of factors were given above.

(3) Growth may result in firms reaching levels of output where technical diseconomies of scale operate.

(4) Marketing and distribution costs per unit of output may have to be increased to dispose of a larger output.

(5) Rapid growth may influence the costs and effectiveness of management and labour relations favourably or otherwise. For example rapid rates of growth may enable a firm to maintain a balanced, or younger labour force, alternatively it may result in a dilution of a skilled and loyal labour force.

Avoiding the Disadvantages of Small Scale

It is possible to avoid some of the disadvantages of operating on a small scale. For example, a firm may buy out production operations or components for which there are large scale economies from domestic suppliers or suppliers in other countries. If these suppliers produce on a large scale or have low costs for other reasons, such as lower wages in other countries, then the firm may be able to buy at prices which are competitive with the costs of larger scale rivals.

The scope for avoiding the disadvantages of small scale apply particularly to research, development, marketing and distribution. Small firms may adopt strategies which enable them to compete. One marketing strategy is to produce for niche markets requiring distinct products for which there are few potential economies of scope for production if they were made with other products. Similarly a small firm may avoid a marketing and distribution handicap by adopting a strategy of selling own-label products to a supermarket or chain store groups which market and distribute the products. Similarly there may be scope for a firm with smaller output than its rivals to concentrate on products which do not require research and development expenditure, or to buy in research and development from a firm operating in another country.

Efficiency

This discussion of the sources of economies and diseconomies of scale and growth would be incomplete without a brief reference to the other forces affecting the success of a business. Most important is the ability of management to ensure efficient operation and to move with the times. More specifically in many industries the ability of management to control the quality of products and rejection rates, to organise production efficiently within the limits set by the size of plant and firm, to develop and introduce new or improved products, to search for profitable investment opportunities, to maintain a high level of capacity utilisation, etc. are very important to the success of a business. Firms which are so large that they control their markets may use their monopoly position to go peacefully to sleep, and efficient firms of less than optimum size may be absolutely more efficient than sleepy firms of a technically optimum size.

Section 3. Methods of Estimating Economies of Scale

Comparisons of costs

If experiments could be conducted to measure economic variables then to measure the economies of scale for plants in an industry, plants of varying size would be constructed and operated. Each plant would be built to incorporate the most efficient techniques for its scale of production. Unit costs of production for each plant would be measured and the economies of scale estimated by comparing unit costs for the plants.

It is, of course, impractical to build plants merely to measure the economies of scale. One alternative is to obtain costs of production for existing plants which operate at varying scales of output. Apart from the difficulties of obtaining such data, the main qualifications to this approach are that the data usually relate to plants built at different points in time. The plant and equipment is of varying vintages and the latest plant and equipment may incorporate knowledge which was not available when the earlier units were built. Also the plants may not be fully adapted to the scale of production at which they operate. Inevitably cost data for actual plants relate to operations in existence and cannot provide estimates for scales of production outside that range. For some industries cost data for a great many actual plants is available and have been analysed to isolate each of the factors influencing costs and to estimate the economies of scale. Electricity generation is the industry most fully researched for this purpose.

Another source of information about economies of scale is the costs of expanding the capacity of plants. Certainly experience of expanding capacity provides insights to the economies of scale, but straight comparisons of costs pre- and post-expansion do not give estimates of scale economies. These comparisons are affected by the extent to which existing plant was written down, technical progress, the extent to which the original and new capacity plant were adapted to their scales of production, as well as economies of scale.

Census data

Censuses of Production contain data on costs for large numbers of plants and firms. The clear advantages of these data are that they cover a great many establishments, again they are actual costs, and they are collected on a standardised basis.

The main limitations on estimating the economies of scale from Census data are that the definition of most Census 'trades' includes the production of a range of products for which economies of scale, market size and growth vary, and affect the size of establishments. For example, one U.K. Census trade includes the production of components for vehicles such as seat belts as well as engines and the assembly of cars, commercial vehicles, buses and battery driven vehicles. Some components for cars can be manufactured very efficiently in a factory of very small absolute size, but for the assembly of standard cars substantial economies of scale extend to an output of at least a quarter of a million cars a year on one site. Similarly production of most agricultural equipment is lumped together in one Census 'trade', and there are wide differences in the complexity and hence economies of scale for different types of agricultural equipment. These trades are not exceptional. The Index to the Standard Industrial Classification(1)

(1) HMSO 1981.

lists many products and processes for each three digit SIC heading. The number of products shown for each of 104 three digit headings was summed and the headings reordered in terms of the number of products and processes listed against them. For the median heading, the number of products and processes distinguished was 38, for the lower quartile 22, and for the upper quartile 75.

Comparisons of Census data for establishments of varying size does not provide unqualified estimates of the economies of scale because plants of different sizes make different products. Another limitation on Census data is that they can be used to derive estimates of the economies of scale for only one or possibly two dimensions of scale - the size of establishments and possibly the size of firms.

Time series data

Another source of cost data for estimating the economies of scale is time series data of costs and prices for products, plants, firms or industries. These data can be related to volumes of output, to trace the reduction in unit costs through time, as output increases. The principal and important qualification to this method is to distinguish the effects of those improvements in technology and efficiency which occur through time and which are independent of scale from the effects of increasing scale. Improvements in technology may involve the introduction of more efficient techniques which were not used previously or the introduction of newly developed methods of production. It is technically very difficult to isolate the effects of technical change and increases in scale.

Engineering Estimates

Another approach to estimating the economies of scale is to assemble estimates from managers, engineers, economists and accountants of the cost of operating at different scales of production, where full adaptation to the scale of production is allowed for. This is the method on which most reliance is placed in this paper and so this method is described in more detail.

In order to make engineering estimates the methods of production have to be broken down into individual processes and operations, and the technical basis for economies of scale has to be investigated. Usually it is not possible to describe processes in terms of engineering production functions which are based on scientific laws or experimental data, and so the estimates of the economies of scale for machines, process units, and operations, are based on engineers', cost accountants' and managers' estimates of costs. Their estimates are based on operating experience for plants of varying size, the experience of planning and building new plants and expanding plant capacity and general experience of their industry. Estimates of the components of costs, capital and operating costs for individual items of equipment of varying size, costs for processes and/or for groups of processes, development, first copy or initial costs for products, etc. are assembled for each industry, and are used to estimate the relationships between unit costs and the various dimensions of scale. The reliability of the estimates depends upon the experience of those making the estimates. Managers familiar with the construction and operation of giant steel works in Japan or cigarette factories in the USA are in a strong position to make estimates for those sizes of plant.

The weakness of 'engineering' estimates of the type described are that they are subject to a margin of error and that they lack rigour. Their accuracy is particularly suspect when dealing with some of the non-technical forces determining the effects of scale, for example, when estimating the relationship between size and the quality and effectiveness of management, and the effect of scale on the development of new techniques and products.

The main advantage of the engineering approach is that it is possible to hold other conditions, such as the state of the arts, the quality of factors of production, their relative prices, and some dimensions of scale, constant when making estimates of the economies of scale.(1) In spite of the limitations of the engineering approach it has been used in this paper because it is the most satisfactory method of making estimates of the economies of scale.

The best of the 'engineering' estimates are based on technical relationships and detailed costings. Such estimates are related to the production of specific ranges of products. The main qualifications to these 'engineering' estimates are that they are estimates for hypothetical operations. In practice, costs may vary from expected levels and such variances could be related to scale. Where 'engineering' estimates extend beyond scales for which experience has been obtained, unforeseen technical and management problems could invalidate the estimates. Transport costs and market constraints are usually excluded from engineering estimates. Transport costs can be

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(1) Plainly the quality of factors of production does vary. For example, the number and quality of apprentice trained craftsmen is greater in Germany than the UK and this difference contributes to differences in labour productivity and the performance of firms in the two countries. But it is separate from the economies of scale.

included, but they have to be related to an actual or hypothetical distribution of markets.

The Survivor Technique

The qualifications to estimates of the economies of scale based on costs have been described. Stigler suggested a method of avoiding these difficulties(1). The survivor technique is based on the reasonable assumption that if there is a most efficient scale of production for an industry then plants of that scale of production will gain an increasing share of an industry's output. A number of attempts have been made to apply the survivor technique to census data. If at successive censuses a size class of establishments gains an increasing share of a trade's output, it is claimed that size range is the optimum scale for the trade. The advantage of the technique is that the effects of all the forces which determine the success of a business are tested. These forces include the effectiveness of management and the ability of a business to adapt to changes in technology and the state of business.

Again the principal problem involved in applying the survivor technique to data for census trades is that each trade covers a wide range of activities for which the optimum scale and the state of business varies.

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(1) C.J. Stigler, 'Economies of Scale', Jnl. of Law and Economics, 1958.

Sources of Estimates

Table 3.1 lists some of the principal sources of estimates of the economies of scale for a range of manufacturing industries[(1)]. Table 3.2 summarises the advantages and disadvantages of the methods of measuring the economies of scale.

Conclusions

There are qualifications to all the methods of estimating the MES and the economies of scale. In practice the only sources of estimates of scale gradients for many industries available for use in this paper were engineering estimates and estimates based on census data. In this paper we concentrate on the engineering estimates. Estimates of the MES and scale gradients based on census data were not used as a principal source of estimates. The main reason for this decision was the author's view that the main dimension of scale to which economies of scale relate is the output of products and closely related products at plants and by firms. Censuses provide no indicators of costs relative to the output of products.[(2)] Engineering estimates are described in Section 5. Estimates made by other methods are included in section 7 where other evidence of the economies of scale is reviewed to assess whether it confirms or conflicts with the engineering estimates.

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(1) Studies of economies of scale for a single industry and for industries apart from manufacturing industries have been excluded from Table 3.1.

(2) There is no justification for assuming that the number of products made at each establishment in a trade is fixed and that the output or size of each establishment indicates the scale of output of the products made there.

Table 3.1 The Principal Sources and Reviews of Estimates of the Economies of Scale for Manufacturing Industries.

Method of Measurement	Source of data	The Studies	Main Country of Application
Cost Comparisons	Data for actual operations	Caleb Smith, 'Survey of Empirical Evidence on the Economies of Scale' in 'Business Concentration and Price Policy', G.J. Stigler and others, NBER, 1955.	USA
		J. Johnston, 'Statistical Cost Analysis', New York and London, 1960.	UK
		A.A. Walters, 'Production and Cost Functions: An Econometric Survey' in Econometrica, Vol. 31, 1963.	International
		Nicholas Owen 'Economies of Scale, Competitiveness, and Trade Patterns within the European Community', Oxford, 1983.	European countries
	Census data	Z. Griliches and V. Ringsjad 'Economies of Scale and the Form of the Production Function'. Amsterdam, 1971.	Norway
		J.R. Baldwin and P.K. Gorecki 'The Role of Scale in Canada-US Productivity Differences in the Manufacturing Sector', Toronto, 1986.	Canada
	Engineering Estimates Industry Studies	J.S. Bain 'Barriers to New Competition' Cambridge, Mass., 1956.	USA
		J. Haldi and D. Whitcomb, 'Economies of Scale in Industrial Plants', Jnl. of Political Economy, Vol. 75, 1967.	USA
		C.F. Pratten 'Economies of Scale in Manufacturing Industry', CUP 1971.	UK
		F.M. Scherer, 'The Economies of Multi-plant Operation' Cambridge, Mass. 1975	USA
		L.W. Weiss 'Optimal Plant Size and the Extent of Suboptimal Capacity' in 'Essays on Industrial Organization in Honor of Joe S. Bain' ed. by R.T. Masson and P. David Qualls, Cambridge Mass., 1976.	USA
Survivor Technique	Census Data	T.R. Saving, 'Estimation of the Optimum Size of Plant by the Survivor Technique' Quarterly Jnl. of Econ. 1961.	USA
		W.G. Shepherd, 'What does the Survivor Technique Show about the Economies of Scale' Southern Econ. Jnl. 1967.	USA

Method of Measurement	Source of data	The Studies	Main Country of Application
		R.D. Rees, 'Optimal Plant Size in United Kingdom Industries: Some Survivor Estimates' Economica, Nov. 1973	UK
		M. Pickford 'Estimating Economies of Plant Scale in New Zealand Manufacturing Industries Using Census Data', New Zealand Economic Papers, 1984.	NZ

Table 3.2 Advantages and Disadvantages of Methods of Measuring the Economies of Scale

	Provides measures of		Estimates available for many manufacturing industries	Dimensions of Scale for which estimates available:				Rigour of Estimates	
	the MES	Scale gradients		Production runs	Products	Plants	Firms	The estimates can be tested by conventional statistical tests	The estimates reflect management costs and effectiveness and response to change
Cost Comparisons:									
Data for actual operations	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes
Census data	Yes	Yes	Yes (but only for a few countries)	No	No	Yes (but the plants make different products invalidating the comparisons)	Generally No	Yes	Yes
Engineering estimates	Yes	Yes	Yes	Yes	Yes	Yes	Yes (but the estimates are not reliable)	No	No
Survivor technique	Yes	No	Yes	No	No	Yes	Generally No	No	Yes

Section 4. Characteristics of Industries and the Economies of Scale

Most businessmen claim that their industry is different from others. There is some justification for these claims, nevertheless industries can be grouped according to various characteristics. In this section some characteristics of industries and their relationships to the economies of scale are considered.

PRODUCTION CHARACTERISTICS

Costs of developing products

Drugs, aircraft and cars are products which involve considerable expenditure for development and testing. Spreading these costs over the output of products to which they relate provides significant economies of scale.

Paradoxically completely new types products also provide opportunities for small and new firms. Where the market for a radically new product is small initially and the costs of development are limited, small firms may be able to grow with the market for the product.

Complexity of products

Aircraft, cars and lorries are products for which there are large economies of scale. One explanation is the complexity of these products, they are made up of many distinct parts. Also many of the parts have to be made very accurately. Complexity affects design, development and production costs.

Similarly where a series of complex manufacturing operations are required to produce products as in oil refining, there will tend to be large economies of scale. Where production processes are simple as for the production of many items of food, the economies of scale for production are smaller.

Standardised products

Industries producing standardised products such as cement tend to be organised in large units. Standard products facilitate large scale production. Although computer control of stocks and production aids manufacture of a variety of products, the scope for economies for joint production depends upon the degree of variation between products. Industries such as paint and footwear which produce a very wide range of products in terms of colours, sizes, fashions, quality and price provide opportunities for small firms and establishments.

An interesting contrast is between the motor and computer industries. The latter provides greater opportunities for small and new firms to enter. The rapid evolution of computer technology has enabled firms to set up and grow with new segments of the market. Another explanation is that a higher proportion of the costs of a car relate to the components which do not vary for special uses or to provide product variety. For many computer systems much of the software and some of the hardware relate to special applications. Much of the hardware can be bought off the shelf.

Units produced

Production of a very large number of units of a product is associated with less significant economies of scale. The tobacco industry produces billions of cigarettes and the scale curve for tobacco factories of the size in existence is shallow.

Size of products

Bulky products such as large ships and process plant have to be built on a one off basis and this limits the scope for scale economies, though there are economies for producing a series of a type of ship or design of process plant through spreading the costs of design and learning from experience.

Processes of production

Some processes are generally associated with large scale economies of scale in relation to the output of products, and others do not lend themselves to large scale operation.

a) Processes associated with large economies of scale for the output of products:

1. Continuous process operations as in oil refining.
2. Rolling operations as in the metal manufacturing, pulp, paper and printing industries.
3. Stamping and forging.
4. Machining metal.
5. Processing in vessels as in the paint and dyes industries.

b) Processes associated with smaller economies of scale:

1. Casting and moulding(1)
2. Extrusion
3. Spinning

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(1) Spreading the costs of moulds over large outputs of a product is a significant source of economies for some applications.

4. Weaving

5. Sewing

6. Assembly

MARKETS

Markets are segmented by the costs of transport which increase with the distance of deliveries, tariffs, legal and language differences, and differences of taste. One approach to estimating the economies of scale is to ignore selling, marketing and distribution costs and focus on the costs of production. This procedure is deceptive because there are economies of scale for marketing and distribution related to a firm's share of a market. For example, advertising by a firm with many customers in an area will result in many messages per advert getting to customers, and unit delivery costs will be less for a firm with large sales in an area, compared with a firm with fewer more scattered sales. An alternative approach is to relate the costs of selling and distribution to an actual or hypothetical pattern of markets and channels of distribution, and estimate the costs of marketing and distribution for firms with different shares of a market.

Distribution costs are important for explaining the actual size of plants in many industries. Other things being equal, the larger the output of a plant the greater will be unit delivery costs. Higher delivery costs may offset the lower costs for large plants compared to costs for a series of plants sited to minimise transport costs. Even for industries in which modern methods of bulk transport have reduced delivery costs, it may not be economic to close existing small plants which serve local markets, and concentrate production. The capital costs of plant and equipment for the small plants will have been written down and the plant may have a low second hand value. The reduction in the costs of production may be more than offset by the increased costs of transport.

The Size of National Markets

In smaller countries, such as Norway and New Zealand, the average size plants is smaller than in the large industrial countries. One explanation is, of course, transport costs and tariffs, but there are more complex reasons for the differences. After barriers to trade are reduced, there will be a legacy of small production units which will persist for many years. Often new small plants would not be set up where existing small plants can compete because the costs of developing products have been incurred and much of their capital equipment has been written off. Easy access and close proximity to a large market provides firms with advantages for developing products and marketing. Firms in relatively small countries may circumvent their small domestic market by exporting, and protecting their position in foreign markets by investment. They may also tend to specialise in producing intermediate goods for sale to other firms to avoid a marketing disadvantage, and make and export goods for which the economies of scale are modest to avoid being at a disadvantage for production costs. Such specialisation can be self-reinforcing. Managers and other employees in smaller countries are experienced and efficient at operating smaller scale units.

Section 5. A Survey of Engineering Estimates of the Economies of Scale

Introduction

Engineering estimates of the economies of scale are based on estimates of the unit costs of operating at different scales of production. In brief the assumptions made when estimating unit costs and the relationship between scale and costs are:

1. The estimates are for hypothetical production runs, plants and firms where the production facilities, manning etc., are adapted to the scale of output so as to minimise costs at that scale.

2. Relative prices of factors of production are those ruling in the countries for which the estimates were made, generally the USA or European countries.

3. The technologies available are those used in the developed industrial countries.

4. The degree of vertical integration is fixed.

There are problems involved in presenting a summary of engineering estimates of the economies of scale. There is a great deal of information to be summarised, the information is not comprehensive, either for all trades, or for all the dimensions of scale for the trades for which information is available, and the assumptions and definitions used by authors who have made the engineering estimates of the economies of scale are not identical.

Table 5.1 summaries the relatively thorough estimates of the economies of scale. The next step was to extend the estimates to some trades for which engineering estimates were not available. This exercise is reported in Table 5.2. In table 5.3 the information available is used to draw conclusions about the economies of scale for industry groups. Tables 5.4 to 5.8 summarise the quantitative estimates of the economies of scale for the main dimensions of scale.

Introduction to Table 5.1

Table 5.1 lists 'engineering' estimates of the economies of scale in NACE3 order. Only the salient sources and figures are given in this survey. For those industries for which a number of studies have been made only the more recent studies are included. The first four columns of Table 5.1 list the NACE3 references, the industries, the sources of the estimates of the economies of scale and the countries from which information was collected to make the estimates. The next two columns summarise the quantitative estimates. The fifth column lists the estimates of the minimum efficient scale (MES) which is defined below. This column gives the dimensions of scale to which quantitative estimates of the MES relate, and the MES scale for each of the dimensions of scale listed. The sixth column gives the increase in unit costs below the MES scale, usually this is given in terms of the increase in unit costs at a half or, one third of the MES scale. The seventh column lists the main dimensions of scale to which economies relate and indicates the extent of the economies. This column includes dimensions of scale for which no quantitative estimates of the MES are available.

Definition of the MES

The information for Table 5.1 is drawn from a number of sources and the definitions used by authors of the sources were not uniform. One problem is the definition of the MES. In practice most engineering

Table 5.1 Survey of the Engineering Estimates of the Economies of Scale.

