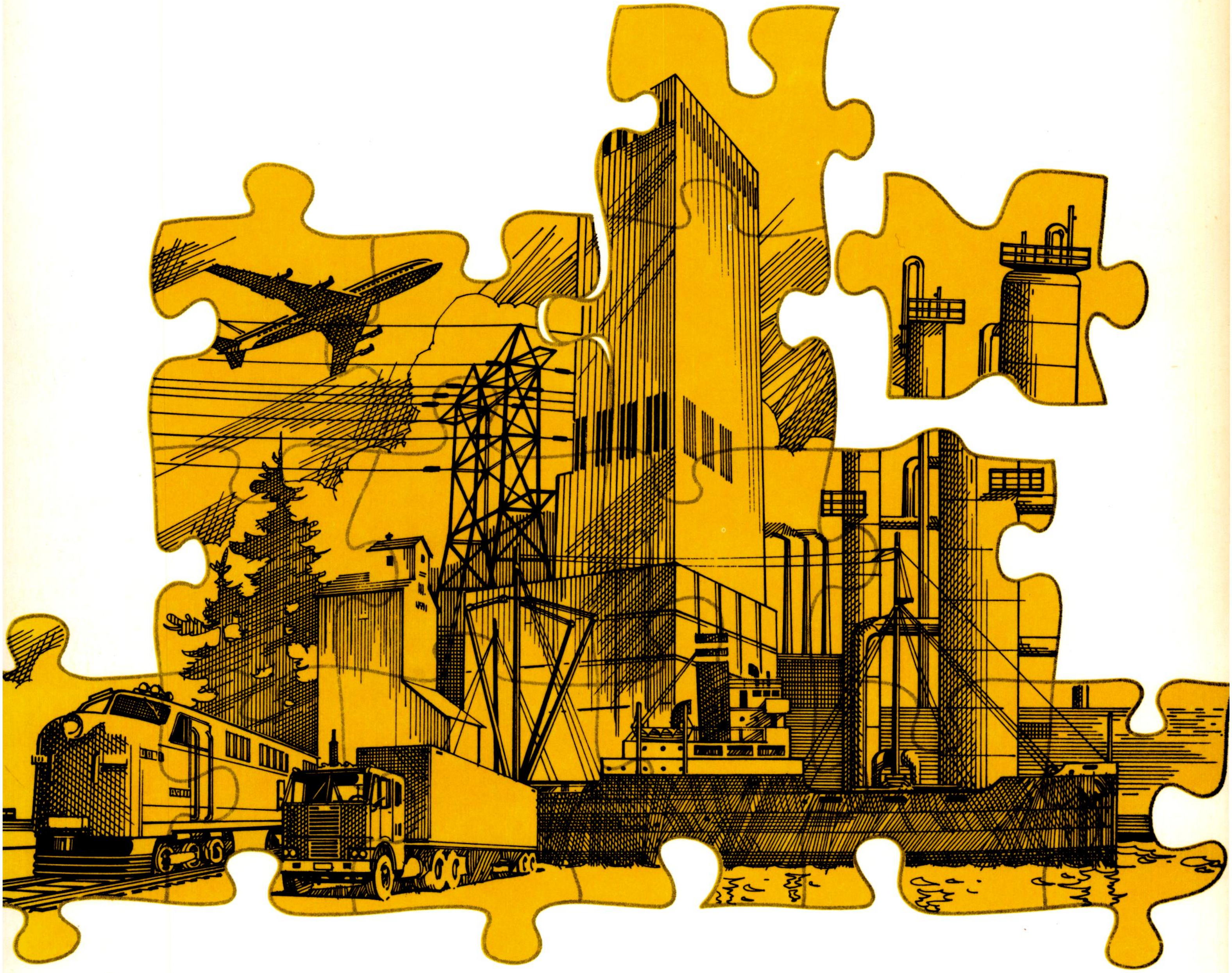
Royal Commission on Corporate Concentration



STUDY NO. 29

Economies of Scale in Canadian Manufacturing: A Survey

A Technical Report

Royal Commission on Corporate Concentration

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Economies of Scale in Canadian Manufacturing: A Survey

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FOREWORD

In April 1973, the Royal Commission on Corporate Concentration was appointed to "inquire into, report upon, and make recommendations concerning:

(a) the nature and role of major concentrations of corporate power in Canada;

(b) the economic and social implications for the public interest of such concentrations; and,

(c) whether safeguards exist or may be required to protect the public interest in the presence of such concentrations."

To gather informed opinion, the Commission invited briefs from interested persons and organizations and held hearings across Canada beginning in November 1975. In addition, the Commission organized a number of research projects relevant to its inquiry.

This study on the economies of scale in manufacturing was prepared by Donald Lecraw of The University of Western Ontario. The study covers an area central to the mandate and interests of the Commission, and many of the issues covered in our hearings and in related research.

Dr. Lecraw is the author of several articles on technology and the theory of the firm, and of 25 cases in business administration. He is Assistant Professor of Business Administration at The University of Western Ontario. He served as Chief Economist for the Royal Commission.

The Commission is publishing this and other background studies in the public interest. We emphasize, however, that the analyses presented and conclusions reached are those of the author, and do not necessarily reflect the views of the Commission.

Donald N. Thompson
Director of Research

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Introduction

The subject of economies of scale in manufacturing has received widespread empirical and theoretical attention in the economic literature. This paper attempts to summarize that literature and to draw implications from it for industrial policy in Canada. Canada has a small, widely dispersed internal market which is contiguous with the U.S. market, one of the largest in the world. Decreasing transportation costs make Japan and the Pacific-rim countries our ever closer neighbours to the west, as are the European Economic Community countries and the Communist-bloc countries to the east. In many industries, firms and their component plants are significantly smaller and less specialized in Canada than in other countries. This small-scale, unspecialized operation can reduce the efficiency and international competitiveness of firms operating in Canada if their size is below that at which most economies can be realized, and if the penalties for operation below this scale are significant.

Until recently, most studies of economies of scale have focused on the product or plant level, and policy recommendations flowing from them have been concerned with the length of product runs and the size of plants in relation to minimum efficient scale (MES). Some recognition was also given to possible economies of scale at the firm level in marketing, research and development (R&D), finance and general management. Recently, several studies have shown that the subject of economies of scale is much more complex than had originally been realized on both theoretical and empirical grounds. A firm is seen as having economies of scale at the product, multi-product, plant, multi-plant, and firm levels. These various economies of scale interact with each other and are dependent on the economic environment in which the firm operates. This complexity makes clear-cut conclusions and policy recommendations very difficult. At least one conclusion emerges, however: reference to the MES plant for an industry is highly suspect and probably incorrect. Hence, policies formulated around the calculated number of MES plants that the market of a country can support are probably misguided.

The purpose of this paper is to describe the various types of economies of scale that may be present in the manufacturing sector; how they are measured; and the evidence that has been collected about their importance both in Canada and elsewhere.

The Analytics of Economies of Scale

Considering the large number of theoretical and empirical studies that have been done on economies of scale, only a few useful conclusions have emerged, for three reasons. (1) There are many different economies of scale associated with the production and sale of a product (or mix of products), and hence many possible definitions of what economies of scale are for firms in an industry. The MES of a firm for production may be very different from its MES for R&D, finance, marketing, or export. Consequently, to speak of "the" efficient scale (as is often done) may be misleading. Firms may wish to merge to increase their size to achieve economies of scale in R&D even though their production is already scale efficient. (2) The different economies of scale available to firms in an industry interact with each other and with the economic characteristics of the country in which they are located in complex and changing ways. For example, as the density of an industry's customers increases, the MES of the plant is usually also increased due to lower transportation costs. (3) Given the large number of economies of scale and their complex interaction with other variables in the firms' economic environment, it is extremely difficult to obtain data to show at what volume the various economies of scale are exhausted and the extent of the cost penalty for operating below this scale. Even if all the economies of scale of an industry could be defined, disentangled, and measured, the implications of these penalties for operation below MES are often unclear and are surely country- and time-specific. Policies appropriate in one country or time may be highly inappropriate in another.

The following subsections describe the various economies of scale that may be available to a firm. It should be remembered that they all interact and overlap with each other; so that any simple classification will inevitably oversimplify the true situation.

Product-Specific Economies of Scale

Scherer (1970, 1974, 1975) emphasized the distinction between product-specific, plant-specific, and multi-plant economies of scale. An increased volume of production for one product may decrease production costs per unit output for several reasons. Economies of scale may be related to volume of output of a product as a function of three related variables:[1] the total expected volume of output, the rate of volume of output per unit time, and the length (in time) of the expected production.[2] For large expected volumes, management is willing to expend more time in developing cost-cutting measures and quality control in production. As the length of the production run increases, both workers and management become more familiar with the production techniques, and production costs may fall over time and as the total volume of output increases. This "learning by doing" has been cited by Arrow (1962) as the most important source of economies of scale. Certainly for new products or processes, learning by doing can lead to substantial cost decreases. As the rate and the total volume of output increase, the production processes can be made increasingly automated and specialized, capital equipment can be substituted for labour, and the production line can be balanced to decrease the idle time of the different machines.

These three factors (rate, time, and volume) combine so that goods whose demand allows high-speed, long-term production runs can be produced using more automated, specialized machinery, and there will be less downtime for changes between similar products that utilize the same machinery. Reduced product changes over the production cycle and more familiar products will also decrease waste of raw material inputs during the production process and increase the quality and uniformity of the output. Also, as volume increases, the "law of large numbers" tends to decrease the importance of random fluctuations in demand and production failure; so that firms can produce closer to the expected demand and carry proportionately lower inventories.[3]

This analysis suggests a J-shaped average cost curve with cost per unit decreasing continuously with volume (Figure 1). At some volume, however, the production process may become so specialized and automated that a further increase in volume does not lead to significant cost decreases in the production process. This volume is called the minimum efficient scale (MES). MES varies from product to product and is also a function of the relative cost of inputs (labour, capital, energy, and raw materials) and hence is country-specific. In general, as labour costs fall relative to capital costs, the MES of a plant decreases since labour will be substituted for capital and economies of scale from automation will be lost. The MES plant in a low-wage, less developed country (LDC), may be smaller than in a high-wage, developed country. This difference in MES plant between countries depends on the technology of the industry, particularly the elasticity of substitution of capital for labour. With production processes that are "naturally" capital or labour intensive, where the elasticity of substitution between capital and labour is low, MES will not change appreciably with changing factor costs.

If input costs (especially labour and materials) or output price is a function of volume, then the MES of a plant not only is a function of total volume, but also depends on the rate of output and the input and output price elasticities of demand. As a firm increases the rate of output (and hence its demand for labour and other inputs), it may have to increase the wages it pays its workers or the price it pays for materials inputs, lower its selling price, and incur increasing transportation costs to reach the larger market required to absorb its increased output. Conversely, an increased rate of output could lead to economies of scale in production and in procurement of inputs and transportation, and hence to lower costs. Usually these costs increase with volume, however. When they are added to the average production cost per unit, it will eventually rise with output, even though the production process shows continuously decreasing costs. (See Figure 2.) This analysis assumes that transportation costs must be absorbed by the producer and cannot be passed on to the consumer as higher prices in more distant markets. This assumption may be realistic in the U.S. and Europe, but in Canada, with its highly concentrated industries and dispersed and isolated markets, firms may be able to set prices to pass on transportation costs to purchasers in distant markets. Notice that in Figure 2 the lowest average total cost (ATC) is at the volume where the slope of the transportation cost curve (plus increases in input prices) is equal (but negative) to that of the average cost (AC) curve for production alone (given constant input prices). The optimal scale of production for a plant will decrease as the slope of the AC curve increases, transport costs per unit increase, the elasticity of input supply decreases, the density (and disposable income) of customers decreases, the market share of a firm decreases, and the elasticity of demand for its output decreases.