NACE3 NUMBER	Industry	Source	Countries for which estimates made	M.E.S. Dimension of Scale - MES Scale for that dimension	Increase in unit costs below MES Scale	Main dimensions of scale to which economies relate	Comments	Size of the Industry Percentage of Employment in UK Manufacturing Industry in 1985	Representativeness of the estimates for UK industry
14	Mineral Oil Refining	Scherer 1975[1]	International	Size of refineries - 200,00 barrels a day Oil companies - 2-3 plants, say, ½ m. barrels a day	4% at 1/3rd MES Slight disadvantage with one plant	Size of refineries - moderate. R & D - slight.		0.3 (Oil refining is a highly capital intensive industry)	Major oil refineries account for more than half the net output of the industry. There is a fringe of medium and small plants reprocessing oil and making specialist products. Technical economies of scale also apply to these operations, but markets are small and/or processing costs low for some of them.
22	Production & Preliminary Processing of Metals							3.2	
221	Iron and Steel Industry							1.3	
	Steel (Crude Steel) Integrated Plants	Scherer 1975[1]	International	Size of plant - 4m. tons a year	11.0% at 1/3rd MES Production runs - some benefits. Products - some benefits. R & D - slight.	Size of plant - substantial.	Depending upon the price of scrap relative to other raw materials, mini plants using scrap can be competitive.	0.8 (estimate)	The estimates showing large economies of scale (the slope of the scale gradient) is representative. Crude steel production forms about half the output of the industry. The MES for some finishing works and special steel works is lower in terms of tonnage of output, but large economies of scale apply for these operations.
				Steel companies 1 plant	Very slight advantage for multi-plant operation	Size of company - a less important factor			
		Cockerill 1984[3]	International	Size of plant making flat rolled products 10m tons a year	No estimate		The scope for scale economies are slightly less for other types of products.		
				Steel companies Economies may extend beyond 10m. tons a year	No estimate				
		Muller et al. 1985[17]	Germany	Integrated steelworks 9.6-12m tons a year Mini steelworks 0.7-0.8m tons a year	> 10% at 1/3rd MES > 10% at 1/3rd MES				
	(Special steels)	Pratten 1971[4]	UK	Groups of products such as stainless steel and tool steels - 10% of UK output	No estimate but significant		In terms of value added there are substantial economies of scale.		
223	Drawing, Cold Rolling etc. of Steel							0.5	There are a great many establishments in this industry making different products. For some simple products like barbed wire the economies of scale are rather limited for others like wire netting there are moderate economies.
	Steel Wire Fencing	UK Monopolies & Mergers Commission Report 1987	UK	Factories: Barbed wire - sales of 1.76m. a year. Wire netting - sales of 14m. a year in 1987	No estimate No estimate			0.04 (estimate)	

NACE3 NUMBER	Industry	Source	Countries for which estimates made	M.E.S. Dimension of Scale - MES Scale for that dimension	Increase in unit costs below MES Scale	Main dimensions of scale to which economies relate	Comments	Size of the Industry Percentage of Employment in UK Manufacturing Industry in 1985	Representativeness of the estimates for UK industry
224 2245	Non Ferrous Metals Industry Primary and Secondary Aluminium							1.0	Aluminium processing is probably representative. There are significant economies for large outputs of products and production runs. The MES varies according to the process used and the market often limits the scale of production in practice.
	Aluminium Semi-manufactures	L. Wagner 1981[2] reference to U.K. National Board for Prices & Incomes Report No. 39 'Costs & Prices for Aluminium semi-manufactures 1967	UK	Works making rolled products - 200,000 tons per annum.		Size of works - no estimate. Production runs - significant. Products - significant. R & D - significant.	Scale economies much smaller for works making extruded products.	<0.1 (estimate)	
241	Manufacture of Clay Products for Construction Purposes							0.4	The estimates for non-fletton bricks are representative for much of the industry, but economies of scale for flettons are greater. Also there are niches where small establishments can compete; for example making bricks which match bricks used in existing buildings and which are no longer made on a large scale.
	Bricks	Pratten 1971[4]	UK	Non-fletton brickworks - 25m bricks at least.	25% at half MES	Size of works - substantial.	The MES for fletton brickworks is higher.		
				Size of company manufacturing non-flettons	Slight if any advantages for multi-works firms.				
242	Manufacture of Concrete or Plaster Products for Construction							0.2	Cement production forms a large part of this industry (more than half), but there are a lot of small establishments presumably making other products or distributing cement.
	Cement	Scherer 1975[1]	International	Cement works 1.3m tons a year	26% at 1/3rd MES	Size of works - substantial.			
		Muller et al 1985[17]	Germany	Cement works 1.3m tons a year	> 10% at 1/3rd MES				
243	Building Products of Concrete, Cement or Plaster							0.7	Plasterboard is not typical for this industry which includes ready mixed concrete and concrete products which are costly to transport and are made at many sites to minimise transport costs.
	Plasterboard	L. Wagner 1981[2] reference to Monopolies & Mergers Commission Report on Plasterboard 1974	UK	Works 18-20m sq. mtrs. a year				0.1(estimate)	
247	Manufacture of glass and glassware							0.8	Glass bottles are not typical for this industry. It includes flat glass for which there are large economies of scale and ornamental and scientific glassware for which there may be large economies for some products but for many of these products markets are so limited that small establishments are competitive.
	Glass Bottles	Scherer 1975[1] UK Monopolies and Mergers Commission Report on 'The proposed merger of Rockware, United Glass & Redfearn National Glass', 1975 and author's knowledge of the industry.	International	Factories 133,000 tons a year or 1000 employees	11% at 1/3rd MES	Size of works - moderate. Production runs and Products - some benefits.	There are scale economies for large outputs of specialised products e.g. pharmaceutical bottles.	0.1 (estimate)	

NACE3 NUMBER	Industry	Source	Countries for which estimates made	M.E.S. Dimension of Scale - MES Scale for that dimension	Increase in unit costs below MES Scale	Main dimensions of scale to which economies relate	Comments	Size of the Industry Percentage of Employment in UK Manufacturing Industry in 1985	Representativeness of the estimates for UK industry
248	Manufacture of Ceramic Goods							1.1	The estimate that the MES for establishments is small is representative for the industry. Also the economies for specialisation and production runs apply in much of the industry. In segments, for example fine china, there are economies of scale for marketing.
	Pottery	P.W. Gay and R.L. Smyth 'The British Pottery Industry', London, 1974	UK	Tableware: Factories - the MES is small in relation to UK output	No estimate	Specialisation and production runs - moderate.	'There are economies of scale ... (for firms)... based on marketing, commercial and financial economies'. The economies of scale may be larger for industrial ceramics		
25.	Chemical Industry								
251	Manufacture of Basic Industrial Chemicals							1.9	The estimates showing steep scale gradients for plants making industrial chemicals are representative for this industry.
	Dyes	Pratten 1971 (4)	UK	Output of a dye - 100% of UK output Works for producing dyes - estimate not available	17% at half of MES	Output of dyes - large. Production runs - large. Size of works - no estimate.			
	Petro-chemicals	Muller and Owen Owen 1983 (5)	Germany	Ethylene plant, Polyethylene plant, PVC plant - 500,000 tons a year.	19% at 1/3rd MES	Output of plants - large.			
	Sulphuric Acid	Pratten 1971 (4)	UK	Plants - 1m. tons a year	1% at ½ MES	Output of plants - large.	Increase in value added per unit 19% at ½ MES.		
		Muller et al 1975 (17)	Germany	- 350,000m tons a year	5-10% at 1/3 scale				
	Titanium Dioxide	Pankas Ghemawat 1984 (7)	USA	Plants - 130,000 tons	8-16% at ½ MES depending on process	Output of plants - large.			
	Synthetic Rubber	Scherer 1980 (8) Weiss	USA	Plants - 60,000 tons a year	15% at ½ MES	Output of plants - large.			
255	Manufacture of Paint							0.6	Paint is representative for the other products included in this trade, varnishes and printing ink.
	Paint	Scherer 1975 (1)	International	Works for producing paint - 10m. US galls a year/600 employees	4.4% at 1/3rd MES	Production runs - moderate. Products - moderate. Works - moderate. R & D - significant or large in certain segments of the trade	There is scope for specialisation in the industry and for small firms to be competitive for some products.		

NACE3 NUMBER	Industry	Source	Countries for which estimates made	M.E.S. Dimension of Scale - MES Scale for that dimension	Increase in unit costs below MES Scale	Main dimensions of scale to which economies relate	Comments	Size of the Industry Percentage of Employment In UK Manufacturing Industry in 1985	Representativeness of the estimates for UK industry
256	**Manufacture of Other Chemical Products**							0.9	NACE 256 includes a wide range of products. Generally there are large economies of scale for production of each of these products, but most of them are made in much smaller plants (measured in tons of capacity) than those used for fertilizers.
	Fertilizers	L. Wagner[2] reference to European Chemical News 'Major New Fertilizer Plants', 1976	International	Ammonia plants - 300,000-350,000 tons		Output of plants - large.		0.1 (estimate)	
257	**Manufacture of Pharmaceutical Products**							1.3	NACE 257 is limited to pharmaceutical products.
	Pharma-ceuticals	Reekie 1975[6]	UK	Works for producing drugs - no estimate but production costs generally a small part of total product costs		Production runs, and Works - scale economies for these dimensions swamped by other factors affecting costs. R & D - large for new drugs. Marketing - large for much of the industry's output.			
258	**Manufacture of Soap and Synthetic Detergents**							0.6	NACE 258 includes perfumes, cosmetics and toilet preparations for which production costs generally represent a small part of the prices charged to consumers. Economies of scale for production are not very significant for these products and so estimates of economies of scale for detergents and soap are not representative for this heading.
	Soap and Detergents	Pratten 1971[4]	UK					0.2	
	Detergents			Plant - 70,000 tons	2½% at half MES	Marketing - large.			
	Soap			Plant - at least 10,000 tons	No estimate				
26.	**Man-Made Fibres**							0.2	NACE 26 is confined to man made fibres for which the estimates are representative.
	Nylon, acrylic and polyester fibres	Scherer 1980[8] Weiss 1976(9) R.W. & S.A. Shaw[10]	USA UK	Works - Nylon - 50m lbs a year	12% at ½ MES	Products - moderate. Production runs - moderate. R & D - moderate.			
				Acrylic - 42.4m lbs a year	9.5% at ½ MES				
				Polyester - 40.0m lbs a year	10% at ½ MES				
				Polyester - 100,000 tons a year	7.6% at ½ MES				
	Cellulosic fibres	Scherer 1980[8] Weiss 1976(9)	USA	Works - Filament - 70m lbs a year	5% at ½ MES				
				Rayon staple - 125m lbs a year	5% at ½ MES				
311	**Foundries**							1.0	NACE 311 includes ferrous and non ferrous foundries, but is confined to foundries. The estimates given are representative.
	Iron castings: Cylinder blocks	Pratten 1971[4]	UK	Foundry - 50,000 tons a year	10% at ½ MES	Products - moderate/large.			

NACE3 NUMBER	Industry	Source	Countries for which estimates made	M.E.S. Dimension of Scale - MES Scale for that dimension	Increase in unit costs below MES Scale	Main dimensions of scale to which economies relate	Comments	Size of the Industry Percentage of Employment in UK Manufacturing Industry in 1985	Representativeness of the estimates for UK industry
	Small engineering castings			Foundry - 10,000 tons a year	5% at ½ MES	Production runs - moderate. Foundries - moderate.			
32	Mechanical Engineering								
321	Manufacture of Agricultural Machinery & Tractors							0.5	Tractors and combines are representative for about half of this NACE heading. Some of the other products such as ploughs and harrows are simpler products or the market is limited and so the MES for firms is smaller than for tractors and combines but there are economies for outputs of most of these products.
	Tractors	Muller & Owen 1983 (5)	Germany	Firm - output of tractors assembled at one site - 90,000 tractors a year.	6% at ½ MES	Output of models - moderate. Production runs - moderate.		0.9 (estimate)	
	Combine Harvesters	Muller & Owen 1983(5)	Germany	Firm - output assembled at one site with bought out engines - 20,000 combine harvesters a year.	7.7% at ½ MES	Output of models - slight. Production runs - slight.			
322	Manufacture of Machine Tools							1.2	NACE 322 is confined to machine tools so the description is representative.
	Machine tools	Boston Consulting Group 1985 (11) Pratten 1971(4)	International UK						
	Standard conventional machine tools			Firm - output at one factory - no estimate given	3-5% if output halved	Output of model - moderate. Production runs - moderate. Output at factory - moderate. R & D - large for some types of products	The range of products made by the industry is immense.		
	Sophisticated machine tools made in volume			Firm - output at one factory at least 400 m/t a year					
	Specialised machine tools			Firm - output at one factory - small firms can be competitive if the market for their specialized tools is small					
326	Manufacture of Transmissions Equipment for Motive Power							0.9	NACE 326 includes a wide range of products such as chains, gears and gear boxes. Rather large economies of scale apply to many, but not all of these products. Difficult to assess the representativeness of ball bearings.
	Ball bearings	Muller & Owen 1983(5) Scherer 1975(1) and author's knowledge of the industry	Germany International	Factory - about 800 employees Firm - say 10% of of world market	8-10% at 1/3rd MES No estimate but large economies by concentrating production of different types and sizes of bearings.	Output of products (types & sizes) - large. Production runs - moderate. Output of factories (including economies for outputs of products) - large. R & D - large for some products.	Factories with less than MES may not have significantly higher costs if they specialise.	0.15 (estimate)	

NACE3 NUMBER	Industry	Source	Countries for which estimates made	M.E.S. Dimension of Scale - MES Scale for that dimension	Increase in unit costs below MES Scale	Main dimensions of scale to which economies relate	Comments	Size of the Industry Percentage of Employment In UK Manufacturing Industry in 1985	Representativeness of the estimates for UK Industry
328	Manufacture of Other Machinery & Equipment							4.3	NACE 328 is a residual heading and includes a wide range of machinery such as compressors, refrigerating machinery, pumps and valves. The MES scale for firms and factories at which these products are made must vary considerably with the complexity of the products and the market for them. Generally there would be large economies of scale for products.
	Diesel engines 50-1500 h.p.	Weiss 1976[9] Pratten 1971[4]	USA UK	Firm output of diesels - 5% of US shipments in 1967. 100,000 units of a design.	10% at ½ MES 4% at ½ MES	Output of designs - moderate. Production runs - moderate. Factories - moderate.		0.3 (estimate)	
	Chain saws	Porter 1983[12]	USA	Firm making petrol chain-saws 150,000 units a year.	No estimate	Insufficient information to complete this section.		<0.1 (estimate)	
33	Manufacture of Office Machinery and Data Processing Equipment							1.0	Again NACE 33 includes a wide range of machinery for which the MES must vary. For most products there are large economies of scale.
	Electronic calculators	L. Wagner 1981[2] reference to R. Levine Financial Times 19 Jan. 1976	UK	Firm output of calculators - 3-4 million a year	No estimate			0	
	Computers, Mainframes	Johnson (1980)[13] P.L. Stoneman 'Computers'.	UK	Firm output of computers - A large share of the world market	No estimate	Output of mainframes - large. Output of computers for specialised uses - large.		0.15 (estimate)	
	Electronic typewriters	Muller et al 1985[17]	Germany	Firm output of typewriters: 500,000 a year	5-10% at 1/3rd MES			<0.1 (estimate)	
34	Electrical Engineering							2.1	NACE 342 includes a wide range of electrical machinery. Scale gradients for many of these products could be moderate to large. MES for factories varies with products and is generally small relative to total output for the NACE heading.
342	Manufacture of Electrical Machinery								
	Transformers Distribution transformers Small power transformers Large power transformers	Weiss 1976[9]	USA	Firms - 2% of US output in 1967 6.9% of US output in 1967 7.1% of US output in 1967	7% at ½ MES 7% at ½ MES 10% at ½ MES	Insufficient information to complete this section		0.2 (estimate)	
	Large Turbo-generators	Pratten 1971[4] Porter 1983 (12) A.S. Surrey and J.H. Cheshire 'The World Market for Electric Power Equipment' Brighton 1972.	UK USA UK	A design - at least four units. Factories - output of at least 6,000 M.W. a year	5% at ½ MES No estimate	Designs - large. Factories - large. R & D - large.		0.1 (estimate)	
	Electric Motors	Pratten 1971[4]	UK	Factories to make a range of motors - [illegible] of UK market in 1970.	15% at ½ MES	Production runs - large. Factories - large.		0.2 (estimate)	

NACE 3 NUMBER	Industry	Source	Countries for which estimates made	M.E.S. Dimension of Scale - MES Scale for that dimension	Increase in unit costs below MES Scale	Main dimensions of scale to which economies relate	Comments	Size of the Industry Percentage of Employment in UK Manufacturing Industry in 1985	Representativeness of the estimates for UK industry
343	Electrical Equipment for Industrial Use, and Batteries and Accumulators							1.2	
	Auto Batteries	Scherer 1975 (1)	International	Factory - 1m. units a year.	4.6% at 1/3rd MES	Factories - moderate.		<0.1 (estimate)	Information for batteries is not representative for this heterogeneous NACE heading.
344	Manufacture of Telecommunications Equipment							4.5	
	Micro processors	F. Malerba - 'The Semi-Conductor Business' London 1985.	USA	Production of types of micro processors by a firm - no estimate of MES, probably greater than the UK market in 1975.	No estimate but large.	R & D - large.	Scope for smaller scale production of devices with special applications.	0.2 (estimate)	The estimates are representative in showing large economies of scale for products. The MES scale of factories and firms varies for the wide range of equipment made by the industry.
	Public switches	Muller et al, 1985 (17)	Germany	Production of exchanges - 400,000 to 500,000 lines a year.	5-10% at 1/3rd MES			0.4 (estimate)	
		J. Ehnes, M.Phil Thesis Cambridge, 1984. U.K. Monopolies & Mergers Commission 'The GEC & Plessey proposed merger' 1986.	UK	Production of exchanges - 500,000 lines a year. Firms - no estimate but economies through spreading R & D extend far beyond 500,000 lines a year.	4.5% of ½ MES	Production - moderate. R & D - large.			
	PABX's	U.K. Monopolies & Mergers Commission, B.T. & Mitel proposed merger.	UK	No estimate	No estimate	R & D - large.			
344	Manufacture of Radio and Television Receiving Sets							1.3	
	T.V. sets	Muller & Owen 1983 (5)	Germany	Factory making a range of sets - 1.1-1.2m. units a year.	15% at 1/3rd MES	Products - moderate/large. Production runs - moderate. Factories - large.		0.2 (estimate)	Similar to NACE 344.
	Videos	Muller et al 1985 (17)	Germany	Factory - 0.8-1m units a year.	No estimate				
	Electronic Capital Goods	Pratten 1971 (4)	UK	Output of a product - 100% of UK market	8% at ½ MES	Products - large Production runs - large.		0.6 (estimate)	
346	Manufacture of Domestic Type Electric Appliances							0.8	NACE 346 is a relatively specialised heading. The estimates for large domestic appliances shown are applicable to smaller appliances such as toasters, showers and food mixers but the MES scale of factories making these products would be smaller.
	Fridges and Washing Machines	Muller & Owen 1983 (5)	Germany	Factory making two types of fridge 1 to 1.2m. units a year. Factory making two models of washing machine - 800,000 units a year.	6.5% at 1/3rd MES 7.5% at 1/3rd MES	Products - moderate. Production runs - moderate. Factories - moderate.		0.3 (estimate)	

NACE3 NUMBER	Industry	Source	Countries for which estimates made	M.E.S. Dimension of Scale - MES Scale for that dimension	Increase in unit costs below MES Scale	Main dimensions of scale to which economies relate	Comments	Size of the Industry Percentage of Employment In UK Manufacturing Industry in 1985	Representativeness of the estimates for UK industry
35	Manufacture and Assembly of Motor Vehicles							3.1	NACE 35 is limited to motor vehicles and the estimates are representative for this large industry
351	Manufacture of Motor Vehicles								
	Cars	Muller & Owen(5) Altshuler & Others 'The Future of the Automobile', London, 1984. Friedlaender et al. USA 1983 (14) Muller et al 1985(17)	Germany International	Firm making a range of four cars - 2m. units a year	15% at 1/3rd MES	Models - large. Production runs - moderate. Factories - depends upon products. Firms - large.	Economies of scale are smaller for specialist manufacturers and the cost disadvantage can be reduced by buying out components.	+22 for motor vehicle bodies and parts (NACE 352 and 353)	
				Firm - 0.5m units a year.	> 10% at 1/3rd MES				
	Trucks	Muller & Owen(5)	Germany	Firm making a range of trucks of more than 6 tons - 250,000 units a year.	12% at 1/3rd MES	Models - large. Production runs - moderate. R & D - large. Firm - large.			
36	Manufacture of Other Means of Transport								
361	Shipbuilding	Daniel Todd 'The World Shipbuilding Industry' London, 1985.	UK	Shipyards - no estimate.		Series of ships - large.		1.7	NACE 361 includes the building of yachts, ship repairing and breaking for which the economies of scale differ from those for major ship construction. The latter represents less than half of the industry.
	Marine diesels	Pratten 1971(4)	UK	Factory - at least 100,000 h.p. a year.	8% at ½ MES	Designs of engine - moderate. Factories - moderate.		0.1 (estimate)	
363	Manufacture of Cycles							0.1	NACE 363 includes motor cycle production but cycle manufacture is the largest component of this heading in the UK. Motor cycles would be more important than cycles in some European countries. For motor cycles the economies of scale are much greater than for cycles.
	Motor Cycles	Muller et al 1985(17)	Germany	Firm making motor cycles - 200,000 a year.	No estimate				
	Bicycles	Pratten 1971(4)	UK	Factory assembling range of bicycles - less than 100,000 a year.	No estimate but small - the difference in costs depends upon the range of operations performed in-house.	Products - slight. Production runs - slight. Factories - slight.	Firms with small outputs can limit their disadvantage by importing components.		
364	Aerospace Equipment Manufacturing							3.4	Apart from commercial aircraft, the industry develops and manufactures defence equipment. The estimate of large economies of scale for products attributable to spreading large development costs is representative for the industry.
	Aeroplanes	Pratten 1971(4)	UK	Firm making commercial aeroplanes - more than 50 of any model.	20% at ½ MES	Models - large. R & D - large. Firm - large.			
37	Instrument Engineering								
371	Instruments	Luc Soete et al. 'Technological Trends and Employment 3 Electronics & Communications', Aldershot, 1985. Instrumentation [illegible]	UK	No estimates		Products - large. R & D - large.	The industry makes a very wide range of products.	0.8	Generally there are economies of scale for products.