Transportation costs, elasticity of input supply, population density, disposable income, and elasticity of demand are country- as well as product-specific; market share is firm-specific. No universal optimal plant size can be constructed when these variables are included (as they must be) in the firm's ATC function. Scherer et al. (1975) calculated the MES plant for production alone (assuming fixed input prices) from technical information and then examined the effect of some of these other variables on the actual choice of scale in several countries and industries. In Canada, high transport costs, a dispersed market, and generally low elasticity of input supply motivate many firms to construct plants that are significantly smaller than those in the U.S. and Europe. But the plants in different countries, even though they operate at different scales, may still be scale efficient: production costs are higher for a small plant than for a larger one, but total costs have been minimized. Over time, as transport costs have fallen relative to other costs (particularly international transport costs), disposable income in Canada has risen, and tariffs have been reduced (thereby increasing the size of the available market), Canadian firms that have constructed plants below MES have found themselves at an increasing cost disadvantage with their international competitors.

Multi-Product Economies of Scale

The problems of operating at a scale sufficient to realize product-level economies of scale are accentuated by the large range of products produced in one plant by firms in many Canadian industries. Caves (1975) showed that Canadian firms (and plants) have a much more diverse output of products than firms (and plants) of the same size in the U.S. This wide diversity of products is caused by two interlocking factors. (1) Marketing considerations may impel firms in many industries to supply a full range of products or face substantial penalties. To achieve a competitive advantage over their smaller competitors, large dominant firms sometimes have a strategy of producing a wide range of products which their competitors must match. In addition, there may be economies of scale in the distribution and marketing, as fixed costs are spread over a wider range of products. (2) There may be economies of scale in production of multiple products. This second factor has been given considerable attention recently. (See Baumol, 1976, 1977, and Baumol, Bailey, and Willig, 1977, for a theoretical treatment of the subject and Baumol and Braustein, 1977, for an empirical test of the existence of economies of scale in multi-product production.) As seems almost inevitable when multiple products are considered, the problems involved in defining scale of operations and economies of scale, and in measuring and relating one to the other, become much more difficult when multi-product economies of scale are introduced. Different products produced by themselves will almost certainly have different ATC functions (different economies of scale and cost penalties), and hence the ATC function of a bundle of products will be highly dependent on the mix of products and the way in which the production processes interact. Baumol (1977, p. 809) drew several important conclusions from his analysis regarding the existence and public policy implications of scale economies for natural monopolies, i.e., industries in which a single firm which produces multiple products is the least costly means of production. These will be discussed in the last section of the paper, when the public policy implications of economies of scale are examined.

Multi-product economies of scale are realized if additional products increase the utilization of existing machinery and allow overhead to be spread over more products.

Plant Economies of Scale

Scherer (1970, and in Goldschmid et al., 1974) described the possible reasons why there may be economies of scale associated with the size of the plant in which the production takes place. Plant economies of scale may arise from indivisibilities in management, maintenance, repair, inventories, and the construction of the plant itself. Production economies of scale for a single product may be exhausted at volumes either above or below the MES plant needed to produce it. If product MES is greater than plant MES, then the plant will produce only one product. If product MES is less than plant MES, a plant may produce several products in order to realize the cost savings of MES plant operation. In such a case the volume of output of individual products may be below MES, depending on the shape of the ATC functions for each product and the plant. In the white goods industry, for example, where product economies of scale are large, the MES plant is one large enough to house MES production of one product line. In the U.S., plants in this industry are dedicated to one product. In Canada, with a smaller market, several lines of the same product are produced in each plant.

Multi-Plant Economies of Scale

Scherer et al. (1975) described how costs were reduced by one firm's operating multiple plants, rather than one large plant or several geographically separated plants owned by different firms. A multi-plant firm may be able to lower its costs (increase its efficiency) by balancing transportation costs (more plants mean lower transportation costs to markets) with product and plant economies of scale (fewer plants usually implying higher transportation but lower production costs). Transportation costs, the geographic distribution of demand, production inputs and raw materials, the size of MES plants, and the cost penalties for operation below MES all influence the size, geographic distribution, and output diversity that will achieve the lowest cost. For example, a firm that produces three products, A, B and C, might produce A at MES and B below MES in one plant while producing C at MES and A and B below MES in a geographically separate plant. Scherer et al. called the overall lowest-cost allocation of production among plants "optimal (geographically) unbalanced specialization". Multi-plant operation and geographically unbalanced specialization may lead firms to produce closer to optimal scale, since they facilitate investment staging which involves bringing large blocks of capacity onto line. Multi-plant firms will thus tend to have a higher level of capacity utilization and therefore lower costs. To try to determine the possible magnitude of the cost savings available through optimal unbalanced specialization, Scherer et al. compared these optimal costs with those that would have been incurred by plants producing a full line of products in each regional plant, and concluded that the "economies attributable to optimal unbalanced specialization by multi-plant firms must be quite small in relation to total production and physical distribution costs" (p. 381).

These production economies of scale related to multiple products and plant size should not be overemphasized as an explanation of the high output diversity of firms in Canada, however. The oligopolistic structure of many industries leads firms to compete through product differentiation, producing a broad line of products to capitalize on the advantages of a brand name. In addition, by producing a broader line of products they may reduce risks, since a loss in one product due to changing technology, market demand, or competitive pressures may be offset by profits in other products that are not affected by these conditions. Such firms may be able to lower their costs by producing many products in one plant rather than one product in each of several plants, although their production costs would be higher than if they had specialized in one product at large volume. Thus, market conditions and a desire to reduce risk may motivate firms to produce a wider range of products at a smaller scale than the optimal size dictated by production efficiency considerations alone.

Firm-Related Economies of Scale

From a public policy point of view, probably the most interesting question is the relationship between the size of the firm and its efficiency. The answer to this question lies deep in the theory of the firm, a highly controversial area of theoretical and empirical research. For our purposes the essential question is why certain activities are internalized within the firm while others remain on the external market for goods and services: why does a firm conduct its own R&D rather than license it; produce its own products rather than subcontract them out; have its own salesmen rather than sell through wholesalers?

The factors that motivate this internal-external decision are complex, and they certainly do not all arise from the firm's desire for increased efficiency. In general, the goal of a firm is thought to be to maximize its returns from its scarce resources. Simpson-Sears Limited, for example, has expertise in sales and distribution, and spends its corporate resources in these areas while subcontracting the production of the goods it sells to others. A firm may change its strategy as it perceives additional profits in either internalizing or externalizing any particular activity. Texas Instruments has moved from licensing its R&D to using it in its own consumer products. In this view, if a firm grows in scale and scope of internalized activities, it does so to increase the profits from all its operations. Imperfections in the market for various firm-level inputs (R&D, marketing, information, etc.) may lead a firm to produce them internally. Information and control costs also affect the internal-external decision. This drive for profits may not be the same as a drive for efficiency, although it usually is. Sears' suppliers can produce its goods more efficiently than Sears can, but Sears can market them more efficiently. The size of a firm in the packaged goods industry may be due to its desire to exercise market power through a national brand image over several products, and not due to any increased efficiency in producing many different products.

The managers (or owners) of a firm may have other goals besides profit maximization in making their decision regarding internal-external scale of operations: for example, risk reduction for the firm, growth (with a profit constraint), security of supply, and managerial prerogatives. A discussion of these factors is beyond the scope of this paper. The central point is that many factors besides economies of scale may motivate a firm to increase the scale and scope of its activities.[4]

When an industry is concentrated, firms may be motivated to operate on a large scale to gain monopoly profits even if economies of scale are not significant. Tariffs that impede international competition through free trade reinforce this tendency toward increased size to achieve market power rather than to achieve economies of scale. This problem is particularly acute in Canada with its high tariffs, small market, and high concentration.

Several recent studies have concluded that there is a strong positive relationship between market share and profitability (Buzzell, Gale and Sultan, 1975, Shepherd, 1975, Mueller, 1977, and Cowling and Waterson, 1976). Whether this relationship is due to increased efficiency of large-scale operation or the ability to exercise market power is not clear. Since other firms in the industry have lower profit rates, however, it might be inferred that the largest firms have indeed been able to realize scale economies. The causality, however, between market share and profits is not clear. The same managerial abilities that allow firms to achieve and maintain a large market share may also be used to achieve high profits.

Economies of scale at the firm level may arise due to increased efficiency in top management, finance, information and control, R&D, marketing, advertising and distribution, export activities, risk-taking in large projects, insurance, and legal services. The extent of the economies of scale in any one of these activities is very much in dispute in the literature. For example, Bain (1968) noted that slowness of response to changing situations is almost inevitable in large organizations. He pointed out that decision making in large organizations is likely to be rigid and lacking coordination among departments and divisions. Scherer (1975, and in Goldschmid et al., 1974) portrayed the top management of large firms as being inundated by a never ending deluge of paperwork and statistics which are necessary to control the large firm. McGee (1974) extolled the efficiency of the modern manager who is able to use the latest computer techniques for processing and assimilating information to obtain the greatest possible leverage for his ability to make decisions. He observed that in his experience economies of scale continued at all volumes. One of the problems in answering these questions about firm-level economies of scale is the difficulty of measuring efficiency along any of these dimensions and then relating it to the size of the firm. For example, what variable can best measure R&D effectiveness: patents, journal articles, "significant" inventions, innovations, or new products and processes? What is the relevant scale against which to measure R&D: plant, related product, or firm scale? Although several studies have tried to relate R&D output (variously defined) to scale, no consensus has emerged. Similar (or worse) problems are encountered with the other activities. Again, the problem of distinguishing between real and pecuniary economies of scale arises. Large firms may obtain lower costs for advertising, capital, or legal advice through the exercise of market power in these factor markets, rather than as a result of truly lower costs of supply.

The next section describes the problems of measuring economies of scale and reviews the available literature about their magnitude.

Measuring Economies of Scale

As might be imagined from the many different economies of scale that may be realized by a firm as it increases its size and the complexity of their interrelationships and their relation to the external economic environment of the firm, it has proven quite difficult, if not impossible, to find acceptable measures of the MES production run, plant, or firm. There are many techniques, but they are all open to attack for lack of theoretical justification, appropriate data, or unbiased statistical techniques. "Scale" itself is not easily defined, and this ambiguity of definition has caused misleading comparisons between the relative scale efficiency of firms within one industry and firms in other industries or firms in the same industry which operate in different countries.

In order to make a valid comparison of the scale of operations of two firms, they must produce identical products (or identical proportions of several products). To compare the relative efficiencies of firms operating at different scales, they must face identical input prices (capital, labour, energy, and raw materials). The scale of operations of such firms can be compared in terms of units of physical output (pounds, yards, cars, etc.) and their efficiency in terms of value added per unit of output. Value added is the difference between the price at which the product is sold and the costs of the materials inputs used in its production. The less the value added per unit, the greater the efficiency. In this way it might be theoretically possible to measure the economies of scale for firms in an industry. Even in this highly simplified model there are several problems: how can firms at different levels of efficiency survive in the same industry, unless they are isolated by transport costs or artificial barriers to trade? If such is the case, what is the incentive for the efficient firm to lower its price to a competitive level? One possibility of measuring economies of scale in this way is to compare the efficiency of firms in different isolated markets as a function of their size. The scale of the firms in each market may be similar; they may compete with each other and earn only economic profits; yet inter-regional or international trade barriers may allow firms to exist at different scales of operations and efficiencies. For such an international comparison, however, it is hard to believe that the strict conditions necessary to ensure comparability of output (value added) and efficiency will exist.

If the output of two firms in an industry differs, we can no longer use units of physical output as measures of scale. Who can compare Chevettes with Cadillacs, a Piaget watch with a Timex? This problem is compounded if different firms produce different mixes of products at either the plant or firm level or have different degrees of vertical integration. Joy Manufacturing (Canada) produces and assembles fans, compressors, and drilling equipment in one plant in Canada. How can the scale of operations of this plant be compared with the scale of one of Joy's plants in the U.S., which produces only one product? One possible way around this problem is to aggregate the units produced in each plant by using some monetary measure of their value. Sales price is inappropriate, however, since different firms may use inputs at different levels of assembly. Joy (Canada) assembles many of its products from parts imported from its U.S. parent; hence its final sales figures per plant could be similar to those of one of Joy's U.S. plants, but the actual scales of operations might be quite different. To try to surmount these difficulties economists have settled on value added as a useful, but far from perfect, measure of scale.

As Spence (in Caves et al.) has shown, value added as a measure of scale is subject to three biases which reduce its reliability as a measure of scale: (1) prices may differ between countries (or firms) in the same industry for output and/or materials input; (2) price-cost margins may vary; and (3) the cost of labour and a "normal" return to capital, which when multiplied by the amount of labour and capital employed make up value added, may differ between countries. Spence's best efforts to correct for these biases by econometric techniques in comparing the scale of operations of Canadian and U.S. plants were not very successful. For example, in Canada a firm in a concentrated industry protected by high tariffs will have relatively higher price-cost margins than its counterpart in the U.S. or a firm in a competitive, low-tariff industry. Using value added as a measure of scale would bias upward the comparative size of firms in the first industry relative to the size of firms in the latter industry. These problems introduce considerable bias into the measurement and comparison of scale between plants and firms in Canada and other countries, since the product mix, price, price-cost margin, materials input prices, and capital and labour costs differ substantially among countries.

With the problems of defining scale and economies of scale at least enumerated, if not resolved, we can turn to the methods of measuring economies of scale, whether at the product, plant, multi-plant, or firm level: (1) econometric estimation of the long run average total cost function (LRATC) of the industry; (2) questionnaires designed to find the cost functions as perceived by the managers (or engineers) of the firms themselves (this technique includes the construction of hypothetical plants to calculate their cost at various scales of operation); and (3)the "survivor technique" which observes which scales of operations are most frequently used or, alternatively, which direction the scales of new capacity (or firms) tend to take over time and designates this size to be the optimal size. Variations of this technique are to use the average size of the largest plants (firms) which produce the bulk of the industry's output. The survivor technique assumes that firms and plants are chosen to be of optimal size from the desire of their owners to maximize profits and the cost and price pressures of competitors.

Scherer et al. (1975) have pointed out one additional problem when the average scales of operations for firms in an industry are compared between two countries. How should the scale of the representative plant in an industry be calculated: the average scale, median, mode? On the assumption that many industries contain many specialty producers which produce at small scale for special markets within the industry and are not representative of the industry, Scherer, Caves et al., Gorecki, and Dickson (1978) have chosen to use the average scale of the largest plants which produce 50% or 80% of the industry's output, or employ 50% or 80% of the industry's workers. They also use these plants when comparing the relative efficiency of plants in different countries. Hence, for example, their calculations of the value added per employee would not be comparable to those published by the Department of Industry, Trade and Commerce in 1976, which took the total industry output and divided by the number of establishments in the industry. The former procedure is reasonable since we are interested in comparing best-use, standardized-product plants, not establishments that operate in specialized segments of the industry.

Empirical Studies of Economies of Scale

Many empirical studies have compared the size and efficiency of Canadian plants to those in other countries, but an unambiguous conclusion does not emerge. In Scherer et al.'s study of multi-plant economies of scale across six countries, Canada was found to have the lowest mean size of plant as measured by employment.

An earlier study by the Economic Council of Canada (1967) concluded that while the average size of firms was larger in the U.S., the average size of plants was larger in Canada. The Council also concluded that there was wider variation in plant sizes in the U.S. than in Canada. They concluded (p. 153):

> Size of plant can be most easily measured by the average number of employees per establishment. About 50 industries, accounting for over three quarters of total value added in manufacturing, have been compared for Canada and the United States, using material from the censuses of manufacturing for 1963, the latest year available. Two conclusions are tentatively suggested by these comparisons. First, for all but a few of the industries examined thus far, while the average size of firms may be larger in the United States, the average size of plant or establishment is actually larger in Canada. Second, there is considerably greater diversity in the size of establishment in the United States, with typically more smaller plants than in comparable Canadian industries, but also usually with a number of larger plants. Also, for a number of industries, there has been a more marked growth in the average size of plant or establishment in Canada than in the United States, at least over recent years. This evidence suggests that the mere size of the establishment is probably not a dominant factor in the differences in productivity between the two economies. But what does appear to be highly relevant is how production is organized within a plant of a given size - in particular, the size of production runs and the degree of specialization or diversification of production.

This problem of short runs and diverse output as the major factor in Canada's low level of efficiency has been raised several times and is the guiding philosophy behind the often mentioned "Industrial Policy" of the Canadian government.

Another viewpoint on the controversy of relative plant size was advanced by Caves (1975): "The average size manufacturing establishment in Canada (measured by value added) does not appear to differ greatly from that in its U.S. counterpart industry."

Gorecki (p. 14) disagreed with the measure used by the Economic Council in its comparisons. He used a more theoretically pure measure which excluded the smallest firms in each industry in both the U.S. and Canada. Gorecki found that in 69 of the 123 industries, the U.S. plant sizes were larger than Canadian plant sizes by an average of 61%. For 50 industries, however, the Canadian plant sizes were larger, but the average size differential was only 32%. The Gorecki data led to the conclusion that although in some industries Canadian plants are larger than those in the U.S., on balance Canadian firms operate plants that are smaller than those in the U.S. But the size differential is not as great as that measured by Scherer and displayed in Table 1. Caves et al. concluded (p.256; see also their Table 11.5): "Canadian value added per establishment is below the U.S. figure more often than it is above, but not that much more often."

A more important comparison than that between average plant sizes is between the average size of plants in each industry in Canada and the MES plant in their respective industries. A comparison between actual plant size and the size needed to achieve most economies of scale in production is necessary to calculate the size of the inefficiencies arising from small-scale operation.

Several studies have compared estimates of the MES of plants in certain industries with the actual size of plants in operation in Canada. Eastman and Stykolt (1967) found that in approximately one-third of the 16 industries in their study there were no plants that operated at MES. For another third only 60% of the industry was at or above MES. All firms operated at MES or above in only one industry. Eastman and Stykolt concluded that a significant percentage of Canadian industry was scale inefficient when compared to plants in the U.S., where 80% operate at about MES (see Table 2).

Gorecki calculated MES plants by the survivor method for plants in Canada and compared these estimates to MES plant sizes calculated by Scherer et al. (1975), Prattan (1971) and Eastman and Stykolt using engineering and survey techniques (see Table 3). In no industry in Gorecki's sample did the estimates made by the two techniques come close to matching; the closest was in "non-rubber shoes", in which the survivor technique gave an MES size of 1 and the engineering technique a size of 1.7. Firms in Canada are able to survive even though they operate plants below MES because of the protection of tariff and non-tariff barriers to trade. The highly competitive market which presumably drives firms to operate at maximum efficiency by constructing plants at or greater than MES is not present in most industries in Canada.

Tariffs may also be the reason why the dispersion of plant sizes in Canada is less than that in the United States, as noted in the quote from the Economic Council above. Import competition will cut off the small end of the distribution of plant sizes in Canada, i.e., plants at very small scale cannot exist since the cost penalties for very small-scale operation are greater than the protection afforded by the tariff. As Spence concluded (in Caves et al., p. 254): "The Canadian industry is therefore likely to be a truncated version of the U.S. industry. The truncation tends to mitigate the effects of increasing returns on observed average costs and labor productivity in Canada."

For many of the industries in Gorecki's sample only a few plants of MES could supply the entire market (see Table 4). On the one hand achievement of economies of scale would, therefore, imply few firms (and plants) in these industries, but on the other hand, firms in tightly oligopolistic industries are often unwilling to construct new capacity which is large in relation to total industry output. In all his multiple regressions (Table 5.6, p. 56), Gorecki found that the variable log (plants of MES compatible with domestic consumption) was highly significant in explaining the number of efficient plants in an industry. Firms in industries whose market size could support many MES plants tended to have more MES plants than industries whose market size could support only a few MES plants. In the former group of industries competition drove firms to choose an MES plant, and such a plant was not large in relation to industry output. For the latter group of industries, market size relative to MES plant implied an oligopolistic structure and an MES plant was large relative to the industry's output; hence MES plants are not usually constructed.

One problem in this line of analysis is the use of engineering or survey MES estimates at the plant level which do not include transportation costs.[5] Scherer et al. calculated that Canada's domestic market could have been served by 2.9 MES breweries and 6.6 MES cement plants, yet the four largest firms in each industry operated 36 breweries and 16 cement plants. If transportation costs had been included in the cost of production, then the MES of these plants would have decreased, especially for Canada's widely dispersed markets. In their multiple regressions Scherer et al. found that the ratio of actual to MES size was related to transportation costs and market density: the higher the per unit transportation costs and the lower the market density, the smaller the ratio of Actual Scale/MES. "When outbound transportation costs are substantial in relation to product value, regional fragmentation occurs." Scherer et al. found that multi-plant operation, even of plants below MES, was induced by the relative size of transportation costs indirectly in their calculations by defining their variables for national and, where appropriate, regional markets. They found that regionalism was important. Dickson's study found a positive relationship between transportation costs and scale inefficiency. Gorecki, however, using a geographic market index as an indirect measure of the importance of transport costs, found that although the variable had the predicted sign, it was not statistically significant.

The calculation of MES using engineering techniques often overstated the scale disadvantage of Canadian firms and understated their efficiency in serving the Canadian market. The studies using these estimates support the conclusion that firms in Canada have constructed plants below MES in order to reduce delivered costs by serving local markets rather than constructing larger plants which would have to ship much of their production to distant markets. Many market areas in Canada are protected from foreign competition by transportation costs, and firms can operate small, geographically dispersed plants at below MES to serve these isolated markets. Canadian manufacturing industry is heavily concentrated in Ontario and Quebec and largely orientated toward Canadian markets. Firms located in the northern U.S., however, face roughly the same transportation costs to Canadian markets, but can operate at MES, since they produce for both Canadian and U.S. markets. The tariff structure in both the U.S. and Canada, therefore, has played a major role in creating and preserving an economic environment in which firms with scale-inefficient plants can survive. In addition, the high degree of foreign ownership may further restrict both import competition and export possibilities and thereby encourage operation below MES. On the variables they measured, Dickson and Scherer et al. were in agreement: the degree of scale efficiency for the industries in their samples was a function of the market size (+), concentration (+), transportation costs (-), the steepness of the ATC curve (+) (i.e., the penalty for operating below minimum efficient scale), and the growth rate of the market (+). Dickson also found that the degree of effective protection (-), export intensity (+), import competition (-, but not significant), foreign ownership (-, but not significant), and product differentiation (-) also were significant in determining scale efficiency.

The signs of these variables "make sense". The larger the market size relative to MES, the more MES plants can be constructed. The higher the industry concentration, the greater the probability that new capacity will be constructed at MES or that older plants will be expanded to MES. The greater the growth rate of market size, the greater the incremental needed capacity, and the greater the probability that existing plants will be expanded to MES and new plants will be MES. The higher the transportation costs, the greater the incentive to construct small, geographically dispersed plants. The steeper the ATC curve, the greater the cost penalty for operation below MES and the greater the incentive to construct MES plants. The greater the protection from foreign competition, the less the incentive to produce at MES. The greater the export intensity, the larger the market, and the more MES plants can be constructed in an industry.

The causality in the ordinary least squares (OLS) regression equations used by these authors is often not clear and is compounded by the often high correlations between the "independent" variables. For example, did export penetration allow scale efficiency or did scale efficiency allow firms to export? What is the relationship between export penetration and foreign ownership? Caves et al, in an extension, still in progress, of their research for the Royal Commission on Corporate Concentration (RCCC), are using a simultaneous equation regression technique to re-estimate the coefficients in their regression equations. They believe, however, that their main results will withstand the increased statistical sophistication of their new method.

In their concentration on plant (and multi-plant) economies of scale, Gorecki, Dickson and Scherer et al. have all given little attention to product-specific economies of scale; yet these may be the major source of production inefficiency in Canada. Beckenstein (1975) has dealt with the production economies of unbalanced, multi-plant production and found them to be small. For reasons to be discussed in the next section, firms in many industries in Canada have followed a strategy of producing a wide range of products within their plants. Caves (1975) found the output diversity of plants in Canada to be above that for similar sized plants in the U.S. For example, several plants of Dominion Textile Limited are as large as those in the U.S. and are much larger than MES, but the company produces more lines of textiles per plant than do textile firms in the U.S. In order to provide a full range of nuts and bolts, the Steel Company of Canada, Limited, has runs which are only 1/100th as long as those of its competitors in the U.S. and Japan.

A Canadian firm which was formed by the merger of three firms that had previously been competitors was able to reduce costs by 20% simply by rationalizing production among its existing plants. This cost reduction was achieved even though marketing considerations forced it to continue to produce all the products of the former firms and maintain all their separate (and competing) brands. These cost savings represented economies of scale at the product, multi-product and plant levels (even though plant size did not increase). Individual products had longer production runs; products that used the same production process at some stage were located in the same plant, and there was a centralization of supervisory and administrative expertise with one product in one plant.