NACE3 NUMBER	Industry	Source	Countries for which estimates made	M.E.S. Dimension of Scale - MES Scale for that dimension	Increase in unit costs below MES Scale	Main dimensions of scale to which economies relate	Comments	Size of the Industry Percentage of Employment In UK Manufacturing Industry in 1985	Representativeness of the estimates for UK industry
41/2	Food, Drink and Tobacco Industry								
411	Manufacture of Vegetable and Animal Oils								
	Soyabean Oil Mills	Connor et al. 1984 (15)	USA	Mill - 4.58% of US shipments c. 1975	4% at 2/3rd MES		In many food trades there is scope for economies of scale for marketing and/or distribution	0.1	
412	Slaughtering, Preparing and Preserving of Meat							2.1	
412	Meat packing,	Connor et al. 1984 (15)	USA	Plants - 0.33% of US shipments c. 1975	5% at 2/3rd of MES				
	Sausage manufacture	D. Lees & J. Morley, 'Competition in the Sausage Market', Jnl. of Ind. Econ. 1970.	UK	Plants - very small	No estimate				
413	Manufacture of Dairy Products							0.8	It is difficult to assess the representativeness of these estimates. Probably they are representative.
	Butter	Connor et al. 1984	USA	Factories - 1.29% of US shipments, c. 1975	2% at 2/3rd of MES				
	Cheese	Connor et al. 1984	USA	Factories - 0.63% of US shipments, c. 1975	2% at 2/3rd of MES				
	Milk products	Connor et al. 1984	USA	Factories - 0.40% of US shipments, c. 1975	2% at 2/3rd of MES				
414	Processing and Preserving of Fruit and Vegetables							0.3	
	Canned fruit and vegetables	Connor et al. 1984	USA	Factories - 7.23% of US shipments, c. 1975	5-12% at 2/3rds MES				
416	Grain Milling							0.1	
	Flour	Connor et al. 1984	USA	Mill - 0.74% of US shipments, c. 1975	21% at 2/3rds of MES				
	Rice	Connor et al. 1984	USA	Mill - 5.15% of US shipments, c. 1975	9% at 2/3rds of MES				

NACE3 NUMBER	Industry	Source	Countries for which estimates made	M.E.S. Dimension of Scale - MES Scale for that dimension	Increase in unit costs below MES Scale	Main dimensions of scale to which economies relate	Comments	Size of the Industry Percentage of Employment In UK Manufacturing Industry in 1985	Representativeness of the estimates for UK industry
419	Bread and Flour Confectionery							2.9	The estimate is representative for most of this industry.
	Bread	Connor et al. 1984	USA	Bakery - 0.2% of US shipments, c. 1975					
470	Sugar Manufacturing and Refining							0.2	Probably the estimate is representative.
	Sugar	Connor et al. 1984	USA	Cane refinery 1.41% of US shipments, c. 1975	8% at 2/3rds of MES				
472	Manufacture of Animal and Poultry Foods							0.4	NACE 422 includes pet food manufacture for which the economies and advantages of a large market share for marketing are important.
	Animal feeds	Connor et al. 1984	USA	Mills - 0.67% of US shipments, c. 1975	8% at 2/3rds of MES				
423	Manufacture of Other Food Products							1.3	NACE 423 is a residual heading. For both the products for which estimates of scale effects are given large economies of scale apply. These are probably not representative for this industry.
	Breakfast Cereals	Richard Schmalensee 'Entry deterrence in the ready to eat breakfast cereal Industry'. Bell Jnl. of Econ. 1978	USA	Firm's share of US market - 3-5%	No estimate				
	Potato crisps	L. Wagner[(2)]. Reference to Bevan, 'The UK Potato Crisp Industry 1960-72' Jnl. of Ind. Econ., 1974	UK	Factory - 30,000-35,000 tons per annum	No estimate				
427	Brewing and Malting							0.7	The estimates are representative for this trade.
	Beer	Scherer 1975[(1)]	International	Breweries - 4.5m. barr. per year Companies - 3-4 breweries to avoid more than a slight handicap.	5% at 1/3rd MES	Breweries - moderate. Marketing - slight to large depending upon strategy.			
		Cockerill 1984[(3)]	International	Breweries 3m. barr. per year.	7% at ½ MES				
		Müller et al 1985[(17)]	Germany	Breweries 7.3m barr. per year.	5-10% at 1/3rd MES				
429	Manufacture of Tobacco Products							0.5	The estimates are representative for this trade.
	Cigarettes	Scherer 1975[(1)]	International	Factories - 36 billion cigs. a year Companies - 1-2 factories	2.2% at 1/3 MES	Factories - slight to moderate Marketing - slight to moderate.			
		Müller et al 1985[(17)]	Germany	Factories - 70 billion cigs. a year.	less than 5% at 1/3rd MES				

NACE3 NUMBER	Industry	Source	Countries for which estimates made	M.E.S. Dimension of Scale - MES Scale for that dimension	Increase in unit costs below MES Scale	Main dimensions of scale to which economies relate	Comments	Size of the Industry Percentage of Employment in UK Manufacturing Industry in 1985	Representativeness of the estimates for UK industry
43	**Textile Industry**								
431	**Wool Industry**	G.F. Rainie 'The Woollen & Worsted Industry', Oxford 1965	UK				There is an ... 'absence over a large part of the industry of any significant economies of scale'	0.8	For the textile, clothing and footwear industries the estimates are representative of the bulk of the industries, but there are segments of these industries for which the economies of scale are larger than indicated.
432	**Cotton Industry**	B. Toyne et al.[16] Scherer 1975 (1)	International International			Production runs and and specialization more important than plant economies	Advantages of large weaving firms generally slight	0.6	
	Integrated weaving			Mill - 1.5% of US capacity c. 1975					
	Spinning-ring			Mill - little evidence of economies of scale					
	Spinning-open-end			Mill - 5000-6000 rotas	Significant economies of scale				
	Weaving			Mill - 300 looms	No estimate				
436	**Knitting Industry**	C. Gulvin 'The Scottish Hosiery & Knitwear Industry 1680-1980	UK				'The advantages of large firms in the knitwear trade seem to have increased but there is still scope for very small firms to set up'.	1.7	
438	**Manufacture of Carpets**							0.4	
	Carpets Tufted	Weiss 1976[9] and author's knowledge of the industry	USA UK	Factory - 64,000 sq. ft. a week	10% at 50% of MES	Production runs - large.		0.2 (estimate)	
	Axminster						The economies of scale for Axminster carpets are much lower than for tufted carpets.		
45	**Footwear and Clothing Industry**								
451	Manufacture of Mass-produced Footwear	Muller & Owen 1983[5]	Germany	Factory - 4000 pairs	1.5% at 1/3rd MES	Products - moderate. Advantages of large firms generally slight.		1.0	
	Leather Shoes	Scherer 1975 (1) and author's knowledge of the industry.	International UK		Production runs - moderate Factories - slight.				

NACE3 NUMBER	Industry	Source	Countries for which estimates made	M.E.S. Dimension of Scale - MES Scale for that dimension	Increase in unit costs below MES Scale	Main dimensions of scale to which economies relate	Comments	Size of the Industry: Percentage of Employment in UK Manufacturing Industry in 1985	Representativeness of the estimates for UK industry
471	Processing of Paper and Board							0.6	The estimates are representative.
	Linerboard	Weiss 1976(9)	USA	Mill - 850 tons a day	8% at 50% of MES				
	Kraft paper	Weiss 1976(9)	USA	Mill - 896 tons a day	13% at 50% of MES				
	Printing paper	Weiss 1976(9)	USA	Mill - 567 tons a day	9% at 50% of MES				
472	Conversion of Paper and Board							2.4	The industry makes a wide range of products. The estimate for diapers is not representative.
	Disposable Diapers	Porter 1983(12)	USA	Factory - 3-4 machines about 3% of US capacity.	No estimate	Factories - moderate/large. R & D - moderate/large.		<0.1 (estimate)	
473	Printing and Allied Industries							6.0	The industry includes publishing. The estimates are representative in showing large economies of scale for products attributable to spreading first copy costs.
	Book printing	Pratten 1971(4)	UK	Titles - Hardback - 10,000 Paperback - 100,000 Firm - 2% of UK industry in 1971.	36% at 50% of MES 20% at 50% of MES				
48	Processing of Rubber and Plastics								
	Manufacture of Rubber Products							1.3	
481	Tyres for passenger cars	Weiss 1976(9)	USA	Factory 16,500 tyres per day (5m a year)	5% at 50% of MES		Economies of scale for remould tyres much less.	0.4 (estimate)	Taken together the estimates for tyres and G.R.G. are representative for this industry.
		Muller et al 1985(17)	Germany	9m a year	5-10% at 1/3rd MES				
	General rubber goods (G.R.G.)	C. Pratten and A. Silberston 'The Optimum Scale in the Production of General Rubber Goods', NEDO, London, 1967.	UK			Products - slight to large economies of scale. Factories - small factories can be competitive.		0.9 (estimate)	
483	Processing of Plastics							0.4	The estimates are representative.
	Moulded plastic products	Pratten 1971(4)	UK			Products - slight to large economies of scale. Factories - small factories can be competitive in this trade.			

<u>Footnotes</u>

(1) F.M. Scherer et al. 'The Economies of Multi-Plant Operations. Cambridge, USA and London 1975.

(2) L. Wagner 'Readings in Applied Macroeconomics'. 2nd Edition, Oxford 1981.

(3) In T.T. Jones and T.A.J. Cockerill 'Structure and Performance of Industries'. New Delhi, 1985, and A. Cockerill in collaboration with A. Silberston 'The Steel Industry International Comparisons of Industrial Structure and Performance' Cambridge, 1974.

(4) C.F. Pratten 'Economies of Scale in Manufacturing Industry', Cambridge 1971.

(5) Jurgen Muller and Nicholas Owen, 'Economic Effects of Free Trade in Manufactured Products within the EC' Berlin, 1983.

(6) W. Duncan Reekie, 'The Economies of the Pharmaceutical Industry', London 1975.

(7) Pankas Ghemawat, 'Capacity Expansion in the Titanium Dioxide Industry', Jnl. of Ind. Econ. Dec. 1984.

(8) F.M. Scherer, 'Industrial Market Structure and Economic Performance', 1980.

(9) Leonard W. Weiss 'Optimal Plant Size and the Extent of Suboptimal Capacity' in 'Essays on Industrial Organisation in Honour of Lae S. Bain', Edited by R.T. Masson & P. David Qualls, Massachusetts, 1976.

(10) R.W. and S.A. Shaw, 'Synthetic Fibres' in 'The Structure of British Industry'. Edited by P.S. Johnson, London, 1980.

(11) Boston Consulting Group, 'Strategic Study of the Machine Tool Industry' for the E.C. 1985.

(12) Michael E. Porter, 'Cases in Competitive Strategy', New York, 1983.

(13) P.S. Johnson 'The Structure of British Industry', London 1980.

(14) Friedlaender, Winston & Wang, 'Costs, technology and productivity in the US automobile industry', The Rand Jnl. of Econ. Vol. 14, No. 1.

(15) J.M. Connor, R.T. Rogers, B.W. Marion, W.F. Mueller, 'The Food Manufacturing Industry', Gower Publishing Co. Ltd.

(16) B. Toyne et al. 'The Global Textile Industry', London 1984.

(17) Jurgen Muller et al 'Empirische Untersuchung von industriellen Grobenvorteilen (Economies of Scale) nach der Methode der Ingenieurschatzengen, Berlin, 1985.

Glossary of Terms used in Table 5.1

MES - Minimum efficient scale. This term was defined on page 2. In Table 5.1 the definition used by the authors of the studies surveyed varies. The definitions used for the main sources are reported on page 35 and 50.

Dimensions of scale. These were described on page 3.

Plants, works, factories. The term establishment is used for censuses of production. It refers to the operations of a firm at a single site. In practice different terms are used for such operations. In the steel industry the terms steel plant or steel works are used, works is the term used in the cement industry and for footwear the term is factory.

Firms, companies. The term enterprise is used for censuses of production for firms operating one or more establishments in a trade. For Table 5.1 the terms firms and companies are used for this purpose.

estimates of unit costs do not identify a scale at which costs are at a minimum. The two main sources of information for Table 5.1 are the studies made by Pratten (1971) and by Scherer (1975). The latter study has spawned derivatives including Owen's and Muller and Owen's studies. Pratten used the following definition of the MES: 'the minimum scale above which any possible doubling in scale would reduce total unit costs by less than five percent and above which any possible subsequent doubling in scale would reduce value added per unit by less than ten per cent'. Also the MES was limited to 'the feasible range of output in ... the UK'. Scherer's definition involved two sets of conditions. 'Where there was considerable experience with plants believed to realize all known scale economies, we have defined the MOS as the smallest scale at which unit costs in 1965 - vintage plants attained a perceived minimum or at least came so close that remaining unexploited scale economies were viewed as insignificantly slight. When little or no experience in the highest-volume and still declining reaches of the long-run cost function existed we defined the MOS as the size of "best current practice" plants in operation during 1965'.

Another definition of the MES for plants and firms lurks in many studies of the economies of scale. Most industries produce a range of products and the market for these products varies. Often the market for some products is small. For multi product industries the MES is sometimes defined as the scale of plant or firm which can make and sell any combination of products and be competitive in terms of costs for those products with larger firms in the industry. This is the definition used in table 5.1 for pottery, machine tools, the knitting industry, general rubber goods and plastics. For some combinations of products the MES could, of course, be much higher than the MES specified for these industries.

The Country of Origin of the Estimates

Column 4 of Table 5.1 reports the country of origin of the estimates. It is sometimes suggested that the size of a country may influence the economies of scale or estimates of the economies of scale. Certainly firms operating in countries with small markets on average have smaller plants. Also, as noted on page 23, firms operating in a country with a small market could be relatively efficient at operating small plants. It may be difficult for managers of these firms to assess costs for large scale operations outside their own operating experience, and this could inject a downward bias on estimates of the economies of scale made in small countries. Pratten's estimates of the MES scale and scale gradients were obtained from managers of firms operating in the UK. Some, but not all of these managers knew about production facilities in the larger US market. Those whose experience and knowledge were limited to the UK market may have given lower estimates of the MES scale than managers of US firms would have estimated.

Scherer's (1975) study is the most helpful for assessing the significance of the countries for which estimates of the MES and the economies of scale were made because he studied firms in different countries. If the country of origin had a systematic influence on estimates of the economies of scale, Scherer could be expected to identify this bias. Scherer's sample of six countries ranged in size from Sweden to the USA. He concluded that 'we found little divergence among the views of producers in the six nations with respect to basic process optima, nor did perceived limits on the size of plants which could be managed successfully vary much between nations for a given product mix'.[1] 'Much more variance was encountered in estimates of the amount by which unit costs rose for plants built with only one-third of the MOS capacity. These deviations were evidently attributable at least in part to systematic international differences in factor costs and especially wages'. In terms of factor costs, Scherer's sample stretched from India to the USA. Most of the estimates surveyed in Table 5.1 were obtained in the USA or Europe. Factor prices in Europe and the USA are closer than they were in 1965 when Scherer made his study.

Engineering estimates generally relate to new plants, factories or production facilities set up at the time the estimates are made. Differences in relative factor prices are an important influence on whether firms install new plant, technology and methods, or soldier on with the existing production facilities. Countries where wages are relatively low have an incentive to retain in use small old plants which may operate efficiently at lower scales than new plant.

Size of country is not the only factor which could cause differences in estimates of economies of scale between countries. For example, Germany has special rules for brewing beer. Such rules could affect the MES scale of production. However, such differences of rules for production are unusual and their effects on estimates of the MES are not important.

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(1) F.M. Scherer et al. 'The Economies of Multi-plant Operation', Cambridge, Mass. 1975, p. 81.

Costs

Most engineering estimates concentrate on production costs. Scherer specifically limited his estimates of the MOS to production costs. The reason for excluding selling and distribution costs is that they vary depending on the characteristics of the market assumed. Nor, in practice, can engineering estimates allow for differences in the effectiveness of management attributable to scale.

Jurgen Muller et al. (1985) go further and exclude development costs from their estimates of MES and scale gradients.

Overview of Table 5.1

There are several features of Table 5.1 which are noteworthy. Firstly, the industries for which engineering estimates of economies of scale have been made are spread right across manufacturing industry. Secondly substantial economies of scale relate to the output of products and production runs. In many trades these dimensions of scale are more important than the size of plants and firms. Thirdly, the extent of economies of scale vary across industries and for different products made in many industries.

Extending the Coverage of Estimates of the Estimates of the Economies of Scale.

Table 5.2 relates trades for which no estimates of the economies of scale are available to trades for which such estimates are to hand. The purpose of the table is to extend, in a rough and ready way, the number of trades for which estimates of the economies of scale are available for statistical exercises. The basis for making the allocation is the

Table 5.2 Economies of Scale for Manufacturing Trades

	(2)	(3)	(4)	(5)	(6)
NACE3 Number	Trades for which estimates of the economies of scale are not available	Size of the Industry: Percentage of Employment in UK manufacturing industry in 1985	NACE3 Number	Trades for which information about the economies of scale is available and can be used for the trade listed in column (2)	Comments
323	Textile machinery	0.2	322	Machine tools	
324	Machinery for the food, chemical and related industries; process engineering industries	1.0	322	Machine tools	Similar to specialised machine tools. Large firms have advantages for tendering for large overseas contracts.
325	Mining machinery, construction and mechanical handling equipment	1.6	322	Machine tools	
327	Machinery for printing, paper, wood, leather, rubber, glass and related industries; laundry and dry cleaning machinery	0.6	322	Machine tools	
328	Miscellaneous machinery and mechanical equipment	4.3	322	Machine tools	
345	Miscellaneous electronic equipment	1.3	344	Electronic Capital Goods	
362	Railway and tramway vehicles	0.6	321	Manufacture of Agricultural Machinery and Tractors	
365	Miscellenous vehicles	0.1	363	Cycles and Motor Cycles	
371	Measuring, checking and precision apparatus.	0.8	344	Electronic Capital Goods	
372	Medical and surgical equipment and orthopaedic appliances	0.3	344	Electronic Capital Goods	
373	Optical precision instruments and photographic equipment	0.4	344	Electronic Capital Goods	

complexity of the products and the manufacturing processes used. No attempt was made to classify chemical, food, textile, clothing or footwear trades in this table. In very broad terms, trades in these groups are adequately represented by the observations included in Table 5.1.

The next stage of the analysis was to relate the estimates of economies of scale to the complete NACE3 classification in Table 5.3(a) and to assess the economies of scale for each industry group or branch. The number of employees engaged in each trade in EC10 is shown in column 3 of the table to indicate the relative importance of each trade. Some additional observations and references to statements about the economies of scale are added.(1) The observations are based on the author's knowledge of the industries obtained during visits to firms.

In the final column of Table 5.3(a) a summing up on the economies of scale for each industry group is attempted. This survey concentrates on the economies of scale for production and the spreading of development costs. For the most part economies of scale for marketing distribution and acquiring finance are ignored.

An ordering of industry groups in terms of the importance of economies of scale is attempted in Table 5.3(b). This classification is qualitative, but it takes into account two indicators - the MES as a percentage of the output of industries and the cost gradient below the MES scale. An attempt is also made in this table to indicate the principal dimension of scale to which economies relate in each industry. For two industries two dimensions are ticked because in the case of

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(1) Studies which include quantitative estimates are included in Table 5.1; the additional reference in Table 5.3 are qualitative.

Table 5.3(a) Economies of Scale for Industry Groups

NACE NO.	Description	Number of Employees in EC10 (thousands)	Comments on Scale Economies	The Economies of Scale for Industry Groups
11	Extraction and briquetting of solid fuels			
12	Coke ovens			
13	Extraction of petroleum and natural gas			
14	Mineral oil refining		See Table 5.1	
15	Nuclear fuels industry		Large economies of scale for production processes & R & D	
16	Production and distribution of electricity, gas, steam and hot water		Economies of scale for generating stations and distribution	
161	Generation and distribution of electric power			
162	Gasworks; gas distribution			
163	Production and distribution of steam, hot water, compressed air, district heating plants			
17	Water supply; collection, purification and distribution of water			
21	Extraction and preparation of metalliferous ores			
211	Extraction and preparation of iron ore			
212	Extraction and preparation of non-ferrous metal ores			
22	Production and preliminary processing of metals	982		
221	Iron and steel industry (as drined in the ESRC Treaty), excluding integrated coke ovens	559	See Table 5.1	
222	Manufacture of steel tubes	104	Large economies of scale for the production processes used in making many types of tubes	Metal Industries Generally large economies of scale for production processes. Scale economies also relate to the output of products and production runs.
223	Drawing, cold rolling and cold folding of steel	101	Wire netting: See Table 5.1	
224	Production and preliminary processing of non-ferrous metals	208	Aluminium, semi manufactures: See Table 5.1	
23	Extraction of minerals other than metalliferous and energy-producing minerals: peat extraction	85		
231	Extraction of building materials and refractory clays	45		

NACE NO.	Description	Number of Employees in EC10 (thousands)	Comments on Scale Economies	The Economies of Scale for Industry Groups
232	Mining of potassium salt and natural phosphates	40		
24	Manufacture of non-metallic mineral products	876		
241	Manufacture of clay products for constructional purposes	78	Bricks: See Table 5.1	
242	Manufacture of cement, lime and plaster	78	Cement: See Table 5.1	Non-metallic Mineral Products For cement and flat glass there are large economies of scale for production processes. For other trades, MES plants are generally much smaller in relation to industry output. There are economies for large outputs of products and production runs. Trade in these goods is limited by relatively heavy transport costs.
243	Manufacture of concrete, cement or plaster products for constructional purposes	209	Plasterboard: See Table 5.1 Generally limited economies of scale and heavy transport costs for moving products	
243.1	Manufacture of asbestos-cement products			
243.6	Manufacture of ready-mixed concrete			
244	Manufacture of articles of asbestos (except articles of asbestos-cement)	19		
245	Working of stone and of non-metallic mineral products	67		
246	Production of grindstones and other abrasive products	17		
247	Manufacture of glass and glassware	209	Glass bottles: see Table 5.1 Flat glass. Large economies of scale for the production of flat glass.	
248	Manufacture of ceramic goods	207	See Table 5.1	
25	Chemical industry	1507		
251	Manufacture of basic industrial chemicals and manufacture followed by further processing of such products	671	See Table 5.1	
255	Manufacture of paint, painter's fittings, varnish and printing ink	161	See Table 5.1	
256	Manufacture of other chemical products, mainly for industrial and agricultural purposes		See Table 5.1	Chemical Industry Generally large economies of scale for production processes; this applies particularly to continuous production processes but also to batch production. For some important segments R & D is a source of large scale economies.
257	Manufacture of pharmaceutical products	303	See Table 5.1	
258	Manufacture of soap, synthetic detergents, perfume and toilet preparations	157	See Table 5.1	
259	Manufacture of other chemical products, chiefly for household and office use	98		
259.1	Manufacture of photographic chemical material (sensitized photographic film, plate, paper, etc., and auxilliary products)			

NACE NO.	Description	Number of Employees in EC10 (thousands)	Comments on Scale Economies	The Economies of Scale for Industry Groups
259.2	Manufacture of polishes and the like for household use (shoe, furniture and floor care products, metal polishes, car polishes, etc.)			
26	Man-made fibres industry	62	See Table 5.1	Man-made Fibres Generally large economies of scale.
31	Manufacture of metal articles (except for mechanical, electrical and instrument engineering and vehicles)	1747		
311	Foundries	253	See Table 5.1	
312	Forging; drop forging, closed dieforging, pressing and stamping	130	Economies for products and production runs	
313	Secondary transformation, treatment and coating of metals	258		
314	Manufacture of structural metal products (incl. integrated assembly and installation)	246		Metal Goods Generally economies of scale for large plants less important but there are economies for large outputs of products and long production runs.
315	Boilermaking, manufacture and reservoirs, tanks and other sheet-metal containers	216		
316	Manufacture of tools and finished metal goods, except electrical equipment	653	Metal cans, S.J. Prais 'Productivity and Industrial Structure' Cambridge 1981. Vast number produced and transport costs limit concentration of this industry.	
316.5	Manufacture of domestic heating appliances and kitchen heating appliances of all kinds			
316.6	Manufacture of metal furniture (including safes)			
319	Other metal workshops not elsewhere specified			
32	Mechanical engineering	2144		
321	Manufacture of agricultural machinery and tractors	161	See Table 5.1 for tractors and combines.	
322	Manufacture of machine-tools for working metal, and of other tools and equipment for use with machines	254	See Table 5.1	
323	Manufacture of textile machinery and accessories: manufacture of sewing machines	91	Similar to machine tools	Mechanical Engineering Economies of scale for large factories and firms limited but there are large economies relating to outputs of models, designs and types of machines and economies for long production runs. The availability of a skilled and experienced labour force very important in these trades.
324	Manufacture of machinery for the food, chemical and related industries	236	Similar to machine tools	
325	Manufacture of plant for mines, the iron and steel industry and foundries, civil engineering and the building trade; manufacture of mechanical handling equipment	385	Similar to machine tools	

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NACE NO.	Description	Number of Employees in EC10 (thousands)	Comments on Scale Economies	The Economies of Scale for Industry Groups
326	Manufacture of transmission equipment for motive power	165	Ball bearings See Table 5.1	
327	Manufacture of other machinery and equipment for use in specific branches of industry	134	Similar to machine tools	
328	Manufacture of other machinery and equipment	711	Diesel engines and chain saws See Table 5.1.	
33	Manufacture of office machinery and data processing machinery	208	See Table 5.1	Office machinery Large economies of scale for products.
34	Electrical engineering			
341	Manufacture of insulated wires and cables	2483		
342	Manufacture of electrical machinery (comprising electric motors, electricity generators, transformers, switches, switchgear and other basic electrical plant).	712	See Table 5.1	
343	Manufacture of electrical apparatus and appliances for industrial use; manufacture of batteries and accumulators		Auto batteries: See Table 5.1	
344	Manufacture of telecommunications equipment, electrical and electronic measuring and recording equipment, and electro-medical equipment	746	See Table 5.1 Electronic equipment similar to electronic capital goods	Electrical Engineering Generally large economies of scale relating to products - turbo generators, public switches, T.V. sets. These economies relate to spreading development costs and production.
345	Manufacture of radio and television receiving sets, sound reproducing and recording equipment and of electronic equipment and apparatus (except electronic computers); manufacture of gramophone records and prerecorded magnetic tapes.	335	See Table 5.1	
346	Manufacture of domestic type electric appliances	209	See Table 5.1	
347	Manufacture of electric lamps and other electric lighting equipment	71		
348	Assembly and installation of electrical equipment and apparatus (except for work relating to the wiring of buildings)			
35	Manufacture of motor vehicles and of motor vehicle parts and accessories	1751		Motor Vehicles Very large economies of scale for production and for spreading development costs for models.
351	Manufacture and assembly of motor vehicles (including road tractors) and manufacture of motor vehicle engines		See Table 5.1	

NACE NO.	Description	Number of Employees in EC10 (thousands)	Comments on Scale Economies	The Economies of Scale for Industry Groups
352	Manufacture of bodies for motor vehicles and of motor-drawn trailers and caravans			
36	Manufacture of other means of transport	758		Other Vehicles Variable scale effects, low for cycles and shipbuilding though there are economies for large outputs of designs for ships but very large economies of scale for aircraft by spreading development costs.
361	Shipbuilding	254	See Table 5.1	
362	Manufacture of standard and narrow-gauge railway and tramway rolling-stock	92	Similar to manufacture of agricultural machinery and tractors	
363	Manufacture of cycles, motor-cycles and parts and accessories thereof	59	See Table 5.1.	
364	Aerospace equipment manufacturing and repairing	345	See Table 5.1	
37	Instrument engineering	289	See Table 5.1	Instrument Engineering Large economies of scale for outputs of products through spreading development costs.
371	Manufacture of measuring, checking and precision instruments and apparatus	116	Similar to electronic capital goods	
372	Manufacture of medical and surgical equipment and orthopaedic appliances (except orthopaedic footwear)	73	Similar to electronic capital goods	
373	Manufacture of optical instruments and photographic equipment	66	Similar to electronic capital goods	
374	Manufacture of clocks and watches and parts thereof	36		
41/42	Food, drink, and tobacco industry			
411	Manufacture of vegetable and animal oils and fats	43		
412	Slaughtering, preparing and preserving of meat (except the butchers' trade)	294		
413	Manufacture of dairy products	231		
414	Processing and preserving of fruit and vegetables	103		
415	Processing and preserving of fish and other sea foods fit for human consumption	64	See Table 5.1	Food Industry The main source of technical economies of scale is for large plants but MES scale of plants generally small in relation to trade output in the UK. There are also scale economies for marketing and distribution.
416	Grain milling	32		
417	Manufacture of spaghetti, macaroni, etc.			
418	Manufacture of starch and starch products	22		
419	Bread and flour confectionery	284		

NACE NO.	Description	Number of Employees in EC10 (thousands)	Comments on Scale Economies	The Economies of Scale for Industry Groups
420	Sugar manufacturing and refining		See Table 5.1	
421	Manufacture of cocoa, chocolate and sugar confectionery	176	For chocolate confectionery there are large economies of scale for factories and production lines for products. Cowling et al 'Mergers and Economic Performance', Cambridge 1980, Marketing economies of scale are described.	
422	Manufacture of animal and poultry foods (including fish meal and flour)	76	See Table 5.1 (422 and 423)	
423	Manufacture of other food products	148		
424	Distilling of ethyl alcohol from fermented materials; spirit distilling and compounding	70		
425	Manufacture of wine of fresh grapes and of beverages based thereon	25		**Drink and Tobacco** Moderate economies of scale for large breweries. Slight economies of scale for large cigarette factories. Marketing economies of scale are more important.
427	Brewing and malting	148	See Table 5.1	
428	Manufacture of soft drinks, including the bottling of natural spa waters	70		
429	Manufacture of tobacco products	96	Cigarettes: See Table 5.1	
43	Textile industry	1054		
431	Wood industry	158	See Table 5.1	
432	Cotton industry	269		
433	Silk industry			
434	Preparation, spinning and weaving of flax, hemp and ramie			
435	Jute industry	12		**Textiles** Generally the economies of scale are more limited than in most other sectors but there are economies for specialisation and for long production runs.
436	Knitting industry	297	See Table 5.1	
437	Textile finishing	93		
438	Manufacture of carpets, linoleum and other floor coverings, including leathercloth and similar supported synthetic sheeting	61		
438.1	Manufacture of carpets, carpeting, rugs, etc. from all types of fibres		Carpets: See Table 5.1	
438.2	Manufacture of linoleum and similar floor coverings (on paper, board or textile base)			

NACE NO.	Description	Number of Employees in EC10 (thousands)	Comments on Scale Economies	The Economies of Scale for Industry Groups
439	Miscellaneous textile industries	91		
44	Leather and leather goods industry (except footwear and clothing)	86		Leather Goods Generally small economies of scale. Some economies for specialisation and long production runs.
441	Tanning and dressing of leather	36		
442	Manufacture of products from leather and leather substitutes	50		
45	Footwear and clothing industry	975		
451	Manufacture of mass-produced footwear (excluding footwear made completely of wood or of rubber)	232	See Table 5.1	
453	Manufacture of ready-made clothing and accessories	689	Small factories and firms can be competitive but there are economies for specialisation and long production runs.	Footwear and Clothing Slight economies of scale for large factories but some economies for specialisation and long production runs.
455	Manufacture of household textiles and other made-up textile goods (outside weaving mills)			
456	Manufacture of furs and of fur goods	11		
46	Timber and wooden furniture industries	688		
461	Sawing and processing of wood	51		
462	Manufacture of semi-finished wood products	62		
463	Manufacture of carpentry and joinery components and of parquet flooring	111		Timber and Furniture Industries No evidence of economies of scale for large factories in these industries. But there is scope for economies for specialisation and long production runs for some lines.
464	Manufacture of wooden containers			
465	Other wood manufactures (except furniture)	35		
466	Manufacture of articles of cork and articles of straw and other plaiting materials (including basketware and wickerwork); manufacture of brushes and brooms	19		
467	Manufacture of wooden furniture	373	Furniture, S.J. Prais 'Productivity and Industrial Structure', Cambridge, 1981. No evidence of substantial economies of scale. The size of factories is very varied. Paul Wannacott 'The US and Canada: The Quest for Free Trade' Washington 1987. Comments suggest there are large economies of scale for specialisation and long production runs.	

NACE NO.	Description	Number of Employees in EC10 (thousands)	Comments on Scale Economies	The Economies of Scale for Industry Groups
47	Manufacture of paper and paper products printing and publishing	1206		
471	Manufacture of pulp, paper and board	166	See Table 5.1	Paper, Printing and Publishing There are large economies of scale for paper mills. There are large economies of scale for titles, but small printing presses are not at a disadvantage for work involving short runs.
472	Processing of paper and board	347		
473	Printing and allied industries	610	Books: See Table 5.1	
474	Publishing		For publishing and printing newspapers, periodicals and books there are large economies for titles by spreading first copy costs and set up costs.	
48	Processing of rubber and plastics	817		Rubber and Plastic Products Moderate economies of scale for tyre factories. Economies of scale for factories making general rubber goods and moulded plastic products generally slight but there are moderate to large economies for large outputs of products and/or long production runs.
481	Manufacture of rubber products	334	Tyres and GRC: See Table 5.1	
482	Retreading and repairing of rubber tyres			
483	Processing of plastics	505	Plastic goods: See Table 5.1	
49	Other manufacturing industries	192		Other Manufacturing Industries Typically firms in these trades operate from small factories. There may be scale economies for specialisation and long production runs.
491	Manufacture of articles of jewellery and goldsmiths' and silversmiths' wares: cutting or otherwise working of precious and semi-precious stones	53		
492	Manufacture of musical instruments	15		
493	Photographic and cinematographic laboratories			
494	Manufacture of toys and sports goods	72	There are economies of scale for specialization and large outputs of products.	
495	Miscellaneous manufacturing industries	38	(see 494)	
50	Building and civil engineering			
500	General building and civil engineering work (without any particular specialization) and demolition work			
501	Construction of flats, office blocks, hospitals and other buildings, both residential and non-residential			
502	Civil engineering: construction of roads, bridges, railways, etc.			
503	Installation (fittings and fixtures)			
504	Building completion work			

Table 5.3(b) <u>Ranking of Manufacturing Industry Groups by Economies of Scale</u>

Industry groups are listed in order of the importance of economies of scale for spreading development costs and for production costs.

	Principal dimensions of scale to which economies relate		
	Products and production runs	Size of establishment	Size of firms
1. Motor vehicles	√		√
2. Other vehicles	√		
3. Chemicals	√		
4. Man-made fibres	√		
5. Metals		√	
6. Office machinery	√		
7. Mechanical engineering	√		
8. Electrical engineering	√		
9. Instrument engineering	√		
10. Paper, printing and publishing	√	√	
11. Non metalic mineral products		√	
12. Metal goods	√		
13. Rubber and plastic products	√		
14. Drink and tobacco		√	
15. Food		√	
16. Other manufacturing industries			
17. Textiles	√		
18. Timber and furniture	√		
19. Footwear and clothing	√		
20. Leather goods	√		

motor vehicles it is difficult to distinguish between the economies for large outputs of products and large firms(1) and for paper, printing and publishing, size of plants are very important for paper products and for printing and publishing. The output of book, periodical and newspaper titles is highly important. This very crude test indicates that the output of products and production runs are the principal dimensions of scale to which economies for development and production costs relate.

Estimates of the Economies of Scale for Products, Production Runs and Specialisation

Most industries produce a wide range of products and so there is scope for varying output of products, for production runs of varying length and specialisation. (A production line or plant specialising on a narrow range of products is in effect an example of production of long runs). There are many references in the literature to the cost advantages of specialisation and long production runs. For example, in 1960, Professor Verdoorn suggested that differences in the length of production runs 'might well account for a considerable part of the differences in productivity' between America and Europe. He suggested the diversity of technical processes carried out in the same plant was much smaller in America.(2)

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(1) In this industry firms have to be large to have large outputs of products.

(2) E.A.G. Robinson, ed., 'Economic Consequences of the Size of Nations', London, 1960, p. 346.

The extent of the economies of long runs and large outputs of products are elusive. The economies of long production runs relate to the use of larger capacity, more efficient equipment as output increases, learning effects and the spreading of the costs of organising production runs. For products which may be made in repeated production runs, development costs can be spread. A substantial and increasing proportion of the costs of firms are fixed or semi-fixed relative to the output of products. These costs include design and development costs, the costs of setting up specialised production facilities and tooling, and product related marketing expenditure.

Increases in trade and hence scale since 1970 have directly increased the length of production runs and outputs of products. The increase in incomes and availability of imports on the other hand has enabled customers to be more choosy. European firms have reduced production of many standard traditional products and moved up market making new and distinctive products. These forces have reduced the average output of products and production runs in Europe, and increased the importance of these dimensions of scale for an assessment of the economies of scale.

One of the problems of assessing the effects of a general increase in the length of production runs for, say, dyes or paints is that such a change is remote from the expectations of managers. Also, in the short run firms would not change their plant and equipment in response to an increase in the length of run. In the long term firms would respond to a, say, doubling of length of production runs by installing larger units of plant and equipment.

Table 5.4 lists some estimates based on production conditions in the UK circa 1970. Substantial economies of scale are indicated in Table 5.4. Although only five estimates are shown, they are illustrative for many other trades; dyes for batch process trades, machine tools for many mechanical engineering trades, electronic capital goods for instruments, cotton weaving for textiles and clothing and books for printing and publishing. Data is not available to test whether the magnitude of these economies has changed since 1970 but it seems unlikely that there have been substantial changes. New methods of machining machine tool components, electronic chips, and computer type setting may have lowered the economies somewhat.

Throughout much of Table 5.1 and the summaries in Table 5.3 qualitative references were made, the economies for long production runs and for large outputs of products. Also the estimates of economies of scale for establishments and firms analysed below include economies of scale for products and production runs. If 'pushed to the wall' to make an estimate of the effects on unit costs of a doubling in the average output of products, production runs and specialisation from the present levels in the EC, the very rough expected orders of magnitude would be 6 per cent for total unit costs and 14 per cent for value added (total unit costs less the bought out component of costs) per unit. These are very large economies. In terms of marginal costs, the total unit costs of the extra output would be 88 per cent of those for the original output and value added per unit for the extra output would be only 72 per cent of that for the original output.

Table 5.4 Economies for Long Production Runs and Specialisation

NACE3 Code		Percentage Increase in Costs at 50% of MES: total unit costs	value added per unit	Comments
	Dyes			
251	New dye made in new plant	22	44	The estimates are representative for other batch process industries
	Traditional dye made in industries	17	56	
322	Machine Tools			
	Models of machine tools	5	10	Approximate estimate. The extent of the economies depends upon the level of development costs. Machine tools are representative of much of the engineering industry.
345	Electronic capital goods	8	13	Approximate estimate. The extent of economies depends upon the level of development costs. Electronic capital goods are representative of instruments
432	Cotton weaving(1)	(5)(2)	15	This estimate is representative for the textile, clothing and footwear industries.
473	Books			
	Hardback	36	50	Spreading first copy and set up costs are very important in this trade.
	Paperback	20	30	

(1) MES runs assumed to be 15,500 yds.
(2) Estimate by author.
Source: C.F. Pratten, 'Economies of Scale in Manufacturing Industry', Cambridge, 1971.

Plants

It is clear that the extent of economies of scale for plants varies across industries in terms of the size of MES plants relative to industry output and the increase in costs below the MES scale. Table 5.5 lists the estimates of the MES for plants and relates them to UK and EC output. Table 5.6 summarises the estimates of the MES for plants as a percentage of EC output.

The estimates of the output to which MES scales are related tend to exaggerate output relative to the MES. In many trades there is scope for plants to specialise. For example, steelworks make a wide range of products and all steelworks specialise. Similarly machine tool factories each make a limited range of tools.

Table 5.6 shows that for 5 per cent of the observations the MES scale of plants is less than 2.5 per cent of EC output, and for 63 per cent the MES scale of plants is less than five per cent of EC output. This is a very rough indicator of the size of MES plants because the figures are not weighted. However, when UK employment was used as weights the percentages rose to 60 per cent below 2.5 per cent and 88 per cent below five per cent.[1] The estimates suggest that in most industries the EC market can support 20 or more MES plants. The equivalent figure for the larger EC industrial economies, such as Germany, France, Italy and the UK would be four or more plants.

These estimates understate the impact of scale economies for plants. It is a common observation that many small plants survive in the metal goods, mechanical engineering, textile, clothing and 'other'

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(1) There are severe problems in weighting the observations; it is difficult to assess how representative estimates for special plants are for industries. Should the chemical plants be taken as representative of all chemical plants, etc. Fortunately the broad conclusions are not sensitive to the weights used.

Table 5.5 Scale Economies for Plants[1]

NACE3 Number	Industry	MES Scale	Percentage increase in costs at less than MES scale(3): total unit costs	Percentage increase in costs at less than MES scale(3): value added per unit	Output Measure	circa 1983 UK	circa 1983 EC	MES as % of UK Output[1]	MES as % of EC Output	Size of the Industry: Percentage of Employment in UK Manufacturing Industry in 1985
14	Oil Refineries a day	200,000 barr	4(1/3)		m tons a year	75	406	14	2.6	0.3
221	Integrated Steel Plants	4 m. tons a year	11(1/3)		m tons a year	15	110	27	3.6	(0.8)
	ditto	9.6-12m. tons a year	> 10(1/3)					72	9.8	
	ditto - for flat rolled products	10 mill tons a year	-	"				67	9	
	Mini steelworks	0.7-0.8m tons a year	> 10(1/3)					5	0.7	
2245	Rolled aluminium semi-manufactures	200,000 tons a year	-		th tons a year	175		114	(15)	(0.1)
223	Barbed wire fencing	£0.76 m sales per year in 1986	-					(10)	(2)	(0.04)
	Wire netting	£4m sales per year in 1986	-					(20)	(4)	
241	Bricks - non flettons	25 m bricks a year (at least)	25(1/2)	30(½)	th m a year	3.4	14	1	0.2	0.4
242	Cement	1.3 m. tons a year	26(1/3)		m tons a year	13	133	10	1.0	0.2
	ditto	ditto	> 10(1/3)							
243	Plasterboard	18 - 20m sq mtrs a year	-		m. sq mtrs	121		16	(3)	(0.1)
247	Class bottles a year	133,000 tons	11(1/3)					(5)	(0.5)	(0.1)
248	Pottery	small relative to UK capacity						(2)	(0.2)	1.1

(1) For footnotes see the end of the table.