These product-related economies of scale have been largely overlooked in the empirical literature, which has largely focused on calculating plant economies of scale. This oversight may be due to the fact that in the U.S., Europe, and Japan, the market size for most products allows for MES production of each individual product within a plant, and the firm is not forced by its marketing strategy to produce several products below MES in one plant.

The production economies of scale of multi-product operations have only recently been explored in the literature. As yet these studies have been on a theoretical level with one exception: Baumol and Braunstein (1977) have estimated that in journal publication, a cost saving of 20% was realized as the number of journals published by one firm rose from 1 to 30. More empirical work in this area is needed, especially in Canada, where product diversity is often a constraining factor in realizing economies of scale in production.

Gorecki made rough calculations for several industries which showed the cost disadvantage of operating plants at the scale found in Canada. As seen in Table 4, these cost disadvantages averaged about 9% for plants operating at only 1/3 MES for the industries in his sample. In many industries, particularly those producing a homogenous product, however, a cost advantage of even 5% would lead to a significant competitive advantage. More importantly, Gorecki's calculations did not include the penalties of multi-product production within one plant.

West (1971) analyzed both price and productivity performance in Canada vis-à-vis the United States by a cross-section regression analysis. His results indicated that about one-third of the variation in productivity performance among industries was associated with a scale effect: industries with a large gross output relative to the U.S. also displayed a high productivity relative to the U.S. On the other hand, his analysis detected no relationship between relative productivity and relative gross output per establishment. West suggested that the economies of scale realized with large volume most likely came not from variations in size of establishments but from greater specialization within particular establishments. He concluded (p. 4):

> ...the analysis of productivity and price differences with the United States reinforces the importance frequently attached to specialization and economies of scale. It supports the conclusion that if expansion of output were possible through access to larger markets, a substantial improvement in productivity levels could be expected. Since differentials in size of establishment between industries were not shown to be a significant factor, the higher productivity might come more readily through increased specialization in production within establishments. The improved productivity performance, in turn, could be expected to contribute to a more than proportional decrease in the higher output prices which prevail in Canadian manufacturing. The price reductions would be further facilitated by a more competitive environment, since the measure of market power was also associated with higher price levels.

Gorecki (p. 14) suggested that this conclusion is open to dispute, since the relative gross output measure used by West showed little correlation with a more precise indicator of economies of scale, the relative amount of sub-optimal capacity in Canada and the U.S. He pointed out that use of the latter indicator may show that plant size is a more important determinant of differences in productivity.

A detailed study of Canadian productivity released by the federal Department of Industry, Trade and Commerce, Establishment Size and Productivity in Canadian Manufacturing Industries, 1973 (1977), suggested that plant size is not a significant influence on productivity, except in a very few industries. The study did not support the view that productivity can be increased through increases in plant size alone; rather it suggested that a large part of the problem of low productivity in Canada may be the way production is organized within Canadian plants. This would be consistent with the view of the Economic Council that the cause of inefficiency at the plant level lies in the larger number of products manufactured within Canadian plants.

This certainly is not a new idea. The Royal Commission on Canada's Economic Prospects observed this phenomenon in 1957:

> It is undoubtedly true that in most secondary industries United States plants are considerably more specialized than Canadian. In comparing manufacturing plants in Canada and the United States one is struck not so much by the relatively greater size of the United States production units--although United States plants usually are somewhat larger--but by the fact that the Canadian plant in practically all cases produces a much greater variety of products for its size. The Hamilton plant of the Steel Company of Canada, for example, is as large as many efficient steel mills in the United States, but it produces many more products. One of our large rubber companies produces 600 different sizes of tires in one plant compared to a small fraction of that number in most United States plants while some Canadian wire and cable plants produce up to 1,000 kinds of wire.

When very long, standardized runs can be achieved, it may be possible to employ completely different production techniques and realize significant savings. Scherer et al. found that in small- and medium-sized antifriction bearings operations, a job-shop method was used, while those operations producing larger volumes adopted a straight-line operation. They indicated that manufacturing cost savings as high as 50% could be gained by shifting from a job-shop method to the straight-line method. Product-specific economies, then, can be as important as or more important than plant-specific economies.

Scherer et al. concluded that product-specific economies of scale in 4, and possibly as many as 7, of the sample of 12 industries that they studied were more important than plant-specific economies (pp. 51-52):

...Canadian textile makers claimed that their unit costs on style-sensitive dress goods and decorative fabrics were 20 to 30 percent higher than the costs of comparable U.S. manufacturers, primarily because of the tenfold difference in market size and the attenuated but still substantial differences in lot size. Paint manufacturers operating in both national markets reported that average batch sizes in Canada were one-fifth to one-half those experienced in the United States. Similar average run-length differences were cited by Canadian glass bottle manufacturers. A Canadian cigarette producer observed that it could not achieve enough volume to support the kind of straight-line, rolling-through packaging setups used for the more popular U.S. brands. Decoupled machines and intermediate in-process inventories were necessary to maintain production balance and good machine utilization. And in 1970 only one type of antifriction bearing was produced by a Canadian firm in sufficient volume to warrant a straight-line, machining-through-assembly operation.

The following testimony was given on the effects of non-specialized production by Canadian rubber tire manufacturers during a Department of Justice Inquiry, as quoted by Eastman and Stykolt:

We run more than five hundred sizes at our plant. Our change costs are tremendous, while some of our larger American plants may run only half a hundred sizes, and our runs are shorter. Then we have to shut down our machines and start them up again and get them running accurately to size, and we have to pay our men during that period of time, while they are tearing down a machine and building it up. And when you consider the multiplicity of sizes we have to run here as compared with larger factories in the United States, on restricted sizes, there is not a fair comparison which could be drawn.

Eastman and Stykolt further reported that:

One synthetic detergent producer complained that Canadian consumers demand basically the same kinds and types of products that are sold in the United States. His firm had only two installations producing four different detergents in four different colours. Constant shutdowns were necessary to allow these facilities to be cleaned as production shifted from one brand to another. In the United States, on the other hand, one item would be produced six days a week, twenty-four hours a day, thereby attaining output levels beyond which there would be no significant unit-cost reductions.

According to Daly et al. (1968), businessmen claimed that short runs were a major factor in explaining the higher costs in Canada for many companies in a wide range of industries. Discussions with a number of companies about the effect on output (with the same labour and machinery as currently being used) of more specialized and longer production runs revealed that (p. 44):

> ...output could be increased and that the extent of increase would be appreciable--in some cases, even dramatic. One steel official indicated an example of a particular product for which output could triple if the length of the typical U.S. production run could be produced in the existing Canadian facilities with the same labour force. Another example of an indicated tripling of output emerged in an interview with officials of a firm producing paper products.

It is this wide range of products per plant that was a major focus of the Economic Council of Canada (1975). It predicted on the basis of detailed studies which had been carried out in the EEC that substantial intra-industry rationalization at the plant level would come about with the advent of free trade:

> The importance of market size in explaining the lower level of productivity in Canadian manufacturing relative to that of other major industrial countries has been brought out in a number of studies. The analysis of productivity and price differences between Canada and the United States reinforces the importance frequently attached to specialization and economies of scale.
>
> Larger markets could stimulate productivity along two broad lines. First, they would permit firms to expand the scale of production of any particular product... Second, productivity could be enhanced by the greater degree of competition that tends to accompany liberalized trade.

Lermer (1973), however, using multiple regression techniques, observed rationalization in only 7 of 16 industries in Canada as a consequence of the trade liberalization under the Kennedy Round of tariff reductions.

The potential economies of scale at the product level are a prime motivation for firms (and their plants) in some industries to move to larger scale and hence to create the concentrated industry structure that is so obvious a feature of the Canadian economy. (But see Reuber and Roseman, p. 78 and pp. 95-97, for an alternative view.)

Thus firms in Canada have adjusted the scale of their operations to the economic realities of the Canadian market. These realities have created a high concentration in many industries of firms whose plants are below MES, given the range of their output. If tariff barriers were reduced, these firms would have to restructure their output and scale or be forced out of the market.

The complicated nature of the subject of MES can be illustrated by one final example. Emerson Electric Co. has followed a strategy of being the low cost producer in its industry by locating small plants in low-wage areas in the United States. If only the size of these plants were compared to an MES plant they would appear to be below MES and hence inefficient, high-cost operations.

Firm-Level Economies of Scale

So far the advantages of large firms and their component plants have been analyzed in terms of their production capabilities. Other activities of a firm should be studied in the same light, since economies of scale might also be encountered there. Among the more important of these activities are research and development, management, finance, operational and accounting control, marketing (advertising and distribution), and risk-taking. The question to be addressed in this section is whether the economies of scale of these activities require a firm size larger than that required by production considerations alone. In measuring these economies of scale, care must be taken to distinguish between real economies of scale and pecuniary economies of scale due to exercise of market power in the factor and product markets.

In general, most researchers have concluded that, despite its concentrated industrial structure, firms are smaller in Canada than in other countries, particularly the U.S. These firms are usually protected from foreign competition by tariff and non-tariff barriers to trade. Caves *et al*. concluded that in many industries tariffs did not afford sufficient protection to enable Canadian firms to achieve price-cost margins and profits equal to those of firms in the U.S. (p. 255):

> The price-cost margin, whose flaws have been discussed elsewhere is generally higher in the United States....The fact that the Canadian margin is often lower suggests that the tariff or effective rate of protection is not high enough to balance the U.S. cost advantage, and that in many industries, foreign competition holds the Canadian prices down. To some extent the rate of return figures, which are lower in Canada, bear this out.

Many foreign firms have set up subsidiaries in Canada which operate at less than optimal scale from a production point of view.[6] The production costs of these foreign subsidiaries are lower than or equal to the production costs in the U.S. plus the tariff and transportation costs, but this situation does not mean that Canadian-owned firms can compete directly at a cost in Canada lower than the cost of foreign production plus the tariff and transportation. These foreign firms often compete at a competitive advantage with Canadian firms. They have access to their parent's product and process innovations and marketing expertise, often at below full cost. Even at full cost, the cost of transfer of technology within a multi-national is often more efficient than transfer via the market. This technology is often available to Canadian firms only in the imperfect market for licenses. Often Canadian firms will not compete with foreign firms directly in their product lines. For example, Canadian appliance firms often produce at the old, standard end of the line, where there is less R&D, innovation, and product differentiation.

The "survivor method" for calculating MES for firms (as opposed to plants) may not give a valid answer to the question of whether there are firm-level economies of scale when it is applied to firms in many industries in Canada. The tariff structure and generally uncompetitive environment in Canada have created an economic environment in which sub-optimal firms may survive in many industries. These firms may be optimal in scale for Canada's environment, but they cannot compete with MES firms in international markets. Consequently, it has been impossible to use the survivor method to calculate an overall measure of returns to scale at the firm level, since firms that would not be viable if the barriers to trade were lowered and Canadian firms were forced to compete on an international basis may well survive in Canada.

Instead, researchers have tried to find measures of returns to scale for the many factors of the firm's operations: administration, research and development, control, advertising and distribution, finance and export penetration. Briefs, reports and testimony before the RCCC have addressed these points, but have not resolved them. A question raised by this evidence is the relevant unit by which to measure size when looking at "firm-level" economies. For example, the relevant size of the diversified firm when it raises capital may be its total size, i.e., the financial resources of all its components. For R&D, however, its relevant size may be the size of its component units. Yet R&D, and finance are related, since adequate finance is required to fund large R&D projects.

Research and Development

Canada has one of the lowest rates of research and development expenditures per capita of any Western industrialized nation. Research and development expenditures in Canada are largely concentrated in the hands of a few large firms and the government. Controversy continues in the literature about the relationship between a firm's size and the amount of R&D it undertakes, and the output of that R&D. It has proven difficult to construct useful measures of R&D inputs (engineers, R&D expenditures, etc.) and outputs (patents, inventions, innovations, etc.) in relation to the relevant size (the plant, division, or firm). Consequently, definitive answers to the question of the relationship between R&D and size are difficult to find and econometric results must be viewed with caution.

An even more important question for Canada is the obtaining by licence of foreign product and process technology, the products of foreign R&D, rather than generating it indigenously. More than 90% of the patents used by firms in Canada are foreign-held. There is little systematic evidence on the determinants of success in licensing, however, or on the effects of scale on a firm's ability to use licences successfully.

A number of hypotheses have been advanced to suggest that large firms are more likely to innovate than small ones. Galbraith (1967) asserted that the costs of technological innovation in modern times are so great that they can be borne only by large firms. Further, he argued that R&D projects are risky as well as expensive and that only large firms can afford to maintain a balanced portfolio of R&D projects, with the profits from those which succeed counterbalancing those which do not. Others have concluded that there may be economies of scale in conducting R&D. A large firm can operate a large laboratory which can utilize specialized equipment. It can also employ specialists in many disciplines. R&D projects may also benefit from scale economies realized in other parts of a large firm's operation: e.g., a large firm's promotional advantages over the small firm may allow it to penetrate markets more rapidly with new products, thereby increasing the profitability of R&D. Finally, large firms might have an advantage in pursuing process innovations due to their large volume of sales. A new process that reduces costs yields larger total savings to companies producing a larger volume of output. The imperfect market for licences may preclude a small firm from realizing these benefits through the sale of its technology.

The ability to license profitably may also be a function of the size of the firm and its ability to carry out its own R&D. A common form of licensing occurs through cross-licensing when two firms trade licences for different products or processes. Cross-licensing may reduce the costs of technology transfer by reducing the information gap and the perceived risk of buying and selling technology. In order to engage in this type of activity, a firm must be able to generate its own R&D. Obtaining technology, especially product technology, by licence instead of developing it indigenously, however, may also place limits on the Canadian firm's export markets. The licensing firm often limits the sale of the licensed products solely to the Canadian market.

On the other hand, it is argued that there are disadvantages of size in research and development and innovation. One such disadvantage might lie with the large administrative structure of big corporations: the decision to proceed with R&D has to filter through a long chain of command, thereby delaying the project and increasing the chance that the idea will be rejected or come too late. A bias away from imaginative innovations in the operation of large firms may result. The inability to find approval of new ideas by top management may drive researchers from large corporate laboratories to start their own ventures. A related problem might be a propensity for research to become over-organized in large laboratories.

In order to use licences effectively, a firm may need to be only large enough to maintain an effective listening post in the world market for technology. A small firm, without a major R&D establishment, may be more able to incorporate new outside technology since it has few inside researchers with a stake in their own products and processes who might block the use of outside technology. Briefs received by the RCCC, including those from the Canadian Manufacturers' Association, Imperial Oil Limited and the Canadian Pulp and Paper Association, stressed the view among many businessmen that large size is essential for creating successful R&D programmes.

It has proven very difficult to test these competing hypotheses since R&D is so idiosyncratic that generalizations may not capture the richness of the process. Another problem in measurement and definition is differentiation between types of R&D: fundamental R&D, new products and processes, development for market, and minor innovation. These all may have quite different economies of scale and size thresholds. Studies of the relationship between size and innovative activity of corporations in Canada have been particularly meagre. The data sources for many of these studies were large companies and those that the Department of Industry, Trade and Commerce knew or believed were engaged in research and development. This sample may capture most of the research and development done in Canada, but it probably imparts a bias to the data due to the more exhaustive coverage of larger firms. A more thorough and extensive approach to the subject has been done only in the U.S. These U.S. studies generally support the conclusion that companies in some size categories are more vigorous than others in conducting R&D, even though the pattern is not uniform across industries.

More specifically, the evidence indicates that, among firms engaged in research and development, R&D intensity initially increases with scale and then declines. As Scherer summarized in testimony before the RCCC (1976) based on research done in 1965: "relative effort tends to increase with size up to a point and then decline, with middle size firms devoting the most effort relative to their size." He drew a similar conclusion on the basis of his own research: "A little bit of bigness--up to sales levels of roughly $75 million to $200 million in most industries--is good for invention and innovation. But beyond the threshold further bigness adds little or nothing, and it carries the danger of diminishing the effectiveness of inventive and innovative performance."

Scherer's sample of firms was taken from Fortune's directory of the 500 largest American firms. In 1964 (the closest year to that in Scherer's study for which data was available in Canada), out of Canada's largest 100 non-financial corporations, only 40 had annual sales exceeding $200 million.

Canadian studies on the relationship between innovation and size have concentrated on the determinants of research and development expenditures, not R&D output or productivity. Until very recently, these studies dealt with specific cases (Bourgault, 1972, Litvak and Maule, 1973) and tentative statistical analysis (Lithwick, 1969, Globerman, 1973).

Bourgault examined the relationships between industrial structure and Canadian R&D. Litvak and Maule interviewed technology-based entrepreneurs to establish a picture of the incentives and impediments to innovation in Canada perceived by entrepreneurs. Lithwick studied academic, industrial, and government R&D in Canada, noting that co-ordination was lacking in the efforts of these three sectors. Globerman found that reduced foreign ownership and increased concentration were associated with greater research intensity in industries classed as facing unfavourable technological opportunities; the effect of foreign ownership and concentration was precisely opposite in industries facing favourable technological opportunities. None of these studies directly examined the relationship between size and R&D.

Research in the area was done for the RCCC by McFetridge and Weatherley (1977), Hewitt (1977), and Caves et al. Hewitt attempted to determine the relationship between size and R&D intensity. He found for his small sample of industries that a company's own commitment of funds to R&D increased with size as measured by sales and employment. In two industries, electrical and some chemical products, Hewitt found that R&D increased more than proportionately with size after a threshold in excess of $200 million was reached. The statistical analysis indicated that beyond a size of approximately $230 million in sales, a firm's self-financed R&D declined relative to sales. This study did not take account of inter-industry differences in the relationship between size and innovation, or such factors as variation in the potential for innovation in specific industries.

Howe and McFetridge (1976) analyzed the determinants of R&D expenditures by industry, taking into account variations among industries. They found that the principal determinants of R&D expenditures were current sales, cash flow, and government incentive grants.

McFetridge and Weatherley found that patent activity in some industries increased more than proportionately to increases in past R&D expenditures. In examining the effect of firm size on the average product of R&D, they found that an increase in firm size resulted in an increase in the number of patents from a given R&D outlay (pp. 240-241):

(a) If it occurs among the larger firms in the electrical industry.
(b) If it occurs among firms with relatively large R&D budgets in the chemical industry.

(c) If it occurs among firms with relatively small R&D budgets in the machinery industry.

They concluded that it was difficult to generalize from these findings and that there was no systematic evidence that innovative activity increased more than proportionately with firm size or that the product of R&D was proportionately larger for large firms.

In a brief to the RCCC Leonard Wrigley estimated the expense of a major, ongoing R&D operation and the volume of sales necessary to support such an effort at $20 million per product division, an estimate which was quite close to that of McFetridge. Firms operating below those sales levels could not generate sufficient funds to mount ongoing R&D efforts.

Crookell, Wrigley and Killing have examined the ability of Canadian firms to generate R&D internally or through licences. Instead of relying on aggregate data from a large number of firms, they conducted extensive in-depth interviews with firms in Canada, the U.S., and Britain. They concluded that Canadian firms lacked the scale and local market size to generate continuous R&D profitably. This is not to say that small firms could not generate new products, but that small firms usually could not do so on a continuous basis. This conclusion has led to Crookell's proposal (1976) that Canadian firms be given tax incentives to grow large enough to carry out continuous, profitable R&D.

These studies can lead to only tentative conclusions. There is some evidence to suggest that large firms do enjoy advantages over small firms in carrying out ongoing research and development activity, as measured by expenditures. Large size, however, is not a prerequisite for participation in the innovative process, and the benefits accruing to large firms seem to be largely confined to the later stages of the process, i.e., investment and development. Increased specialization might also allow small firms to engage in R&D.

There have been few studies relating the size of the firm to its ability to license technology or to use licensed technology effectively.

This is an area of major importance to Canada which should be addressed in future research.

Administration

As yet, no way has been found to measure the effectiveness of management as a function of scale. Economies of management at the firm level (for both single- and multi-plant firms) may result from activities requiring a staff of roughly fixed and indivisible size over a broad range of production levels.[7] The costs per unit of output of such functions may decline as corporate size increases. There may also be economies of massed reserves if the need for a staff service fluctuates randomly over time. The large multi-plant, multi-product firm can average out the fluctuations in demand for staff services, thus securing better staff utilization and carrying proportionately smaller reserves against its relatively flat demand peaks. Large firms can use a greater division of labour to employ specialists in linear programming, arbitration law, etc., whereas small firms must do without or employ less intensively trained personnel. The external market for these management services often does not allow for their efficient use on an irregular basis and can be very costly, as in the case of management consultants and outside legal advice.

Size may also have its disadvantages. As with research and development, the large administrative staff necessary to run big corporations may frustrate young, imaginative managers, and the added layers of bureaucracy needed to maintain control may lead to delay, lack of relevant information, mistakes, and unnecessary costs.

A very rough indication of the magnitude of management costs in relation to operating costs can be made by comparing the wages of administrative, office, and other non-production employees to the total costs of production. In Canadian manufacturing these administrative costs were about 10% of total costs in 1975.

These studies again come to no firm conclusions; but Scherer et al. concluded in their study of several industries that in only a few cases did management costs rise less than proportionately with size (p. 324):

> We identified a few cases in which the rise in administrative costs was believed to be less than proportional to output, but the preponderance of evidence suggested that the largest firms bore a higher unit administrative cost burden than small- and medium-sized rivals. The cost disadvantage of industry leaders appeared especially marked in the steel, glass bottle, petroleum refining, textile, battery, and refrigerator industries.

The only industry for which Scherer et al. were able to obtain systematic data about the cost of administrative staff was paints. The data suggested the existence of a significant advantage in unit costs for paint manufacturers with sales exceeding $10 million. A single MES plant in the paint industry, however, had sales of more than $30 million at 1969 price levels, and thus a firm larger than one optimal plant experienced only a slight management advantage over a producer with one plant of minimum efficient scale.

As for the quality of management and administrative staff personnel, Scherer et al. (p. 324) "...perceived no obvious association between the size of the firms in their study and such attributes of managerial quality as dynamism, intelligence, awareness, and skill in inter-personal relations". Larger companies displayed a tendency to maintain an array of staff specialists, but the correlation between size and staff expertise was modest, partly because staff personnel in smaller companies had learned to wear several hats, and small firms exercised ingenuity in utilizing outside sources of expertise.

The RCC received briefs and testimony on the subject of management as it related to large firms. Wrigley and Leighton in their briefs expressed the view that there exist significant economies of scale in both theory and practice in the use of top management which increase the efficiency of large, diversified firms. Testimony by executive officers of such large Canadian firms as Canadian Pacific Limited, The Royal Bank of Canada, and The Investors Group extolled the benefits which their subsidiaries derived from the head-office staff in coordinating operations, finance, and long-range strategic planning. Rothmans of Pall Mall Canada Limited and Redpath Industries Limited pointed out increases in the size, employment and profitability of some of their subsidiaries after acquisition. Nevertheless, the performance of large, diversified firms both in the U.S. and Canada does not support these contentions if return on assets is used as an overall measure of economies of scale.

Spence (in Caves et al., 1978) showed that Canadian industries have a greater proportion of non-production workers than comparable U.S. industries. The difference between the two was statistically significant in explaining some of the difference in productivity of firms in Canada and the United States. The difference in this proportion is probably a function of both the greater diversity of the output of Canadian plants and the smaller size of Canadian firms. These findings suggest that significant management savings might be forthcoming if Canadian firms were less diversified and operated at larger scale. Caves and Uekusa (1976, pp. 119-122) found that administrative costs as a percentage of total costs declined as the size of firms increased in Japan.

Canadian management is often thought to be of lower quality than that found in U.S. industry. Two major studies have dealt with this issue. Both acknowledge the extreme difficulty of evaluating quality differences and the need to rely on mainly subjective opinion. The Gordon Commission (The Royal Commission on Canada's Economic Prospects, 1957) sought the opinion of observers and industry representatives with knowledge of management in the two countries. They concluded that:

> The composite picture which emerges from these and other private comments made to us, while by no means entirely conclusive, suggests that there is some truth in the view that management of Canadian secondary industry as a whole is somewhat less progressive and forward-looking than that of its competitors in the United States, although this is clearly not true in many individual cases. In large part the relative weaknesses of Canadian management may be due to the greater shortages of trained personnel in this country, reflecting both our more recent industrialization and our more rapid growth. However, there is a fairly widespread feeling that there has been a very significant improvement in the relative quality of

Canadian management since before the war, and that this improvement has been most marked in the last half dozen years.