NACE3 Number	Industry	MES Scale	Percentage increase in costs at less than MES scale(3): total unit costs	value added per unit	Output Measure	circa 1983: UK	EC	MES as % of: UK Output (1)	EC Output	Size of the Industry: Percentage of Employment in UK Manufacturing Industry in 1985
251	Petrochemicals	500,000 tons a year	19(1/3)		m tons all plastics a year	2.2	18	23(2)	2.8(2)	(0.2)
	Sulphuric acid	1 m tons a year	1(1/2)	19(1/2)	m tons a year	2.6	18	38	5.6	(0.01)
	ditto	0.35m tons a year	5-10(1/3)					13	2.0	
251	Titanium Oxides	130,000 tons a year	8-16(1/2)		th tons a year Titanium Oxides	206	262	63	50	(0.01)
	Synthetic Rubber	60,000 tons a year	15(1/2)		m tons a year	0.25	1.7	24	3.5	(0.01)
255	Paint	10 m galls. a year	4.4(1/3)		m tons	0.7	3.0	7	2	0.6
256	Fertilizers	300,000-350,000 tons a year	-		m tons a year	1.4	8	23	4.1	(0.1)
258	Detergents	70,000 tons a year	2½(½)	20(½)				207	(3)	
	Soap	10,000 tons a year	-					(4)	(1)	(0.2)
26	Synthetic fibres									
	Nylon	50 m.lbs a year	12(½)					4(2)	1(2)	0.2
	Acrylic	42.4m lbs a year	9.5(½)		th tons of the synthetic fibres	530	1,901	4	1(2)	
	Polyester	40m lbs a year	10(½)					3(2)	1(2)	
		100,000 tons a year	2.6(½)					18	5(2)	
	Cullulosic fibres	70 m lbs a year	5(½)		th tons a year	25	188	125	16	
	Rayon staple	125 m lbs a year	5(½)		"	128	246	40	23	

NACE3 Number	Industry	MES Scale	Percentage increase in costs at less than MES scale(3): total unit costs	Percentage increase in costs at less than MES scale(3): value added per unit	Output Measure	circa 1983 UK	circa 1983 EC	MES as % of UK Output (1)	MES as % of EC Output	Size of the Industry: Percentage of Employment in UK Manufacturing Industry in 1985
311	Foundries									
	Cylinder blocks	50,000 tons a year	10(½)	15(½)	th tons of all iron castings		1,435	3	0.3	1.0
	Small engineering castings	10,000 tons a year	5(½)	10(½)				0.7	0.1	
322	Machine tools	Small relative to UK capacity						(1)	(0.2)	1.2
326	Ball-bearings	800 employee	8-10(1/3)					(20)	(2)	(0.15)
342	Large Turbo-generators	6,000 MW a						(50)	(10)	(0.1)
	Electric Motors	60% of UK market c. 1970	15(½)	20(½)				(60)	(6)	(0.2)
343	Auto batteries	1m units a year	4.6(1/3)		m units a year	4.5	25	(22)	(4)	(<0.1)
344	Public switches	4-500,000 lines a year	5-10(1/3)		m units a year	(2.0)		(25)	(4)	(0.4)
	ditto	500,000 lines a year	4.5 (½)							
	TV sets	1.1-1.2m. units a year	15(1/3)		m units a year	2.9	12.4	(40)	(9)	(0.2)
	Videos	0.8-1m units a year	-						(20)	(<0.1)
346	Refrigerator factory	1.0 - 1.2 m units a year	6.5(1/3)		m units a year	1.3	9.7	(85)	11	} 0.3
	Washing machine factory	800,000 units a year	7.5(1/3)		m units a year	1.4	8.0	57	10	}
361	Marine diesels	100,000 hp a year	8(½)	10(½)				(30)	(5)	(<0.1)
363	Bicycles	100,000 units a year	-		m units a year	(1.0)	10.3	(10)	1	(0.1)

NACE3 Number	Industry	MES Scale	Percentage increase in costs at less than MES scale(3): total unit costs	Percentage increase in costs at less than MES scale(3): value added per unit	Output Measure	circa 1983 UK	circa 1983 EC	MES as % of UK (1) Output	MES as % of EC Output	Size of the Industry: Percentage of Employment in UK Manufacturing Industry in 1985
411	Soyabean Oil	4.58% of US market c. 1975	4(2/3)							(0.02)
412	Meat packing	0.33% "	5(2/3)							(0.1)
	Sausages	Very small								(0.2)
413	Butter	1.29% "	2(2/3)							(0.2)
	Cheese	0.63% "	2(2/3)							(0.3)
	Milk products	0.40% "	2(2/3)						For most products similar to the share of the US market	(0.2)
414	Canned fruit & vegetables	7.23% "	5-12(2/3)							(0.1)
416	Flour	0.74% "	21(2/3)							(0.1)
	Rice	5.15% "	9(2/3)							(0.1)
419	Bread	0.2% "	-							2.9
420	Sugar	1.4% "	8(2/3)							0.2
422	Animal feeds	0.62% "	8(2/3)							0.4
423	Potato crisps	30,000 - 35,000 tons a year	-					(10)	(2)	(<0.1)
427	Beer	4.5 m barr. per year	5(1/3)		m barr. per year	37	143	12	3	0.7
		3 m " 2-3m	7(½) 5-10(1/3)							
429	Cigarettes	36 bill cigs a year	2.2(1/3)		bill a year	149	566	24	6	0.5
431	Wool industry	Small relative to UK capacity	-					(1)	(less than 1)	0.8

NACE3 Number	Industry	MES Scale	Percentage increase in costs at less than MES scale(3): total unit costs	Percentage increase in costs at less than MES scale(3): value added per unit	Output Measure	Output circa 1983: UK	Output circa 1983: EC	MES as % of UK (1) Output	MES as % of EC Output	Size of the Industry: Percentage of Employment in UK Manufacturing Industry in 1985
432	Cotton spinning	"	-					(1)	(less than 1)	
	Integrated cotton weaving mill	1.5% of US capacity c 1975	-					(5)	(1)	0.6
	Weaving cotton	300 looms	-		th looms installed	18.7	142	2	0.2	
438	Tufted carpets	64,000 sq. ft. a week	10(½)		m. sq mtrs	114		0.3	(0.04)	(0.2)
451	Footwear factory	4,000 pairs a week	1.5(1/3)		m. pairs a year	58		0.3	(0.03)	1.0
471	Linerboard	850 tons a day	8(½)					10[2]	1.3[2]	
	Kraft paper	986 "	13(½)		total output of paper excl. news-print m tons	3.1	23.2	11[2]	1.4[2]	0.6
	Printing paper	567 "	9(½)					7[2]	0.9[2]	
472	Disposable diapers	3% of US capacity	-					(10)	(2)	(<0.1)
481	Tyres	16,500 tyres a day	5(½)		m.a. year	24	136	17	3	(0.4)

Footnotes

(1) The figures in brackets are guess estimates. In most cases they provide reasonable orders of magnitude.

(2) For many trades, and particularly those referred to footnote (2) the MES should be related to a more narrowly defined output. This would have the effect of increasing the MES as a percentage of output.

(3) The figure shown in brackets indicates the proportion of the MES to which the percentage refers.

Table 5.6 Summary of MES Scale of Plants and Output in the EC

Percentage of EC output	Number of observations	% of total	Weighted by UK employment
0- < 1	20	29	50
1- < 2.5	17	25	10
2.5- < 5	13	19	28
5- < 10	11	16	9
10- < 20	5	7	3
20- < 50	2	3	0
50- < 100	1	1	0
100 and over	-	-	-
	68	100	100

manufacturing industries. However for many of these plants the secrets of survival are that they are sub-contractors or they specialise. Pins provide an example. In Adam Smith's time a whole trade made up of many firms manufactured pins. Now all the production of pins in the UK is concentrated in quite small parts of two factories. For the most part small plants make different product ranges to those made by the large plants, and for these products there are economies for specialisation and large outputs of products. Specialisation can take the form of differences in quality rather than distinct products. A firm with a small plant may specialise in making high quality products or products of low quality and/or specialise in selling own branded products to retailers or selling products without advertising.

Again the estimates of scale gradients in Table 5.5 vary. No doubt the extent of economies does vary for different types of plants but also there is a margin of error for all the estimates. Unfortunately there is no way of estimating the extent of the possible errors. Table 5.7 summarises the increase in costs at ½ the MES for the plants listed in Table 5.5.

Table 5.7 The Increase in Average Costs at half the MES

Increase in costs (percentage)	Number of plants	Plants for which estimates of the increase in average value added are also available	
		Average costs	Average value added per unit
0-2	2	1	-
2-5	16	2	-
5-10	13	2	2
10-15	11	1	1
15-20	1	0	2
20-25	1	1	1
25 and over	1	0	1
	45	7	7
Average	8	9	18

One reason why the estimates of scale gradients vary for different industries is that the proportion of output bought out varies for different types of plant, and the bought out content of output often offers much less scope for economies of scale. Average unit costs and value added per unit are also shown in Table 5.7 for the plants for which both estimates are available. The unweighted average increase in value added per unit is twice that for average unit costs.

It is important to note that the estimates of economies of scale for plants are based on the assumption that the range of products made at a plant is fixed and does not increase with the scale of the plants. The estimates of the effects of increasing the size of plants therefore includes the effects of increasing the output of the products made at the plants and of increasing the length of production runs.

Firms

Table 5.8 lists the MES for firms for the trades for which estimates of the economies of scale for firms were given in Table 5.1. The size of firm is used as the main dimension of scale for these observations because some division of output between plants is possible without substantially increasing costs.(1) Again it is important to note that the economies of larger outputs of products are incorporated in these estimates. It is assumed that the range of products is fixed and does not increase with the size of firms. The reductions in unit costs for large firms includes the cost reducing effects of spreading development costs over a larger output and for longer production runs. The unweighted average MES as a percentage of the EC market was 34 and weighted by UK employment 55. These two estimates are heavily influenced by the motor vehicle and aerospace industries. The increase in costs at half the MES for the six trades for which estimates are available is 9 per cent.

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(1) For example, car manufacturers can separate the manufacture of engines and the assembly of the cars.

Table 5.8 Scale Economies for Firms(1)

NACE3 Number	Industry	MES Scale	Percentage increase in costs at less than MES scale: total unit costs	Percentage increase in costs at less than MES scale: value added per unit	Output Measure	Output circa 1983: UK	Output circa 1983: EC	MES as % of UK Output	MES as % of EC Output	Size of the Industry: Percentage of Employment in UK Manufacturing Industry in 1985
321	Tractors	90,000 tractors a year	6(½)		th a year	92	477	98	19	0.9
	Combine Harvester	20,000 combines a year	7.7(½)		th a year	-	24	-	83	-
328	Diesels	5% of US shipments c 1967	10(½)						similar share to that of the US market	(0.3)
	Chain saws	150,000 units a year	-						(15)	(<0.1)
33	Calculators	3-4 m a year			few calculators are made in Europe					0
	Computers Mainframes	A large share of world output						(100+)	(very large share)	(0.15)
	Electronic typewriters	500,000	5-10(1/3)	m. a year		1.5			(33)	(<0.1)
342	Transformers									
	Distribution	2% of US output c 1967							Similar share to that of the US market	(0.2)
	Small power	6.9% "								
	Large power	7.1% "								
351	Motor cars	2m cars a year	15(1/3)		m.a. year	1.0	9.9	200	20	3.1 (Motor cars and Trucks together)
		0.5m "(2)	>10(1/3)							
	Trucks	250,000 units a year	12(1/3)		m, comm. vehicles a year	0.24	1.2	104	21	

363	Motor cycles	200,000 units a year		(<0.05)
364	Aeroplanes	More than 50 of a model	(100)	3.4

(1) The figures in brackets are guess estimates. In most cases they provide reasonable orders of magnitude.

Cars and Trucks

The estimates of scale effects for the production of cars are noteworthy for several reasons. First the two estimates of the MES are widely different, two million and 500,000 cars a year. One explanation for this divergence is that the first estimate by Muller and Owen includes the spreading of development costs, while the second estimate by Muller excludes these costs. For cars the effects of spreading product development costs are an important source of economies of scale. The MES estimate of two million cars a year exceeds the production in Europe of any single firm and suggests there would be scale economies associated with further concentration of the industry.

Another reason why the estimates for cars and trucks are of great interest is that they are representative for many products made by the mechanical engineering, electrical and instrument industries. Cars and trucks are more or less complex than the products of these industries, but the main difference is the much greater output in terms of numbers of cars and trucks. This suggests that there are substantial unexploited economies of scale for the production of many products made by these industries. Another example of the economies of scale for precision engineering products continuing to very large outputs is ball bearings. These products are made in vast quantities. SKF claims about twenty per cent of the Western World market. When it was challenged by Japanese producers in the 1970s, it cut costs by rationalising production at its European factories. Each of its subsidiaries in the U.K., France, Germany and Italy ceased to produce a full range; instead they manufactured a limited range and took supplies from other subsidiaries to complete their range.

Another example of economies of scale continuing to very large outputs is for semiconductors. It is claimed that the large domestic markets for chips from the domestic and electronic appliance industries in Japan and the computer industry in the USA have given these countries advantages for chip production.

The output of motor vehicle and computer companies is concentrated on cars and trucks, and computers. In most industries the possible permutations of products for firms is in practice immense and it is difficult to pin down a range of output for estimating the economies of scale. This is the explanation for Table 5.1 including only a few estimates of the MES for firms. Plainly there are economies of scale for, say, giant chemical companies for organising and controlling production of intermediate chemicals, basic research and development, for marketing and distribution, for raising finance and for risk taking. These economies are difficult to estimate but they can not be ignored. In the following section they are described.

Estimates of the MES 1951 to 1982

Many of the estimates of the economies of scale used in this Section were made during the 1960s. Are these estimates accurate for the technological and marketing conditions of the 1980s? Table 5.9 compares estimates of the MES for eight industries for which DIW prepared estimates of the economies of scale in 1982. The DIW estimates are compared with those made by J.S. Bain in 1951[1], and by Scherer, Weiss and Pratten between about 1965 and 1969.

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(1) J.S. Bain, 'Barriers to new Competition', Cambridge, Mass., 1965.

The lower estimate of the MES for cars in 1982 is striking. As noted earlier it may be explained by the fact that the DIW estimates are based on production costs, they do not include the costs of spreading research and development costs.

As is usual with studies of the economies of scale, the pattern is not uniform. On balance there is evidence of an upward drift of the MES scale. The DIW estimates of the MES scale are higher than Bain's for four out of five industries, and the exception is cars. The DIW estimates are higher than those made between 1965 and 1969 for eleven of the sixteen observations and lower in three cases. These results are not surprising. Many technological developments are increasing the MES and the integration of national markets is providing firms with opportunities to test larger scale operations.

Conclusions

In this section engineering estimates of the economies of scale for products have been surveyed. One conclusion is that the economies of scale for production and development costs for complex engineering products such as cars continue to levels of output which represent a substantial fraction of the EC output of the products. Also in these trades scope for achieving some economies continues more or less indefinitely.

For other trades the MES varies in relation to the EC market as does the steepness of the scale gradients. It is not possible to provide a synopsis for these trades.

Table 5.9 Estimates of the MES Scale 1951 to 1982

Industry	MES Scale: Bain* 1951+ USA++	Scherer* 1965+ International++	Weiss* 1967+ USA++	Pratten* 1969+ UK++	D.I.W.* 1982+ Germany++
Cars (th. a year)	300-600			1,000 (3 models)	500 (2 models)
Domestic Appliances White Goods (th. a year)		800		500	1,500
Tyres for Cars (th. a day)	4-5		16.5		20-40
Oil Refineries (m. tons a year)	6	10	5.95	10	10
Steel (m. tons a year)	0.9-2.3	3.6	3.6	4.1	9.5-12
Cement (m. tons a year)		1.2		2.0	1.3
Beer (m. hectolitres a year)		5.3	2.4	1.6	2.8
Cigarettes (bills a year)	18-23	36			70

* Source

\+ Approximate year of study

++ Country for which estimates made

Source: The table was prepared from comparisons made by Dr J. Schwalbach

Section 6. Economies of Scale for Firms

A firm which achieves large scale by producing large outputs of individual products, long production runs and operating large plants will achieve the technical economies of scale for production and for spreading development costs which were surveyed in Section 5. In this section, we consider the economies of scale for marketing, research and development and risk taking which may apply to firms making a limited or wide range of products. First, the scope for technical economies of scale for firms making a wider range of products than those included in Section 5 are outlined.

Scale and concentration are related. Other things being equal, if some firms increase their scale of output, concentration increases. Both scale and the degree of concentration affect marketing and research and development expenditure. In this section we side step the relationships with concentration and focus on the scale effects. Completion of the Community will not result in 'other things being equal', it will increase competition within the Community and offset the effects of increased scale leading to greater concentration.

PRODUCTION

It is not possible to generalise about the economies of scope for production costs. For a firm making a range of products, the economies of scope for production relate to processes which are common to a number of products, for example, processes to harden or coat metals or dye textiles.

There are also important technical economies of scope for a firm which produces products by a sequence of operations. Chemicals provide an example. A chemical company which produces a wide range of final chemical products can achieve large scale for the production of intermediate and basic chemicals which are used to produce the final products. These technical economies relate to the scale of production of the basic and intermediate chemicals, to linking processes, to control of the markets for the output of the initial processes and to the coordination of production.

Although it is not possible to quantify these economies except on a case by case basis, they are quantitatively important in some cases.

MARKETING

Scherer has provided the following description of the economies of scale for marketing:(1)

> 'Economies of large-scale promotion and marketing also raise analytic difficulties. For one, they may show up not only in the form of lower costs, but also in the ability of firms to charge prices higher than those of smaller rivals for comparable products, or in some combination of price premiums and cost savings. Thus, both cost curves and demand curves are affected. A second complication is the element of chance associated with sales promotion. A massive advertising campaign may be a spectacular success or a resounding flop, depending upon the ingenuity and luck of the Madison Avenue people in charge. And most important of all, the private benefits realized through large-scale promotion may not be mirrored by benefits to the public. It is not clear that society gains when one firm's monopoly power is bolstered by a successful promotional campaign or whether bleary-eyed television viewers are better off from the barrage of messages to which they are subjected. Here we confine ourselves to the narrower question, to what extent is market concentration encouraged or entrenched by the private advantages of large scale promotion?

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(1) F.M. Scherer, 'Industrial Market Structure and Economic Performance'. Chicago, 1980. p. 108....

Even there, no simple answer can be provided. In his pioneering study of 20 American industries, Professor Bain concluded that product differentiation was "of at least the same general order of importance ... as economies of large scale production and distribution" in giving established market leaders a price or cost advantage over rivals, and especially over new entrants.(1) (Product differentiation is a condition for the advertising of products by firms). However, a later 12-industry study found that although product differentiation was very important, firms with only a single plant of efficient scale were by no means barred from success.(2) In several industries, single-plant enterprises were able to promote their products on virtually equal terms, realizing all or most scale economies; and in others they could find sizeable market segments in which to operate profitability despite a promotional handicap.

To explore further the reasons for these somewhat disparate conclusions, let us begin by focusing on advertising, which Bain found to be the single most important basis of large-firm advantages.

One possible source of scale economies is the need to attain a certain threshold level of advertising messages before reaching maximum effectiveness. There are two main reasons why this might be so. First, the average consumer's behaviour may not be influenced by a single message, whereas five or six delivered messages (out of a possibly larger number sent) are likely to induce action, if indeed advertising is able to do so at all.(3) Second, when advertising messages are communicated further by word

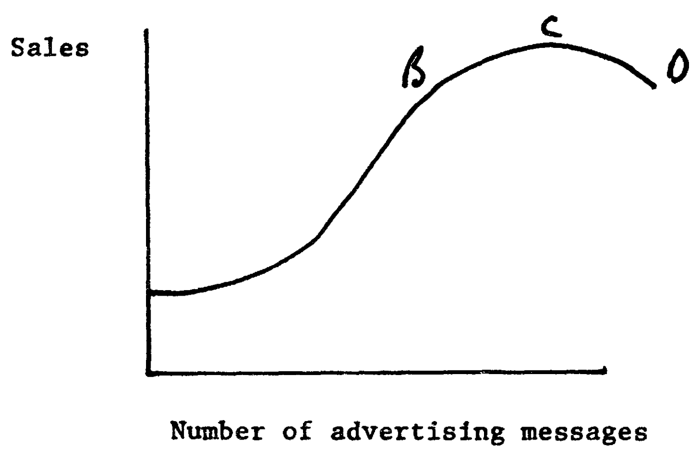
(1) Bain, Barriers to New Competition, pp. 142-43, 216.

(2) Scherer et al, 'The Economies of Multi-Plant Operation', p. 258.

(3) See "Advertising: Frequency and Effectiveness", New York Times, 22 June 1976, p. 57

of mouth and peer influence, conditions analogous to those governing chain reactions or the spread of epidemics may apply.(1) A small impulse soon peters out, but one that affects a sufficiently large initial critical mass spreads rapidly and covers a large segment of the population. To the extent that either of these two models of advertising effectiveness is valid, there must exist an "advertising response function" of the logistic shape illustrated in Diagram 6.1. Over the range AB the threshold (no doubt varying for different consumers) is being approached and surmounted, and the average sales generated by an additional message rise. But beyond point B average returns fall, at first slowly and then (if oversaturation can occur) precipitously.

Diagram 6.1 Advertising response function



There is a debate as to whether the shape assumed in Diagram 6.1 in fact reflects real-world conditions or whether diminishing returns set in immediately. The answer may depend upon the specific advertising medium. Julian Simon has brought together a persuasive body of evidence showing continuously diminishing

(1) See Stephen Glaister, 'Advertising Policy and Returns to Scale Where Information is Passed Between Individuals', Economica 41 (May 1974): 139-56.

returns for direct-mail and clip-out coupon methods.[1] The studies he cites on other media suffer from methodological shortcomings and therefore are less convincing. Perhaps the most carefully controlled marketing research on which a published account is available, covering beer advertising on television, suggests a relationship like Diagram 6.1 but with separate maxima for each of two distinct market segments.[2] When the intensity of Budweiser beer advertising was varied systematically among local markets, increasing returns showed up at lower message levels. But at high intensities, the response function turned downward, as with segment CD. Consumers deluged with Budweiser adds reportedly requested of their liquor dealers, "Give me anything but Bud".

The existence of an increasing returns range AB is not by itself enough to imply an advertising cost advantage for larger firms. If all firms face essentially the same advertising response

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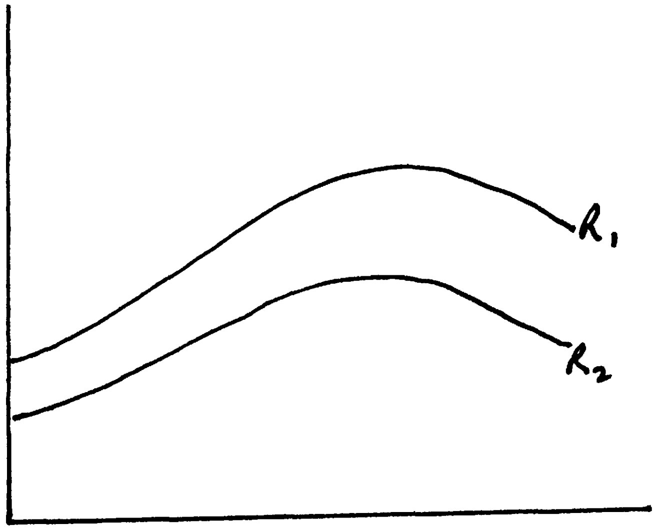
(1) Julian L. Simon, 'Issues in the Economics of Advertising' (Urbana, Ill: University of Illinois Press, 1974), Chapter 1.

(2) Russell L. Ackoff and James R. Emshoff, 'Advertising Research at Anheuser-Busch, Inc. (1963-68)', Sloan Management Review 17 (Winter 1975): 1-15. The response function derived by Ackoff and Emshoff was measured in terms of percentage changes in sales rather than absolute sales levels, but it can be transformed into one like Figure 6.1.
For other evidence on response functions and economies of scale in advertising, see William S. Comanor and Thomas A. Wilson, 'Advertising and Market Power (Cambridge, Mass: Harvard University Press, 1974), pp 49-53; Jean-Jacques Lambin, 'Advertising, Competition and Market Conduct in Oligopoly over Time' (Amsterdam: North-Holland, 1976), pp. 94-98, 127-29; and Randall S. Brown, 'Estimating Advantages to Large-Scale Advertising', Review of Economics and Statistics 60 (August 1978): pp. 428-37.

function, all will find it profitable to carry their advertising to approximately the threshold level B if they advertise at all, and all will thereby enjoy similar sales responses. For economies of scale to exist, there must be some further interacting set of circumstances conferring an advantage to larger firms - e.g., by letting them have different and more favourably configured response functions than their smaller rivals. This may stem from consumer inertia or from physical barriers to the rapid expansion of sales. For example, one supermarket chain may for a variety of historical reasons operate 50 stores in some metropolitan area, another chain only 15. Most of both chains' customers are apt to be tied by force of habit or other considerations to their regular shopping locales; only a small fraction are movable in any given short period by advertising. And if either chain did attract customers very rapidly through advertising, congestion would build up in its aisles, curbing the patronage gains. The large chain may therefore face a response function like LR_1 in Diagram 6.2 while the small chain faces SR_2. If both must send approximately OX advertising messages to achieve a threshold level of awareness, the large chain will cover the population of switchable consumers and reinforce the purchasing habits of its (larger) group of regular patrons at a substantially lower advertising cost per sales dollar than the smaller chain. The response functions facing firms of varying size may also differ because advertising has cumulative as well as current effects. It takes a long time to build an image and get consumers in the habit of requesting Prestone when what the need is ethylene glycol antifreeze. In the short or medium run, the small firm trying to expand its sales of an essentially equivalent product through vigorous advertising runs into sharply diminishing returns long before it has achieved the size of the well-established sellers it is seeking to displace. What this says is that short- or medium-run response functions may differ between small and/or new as compared to large firms, but it does not necessarily imply that over the long run a newcomer cannot gain an equivalent sales volume at comparable advertising cost if it cultivates the market slowly and patiently. Such long-run equivalence may be ruled out as well, however, Diagram 6.2 Possible Advertising Response Functions for Large and Small firms

Sales



Number of advertising messages

if more or less permanent marketing advantages accrue to firms that pioneered some product segment, or managed through superior skill or luck to come up with a captivating product image.

This overview of the advantage of size in advertising has skipped over some potentially important tactical details. For one, with respect to what organizational unit are advertising scale economies realized? For supermarket chains, advertising strives to lure consumers into stores, but most advertising by consumer goods manufacturers is focused on individual brands, not (the output of) plants or firms. When threshold effects apply in the latter case, they may have to be attained brand by brand not at the aggregate firm level. Unless there are multibrand interactions, firm size is largely irrelevant. Partly related questions are, how does the array of feasible media vary with firm size, and how in turn are costs affected by any such variations? Jewel, a Chicago area retail grocery chain with the largest local market share, cannot sensibly advertise on nationwide network television or in national magazines. A & P, with a much smaller Chicago position but broader geographical compass might.

Multibrand and multi-product interactions can occur if a favourable reputation from one set of products (e.g. General /Electric's refrigerators) spills over to other products (such as hair dryers), or if the media offer discounts for combining a large volume of advertising, perhaps spanning multiple brands, in one place or time period. Discounts do exist. The New York Times, for example, offered general contract advertisers volume discounts ranging up to 4.5 per cent for buying the equivalent of 40 pages in a year as compared to one page. ...(1)

Potentially more important than such volume-massing advantages might be the savings nationwide advertisers enjoy by purchasing network time, which, depending upon the time of day, costs 15 to 30 per cent less than what one would pay buying the same coverage through individual station spot messages. For regional firms, more costly spot messages may be the only practical option. ....

For industries like brewing with high product transportation costs, the chief advantage of nationwide multi-plant operation may lie not so much in having a more attractive array of advertising options as in capitalizing fully on the nationwide image one enjoys. That is, somehow or other, certain products catch on, and once they do, the word spreads. As with Coors beer, this can happen even without any advertising outside one's home territory. Once a product does gain a favourable nationwide image, that image is an asset whose full value is captured only through nationwide distribution. If transportation costs are high, this in turn may require the operation of multiple decentralized plants.

Another quite different advantage of large scale is sometimes enjoyed by the sellers of complex durable goods, especially consumer durables. The automobile industry affords the leading example. Most consumers are unwilling to buy a particular new car unless they are confident they can obtain prompt, reliable service not only at home, but wherever they may travel or migrate. This gives the manufacturer with a far-flung, high-quality dealer

(1) Simon, '<u>Issues in the Economics of Advertising</u>', p. 148

network a sales advantage. Establishing such a network is difficult for the smaller manufacturer, since there are economies of scale at the sales and service establishment level.(1) A certain minimum investment in specialized testing equipment, tools and spare parts is necessary.

The automobile industry provides the premier example of a further interacting advantage of size associated with product differentiation. Through some perverse quirk of human nature, the average consumer is decidedly unhappy driving around last season's assemblage of metal stampings. Body designs are therefore altered periodically-usually with thorough going changes every three to five years and exterior facelifts of varying extent more frequently. This is expensive. (These development costs have been included in the estimates of economies of scale given in Section 5.)

In summary, in at least some industries and especially in certain consumer goods industries, there are appreciable economies of scale in many aspects of sales promotion and product differentiation. The implication conveyed thus far is that these advantages of size and their interactions can lead to market concentration exceeding what is required to realize all narrowly construed production and physical distribution economies. This is correct, but it does not tell the whole story. The product differentiation sword can also cut in the opposite direction. Through successful product differentiation, smaller firms may be able to carve out for themselves a small but profitable niche in some special segment of a large market. Their sales volume may be too low to confer all production and promotional scale economies, but the higher costs associated with foregoing these advantages

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(1) On similar scale economies in servicing computers, see Brock, 'The U.S. Computer Industry', pp. 33-37.

may be more than offset by the price premium consumers pay for the special product features they offer. Product innovation is one tactic by which smaller firms can survive despite conventional scale disadvantages.

Another strategy is to cater to some narrow geographic market segments, or to some special consumer taste with a sales potential too small to interest the leading firms'.

Many small firms do not sell to final consumers. For example, they manufacture and sell machinery or instruments to other firms. Such firms do not use the mass media for advertising. Nevertheless, many small firms of this sort which compete with giant companies fear the marketing advantages of large companies most. The giant companies have much more knowledge about markets - the firms likely to use a product and the people within firms likely to decide whether to buy it, etc. The giant companies can afford to take a loss to gain a sale and even give away some products. Also international companies should be able to rapidly develop export markets for a new product. Where the product is important for the viability of customers then the greater creditibility and reliability of a giant company or a smaller company with a large share of a product market may win orders against smaller competitors and firms with a small share of a market.

Marketing and Completion of the EC

Completion of the EC will provide opportunities for economies of scale for marketing, but economies for advertising are probably of second order importance. Given the language differences in the EC much of the media will remain national.

There are, however, some potential sources of economies. For example, the introduction of more European brands (brands sold in more than one European country) will offer some possibilities for economies. These brands will become progressively more important. They will provide opportunities for spreading the costs of making adverts over a greater audience. (This is a source of economies not included in Scherer's description of economies of scale for advertising[1].) Some advertising messages in existing media, for example, in periodicals which are read in a number of countries, and which are wasted for national brands will score for European brands, and new television channels may provide efficient advertising to a number of European countries simultaneously which will not be cost effective for advertising national brands.

More important are some marketing costs, for example, market research for new products, preparation of catalogues, product descriptions,manuals for new products and other costs of informing potential customers about new products which are an essential part of development costs. Spreading these costs over greater sales will provide important economies in some industries. If national controls for products are harmonised and/or centralised that too will provide a source of very substantial economies for marketing in certain industries. These economies relate to the output of individual products or narrow ranges of products.

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(1) Costs of making television adverts represented of the order of ten per cent of television advertising circa 1970.

RESEARCH AND DEVELOPMENT

Research and development expenditure effects not only the costs of products but also the products and demand. Again, as for marketing, the results of R & D expenditure is uncertain, programmes to develop new products may or may not be successful, and if new products are produced they may or may not be well received by consumers or users. Also much R & D expenditure is in the nature of a sunk cost. A firm can sell many types of capital equipment; there is a second hand market for machine tools, printing machines, etc. The market for half completed R & D projects is not so well developed, and if a firm offers a project for sale it may lose the benefits of secrecy for its innovation. Another feature of R & D expenditure is that in many industries innovation created by R & D is the main key to international competitiveness for European countries.

In this sub-section we start by considering the general relationships between scale and research and development. The bulk of expenditure on R & D expenditure - of the order of 90 per cent of total industrial R & D in the UK - is for development which is product specific. These costs were included in the estimates of economies of scale given in Section 5.

The Sources of Economies of Scale for R & D

One source of economies of scale for R & D is simply the requirement for a large team to develop products such as large commercial aeroplanes. A firm with large R & D resources can devote more staff to such a project and should be able to develop a superior product to those of smaller firms or be able to develop the product faster. These are product specific advantages or economies. Aeroplanes and cars are extreme examples of products which require very large teams of development engineers. Nevertheless, similar economies apply to many other products, including machinery, for which total output in value terms is much less.

Another source of advantage for large chemical and electrical companies such as Hoechst, ICI, IBM, AT & T, GE, Siemens, Philips and GEC is that they have teams of R & D personnel who have and pursue knowledge relevant to their industries, and apply this knowledge. These companies have the equivalent of an internal research university. Smaller competitors have to rely on outside sources of research information and/or have more specialised internal research departments. Compared to a number of smaller competitors a large company can avoid duplication of research.

The potential sources of diseconomies of scale for R & D are that in a large organisation, R & D personnel may not be in close touch with marketing and production staff, and so their work may lose commercial relevance. Commercial motivation may be more difficult to maintain in a large organisation. Also there are the general problems involving the flow of, and assimulation of information and control within large organisations. Finally the ability or talent to successfully organise, manage and carry thorough development projects is scarce even at large companies.

The Importance of Research and Development

Recent technological changes which are considered in Section 8, may on balance have favoured small scale operations, but another powerful economic development has swamped these changes. The vast expansion of markets since 1950 brought about by reductions in barriers to trade and the growth of income, has given large scale producers an increased advantage. The motor industry provides an example. In 1950, there were five companies manufacturing standard cars in Britain, as many as in the USA. They were secure in the much smaller UK market which was protected. For cars and for many other industrial products, the market is now world-wide. Other changes opening national markets have been improvements in transport and communications. Simultaneously industrialization in developing countries has increased competition. Even for each of the larger European countries their markets for cars, telecommunications equipment, chemicals and so on, are only about five per cent of the Western world markets.

An increase in market size operates in two ways to increase the significance of the economies of scale for spreading research and development costs. Firstly, some firms grow larger with the market. If there are technical or other economies of scale, firms which do not grow with the market will be at a disadvantage. A motor company which produces 500,000 cars a year will be competitive in a market for 1,500,000 cars a year. It will be handicapped if it competes in a world market for 20 million cars with companies producing two million or more cars a year. Secondly, competition intensifies as barriers to trade are reduced, and in many industries competition focuses on the quality and novelty of products, so product development and improvement are key factors for the success of companies. Development costs have to be recovered from the sales of products to which they relate. A motor manufacturer which can sell 500,000 of a model a year is in a much stronger position to spend on development, than a company which can sell only 100,000 of a similar model.

The growth of markets has not only focused attention on product development, it has also speeded up developments. Generally there are limits to the extent of technical economies of scale as machines and processes have a finite capacity. In contrast, for many products expenditure on R & D is relatively unlimited, so the economies of scale through spreading these costs can extend over far greater outputs. As firms increase development expenditure the evolution of products speeds up. For many lines of business, product lives are less than ten years. In the 1980's a company which develops a new, or improved product, is likely to have less time in which to build its market position before competitors produce rival products than was the case in the 1960s. This increases the advantage of an existing giant international company which has knowledge of, and access to, world markets.

It is easy to claim that markets have expanded with the reductions in trade barriers. In reality the changes are complex. International differences in consumer tastes and preferences have not disappeared. Many products have to be adapted to the special features of demand and requirements in each country. To give an obvious example, air conditioning of cars is essential in some markets but not others. Also governments, companies and consumers favour suppliers in their own country for all sorts of reasons. Local suppliers may provide a more reliable service and, directly or indirectly, create demand for the products or services produced by their customers. In some countries nationalistic practices and sentiment may be stronger than in other countries and such barriers to free markets are much more difficult to eliminate than tariff barriers. Again, the differences in national markets and preference for national firms provide giant multi-national companies with a potential source of advantage. They will be familiar with, and have experience of operating in, different markets. If they have manufacturing operations in a country, that may enable them to market imported products or components more readily.

There are two other effects of the increase in the size of markets. Firstly, firms can grow but still be disciplined by the market. Most giant industrial companies face intense competition in international markets. Secondly, the rewards for innovation as well as the costs of product development have increased. A company that can launch a new product - drug, machine, computer - on world markets obtains far greater sales and profits than a company limited to a small domestic market.

A possible argument to refute the importance of R & D might be that total expenditure on R & D is small in relation to total costs. For Germany, France, UK and Italy expenditure on R & D averages about two per cent of GDP. The percentage is larger for manufacturing - R & D expenditure represents six per cent of value added by UK manufacturing industry. However the main point is that these statistics underestimate the significance of product specific expenditure. Official estimates of R & D expenditure do not include much of the design and product specific marketing expenditure undertaken by firms. Nor do they include the loss of production when a new product is introduced.

Scale and Research and Development - The Evidence

If, as suggested, the spreading of research and development costs is an important source of economies of scale, there should be evidence to support the claim. The relationship between the size of companies and innovative activity has been studied intensively but the various dimensions of scale have not been clearly differentiated in much of this research.

There is some evidence that organized research and development activities do increase with the size of companies, large companies spend proportionally more on research and development and that R & D programmes are highly concentrated. Twenty firms account for about a half or more of R & D expenditure in each of the Western industrial countries. There is no evidence that the productivity of research expenditure increases with the scale of companies. Indeed the evidence, for what it is worth, points weakly in the other direction, towards diminishing productivity. However, the studies are not conclusive because of the difficulty of measuring the output from research and development effort. The main measures which are used by respected scholars are numbers of significant technological innovations achieved and the numbers of patents obtained. Both are seriously flawed as measures of output. The value of individual innovations and patents varies greatly. Also the measures do not provide a guide to the use companies are able to make of innovations or patents; a principal advantage of a giant company may lie in its ability to fully exploit an invention. Even more important is the fact that much development expenditure (perhaps more than half of all expenditure) is not aimed to create innovations or patents but to develop improved products with known technology. In any case, the result that R & D expenditure and the effectiveness of R & D is not closely related to the size of companies would not be surprising when the analysis relates to all companies. 'The major source of variations in research intensity between firms is the industry concerned'.(1) Some large companies, including large motor car manufacturers which spend heavily on R & D, are not searching for new products. Much, if not all, of their R & D is devoted to improving their existing products. Many small firms are set up to exploit ideas for new products, and the proprietors of many small firms are continuously searching for ideas for new products and markets.

The estimates of the effects of spreading development costs included in Section 5 relate to individual products and narrow ranges of products. Research to assess the relationship between scale and research and development expenditure at this level of disaggregation are scarce. Research at an industry group level suggests that in some trades small firms do contribute to innovation. These include machinery, instruments, electronics, clothing and footwear.(2) The safest conclusion is that existing research does not provide conclusive results on the advantages of large companies for research and development. It does not disprove the common sense notion that a

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(1) F.M. Scherer in 'Innovation and Growth - Schumpeterian Perspectives', MIT Press, Cambridge, USA, 1984, C. Freeman in 'The Economies of Industrial Innovation', London 1982 and Kamien and Schwartz in 'Market Structure and Innovation', Cambridge, 1982, report the state of research on the relationship between corporate size and innovative activity.

(2) C. Freeman, 'The Economics of Industrial Innovation', London, 1982.

company with a larger share of a market than its rivals for a technically sophisticated product has an important though not necessarily decisive source of advantage in being able to spread research and development costs over a larger output.[1]

Research and Development and Completion of the EC.

Completion of the EC will provide a number of opportunities for economies of scale for research and development. The principal source will be for firms to spread product specific development costs over larger output of products and/or to speed up development. These economies were included in Section 5. In addition as larger firms emerge within the EC there will be potential economies from reducing duplication of both research and development which will make it possible to use R & D resources more efficiently. As R & D personnel are one of the principal scarce resources for creating new industry and jobs in the EC this increased efficiency would be doubly significant as it would release resources which could have a multiplier effect on employment elsewhere.

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(1) F.M. Scherer in 'Innovation and Growth - Schumpeterian Perspectives', MIT Press, Cambridge, USA, 1984 and C. Freeman in 'The Economies of Industrial Innovation', London 1982, report state of research on the relationship between corporate size and innovative activity.

RISK TAKING AND THE COST OF FINANCE

The advantages of a large company with a large share of a market for development are not only the greater resources at its disposal and its scope for employing more specialists. Within large companies development work is carried out by teams of scientists, engineers and craftsmen, and the teams are often quite small. The increasing importance and pace of development has increased risks. While it is true that an entrepreneur managing a small firm may be willing to take immense risks because he is particularly knowledgeable and in a position to assess the chances of success, or, in some cases, because he is simply unaware of the risk; large companies do have advantages in risk taking. Firstly, they can spread their risks; they can take on a number of projects and if some fail, or absorb more resources than expected, this need not jeopardise the future of a large company. This advantage of large companies reflects a market failure. Development of new products is risky but it is not possible for a firm concentrating on one or a small range of new products to insure to cover these risks. Another source of advantage is that a large company may have access to more information about technology, markets, and strategies of rivals when deciding whether to take on a project.

Riskiness and the cost of finance are related. A large company which can spread its resources over a number of individually risky projects may expect to be able to obtain finance at a lower cost. Its shares may trade at a lower yield on the stock market, and it will pay a lower rate of interest for loans. The difference in interest rates for the smallest and giant companies is about four per cent.

The fact that the shares of many small hi-tech companies are on very low dividend yields does not wholly disprove the link between equity yields and size of companies. Clearly investors may achieve a spread of risks by buying shares in a range of small companies. However, the problem for small companies is the availability, and very high cost of finance when they encounter a crisis. A large company with diversified risks may be able to carry a few failures, and is able to move resources within the group. This difference may reflect another market failure. The top managers of a large company may be able to assess the possibilities for recovery of one of its operating businesses more accurately than independent shareholders or financiers assessing the prospects for a small company beset by a crisis. The top managers of a large company will have more information than the independent shareholders of a small company when taking decisions.

The advantage of small firms for risk taking is that their managers are under greater pressure to make the right decisions about which options to take. Also the managers taking decisions may have better information, for example, they may themselves deal with customers and be familiar with production and development.

MANAGEMENT

Economists have long seen management as the main source of diseconomies of scale and the limitation on the optimum scale of firms. For example, EAG Robinson concluded the 'problems of management in certain contexts set an upper limit to the optimum size of the closely integrated production unit.'(1) Scherer states boldly that 'it is much

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(1) E.A.G. Robinson 'The Structure of Competitive Industry', Cambridge, 1958, p. 49.

harder to manage a big plant than a small one, all else being equal'.[1] Peters and Waterman have claimed that 'the excellent companies understand that beyond a certain surprisingly small size, diseconomies of scale seem to set in with a vengeance'.[2] The source of diseconomies they describe are problems of management, organising operations and motivating employees.

Robinson stresses the inter action between 'change' and management. 'If change is not required, I should not be inclined to stress the difficulties of managing the very large resulting concern, so long as it remains engaged in continuous and unvaried production'. Again cement plants provide an example of unvaried production, though they have to contend with varying demand. The argument of this section has been that the pace of change and in particular the rate of evolution of many products has increased, reinforcing the importance of management. The stress placed on the 'management of change' in management schools and literature show that the problems are recognised.

O.E. Williamson has analysed management relationships in a series of major studies, and provides case studies to illustrate his theoretical analysis.[3] So far, however, it has not been possible to quantify the relationships between scale and the costs and effectiveness of management, and specify an MES scale of management. In part this

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(1) F.S. Scherer, 'Industrial Market Structure and Economic Performance', Chicago, 1980, p. 85.

(2) T.J. Peters and R.H. Waterman, 'In Search of Excellence', New York, 1981, p. 112.

(3) O.E. Williamson, 'Corporate Control and Business Behaviour', Englewood Cliffs, 1970 and 'Markets and Hierarchies', 1975.

reflects the fact that the ability of individual managers to manage large organisations varies, the ease of managing different types of operations varies and there may be international differences in the difficulty of managing large organisations. The competitiveness of some giant companies such as IBM, Toyota, Boeing, Siemens, etc shows that the problems of managing very large organisations and motivating employees of large organisations are surmountable.

ACCOUNTING RATES OF RETURN

If large companies have general advantages and benefit from economies of scale, it might be expected that rates of return on assets would be positively related to size. There are all sorts of qualifications to using such tests. Large and small companies operate in different trades and/or may produce different products if they are in the same trade. They may pay different prices for factors of production and there may be differences in the accounting methods companies use systematically related to the size of companies.

For what they are worth, studies indicate that for US companies, rates of return on assets are positively related to scale measured by total assets but that the relationship is a weak one(1). For the UK, the results of tests indicate a negative relationship but 'it is unlikely that size will have an appreciable influence on ... profitability'.(2)

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(1) G.L. Salomon, 'Accounting Rates of Return', American Economic Review, 1985, p. 495.

(2) A. Singh and G. Whittington, 'Growth, Profitability and Valuation, Cambridge, 1968, p. 67.

CONCLUSIONS ON ECONOMIES OF SCALE FOR FIRMS

The a priori analysis and the review of evidence of the economies of scale for firms given in this section and the studies of company profits do not lead to any simple rules such as "the bigger the better" or "small firms are best". Nevertheless a range of potential sources of economies of scale for firms is identified. This suggests that in manufacturing trades where all the leading EC companies have lower output than their Japanese and US counterparts this must be a prima facie cause for concern.

Section 7. Other Evidence on the Economies of Scale

Ideally economists would measure the contribution of economies of scale to productivity and growth as accurately as scientists measure physical forces. That is not at present possible; assessing the contribution of economic forces is more akin to the practice of lawyers sifting evidence. Fortunately there is a wide range of evidence which corroberates the 'engineering' estimates indicating large economies of scale.

International Comparisons

Productivity in the US

Trade 7.1 shows two comparisons of output per person in manufacturing industries for the US and European countries. Both comparisons were made by the National Institute of Economic Research which has made thorough studies of international differences in labour productivity. The Institute claimed that the first column 'extracted from the many in the papers (in their special productivity issue) can perhaps be taken as indicative of the central findings'. The tables referred to showed estimates of output per person based on PPP. The National Institute has also made some comparisons of output per person for certain industries based upon measures of physical output. The second column shows an up-dated comparison.