A more recent study suggests that management performance in Canada can still be improved. Daly and Peterson (1973) examined the role of management in the productivity gap between U.S. and Canadian firms. Although they acknowledged that the central areas of importance in the performance differential were tariffs in Canada and other countries which contributed to the existing product diversity, short production runs, high cost, and low productivity, they concluded that another important area was the pattern of decision-making in Canada which had led to a survival strategy for the firm and a resistance to change rather than innovation, creativity and risk-taking. These attitudes tend to perpetuate the lower levels of productivity found to exist. (See also Clement, 1975, for very strong opinions on Canadian management.) Small scale and the inward-looking nature of Canadian firms may have led to this management orientation.

Marketing: Advertising and Distribution

In examining economies of scale in advertising, it is crucial to differentiate between real and pecuniary economies of scale. Advertising costs for the firm may decrease with size due to both the market power of larger firms in purchasing advertising and real cost savings of large-scale advertising. Advertising campaigns often require a high threshold level to be effective, so there may be high absolute returns to advertising expenditures up to some level, after which diminishing returns set in. Advertising messages are purchased from the various information media, and advertiser economies are available where the price per message declines as the number of purchases increases. What percentage of these discounts reflects real cost savings to the firm that supplies the advertising, rather than buying power by the advertiser, cannot be calculated from the data presently available.

Large firms often brand their products to introduce artificial economies of scale in marketing which serve as barriers to entry for small firms. For example, to enter many consumer goods industries, a new product must be introduced with millions of dollars of advertising expenditures, a barrier to entry for small firms. Bain (1968, p. 36) concluded in his study of 20 American industries that product differentiation was "of at least the same general order of importance... [notably in consumer goods]...as economies of large-scale production and distribution" in giving established market leaders a price or cost advantage over rivals. Scherer et al. (p. 241) found that brand image conferred a price advantage at the wholesale level of from 1% to 50% across their small sample of eight consumer goods industries. Of these, however, image differentiation was found to be of substantial importance in only two industries in their sample: brewing and cigarettes. They found that a strong brand image in these two industries was associated with a wholesale price advantage of from 8% to 40% in brewing and from 10% to 50% in cigarettes. Only in brewing was multi-plant size essential to the exploitation of this brand image advantage. John Labatt Limited, in testimony before the RCCC, stated that advertising economies allowed breweries to produce a wider range of quality products at a given price.

The only measurable statistic to use in relating size to the profitability of advertising is advertising expenditures. Comanor and Wilson (1974) concluded that, in most industries, larger firms spent proportionately more on advertising than did their smaller rivals, for several definitions of large and small firms. For a number of industries, however, the data showed that large, but not dominant, firms spent proportionately as much as or more than the leading firms in their industry. Such industries included those with high advertising to sales ratios. Very small firms (those ranked below the top 20) spent little on advertising, both absolutely and in relation to sales. Block (1974) concluded, however, that the returns in advertising were not above the normal rate of return on other investments. Large firms were not able to achieve high returns on the basis of their ability to advertise more effectively than small firms.

Caves et al. found that in Canada high advertising was accompanied by high profits in industries without substantial import competition, but was accompanied by low profits in industries with substantial imports. This evidence suggests that the ability of large Canadian firms to establish brand images and reap above-average profits was decreased by foreign competition.

There may also be large marketing and distribution economies of scale. Canadian firms produce more products within their industries than do firms in the U.S. of the same size. This phenomenon is due to a large extent to the costs of branding, selling and distributing products; once the brand name has been estabished, other products can be sold under that label at lower cost. A salesman can sell a full line of products as easily as one product. Retail sales stores also have large search, learning and start-up costs associated with their purchases, so they are more apt to buy products which are part of a full line. In the case cited earlier of the merger of three Canadian firms, the management of the combined firm was compelled to continue the brands of all the previous firms in order to retain a sufficient share of the market to achieve economies of scale from rationalizing production.

Firms that produce a limited line of products can overcome such preferences by seeking out that subset of dealers without broad-line preferences, by offering price discounts sufficient to induce middlemen to do their own coordination or repairs, by filling out their lines through purchases from other producers, and by selling their narrow line for labeling by large buyers. With any of these strategies firms may achieve viability, but at some cost disadvantage. Scherer et al. concluded (p. 258):

> Perhaps [the] most prominent feature is the relative scarcity of industries in which large multi-plant operators are found to enjoy major promotional advantages. To be sure, product differentiation was very important in many of our industries. In six--brewing, cigarettes, textiles, petroleum refining, refrigerators, and shoes--an overwhelming majority of our North American interviewees agreed that marketing was a much more important dimension of business strategy than production. If promotional and product image efforts go astray, efficient

> production would not be sufficient to save the day. Yet firms with only a single MOS plant are by no means barred from success in the product differentiation arena. In several cases they can promote their products on virtually equal terms, realizing most or all promotional scale economies; in others they can find sizeable market segments in which to operate profitably despite a promotional handicap. Only in brewing, cigarettes, refrigerators, bearings, shoes, and perhaps petroleum refining and broad-woven fabrics do single-plant enterprises face more than slight promotional handicaps, and for five of these our judgments span a range of uncertainty because marketing strategies exist by which the relatively small but efficient producer can thrive. However, in refrigerators and (less confidently) bearings the promotional and distribution channel access advantages of size appear sufficiently compelling that they enable multi-plant firms to dominate all but small market segments, at least in the very large U.S. market.

In their sample of firms, large multi-plant firms enjoyed significant cost advantages in advertising over their single-plant rivals. In many industries these pecuniary and real advertising and marketing economies of scale outweighed production economies of scale.

There is evidence of marketing and distribution economies of full-line production which impel a firm to offer a full line of products, even if it faces substantial production diseconomies of scale for some of the lines it must carry for marketing reasons.

Exporting

The argument has often been advanced that large firms have an advantage in export activity. For example, in their submission to the Royal Commission on Corporate Concentration, officers of MacMillan Bloedel Limited stated that there are great economies of scale in export marketing. Their brief contains most of the arguments associated with this hypothesis (pp. 2-12):

> International Trade...has important implications for MB's scale of operations. If MB did not have substantial size, it would not be a major exporter of Canadian products. To be successful in international trade in commodities, a company must have large volume of its products available for sale. It must also have access to an adequate supply of raw materials, low cost manufacturing facilities, and a large marketing and

> transportation organization to sell and service a variety of foreign markets.
>
> The large volume of forest products MB sells enabled the Company to develop a worldwide marketing system at minimum unit sales costs.
>
> MB's network of sales agents and subsidiary companies keeps its head office in continuous contact with markets throughout the world and assists it in making long-term marketing plans in an attempt to maximize mill returns and ensure stability for both mill and customers.
>
> New markets can be opened when opportunities develop and existing markets can be expanded and services to them improved. With its existing large marketing network, MB has also been able to provide marketing services to smaller Canadian companies whose product volumes do not permit development of such a network.

They argued that there are marketing functions associated with international trade which are subject to indivisibilities: a certain minimum expenditure on marketing services is required to sell abroad. The small firm spreads these fixed costs over a smaller output and thus operates at a cost disadvantage in export markets. More important, the size of the expenditure necessary to enter into sustained export activity and the perceived risk in export operations often daunt smaller firms. This argument makes the assumption (a generally realistic one) that the services required by a firm engaged in international trade cannot be purchased from independent suppliers in small quantities. If a small firm can obtain market research in export markets, selling effort and customs brokerage services from independent specialists at the same cost as a large firm, it will not necessarily face a cost disadvantage. To overcome these cost disadvantages, several firms, most notably Interimco Company Limited, and the federal government have brought small producers together to form export consortia to bid on large-scale international contracts. Section 32 of the Combines Investigation Act exempts these export associations from prosecution.

In research done for the RCCC, McFetridge and Weatherley concluded that export performance was not related to size (pp. 81 and 86):

> ...holding industry and ownership effects constant, firm size exerts no effect on the proportion of sales exported. Large firms are not more "export oriented" or "export intensive" than small firms.
>
> * * *
>
> ...as firm size increases the proportion of sales going to foreign parents and affiliates increases while the proportion of sales going to foreign arm's length customers decreases. The net effect is that total exports as a proportion of sales do not change with firm size. One must conclude that the larger a foreign owned firm becomes the more closely it is integrated with affiliates abroad."

To test their general conclusion about the effect of firm size on export to sales ratios, they allowed for inter-industry variation. After analyzing the results, they concluded (pp. 89-90):

> In only one industry, machinery and metal fabricating, does overall export intensity increase with firm size. In this case the increase is due solely to proportionally larger sales to foreign affiliates among the larger firms. The proportion of sales made to arm's length customers does not change with firm size.
>
> In one other industry, transportation equipment, exports to parents and affiliates rise more than proportionally, with sales. This is offset, however, by exports to arm's length customers which rise less than proportionally with sales. The net effect is that total exports increase proportionally with sales and no more.

In summation, they stated that the data provided no indication that small firms were relatively disadvantaged in exporting activity. Moreover, they found no support for those who claimed that bigger firms were more export-oriented than smaller companies, nor for the proposition that mergers should be allowed in order to increase exports.

As they pointed out, however, the two data samples used in their study, while better than those in previous studies, were not representative of the Canadian manufacturing sector (pp. 78-79). In order to accept their conclusions, we must accept the premises that not only are there no production cost economies of scale that make large firms more cost competitive, but that there are also no export economies of scale. Such a finding is not supported by evidence from other countries or by the analysis conducted by the Department of Industry, Trade and Commerce, where industrial rationalization and export consortia are seen as aids to exports. During 1976-1978, when the world trade picture was changing rapidly, several countries (notably Sweden and Japan) followed a policy of merging already large firms in order to increase their effectiveness on the export markets. Analyses in the U.S. of export consortia and export incentives by government through tax breaks (the Webb Pomerene Act (export cartels) and the Domestic International Sales Corporation), however, have found that their impact has been small.

Again the question of the relevant measure of size arises. Paul Desmarais, in his testimony before the RCCC, used the example of Power Corporation of Canada, Limited, being small and a hypothetical Power-Argus Corporation being larger and more competitive internationally. John A. McDougald, on the other hand, portrayed export performance as a function of the strength of a firm's <u>individual</u> <u>components</u>: Massey-Ferguson Limited can compete internationally because of its size, not because it is part of the Argus group. Probably both views contain parts of the truth. As demonstrated by the Japanese trading companies, total firm size can increase the ability to operate in international markets, even when diverse products and services are sold by one group. It is difficult, however, to see how the size achieved through conglomerate diversification would increase the export intensity of the firm in most cases.

In developed countries with high labour costs, exports of manufacturers come mainly from innovative products and imports of manufacturers from standardized products. As described above, innovation, at least continuous innovation, at the product and process level increases with scale, where scale is defined as the scale of the related product unit, not the firm as a whole. It would seem that, despite the findings of McFetridge and Weatherley, it is necessary to increase scale to increase export intensity. In addition, for many products there is an initial size barrier that must be crossed before continuous exports can be expected. For some products, word of mouth, trade fairs, trade journals, etc., may lead to exports, at least initially. This type of export tends to disappear over time as the product is copied in overseas markets, unless a permanent export presence is maintained. In general a firm must be able both to generate new products and to sustain the high fixed costs of overseas operations. There are often substantial start-up costs in penetrating an export market for manufactured goods which can best be sustained by large firms which can generate continuous innovation.[8] Possibly the sample used by McFetridge and Weatherley did not contain many (or any) firms whose units were large enough to generate continuous innovation and exports, which might explain why their data showed no relationship between size and exports. Again, there is also the question of the relevant unit to use in measuring size. Also, given the inward-looking nature of much of Canadian business and the substantial foreign ownership in Canada, size may not imply exports, although large size may be necessary to achieve exports.