Labour productivity for manufacturing industries is shown to be 50 percent higher in the US than in Germany in 1986. It may be that this estimate exaggerates the difference in productivity because insufficient allowance is made for the high quality of German products.(1) Also the much higher US productivity is not consistent with its weak international trade performance for manufactures. Indeed the weak export performance of some US industries, including steel (compared to Japanese firms), motors (compared to Japanese and European car and truck manufacturers) and telecommunications (compared to some European producers of telecommunications equipment) in which, circa 1960, the leading US companies were far larger than their international rivals cautions against exaggerating the significance of economies of scale compared to other factors, wage levels, efficiency, technical progress, design and quality, which affect international competitiveness. Nevertheless US productivity is higher than the German level and it seems unlikely that differences in education and training account for the difference because German standards of education and particularly industrial training are reckoned to be high relative to other countries. Nor do differences in investment account for the difference in labour productivity. The main potential economic explanation is the advantage the US still obtains from its larger fully integrated market via economies of scale. The evidence does suggest that the scale of US firms, plants and outputs of products are greater than in Germany for most though not all industries. A knowledgeable American industrial economist suggested that an alternative explanation to America benefiting from greater economies of scale. He claimed that American

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(1) It is difficult to make international comparisons of productivity for Germany's important mechanical engineering industry because of its wide range of specialised products.

workers, on average, work harder than their German counterparts.[1]

Table 7.1 International Comparisons of Labour Productivity for Manufacturing Industry for 1980 and 1986

	Output per employee 1980	Output per hour 1986
USA	100	100
Germany	50–59	67
France	60–65	69
Italy	50–54	58
U.K.	33–36	37
Belgium	60–65	58
Netherlands	76–83	77
Japan		66

Source: National Institute Review August, 1982, p. 11, and May, 1987, p. 73.

Japanese Competition

The source of the most severe competition for some important European industries is Japan. Again the Japanese market is much larger than any single European national market. Japanese manufacturing industries seem intensively competitive. There are a significant number of Japanese firms competing in most markets. Generally there are more firms producing each group of products than in any one European country but far fewer than in Europe as a whole. The international competition

(1) In 1960 Professor Jenkes suggested the same possible explanation for differences in productivity between America and Europe. E.A.G. Robinson, ed., 'Economic Consequences of the Size of Nations', London, 1960, p. 342.

for European firms generally comes from large Japanese firms. Even in industries where some of the Japanese competitors are smaller firms as in mechanical engineering, they are often supported by the giant 'Zaibatus', and their exports are channelled through trading houses.

The mainspring of Japanese industrial competitiveness has been the rapid assimilation of technical advances into products and for production processes. Another feature of Japanese competitiveness is that it is spearheaded by a small group of products for which there is a mass market. In 1986 cars accounted for 16 per cent of Japanese exports to the UK; trucks and vans, two per cent; parts for cars, trucks and vans, three per cent; motor cycles, one per cent; colour t.vs, one per cent, video recorders, three per cent; radio equipment, two and a half per cent. For each of these products some Japanese firms have greater output than European producers. In recent years Japanese competition has been led by very large organisations including Japanese motor vehicle and electrical companies which through control of their large home market and their exports to overseas markets have much larger outputs of many products than their European rivals. The strength of Japanese competition corroberates claims that the economies of scale are substantial and significant for competition.

An expert on Japanese industrial policy suggested in discussion that MITI is now less concerned with economies of scale than in the earlier post-war period. Earlier policies for concentrating the steel and motor industries had operated. MITI's more relaxed attitude towards economies of scale reflects the fact that Japanese firms in many industries are now among the largest in the world. The reduction in trade barriers has given Japanese firms access to world markets. In the 1980s MITI recognises the importance of fierce inter firm competition. Recent changes in exchange rates have led Japanese firms to adopt survival strategies. These strategies result in firms transferring some manufacturing operations overseas to take advantage of wages lower than those in Japan. These moves reduce the scale of some manufacturing operations in Japan.

Sweden & Switzerland

Sweden and Switzerland, two smaller European countries, have achieved high levels of labour productivity and output per head of population by world standards. Superficially their success conflicts with the evidence for the existence of large economies of scale. In fact, Sweden's industrial performance supports the view that there are large economies of scale. Since the development of the Swedish Match Corporation in the C19th, Swedish industrialists have been aware of the economic handicap imposed by the relatively limited size of their domestic market, and the opportunities available through exports and foreign investment to compensate for this. SKF, Alfa Laval, Atlas Copco, Ericsson, Sandvik and Electrolux are international companies which have reaped economies of scale at their Swedish plants through control of overseas markets by investing in other countries particularly the major industrial countries. Foreign investment has also played an important role in the development of Swiss manufacturing industry.

Again there are alternative explanations of Swedish and Swiss industrial competitiveness. The high quality of education and industrial training contribute to this.

Corporate Strategies and Practices

Take overs

The strategies adopted by companies are generally consistent with the view that economies of scale in manufacturing industries are substantial and that the costs and effectiveness of administration and management do not necessarily rise with horizontal increases in scale. Throughout the post-war period there have been waves of horizontal, conglomerate and cross border mergers and takeovers. There are alternative explanations for these takeovers but they are consistent with management perceiving scope for achieving economies of scale through growth by take overs.(1)

If it could be shown that mergers generally led to increases in efficiency that would provide further support for the theme that scale economies are large. In fact the results of studies of post-merger performance are not clear cut. Many reviews have been made of these studies and it is outside the scope of this report to delve into this muddy area of applied economies.(2) One piece of information the author of this report can add is, however, relevant to this review. Many of the studies of post-merger performance have used UK data from published accounts. These studies distinguished horizontal and conglomerate mergers, where horizontal mergers were defined as mergers between companies within the same industrial group or branch of manufacturing

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(1) The alternative explanations are that management want to take over competing firms to eliminate competition or simply to control more assets.

(2) The most recent review is by Brian Chiplin and Mike Wright, 'The Logic of Mergers', Hobart Paper 107, London. 1985.

industry. This is a very broad definition; it means that two firms making any food products which merge are considered a horizontal merger. The same definition was used in a recent American study of post-merger profitability. The author made a survey of these so-called horizontal mergers in the UK and found that only about ten per cent were between companies for which there would be substantial scope for obtaining any technical economies of scale in production or for spreading the development costs of products. In 90 per cent of cases the products made by the merging companies were too distinct. Thus, even if average post merger profitability for widely defined horizontal mergers does not increase this is not evidence that there are no economies of scale for products.

Sourcing components

Vehicle and other companies generally source (buy) each component from one or a very small number of suppliers. Many companies recognise that single sourcing provides lowest costs via economies of scale. The main reason for dual sourcing where it occurs is to secure alternative supplies and/or to provide a check on quality and prices.

Rationalization

Particularly during recessions, firms rationalise their production facilities. Firms rationalize their production facilities because they develop or acquire excess capacity, intensified competition or because they reckon they will cut costs and increase their profits. Although the author is not aware of any comparative studies of rationalisation, the pattern of most schemes is to concentrate production. There is no evidence that when firms are faced with a need to cut costs they rarely divide production.(1) This suggests that there are no effective managerial diseconomies of scale for increasing production of a limited range of products at an establishment.

Focusing Businesses

A fashionable management practice during the 1980s has been for large companies, especially large UK companies, to focus their activities on a small number of businesses in which they consider they have, or can achieve a competitive advantage. To achieve the focus, other activities are sold off and the businesses retained are often expanded by acquisitions. This practice is consistent with the existence of economies of scale. There are of course, other possible motives for the practice such as achieving large market shares for their monopoly advantages.

Another feature of management practice is to delegate management responsibility for distinct activities. This suggests there are management or other diseconomies of scale for bundling together under a single operational management, activities of a distinct nature.

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(1) A recent example of a move to divide production was General Motors' decision to give its US car divisions greater control over their supply of components. Previously component production had been highly concentrated to take advantage of the economies of scale. In recent years these economies of scale had been offset by the higher wages per man paid by General Motors at its component manufacturing units compared to the wages paid by independent component manufacturers.

The important point suggested by corporate strategies and practices is that the costs and effectiveness of management does not impose increasing costs as horizontal scale is increased.

The use of Census Data to estimate the MES and the Economies of Scale

Lyons

Bruce Lyons has proposed a neat method of estimating the minimum efficient scale of production.(1) In effect he argues that if a firm operates more than one plant then its output exceeds the minimum efficient scale of a plant. From a distribution of the number of plants operated by firms in size groups, he estimated the minimum efficient scale of production for plants.

Lyons recognised that there are qualifications to his method of estimating the MES for multi-product industries. Firms may operate more than one plant because they make a number of distinct products not because they have exhausted the economies of scale for any one product. All census trades are multi-product trades. Nevertheless Lyons' estimates are of interest because they draw attention to the great number of small plants. He analysed 118 trades. For 105 trades his estimate of the MES was below 250 employees, for ten it was between 250 and 500, for one it was between 500 and 1,000 and for two trades it was above 1,000. Lyons' estimates indicate that many small plants are efficient, but his estimates are not inconsistent with there being technical economies of scale for large plants in segments of trades. For example, the existence of small plants making fasteners for cars or

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(1) Bruce Lyons, 'A New Measure of Minimum Efficient Plant Size in U.K. Manufacturing Industry', Economica Feb. 1980.

replicas of vintage cars is not inconsistent with economies of scale for large factories at which standard cars are assembled.

Lyons acknowledged that his method provides estimates of the MES for only one dimension of scale, the size of plants. It does not estimate the economies of scale for products, production runs or firms.

Griliches & Ringsjad

The limitations to using Census data as a source for estimating the economies of scale are again illustrated by an elegant study made by Z. Griliches and V. Ringsjad.(1) Although their "principal finding is the evidence for increasing returns to scale ...", their estimates of scale coefficients imply generally small economies of scale for establishments in manufacturing and mining industries. This conclusion is reinforced by the fact that their study is based upon Norwegian data, and establishments in Norway are smaller than in the larger industrial countries. However, the results may not apply to industry in other countries Norwegian industry is concentrated on some industries for which economies of scale are limited, for example, food and fish processing and sawmills, where the manufacturing processes are relatively simple and the transport costs involved in concentrating production would be high. The Norwegian market is relatively small, so Norwegian firms have not developed industries, such as motor vehicles, requiring large scale.

Griliches and Ringsjad obtained their estimates of the economies of scale by fitting data for 5,361 individual establishments to a Cobb

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(1) 'Economies of Scale and the Form of the Production Function', Amsterdam, 1971. This study was up-dated by V. Ringsjad in the Swedish Journal of Economics Vol. 80, 1978, No. 3.

Douglas production function. Their tests show that the estimates of scale effects are not very sensitive to the specification of the production function. Their main measures of labour input are in terms of hours worked at prevailing wage rates and for fixed capital, insurances values.

The economic interpretation of a scale coefficient for data for establishments drawn from all of Norwegian manufacturing industry is not clear. In effect small businesses making, for example, bespoke products or breaking bulky consignments and repacking, are compared with paper mills making newsprint and bulk chemicals. One would expect approximate equality of value added per unit of (weighted) inputs across this spectrum. The scale coefficient perhaps measures the effects of the greater barriers to entry in the trades with large plants. On a more positive note, the estimates do indicate that large is not inevitably best. If large establishments were much more efficient than small ones whatever the combination of products produced in the large establishments, Norwegian industry would be organised with fewer small units and the scale coefficient would be larger.

The authors also provide estimates for individual industries. But many of these industries are amalgamations of different trades (subject to varying market conditions in 1963). For example, besides grouping pulp and paper mills together, small mills making high quality special papers are grouped with large mills making newsprint and packaging paper. The problems of comparing different kinds of business applies within many industries as well as to all manufacturing. The authors recognise this problem. They also recognise other sources of qualifications which may bias the results to an unquantifiable extent.(1).

Baldwin and Gorecki(2)

The attempt by Baldwin and Gorecki to measure the economies of scale from Canadian Census data is the most ambitious so far. They focus on the results obtained by fitting data for Canadian manufacturing establishments in 1979 to a Cobb Douglas production function. Again their results indicate that economies of scale apply. Their results indicate that the increase in unit costs for each halving in the size of establishments would be about ten per cent. They also fit data for each industry to a Cobb Douglas production function. The median result for estimates for individual industries also indicates that unit costs would rise by about ten per cent with each halving of scale. These results suggest larger economies of scale than the estimates made by Griliches and Ringsjad using Norwegian data. Their estimates indicated

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(1) The authors admit that 'there is a great deal of variability in their micro-data which is not explained by the variables at their command'. They say that the bias 'is just as likely to result in estimates that are too low as too high'. They do not examine the economic justification for this claim. Where large economies of scale exist small establishments will have been forced out of business or the value of their capital stock will have been lowered. (The use of insurance policy replacement values may not get around this problem of valuation because values may in part reflect expectations of profits. For example, a firm might not insure at full replacement value if it would not replace a small scale unit in the event of fire because a new plant would not be profitable at full replacement cost). The authors mention the likelihood that if economies of scale exist prices of the output of large establishments could be lower.

(2) John R. Baldwin and Paul K. Gorecki 'The Role of Scale in Canada-US Productivity Differences in the Manufacturing Sector', Toronto, 1986.

that costs would rise by about four per cent with each halving of scale. However both sets of estimates are qualified for the reasons outlined.

Baldwin and Gorecki give estimates of scale coefficients for industry groups in their Table 4.1. Industry groups were ranked according to the scale coefficients calculated for 1979. There was a weak correspondence with the ordering given in table 5.3(b); the rank correlation coefficient was 0.09. The Baldwin and Gorecki estimates showed clothing manufacture, knitting, leather and textiles to have low economies of scale, similar to the assessment based on industry studies. Chemicals were ranked fifth; printing, sixth; and paper, seventh. But tobacco was ranked first; non-metallic mineral goods, second; and food and beverages third, much higher positions than in Table 5.3(b) and machinery was lower at fifteenth. Apart from tobacco these industry groups include a very wide range of products. The estimated scale coefficients may reflect differences between sub sectors of these industry groups not the existence of economies of scale for firms making similar products.

Studies of Costs and Prices

Owen

Nicholas Owen has used price and cost data to check engineering estimates of the economies of scale for the car, truck and consumer durables industries.[(1)] Owen shows there was a decline in real costs per car through time as European car producers increased their output. The average reduction in costs was in line with the expected effects of

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(1) Nicholas Owen, 'Economies of Scale, Competitiveness, and Trade Patterns within the European Community', Oxford, 1983.

increasing scale based on engineering estimates of the economies of scale. However, the reduction in unit costs estimated by Owen was attributable to technical progress as well as scale increases. For the other industries Owen studied, cost data did not conflict with engineering estimates of the economies of scale.

Conclusions

International comparisons and the conduct of industrialists supports the view that there are economies of scale where scale is increased horizontally and that the costs and effectiveness of management do not impose a limit on these economies. The results of studies based on census data costs and prices certainly do not conflict with the existence of economies of scale, but the quantitative estimates produced by these methods are marred by serious qualifications.

Section 8. The Resurgence of Small Firms

Mrs. Thatcher's origins as the daughter of a one-shop grocer and her promotion of small and new businesses have drawn attention to the role of small businesses in Britain. Other reasons for the current emphasis on small businesses in Britain are that the small business sector accounted for relatively less output in Britain than in other developed industrial countries by the 1970s, and high levels of unemployment.

The extent to which small businesses in Britain have outperformed larger firms in terms of the growth of employment is, however, not settled. The collection of statistics for small businesses is not comprehensive and estimates of employment and changes of employment in small businesses are unreliable.(1) Nevertheless there is strong evidence that small businesses in the USA are an important source, perhaps the main source, of net new jobs in recent years and that the decline in the proportion of people who are self-employed has been reversed.(2)

The resurgence of, and emphasis on, small firms is common to the developed industrial countries. Superficially at least this trend counters the view that the economies of scale are large. In this section the paradox of the resurgence of small firms and the existence of large economies of scale is considered.

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(1) P.E. Hart, 'Job Generation and Size of Firms', National Institute of Economic and Social Research Discussion Paper No. 125.

(2) David M. Blau, 'A Time-Series Analysis of Self-Employment in the United States', Jnl. of Pol. Econ. June 1987. Blau refers to evidence of the reversal of the long-run declining trends in non-agricultural self-employment.

Technical Change

It is clear that in the many important industries including steel, automobiles, and engineering, technical developments such as the speeding up of processes, new techniques for shaping metal, the substitution of electronic for mechanical devices, the use of plastic instead of metal components and the introduction of computers and robots have greatly increased labour productivity. These changes have certainly reduced the number of employees required to produce a given output of many products. They have also reduced the MES of plants in many industries where the size of plants is measured in terms of numbers of employees, but this is an unsatisfactory measure in any case. These changes have not necessarily reduced the economies of scale for large outputs of products.

Technical change has worked in both directions. Numerical control of machine tools has reduced the cost penalty for producing repeated short batches of machined products and so reduced costs for firms which produce small batches. It has been argued that numerical control and computer aids for production also aid small firms because small firms are more flexible and have more informal management systems. In particular there is less polarization within small firms between operators and specialists such as programmers. The introduction and efficient use of numerical control and computer aids to production is facilitated by flexible working arrangements.(1) At the same time computer stock control systems, computer aided design, and the use of computers for production control have reduced the costs of small batch

(1) A. Sorge et al. 'Microelectronics and Manpower in Manufacturing'. Berlin, 1983.

production at large plants. For example, one of the handicaps of a large footwear factory producing a range of styles, sizes and fittings is the problems of organising production to fully utilize capacity. Computer systems provide firms with an important aid for organising such production efficiently.

Generally the substitution of plastic for metal components has reduced the economies of scale for products, but the substitution of plastic for leather and wood has tended to increase the economies of scale for producing large outputs of products because the quality of synthetic materials is more standardised and this facilitates cutting etc. Computer type setting has reduced the scale of operations required for type setting for books to the point where outworkers are used. On the other side, economies of scale for non-woven fabrics are generally greater than for woven fabrics which they are replacing. Also the manufacture of carpets by tufting in place of weaving has increased the economies of scale in that trade.

Faster Technical Development

The explosion in technical development has presented many opportunities for the invention of radically new products and processes. Many of these inventions have been pioneered by small and new firms. Throughout industrial history there has been a tendency for many existing and new firms to enter new industries. One relatively new source of advantage for some of the small firms in the engineering/electrical/instrument industries is that they have skilled staff who can develop efficient software to control the operation of the machines or instruments. This is critical for the development of many products in these trades. Of course, large firms have software experts and consultants can be hired, but shortages of these skills limit the range of products for which large firms compete and this leaves gaps for small firms to exploit. For some new products made by small firms the UK market alone is too small to achieve competitive scales of production. This applies to other EEC countries. The firms have to export into foreign markets to increase output and move along the scale curve for their products. The hand calculator and domestic computer markets provide obvious illustrations of this point. The UK market did not enable firms in these trades to achieve the scale necessary to reap sufficient economies of scale to be competitive with Japanese and American producers. In some segments of trades the domestic market is sufficient because, so far, foreign firms have not attempted to compete or domestic buyers, such as universities when buying instruments, prefer to buy locally.

Increase in the Output of Skilled Staff

Technical change may have worked in a different way. The merging of national markets and speeding up of technical change have combined to increase the value of the output of those employees who can affect the international competitiveness of firms. The return for developing and marketing new products is increased by the enlarged market to which the products can be sold, and increased competition in developing new and improved products puts pressure on firms to innovate and introduce more new products.

The output of skilled staff may have increased, but the pay structures of large companies are rather rigid and in many cases it is difficult for large firms to target increased pay to the staff responsible for new developments to fully reflect their contribution. Also large companies do not give their employees a major share of the property rights in the innovations they create. Skilled staff set up their own firms in order to identify and secure a higher proportion of their output. The incentive to do this has increased with the increase in the output of the skilled staff.

Economic Forces

The emphasis on small firms does not reflect technical developments alone. Demand for the products of the motor vehicle and domestic appliance industries which are dominated by large firms and economies of scale have reached maturity in European countries. The slowing growth of these industries has been further depressed by intensified international competition. In part the focus on small and new firms is to replace the growth of these mature industries.

Another development which has transferred employment from large to small firms is the move by many large companies to focus their business and operations on products and processes for which they have a competitive advantage. One aspect of this process is to buy out services and manufacturing operations from other firms instead of performing the services in-house. This trend has been reinforced by the perceived need of managers to increase flexibility to meet fluctuations in total demand and changes in demand for products. Also the recession circa 1980 led managers to search for ways of reducing costs, and buying out reduces overhead costs such as commitments for pensions and may free firms from labour restrictive practices and wage and other agreements with trade unions. The increasing importance of information or knowledge services for firms may have led them to look for more efficient ways of procuring the services. Earlier hiring experts as full-time employees was not too expensive. Now with the increase in the relative salaries and the proliferation of the expert services a company requires because of faster technical progress and the integration of national markets, it is important to hire experts in the most efficient way, which may be from an independent business. In this way fluctuations in demand for experts from individual firms through time may be evened out and expert knowledge may be selected for tasks more precisely. Finally once a market for firms supplying expert services develops, the firms supplying the expertise may have the advantage of wider experience than the internal experts of firms. Increases in unemployment have weakened the bargaining position of trade unions, but the wages paid by most firms have continued to rise. Buying out services may in effect enable firms to reduce wages because the employees of the firms from which goods or services are bought pay lower wages.

Examples abound; many companies buy out computer software and the services of consultants, instead of employing specialised staff, and at a more mundane level use contract cleaners instead of employing cleaners. Some firms have also increased the manufacturing operations they buy out. Firms now buy out steel, castings, and machining operations which earlier they made or performed in-house. These trends have certainly opened opportunities for many small, new and specialised firms. They do not, however, reduce the real economies of scale for products.

The growth of international trade has changed the competitiveness of both small and large firms. Perhaps the main advantage for small scale firms in manufacturing industries from the growth of trade is that they can buy components from suppliers in other countries. This often takes away the scale advantage of larger domestic manufacturers who could make the components in-house on a large scale. The small firms use the scale advantage or low costs of suppliers in other countries. On the other side only large firms with an international marketing network may be able to gain a large enough share of world markets for a new product to be competitive. But again a small firm may be able to market its products in other countries in collaboration with a large company with an international sales network.