Economies of Scale in Banking

Banking is one of the few industries in which Canadian firms are comparable in size to firms in other countries. The industry is highly concentrated and takes the form of a regulated oligopoly, in sharp contrast to the U.S. banking industry, where legal requirements have resulted in a largely atomistic industrial structure, although the largest banks in the U.S. are large by any standard. Have Canadian banks achieved large size in order to realize economies of scale, or is their growth occasioned by pursuing other goals such as growth *per se*, oligopoly profits, or stability?

Banks could potentially achieve economies of scale in much the same manner as other firms. Product-specific economies may be realized as a bank increases the average size of deposits, loans or holdings of securities, since relatively fixed costs per transaction will be spread over greater dollar amounts of business. Plant and multi-plant economies might be realized through specialization of staff, equipment, or branches, through spreading of overhead costs, and so on. A large bank may achieve firm-level economies of scale in advertising, R&D, finance, and other areas, in addition possibly to attracting customers through an image of size, strength, and stability.

Research in the U.S., cited in a brief to the RCCC by the Canadian Bankers' Association (1976, pp. 89-93), suggests that economies of scale are achieved by small U.S. banks in such areas as business loans, chequing accounts, securities transactions, and the use of computers. This research showed that, for these small banks, economies of scale averaged about 7% for a doubling of a given volume of business. The economies of scale were negated, however, if the new business was obtained by opening branches, since the cost of renting or leasing premises for individual branches outweighed the per-unit cost savings obtained from a greater volume of business. Only 30% of U.S. commercial banks operate branches; the rest are single-office or "unit" banks. By contrast, the top 7 Canadian banks operate an average of 993 branches each.

Research on the major Canadian banks, which are at least ten times the size of the banks covered in this U.S. research, has found no evidence of economies of scale. Jones and Laudadio (1972) showed that the productivity of the major Canadian banks improved over the period 1955-1969, but attributed this result to technological progress and found no indication that efficiency increased with size. The Economic Council of Canada (1977) found that Canadian chartered banks have higher and more stable profits than U.S. banks and large firms in other Canadian industries. The study showed that these profits were not due to greater efficiency or more risk-taking, but rather to the greater spread between interest paid for deposits and interest charged by the Canadian banks. For the most probable estimate in this study, Canadians paid more than $170 million a year more between 1968 and 1973 than they would have paid if prevailing U.S. interest rates had existed in Canada. The Economic Council concluded that these higher charges were the results of market power, inefficiency, and the higher taxes paid by Canadian banks, not increased efficiency due to their large size. Several of the conclusions of this study have been called into question, however.

On balance, it would appear that Canadian banks have expanded beyond the point where greater size results in greater efficiency. In fact, the smaller U.S. banks charge less for banking services and appear to be more efficient than the large Canadian banks. It must be concluded that the large size of Canadian banks is attributable to a desire for growth, oligopoly profits, and stability rather than the pursuit of economies of scale. It must be remembered, however, that Canadian banks operate in a much different geographic, economic, and social environment.

Economies of Scale in Finance

Large firms are said to enjoy cost advantages in raising capital in that they tend to pay lower interest rates on debt than smaller establishments and they can issue debt and equity at lower costs per dollar of usable funds received, all else being equal. Again there is some doubt as to how much of these costs are real rather than pecuniary. The real economies of scale in finance of large size have two bases. First, certain more or less fixed transaction costs are incurred in executing a stock or bond issue. The larger the issue, the lower the fixed expense incurred per dollar of money received. Second, investors are usually willing to buy the securities of large firms at lower interest and return yields than the securities of small firms. This is said to be partly because large firms are better known, their stock is more liquid, and they have longer earnings records, and partly because investments in large firms are thought to be less risky, in the sense that earnings tend to be more stable, default rarer and the return to the equity holder more predictable.

Small firms in Canada not only pay more for the money they raise externally, but, more importantly, are often entirely excluded from outside funding at any interest rate, i.e., there are imperfections in the capital markets. The lower risk of large and diversified firms may follow from the diversified nature of their operations and their ability to partially control demand for their products. Reduced demand in one industry can be partially offset by gains in another, over the business cycle.

Scott (in Caves _et al._, 1977) showed that the cost of equity capital for firms in Canada decreased with size and diversity. Surprisingly, he also found that the variation in the return to stockholders was greater for more diversified firms.[9] Scott hypothesized that stockholders may have perceived a lower downside risk in diversified firms and hence were willing to have both lower and more variable returns where variation was measured by the standard deviation of returns. The possibility also exists that investors have been fooled by conglomerate diversification and have not received benefits commensurate with the risks they have run. This is not a possibility that is accepted by academics in finance. He also found some weak evidence that the cost of debt to large, diversified firms was lower. Even if large, diversified firms have a lower cost of capital because of risk reduction, i.e., they have economies of scale in finance, this may be of benefit to the firm only, but not to society. If society is risk-neutral over the range of its investment opportunities, firm-related economies of scale in finance are not valued by society as a whole since investors can achieve a similar diversification and risk reduction through their choice of portfolios.[10]

Empirical work indicates that large firms do obtain lower interest rates on bank financing, on the order of 1-2 percentage points. Research by the staff of the RCCC uncovered some evidence that chartered banks in Canada engage in formula lending, i.e., characteristics of the firm are used in a matrix to determine the spread above prime at which the loan will be made. The highest spread is typically prime plus 3%. If the firm falls out of this range, it is either denied financing or receives money at prime plus 3. This technique can exclude smaller, more risky firms from receiving financing at the banks. Empirical evidence also substantiates the prediction that there are economies of scale in floating stock issues. Caves, in his appearance before the Commission, testified:

> From other countries, especially the United States, Japan and certain European countries, we do have certain evidence on the access of large companies to the financial markets. It says clearly the following things: There certainly are scale economies in issuing securities so that the flotation costs of a large issue are generally smaller per dollar of capital you collect than the flotation costs of a small issue and those are real economies of scale.

On the question of whether large diversified firms allocate their capital more efficiently than smaller firms, Lecraw and Thompson (1978) showed that highly diversified firms had a lower return on their investment and lower returns to their stockholders than other firms. Nor did McFetridge and Weatherley find support for the claim that large firms had a financial advantage over smaller firms in their ability to raise large amounts of capital at lower costs or to achieve a higher return on assets. They attempted to isolate that portion of profits that would accrue to a company because of a size advantage in financing, taking into account profits that would result from interfirm variation in unlevered profit streams, differences in leverage ratios, rates of sales growth, industry concentration, and diversification. They found no statistical relationship between profit rates and firm sizes. In a second analysis they hypothesized that larger firms, if they did have preferred access to external sources of finance, would have a lower ratio of retained earnings to assets and a higher leverage ratio than smaller firms, their rate of return would be higher, and dividend payout ratio would increase with size. Their results indicated that the ratios designed to reflect the financial environment of the firm did not differ statistically across size classes. In fact, in some instances the ratios were found to support the converse of the hypothesis being tested.

On the basis of the above studies it appears that, although larger firms do have a financing advantage over smaller firms, this advantage does not seem to be reflected in better performance.

Large firms have accepted the substantial risks involved in undertaking large investment projects. In many of these large projects the degree of regulatory uncertainty was high. The risks of technological failure or basic changes in the economies of the venture were also high. Inflation and the stagnating Canadian and world economy have added to the problem of large projects which require long lead times between their conception and the generation of revenue. Large firms are often the only ones who can undertake such ventures, for there are great economies of scale in risk-taking ability.

Scherer _et al_. have summarized the economies of scale realized by _multi-plant_ operations in advertising, distribution, finance, management, and R&D in their Table 7.5 for the 12 industries in their study. The distinction between their "multi-plant" economies of scale and "firm level" economies of scale is not clear, however. This table is reproduced as our Tables 5 and 6. Their evidence for these economies of multi-plant operation has been cited earlier in the study.[11] The disadvantages of a single plant operating at MES compared to a multi-plant firm range from "none" to "severe", depending on the industry and the type of activity.

Edward Miller (1978), a researcher for the United States Department of Commerce, concluded (p. 486) that "...there is compelling evidence of large economies of scale at the firm level for a major portion of American industry". Again using U.S. data, he concluded that there was a strong relationship between the size of the firm and the size of its plants (p. 870): "Thus, large firms build large plants when they expand, and small firms are often limited to building relatively small plants, even at the sacrifice of some economies of scale." Since the MES of plants is increasing in many industries due to technological change (see Richard Levin, 1977), a competition policy which tries to limit the size of firms through concern with reducing industry concentration may reduce the efficiency of the Canadian economy.

Summary

Many studies have been made concerning the effect of scale on the efficiency of Canadian industry. Canadian plants in many industries are smaller than those in other countries, but when the low end of the plant size distribution is excluded, Canadian plants are not, in general, very much smaller. The fact that the Canadian market is only one-tenth the size of the U.S. market does not necessarily imply that industrial plants in Canada are one-tenth the size of U.S. plants as well.[12] Plant-specific economies of scale, which have been the main focus of most of these studies, have not, in general, imposed a significant cost disadvantage on Canadian firms.

There are two more important sources of scale inefficiency in Canada. First, in order to compete with imports and to satisfy consumer demand, Canadian firms have produced a wider range of products than do firms of comparable size outside Canada. Each plant produces a much more diverse line of products than similar-sized plants in the U.S., and Canadian plants employ much less specialized equipment, have more set-up time, and experience fewer of the economies of scale that arise from "learning by doing". These diseconomies of scale due to product diversity have not, in general, been quantified, although on the basis of individual case studies they would seem to be quite large. Secondly, because of heavy foreign ownership, the small size of firms, particularly Canadian-owned firms, and high product diversity within firms, Canadian firms are often unwilling and unable to compete both at home and abroad with R&D-intensive products. The cost disadvantage at which this low level of R&D places Canadian firms is large, but hard to quantify. Many Canadian-owned firms do not manufacture products which compete directly with foreign products or products of foreign-owned subsidiaries. Canadian firms have been placed in the position of competing at the lower end, the price-sensitive end, of the product line. For firms that operate in a country with high labour and capital costs, this is not an attractive position. Many of these problems can be attributed to the presence of Canadian and international tariffs over a long period which have encouraged both scale-inefficient production and heavy foreign ownership. This foreign ownership, however, has brought with it increased competition and a higher degree of product and process innovation than would have existed without it.

In addition, large diversified firms seem to be able to realize both real and pecuniary economies of scale in finance and marketing. There is no systematic evidence that large, <u>diversified</u> firms have realized any economies of scale in exports or management. Economies of scale at the product, multi-product, plant, and firm levels have pushed Canadian firms into forming larger and larger units in many industries. Since competitive reaction (and to some extent the Combines Investigation Act) prevents the complete monopolization of most industries, firms have taken to conglomerate mergers to increase their size. The size achieved through conglomerate diversification seems to have achieved little or nothing for these firms in terms of increased economies of scale or increased efficiency.

The plant-level economies of scale, which have been most often cited in discussions of size, are often not as important as product-level and firm-level economies of scale. Firm-level economies in Canada often justify larger businesses than do plant-level economies. How large a firm is justified depends on the industry, but it may be sizable. The major firm-level economy is probably found in risk-taking ability, export, and R&D, and large firm sizes are often justified in high-risk sectors such as energy exploration, aerospace, and similar fields.

These conclusions do not imply that large firms are either necessary or desirable in all industries, but simply that public policy should not limit the size of firms to that necessary to achieve only plant-level economies of scale. In many industries small firms are scale-efficient and in others they can compete in small niches in the market which cannot be served efficiently by large firms. Public policy should be directed toward increasing the efficiency of the marketplace in Canada so that firms are pushed toward their optimal size, small or large. A policy that artificially restricts the size of firms via laws governing competition and mergers is misdirected.

FIGURES AND TABLES

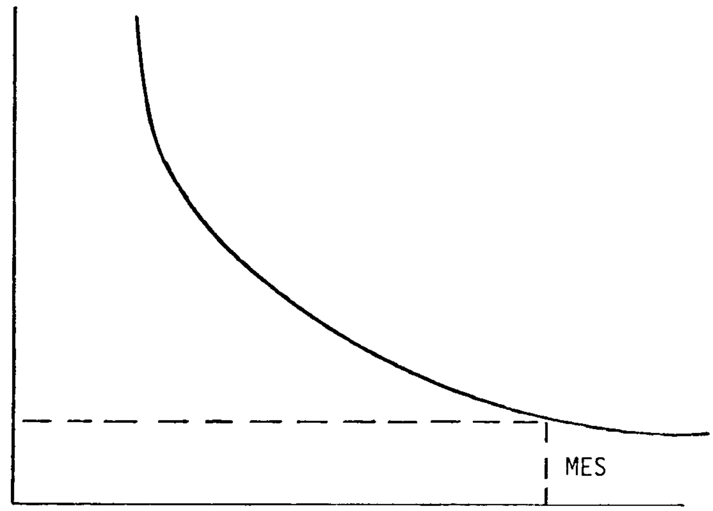

Figure 1. Production Cost per unit as a function of volume.

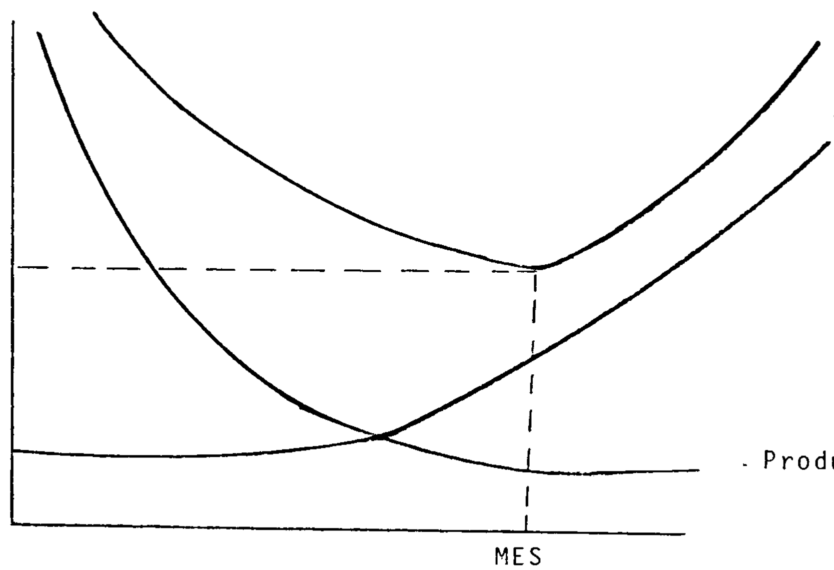

Figure 2. Total Cost per unit.

Table 1

Observed Top 50% Plant Sizes as a Percentage
of the Estimated Minimum Optimal Scales

Industry	Country					
	U.S.	Canada	U.K.	Sweden	France	Germany
Brewing	80p	26p	24p	5p	14p	10p
Cigarettes	206e	31a	50a	16a	19p	25a
Cotton and synthetic fabrics	250e	187e	65e	117e	68e	227e
Paints	55e	32a	43a	33a	16a	26a
Petroleum refining	97p	38p	130p	46p	108p	62p
Shoes	226e	110a	136a	45a	149a	221e
Glass bottles	126e	118e	59a	61a	93a	144e
Cement	69p	83p	61p	82p	79p	76p
Steel	123p	92p	53p	23p	58p	90p
Antifriction bearings	334e	97e	264a	698e	217e	411e
Refrigerators	101p	13p	22p	13p	36p	71p
Storage batteries	170e	63p	187p	56p	213e	811e
Mean of national values	153	74	91	99	89	181
Median of national values	125	73	60	46	74	83

Source: Scherer (1975).

Note: p = measured in terms of physical output or capacity; a = employment index productivity-adjusted; e = measured in terms of unadjusted employment.

Table 2

The Efficiency of Plants in
Sixteen Canadian Manufacturing Industries,
circa 1959

Industry	No. of Plants of Minimum Efficient Size Compatible With the Canadian Market[1]	Actual No. of Plants	Percentage of Industry Capacity of Efficient[2] Size
Fruit canning	4	13	0
Vegetable canning	24	43	50
Cement[3]	18	18	80
Container board[3]	5	10	57
Shipping containers	28	37	72
Synthetic detergent			
Solid detergent	7	3	100
Liquid detergent	49	n.a.	75
Electric refrigerators	0.6	10	0
Electric ranges	0.9	23	0
Wringer washing machines	8	14	58
Newsprint	36	39	80
Beef packing[3]	42	47	68
Pork packing[3]	16	45	9
Petroleum refining[3]	7	40	0
Primary steel	4	4	0
Rubber tires	7	9	20

Source: Eastman & Stykolt (1967).

[1]Including international where relevant.

[2]Minimum efficient size or greater.

[3]Regional industry.

Table 3

Size of MES Plant Expressed as a
Percentage of Industry Size, Canada, 1967

Industry	Size of MES Plant	
	Survivor Estimate 1961-66	Engineering Estimate
Petroleum refining	1.1	16.7
Non-rubber shoes	1.0	1.7
Integrated steel	0.2	38.5
Refrigerators and freezers	3.7	142.9
Automobile storage batteries	4.3	21.7
Bakeries	0.3	2.5
Bricks	1.4	3.1

Source: Adapted from Gorecki (1976).

Table 4

Comparison of Number of MES Plants
Compatible with Domestic Consumption,
Canada, circa 1968,
with Actual Number of Plants, 1967

Industry	Number of MES Plants Compatible with Domestic Consumption, circa 1968	Actual Number of Plants, 1967	Percentage Increase in Unit Costs for Plants Operating at One-third MES
Refrigerators and freezers	0.7	33	6.5
Cigarettes	1.3	21	2.2
Solid detergent	1.7	n.a.	3.8
Integrated steel	2.6	44	11.0
Suphuric acid	2.7	n.a.	1.5
Breweries	2.9	48	5.0
Automobile storage batteries	4.6	24	4.6
Anti-friction bearings	5.9	n.a.	8.0
Petroleum refining	6.0	41	4.8
Paint and varnish	6.3	159	4.4
Portland cement	6.6	24	26.0
Glass bottles	7.2	n.a.	11.0
Cotton and synthetic broad-woven fabric	17.4	n.a.	7.6
Bricks	32.0	78	37.5
Bakeries	40.8	2,275	11.3
Non-rubber shoes	59.2	206	1.5

Source: Gorecki (1976) Table 6.4.

n.a. = not available

Table 5

Summary Evaluation of the Number of MOS Plants Required to Realize Multi-Plant Scale Advantages under U.S. Market Conditions and the Extent to which Efficient Single-Plant Firms are Disadvantaged, 1970

INDUSTRY	Advertising and image differentiation	Access to markets; distribution channels	Procurement of materials	Vertical integration into key inputs	Outbound transport pooling	Peak spreading, risk spreading, and other massed reserves	Acquisition of capital	Optimal investment staging	Product specialization and lot-size economies	Managerial and central staff economies	Research, development, and technical services
Beer brewing	(1-5) Slight to severe	(1) Little or none	(1-2) Very slight	(1) None	(1) None	(2-3) Moderate	(no clear limit) Slight	(4-5) Slight to moderate	(2-3) Very slight	(2-3) Slight to moderate	(1) None
Cigarettes	(2) Slight to moderate	(4) Slight	(1) None	(1) None	(1) None	(2) Moderate	(no clear limit) Slight	(1) None	(1-3) Slight	No evidence	(1) None
Fabric weaving	(Up to 20) Very slight to moderate	(6-15) Slight to moderate	(5-10) Slight	(3-5 weaving mills) Slight to moderate	(3-6) Very slight	(5-15)	(no clear limit)	(1)	(1-12)	Multi-plant size probably disadvantageous	(20-35) Very slight
Paints	(3-4) Slight	(1) None	(2-3) Slight	(3-5) Moderate	(1) Little or none	(2) Slight	(no clear limit) Slight	(1) None	(3-5) Slight	(2-3) Slight	(2-3) Very slight (trade) to moderate
Petroleum refining	(1-4) Slight to moderate	(1) None	No evidence; probably none	(2-5) Moderate	(1) None	(2-3) Slight	(no clear limit) Moderate	(2-3) None	(1) Slight to moderate	Multi-plant size probably disadvantageous	(2-4) Slight
Shoes	(4-8) Moderate	(3-5) Slight to moderate	(3-5) Slight	(2-4) Very slight	(5-8) Slight	(3-5) Moderate	(no clear limit) Slight	(1) None	(3-5) Slight to moderate	Beyond several plants multi-plant size probably disadvantageous	(20-50) Very slight
Glass bottles	(1) None	(1) None	No evidence; probably none	(3) Very slight	(1) None	(2-3) Slight	(no clear limit) Slight to moderate	(2-3) Very slight	(2-3) Very slight	(3-4) Slight; beyond 4-6 plants, size is probably disadvant.	(3-4) Severe
Cement	(1) None	(1) None	No evidence; probably none	(1) None	(2-4) Slight	(1-3) Slight	(no clear limit) Moderate to severe	(2-3) Very slight	(1) Little or none	(2-5) Very slight	(20-30) Very slight
Steel	(1) Very slight	(4) Very slight	No evidence; probably none	(1-3) Slight for inland taconite users; none for coastal mills with competitive world market	(1) None	(1) Little or none	(no clear limit) Moderate	(2-3) Slight	(1-3) None to slight	Multi-plant size probably disadvantageous	(1-2) Slight
Bearings	(4) Slight	(4-8) Moderate	No evidence; at most slight	(1-5) Very slight	(2-5) Very slight	(1) Little or none	(no clear limit) Slight to moderate	(1) None	(3-8) Moderate to severe	No evidence	(5-8) Moderate
Refrigerators	(1-3) Slight	(up to 12, including other appliances) Moderate to severe	(1-2) Slight	(2-3) Slight to moderate	(up to 5, including other appliances) Moderate	(1-2) Little or none	(no clear limit) Slight	(1) None	(2-3) Moderate	Doubtful whether multi-plant size confers any advantage	(1-3) Slight to moderate
Storage batteries (automobile)	(3-5) Slight	(5) Moderate	(1) Little or none	(1-3) Little or none	(2-3) Slight	(2-3) Moderate	(no clear limit) Slight	(1) None	(2-3) Slight	Multi-plant size probably disadvantageous	(4-6) Slight

Source: Scherer et. al. (1975)

Note: Figures in parenthesis indicate the number of MOS plants a firm must operate to realize all the advantages of size.

Table 6

Size Thresholds above Which Companies Experience No Significant Research, Development, and Innovation Scope or Size Handicaps, Estimated from Interview Evidence.

Industry		Number of MES plants to size threshold	Adverse strategic consequences of being large enough to operate only one MES plant
Brewing		1	None
Cigarettes		1	None
Broad-woven fabrics		20-35	Very slight
Paints	trade	2-3	Very slight
	industrial	2-3	Moderate
Petroleum refining		2-4	Slight
Shoes		20-50	Very slight
Bottles	including basic research and major developments	10-20	Fairly serious, compared to three-plant firm; slight thereafter
	orthodox product and process development	3-4	
Cement		20-30	Very slight
Steel		½-2	Slight
Antifriction bearings		5-8	Moderate to fairly serious
Refrigerators		1-3	Slight to moderate
Automobile batteries		4-6	Slight

Source: Scherer (1975)

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NOTES

[1]These ideas were first developed by Alchian.

[2]Of course, $\frac{\text{units}}{\text{time}}$ X time = total volume.

[3]The Boston Consulting Group has estimated that in a sample of industries a doubling of volume from the level of the smallest plant in each industry gives a cost reduction of 20-30%.

[4]If there were perfect markets for all inputs and outputs, each firm would grow to its optimal size (market size permitting) from an efficiency point of view, but the markets are not perfect in general.

[5]Output diversity at the plant level is also neglected.

[6]Closer contact with the market is also a factor.

[7]As an obscure example, several small bars in Bangkok have combined operations for this reason.

[8]See Weiss Electronics, Harvard Business School, ICCH, for a good example of the problems faced by a small firm in the export markets.

[9]Their measures of diversity did not distinguish between unrelated diversification and vertical integration: a vertically integrated firm whose final output was only in one industry was seen as highly diversified (see Lecraw and Thompson, 1978, for a discussion of this problem).

[10]There is an extensive theoretical and empirical literature on this subject (see Lecraw and Thompson, 1978, for citations). Part of the dispute concerns the cost of bankruptcies, and who bears this cost.

[11]See Scherer _et al._, Chapter 7, for a full description of their methodology and conclusions.

[12]In fact, in a world of free trade, plant sizes would necesarily all be at least MES when transport costs are included.