The 'Cambridge Phenomenon'

The technical and economic forces listed have contributed to the mushroom growth of small firms in the Cambridge area since 1970. Many of the firms provide consultancy services; firms which make hardware buy out components from the UK suppliers and buy many important components overseas. The new products and services they supply to niche markets result from technological developments. These rather obvious points are listed because they lead to another explanation for the 'Cambridge Phenomenon' which has been given wide publicity. Success leads to success. Employees of small and new firms serving niche markets learn how it is done and themselves set up new firms. An infrastructure of firms supplying the new firms with a great range of services and finance emerges and facilitates the growth of more new firms. 'Agglomeration economies no longer result from manufacturing in a single industry such as cotton or steel, but relate to the output of a highly skilled research, development and production-oriented workforce that can adapt to totally new technical innovations and production concepts'.(1)

Purchases of a Leading UK Manufacturing Company.

To check on the conclusions of this section the director of a leading UK manufacturing company responsible for buying was asked if he had noted any shift towards buying from smaller firms. He answered with the comments

> 'There has not been any detectable transfer of business from large companies to small ones, but some of the new products such as software and consultancy are bought from very small organisations'.
>
> 'The company has been following a policy of supplier reduction. The idea is that a smaller number of companies enjoying higher volumes will be better able to afford the research and development, the investment and the introduction of new production and management systems that are necessary to meet our quality and productivity objectives'.
>
> 'So, alongside the industrial giants we have always done business with, are hundreds of companies with employment levels measured in hundreds and sometimes tens. These small companies are more numerous in the provision of services to our offices and factories, such as cleaning, construction maintenance and low volume quick service engineering products'.

Conclusion

In brief, the resurgence of small firms is not evidence that the economies of scale have disappeared or even diminished. For the most part the estimates of economies of scale for technical and development costs given in Section 5 stand. New and small firms have not made

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(1) R. Oakey, 'High Technology and Small Firms' London, 1984.

inroads into the markets for cars, advanced aeroplanes, tractors, or combines. They have developed some new products and have found some niches in markets.

Section 9. The Community's Exports of Manufactures and the Economies of Scale

In this section the pattern of the EC's export trade is related to the estimates of the economies of scale reported in this survey.

Table 9.1 records the distribution of value added, production and exports by EC manufacturing industries. The final column of the table shows the ordering of industry groups according to the magnitude of economies of scale developed in Table 5.3(b). The ordering is intended to give a general indicator of the importance of the economies of scale for industries.

The unweighted average indicator of scale for industry groups is 10.5. When value added by industry is used as weights for the economies of scale indicator, the average is 8.8. This variation from the unweighted average is explained by some of the industry groups such as leather and leather goods with relatively small economies of scale having relatively small output. Motor vehicles for which scale economies are largest has a larger than average weight.

The weighting by exports is more interesting. When the scale indicators are weighted by 'Extra Community Exports', exports to countries outside the community, the average falls from 8.8 to 7.4. For 'Intra Community Exports' the weighted average was 7.8. Another statistic used to illustrate the relationship between the variables included in Table 9.1 is the rank correlation coefficient. The rank correlation between extra community exports and scale, 0.64, is shown to be closer than that between value added and scale, 0.47.(1) The

(1) The industry with the greatest value added is ranked 1, the industry with the second greatest value added is ranked 2 and so on.

Table 9.1 EUR 10 Exports and the Economies of Scale

Industry	Percentage Share of Industries in Value Added (1980) (1)	Percentage Share of Industries in Production Value (1980) (2)	Extra Community Exports as Percentage of Total (1983) (3)	Share of Extra Community Exports as Percentage Share of Community Production Value (4)	Intra Community Exports as Percentage of Total (1983) (5)	Share of Intra Community Exports as Percentage of Share of Community Production Value (6)	Indicator of Economies of Scale (7)
Mineral oil refining	2.7	8.3	3.4	41	8.5	102	3
Production and preliminary processing of metals	5.7	7.2	7.5	104	7.7	107	5
Iron and Steel	3.2	3.9	2.9	74	3.3	85	
Non-metallic mineral products	5.0	3.9	2.4	62	2.2	56	11
Concrete, cement, plaster products for construction	1.2	1.0	0.2	20	0.1	10	
Glass and glassware	1.2	0.9	0.7	78	0.8	89	
Chemicals and man-made fibres	9.7	10.2	12.7	125	13.5	132	3
Basic Industrial Chemicals	4.3	5.2	6.3	121	7.7	148	
Pharmaceutical products	2.0	1.6	1.8	113	1.0	63	
Metal articles	8.3	6.7	4.8	72	3.1	46	12
Tools and finished metal goods	2.9	2.4	1.7	71	1.7	71	
Mechanical Engineering	10.9	8.6	17.0	198	8.2	95	7
Machine tools for working metal	1.4	0.9	1.7	189	0.7	78	
Plant for mines, iron and steel, etc.	1.9	1.8	2.9	161	1.3	72	
Office and data-processing equipment	1.5	1.0	1.9	190	3.0	300	6
Electrical Engineering	11.2	8.3	9.8	118	7.2	87	8
Electrical machinery	3.4	2.5	2.5	100	1.3	52	
Telecommunications equipment etc.	3.5	2.2	3.4	153	2.1	96	
Radio, television, etc.	1.6	1.4	1.2	86	1.4	100	
Domestic type electrical appliances	0.9	0.9	0.6	67	1.0	111	
Motor vehicles	8.7	8.0	10.6	133	10.9	136	1
Other means of transport	3.5	2.8	4.2	150	2.4	86	2
Shipbuilding	0.9	0.7	1.5	64	0.3	43	
Aerospace equipment manufacturing and repairs	2.0	1.5	2.2	147	1.7	113	
Instrument engineering	1.4	1.0	1.9	190	1.4	140	9
Food drink and tobacco	9.6	15.0	7.0	47	11.0	73	15
Textiles	4.0	3.7	3.4	92	5.3	143	17
Leather and leather goods	0.4	0.4	0.5	125	0.5	125	19
Mass-produced footwear	0.8	0.6	0.9	150	1.1	183	19
Ready-made clothing	2.1	1.8	1.2	67	1.7	94	19
Timber and wooden furniture	3.1	2.9	1.4	48	1.7	59	18
Pulp, paper and paper products	2.5	2.5	1.1	44	2.2	88	10
Printing	3.0	2.2	0.8	36	0.7	32	10
Rubber products	1.6	1.2	1.0	83	1.2	100	13
Plastic Products	2.2	2.0	1.5	75	2.2	110	13
Weighted average for the indicator of scale for industry groups	8.8		7.4		7.8		Unweighted 10.5
Rank correlation coefficient with column 7	0.46	0.47	0.64	0.16	0.61	0.11	

Source: 'Eurostat Yearbook of Industrial Statistics, 1984'.

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correlation between the magnitude of value added and the economies of scale indicator, again shows that the large manufacturing industries tend to have larger than average economies of scale. The rank correlation coefficient is higher for both extra and intra Community exports than for value added. The share of community exports is taken as a percentage of the share of production value for each industry in columns (4) and (6) to eliminate the effects of large industries tending to have larger than average economies of scale. Columns (4) and (6) indicate the export intensity of industries. The rank correlation for extra community exports and economies of scale of 0.16, and for intra community exports and economies of scale of 0.11, indicate the extent of the concentration of EC exports from industries with larger than average economies of scale.

The results are in the direction expected. The Community tends to export relatively more of products for which the economies of scale are relatively large. However the result for extra EC exports is very weak and is not as decisive as the author expected. There are several explanations:

1. The extra and particularly intra Community exports of food and textiles for which economies of scale are modest are substantial relative to the contribution of the industries making these products to value added. One explanation for the large trade in these products is the wide variety of products. The contribution of vehicles, chemicals and mechanical engineering - the industries with large economies of scale - to exports is greater than their share of value added but the difference in weighting is not very great.

2. The results reflect in part the failure of EC electronic industries. The share of electrical engineering exports is less than for its share of value added. Japanese and US companies have benefited from economies of scale in these industries.

3. The weighting may understate the relationship between exports and scale economies because within each industry group exports may be concentrated upon products for which economies of scale are greater than average for the industry group.

The fact that EC exports are not more heavily concentrated on industries with large economies of scale could be explained in another way. Trade is created by differences in products produced in different countries to satisfy consumers' quest for variety and change and/or differences in efficiency. Exports originate from efficient producers and reduce the output of inefficient firms. Either way there are gains from trade.

Section 10. Economies of Scale for the Service Sector

Estimates of the economies of scale for the service sector are scarce. This reflects the difficulty of making such estimates and, possibly, that economies of scale for service trades are lower than for manufacturing industries.

Methods of Measuring Economies of Scale for Services

The methods of measuring economies of scale which apply to manufactures can be used for services, but the engineering method is less reliable for services. The industrial processes used in manufacturing trades for which engineering estimates are made do have counterparts in the service trades. The aeroplanes used by an air line or the computer systems used by a bank spring to mind. But for many service trades capital equipment comes in quite small units relative to national output. The largest hotel, shop or retail banking premises is small relative to the national markets in which they operate. This replication of units doing the same kind of business means that comparisons of actual cost for units of varying size is a possible method of estimating economies of scale for some services. However, because there is much replication within national markets, the scope for economies of scale through completion of the EC is likely to be limited in these trades.

Sources of Economies of Scale for Services

Completion of the market will have two sets of effects via the economies of scale for service trades. Firstly, for service trades in which trade between member countries increases, there will be scope for economies of scale. The second set of effects will be generated by the increase in income in the EC which will be caused by completion of the market and which will increase demand and output of the service and other industries. In this section, the service trades which will be affected by increased trade in services between member countries are considered first.

The groups of services which are distinguished in the UK balance of payments statistics are listed in Table 10.1. The first column of the table which shows UK exports in 1984 provides a rough and ready indicator of the importance of the headings. Financial and other services are a relatively important source of exports for the UK and so UK exports provide an exaggerated measure of these services for total Community exports.

In the second column an assessment of the impact of completion of the EC for trade in each group of services is attempted. The services directly affected by the completion of the EC are insurance, banking, trading and consultancy.

The final column of the table comments on the sources of economies of scale for each service. One general source of economies of scale will be that transactions and deals increase in size and lead to a reduction in costs because costs which are fixed or semi-fixed relative to the size of transactions and deals can be spread over a larger output. The broad picture is that there are economies of scale in providing services, but that they are perhaps not as great as for

Table 10.1 Trade in Services and the Sources of Economies of Scale

Services	UK exports 1984 £bn	Effects of Completion of the EC for trade in these services	Sources of Economies of Scale
Sea transport	3.2	The increase in trade within the EC is likely to have very limited effects.	There are economies of scale for using large ships and aircraft, and economies from fully utilizing the capacity of ports, airports and railway systems more intensively. Consumption of the market will generate more traffic and increase the density of traffic on routes.
Civil Aviation	3.0	There will be some increase in demand for these services as a result of completion of the EC because of the removal of customs barriers and in response to increases in trade, but removal of restrictions on air fares may be more important	
Travel	4.2		
Insurance	0.7		The main sources of economies of scale in these industries which may be exploited through completion of the EC are: 1. There are technical economies for large data and information processing systems. There may be some scope for spreading the costs of developing and using these systems. 2. There is scope for spreading costs of acquiring expertise and knowledge over increased throughputs. 3. Completion of the EC will increase the size of some transactions and deals. Some costs of providing services are specific and fixed or semi-fixed relative to the size of transactions. An advantage of larger organisations providing these services will be that they are able to cope with larger transactions and deals.
Banking	1.0		
Commodity traders	0.3	Increase in trade expected	
Export houses and other brokers	0.8		
Consultancy	1.2		
Telecommunications and postal	0.4	Increases in Community trade will increase demand for these services	The increase in trade will generate increased communications and will generate economies of scale through more intensive utilization of facilities.
Films and TV programmes	0.3	Not much affected by completion of the EC	There are large economies of scale through widening the audiences for films and TV programmes as many of the real costs of producing programmes are fixed.
Oil and gas	0.2		
Land Transport	0.1	Increase in Community trade will increase demand for these services	Little scope for economies of scale
Advertising	0.1	Increase in trade expected	As markets coalesce and industries rationalise there will be economies through spreading the costs of making adverts over larger outputs. There may be some increase in advertising.

Services	UK exports 1984 £bn	Effects of Completion of the EC for trade in these services	Extent of Economies of Scale
Royalties	0.9	Not much affected by completion of the EC.	The effects of scale economies not significant.
Other services provided by companies	1.9		
Education Courses	0.5		
Diplomats	0.6	Not affected by completion of the EC	
Personnel at US bases in the UK	0.4		

manufacturing. As noted earlier there are obvious limits to the size of lorries, aircraft, ships, hotels and shops. Increased business will be met by duplication of facilities. The structure of the service trades supports this conclusion. There are more firms and establishments providing most individual services than manufacturer plants or factories producing most individual products.

It is outside the scope of this report to consider the sources of economies of scale in other service trades, including retailing and other channels of distribution, which will be affected by the increase in income generated by completion of the EC. The main sources of economies here are in the scope for spreading fixed and semi-fixed costs, for example, the costs of public administration, from the increased density of traffic in the post and telecommunications services,[1] and for large transactions in the retail trade both for buying and selling.

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(1) An example of a semi fixed cost for the postal service is the cost of postmen. Delivery of more mail to each household would not increase costs proportionately.

THE EVIDENCE

Industry Studies:

Banking and Financial Institutions

Sources: P.M. Horvitz, 'Economies of Scale in Banking' in 'Private Financial Institutions', for the 'Commission on Money and Credit', Englewood Cliffs, N.J. 1963.

J. Pacolet and A. Verheirstraetan, 'Concentration and Economies of Scale in the Belgian Financial Sector', in A. Verheirstraeten ed., 'Competition and Regulation in Financial Markets', New York, 1981.

J. Johnston, 'Statistical Cost Analysis', New York and London, 1960. (Section 5. Building Societies and Life Assurance Companies).

The sources describe studies of costs and scale and provide evidence of economies of scale at least over certain ranges of scale, but there are qualifications to the conclusions. Apparent scale effects are often later shown to reflect differences in the type of businesses done by large and small banks. The qualifications relate to the dimensions of scale. For example, the extent to which banks obtain deposits from a branch network or in the wholesale money markets varies. In the USA some banks operate branches while others do not. Small branches of banks tend to be sited in isolated communities. The existence of higher costs for such branches may influence a comparison of costs for the size of branches. Also there are problems relating to the measurement of costs. Horvitz shows that large banks in the USA pay higher salaries than small banks. The costs of buildings vary greatly according to the price of property in each locality and large banks tend to have headquarters sited in the centre of large towns where property prices are high.

No general estimates of the MES or scale gradients have been published for financial institutions.

Air Transport

Sources: D. Sawers, 'The Trouble with Big Airlines' Financial Times, August 24th, 1987.

P. Forsyth, R. Hill and C. Trengove, 'Measuring Airline Efficiency', Fiscal Studies, February 1986.

The sources refer to estimates that show that an airline's costs are not affected by the size of its route network. The marketing advantage of a large network is to be able to offer more through journeys without passengers having to change airlines. There are economies associated with density of traffic; high density allows an airline to use large aircraft on a route, and large aircraft have lower operating costs per passenger seat mile. Also staff and facilities on the ground at terminals can be used more efficiently where traffic on a route is dense. Extensions to a route network will increase the density of traffic on the airline's existing network.

Studies of Labour Productivity

In Section 7 we claimed that higher labour productivity in the USA supports the argument that economies of scale apply in manufacturing trades. Unfortunately the measurement of labour productivity for service trades is even more hazardous than for manufacturing trades. For what they are worth, the National Institute's estimates of productivity differentials between America and Europe show a smaller gap for services than for manufacturers.[1] This is compatible with economies of scale being less important in service trades. But it is weak evidence only, as there are other possible explanations and the estimates are subject to a wide margin of error.

Conclusions on the Economies of Scale for Services

There are reasons for expecting the economies of scale for services to be less than for manufacturing and the evidence does not conflict with this assessment. Plainly every European country cannot make commercial aircraft, motor cars or many other manufactured products efficiently, but each country does have a range of banks, insurance companies, stock brokers, shops, hotels, etc. There are market niches where there may be economies of scale, for example, banks arranging large corporate deals and re-insurance markets, but these are exceptions. In addition, as completion of the EC raises income and output, there will be some economies of scale in the service trades stemming from larger transactions and the economies of scale related to the size of bank branches, etc.

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(1) National Institute Economic Review, August, 1982 p. 29. The gap for services is about two-thirds that for manufactures.

Section 11. Conclusions

The Completion of the EC and the Economies of Scale

Completion of the EC will have three groups of effects via economies of scale. Where completion of the market results in substantial changes in the conditions of trade, for example, by changing the rules for public procurement, there will be direct effects on industries, inter country trade will increase, structural change will occur in the industries and firms will benefit from economies of scale. If the national electricity authorities open their tendering to all EC manufacturers of equipment, trade in generating equipment between member states will increase, some firms will increase their share of EC markets and will gain economies of scale for the development and manufacture of this equipment. These effects of completing the EC can only be assessed on a case by case basis.

The second effect of completion of the market will be the widespread reduction of impediments to trade, increasing trade in all sectors, causing structural change in industries and generating benefits from economies of scale. This result will be reinforced by the third effect of completion of the market which will be to increase the growth of income within the community through achieving economies of scale and through the pressure of more intense competition. The increase in Community income will increase demand, output and inter-community trade, leading to further gains through economies of scale.

For reasons given in this report, estimates of the economies of scale are elusive and many of the estimates which are available are hedged around with qualifications. Nevertheless the evidence reported in this paper does support the hypothesis that economies of scale are a widespread feature of manufacturing industries and to a lesser extent of service trades.

The important result of this survey is to focus attention on the effects of changes in output of distinct products and production runs on costs. Economies of scale are usually associated with the size of establishments and firms. This is too limited a view. The main effects of completion of the market will result from many firms being able to increase their output of particular products, without necessarily increasing the average output of their establishments. This survey shows that there are substantial scale effects for products and production runs to be obtained in a wide range of manufacturing industries. The sources of these economies are technical economies of scale for production processes and the spreading of product development costs over the output to which they relate.

The competitiveness of EC Industries

The second question concerning the effects of completion of the EC is the impact on competitiveness of EC industries in third markets. A conclusion of Section 5 was that economies of scale continue indefinitely for complex products made by the vehicle, mechanical and electrical engineering and instrument industries. These are important EC export industries. Completion of the market will facilitate the restructuring of firms in these industries so that they increase their output of products and increase their competitiveness.

In Section 6 the advantages of large firms for R & D were described. Completion of the market will lead to the emergence of larger firms which can reap these advantages and cut the duplication of R & D within the EC. More efficient use of R & D personnel could have a multiplier effect on employment through job creation because R & D personnel are scarce.

Industrial Distribution of the Effects

Column 1 of Table 11.1 lists the manufacturing industry groups in order of the importance of economies of scale as in Table 5.3(b). This classification was based upon economies of scale for production and development. A noteworthy feature of this ordering is that the industries most subject to the economies of scale are the most concentrated in terms of the share of output produced by the largest companies. The vehicles, chemical, man-made fibres, metals and office machinery industries are all highly concentrated. Mechanical engineering is not concentrated but that reflects the immense range of products produced by that industry. At the other end of the list other manufacturing, textiles, timber, furniture, clothing and footwear and leather goods are all fragmented in part because of the diversity of their products.

The fact that the industries subject to the largest economies of scale are the most concentrated suggests that economies of scale are more fully exploited in these industries. The car, truck and aircraft industries have re-structured within the EC to take advantage of the economies of scale. It therefore seems unlikely that the economies of scale effects of completion of the EC will be concentrated on industries subject to especially large economies of scale. The effects will be spread right across manufacturing industries and service trades. The exceptions where the economies of scale will be substantial are the industries affected by changes in public procurement policy and national regulation of markets. These trades are pinpointed in column 3 of Table 11.1.

Table 11.1 The Industrial Distribution of the Effects of Completion of the EC.

Industry Groups in order of importance of economies of scale for production and development	Scope for economies of scale for research and development	Effects via economies of scale of lifting non-tariff barriers to trade in the EC.
1. Motor Vehicles	Major source of economies	Moderate effects of standardising national regulations for cars.
2. Other Vehicles	ditto	Moderate effects of standardising regulations for other vehicles and for lifting national preferences for public sector purchases of vehicles. Large effects for concentration of defence equipment procurement within the EC.
3. Chemicals 4. Man-made fibres	Large chemical companies have advantages for research and development.	Small effects (3.–7.)
5. Metals 6. Office machinery 7. Mechanical engineering 8. Electrical engineering 9. Instrument engineering	There are advantages for large companies for research and development but small firms can and do invent and develop new products particularly products for niche markets.	8.–9.: Substantial effects for lifting restrictions on public sector procurement of electricity generating, telecoms and broadcasting equipment. There would be substantial effects from EC procurement of defence equipment.
10. Paper, printing and publishing 11. Non metallic mineral goods	R & D not as important in these industries, though some new products and processes are introduced and R & D is important in certain segments of the industries.	Small effects

Industry Groups in order of importance of economies of scale for production and development	Scope for economies of scale for research and development	Effects via economies of scale of lifting non-tariff barriers to trade in the EC.
12. Metal goods	R & D not as important in these industries, though some new products and processes are introduced, and R & D is important in certain segments of the industries.	Small effects
13. Rubber and plastic products		
14. Drink and tobacco		Moderate effects for standardising regulations
15: Food		Small effects
16. Other manufacturing industries		
17. Textiles		
18. Timber and furniture		
19. Footwear and clothing		
20. Leather goods		

Economic Papers

The following papers have been issued. Copies may be obtained by applying to the address mentioned on the inside front cover.

No. 1 EEC-DG II inflationary expectations. Survey based inflationary expectations for the EEC countries, by F. Papadia and V. Basano (May 1981).

No. 3 A review of the informal economy in the European Community, by Adrian Smith (July 1981).

No. 4 Problems of interdependence in a multipolar world, by Tommaso Padoa-Schioppa (August 1981).

No. 5 European Dimensions in the Adjustment Problems, by Michael Emerson (August 1981).

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