

Lücke, Matthias

Working Paper — Digitized Version

Scale efficiency in the Brazilian motor vehicle industry: An international comparison

Kiel Working Paper, No. 298

Provided in Cooperation with:

Kiel Institute for the World Economy – Leibniz Center for Research on Global Economic Challenges

Suggested Citation: Lücke, Matthias (1987) : Scale efficiency in the Brazilian motor vehicle industry: An international comparison, Kiel Working Paper, No. 298, Kiel Institute of World Economics (IfW), Kiel

This Version is available at:

<https://hdl.handle.net/10419/1113>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.

Kieler Arbeitspapiere

Kiel Working Papers

Kiel Working Paper No. 298

Scale Efficiency in the Brazilian
Motor Vehicle Industry:
An International Comparison

by

Matthias Lücke

Institut für Weltwirtschaft an der Universität Kiel

ISSN 0342-0787

Kiel Institute of World Economics
Department IV
Düsternbrooker Weg 120, D-2300 Kiel

Kiel Working Paper No. 298

Scale Efficiency in the Brazilian
Motor Vehicle Industry:
An International Comparison

by

Matthias Lücke

August 1987

A 9 3246 / 87
Wirtschaft
Kiel

The author himself, not the Kiel Institute of World Economics, is solely responsible for the contents and distribution of each Kiel Working Paper.

Since the series involves manuscripts in a preliminary form, interested readers are requested to direct criticisms and suggestions directly to the authors and to clear any quotations with them.

ISSN 0341 - 0787

Table of Contents

	<u>Page</u>
List of Tables	III
1. Introduction	1
2. Economies of Scale and Per-Unit Costs in Motor Vehicle Production	3
2.1. The Concept of Economies of Scale	3
2.2. Estimates of the Minimum Efficient Scale and Long-Run Average Cost Function in Motor Vehicle Manufacturing	5
2.2.1. Passenger Car Production	8
2.2.2. Commercial Vehicle Production	10
2.3. Methodological Limitations and Data Problems	11
3. The Scale Efficiency of Motor Vehicle Production in Brazil	13
3.1. The Passenger Car Sector	13
3.2. The Commercial Vehicle Sector	16
4. An International Comparison of Scale Efficiency in Motor Vehicle Manufacturing	20
4.1. The Passenger Car Sector	21
4.2. The Commercial Vehicle Sector	23
5. Implications for Firm Strategies and the Role of Government Policies	25
6. Summary and Conclusions	30
Appendix - Tables	33
References	35

III

List of Tables

	<u>Page</u>
Table 1 - Estimates of the Minimum Efficient Scale of Motor Vehicle Production in Industrialized Countries	6
Table 2 - Estimates of the Relationship between Per-Unit Costs and the Scale of Production	7
Table 3 - Production of Passenger Cars and Light Multiple-Usage Vehicles in Brazil, 1960-1985	14
Table 4 - Production of Commercial Vehicles in Brazil by Firm and Type of Vehicle, 1980 and 1985	18
Table 5 - Production of Commercial Vehicles in Brazil, 1960-1985	19
Table 6 - Production of Passenger Cars and Light Multiple-Usage Vehicles in Brazil and Selected Countries, 1984	22
Table 7 - Production of Commercial Vehicles in Brazil and Selected Countries, 1984	24
Table 8 - Average Length of Production of Mass-produced Basic Passenger Car Models in Brazil and the Federal Republic of Germany, 1984	27
Table A1 - The Firm Structure of the Brazilian Motor Vehicle Industry, 1956-1985	33
Table A2 - The Brazilian Motor Vehicle Industry: Total Capacity, Capacity Utilization, and Exports, 1960-1985	34

1. Introduction*

Starting in the 1950s, a number of newly industrializing countries in Latin America (Mexico, Brazil, Argentina) and Asia (India, South Korea, Taiwan) have begun to establish motor vehicle industries. Because of its strong linkages to other industries, both backward (steel, glass, plastics, electric) and forward (transportation), the motor vehicle sector was often given a leading role in industrial development.

One important problem encountered in newly setting up a motor vehicle industry lies in the presence of considerable economies of scale, which imply that per-unit costs decrease as the scale of production increases. Cost efficiency thus depends - inter alia - on whether the volume of production is large enough to take advantage of economies of scale. Expanding production in a newly established industry as complex as motor vehicle manufacturing to the level where most economies of scale are realized (commonly referred to as 'minimum economic size') is bound to take some time; this fact has been used to justify infant industry protection of the motor vehicle sector in all the countries mentioned. Hence, it is hardly surprising that previous studies - most of them carried out in the 1960s - found that per-unit costs in motor vehicle manufacturing in less developed countries exceeded significantly those in industrialized countries, which was attributed largely to a lack of scale efficiency¹.

More recently this gap seems to have narrowed considerably in the case of the larger producers among newly industrializing countries, particularly Brazil and South Korea. This improvement coincided with a shift towards a more outward-oriented policy in relation to the motor vehicle industry in those countries, involving mainly the introduction of export incentives in addition to the continuing protection of the domestic market.

* The author gratefully acknowledges many helpful comments and suggestions by P. Nunnenkamp, B. Fischer, and U. Hiemenz.

¹ Nunnenkamp (1987) provides an overview of international comparisons of the costs of production in motor vehicle manufacturing.

This paper investigates the validity of the hypothesis that the scale efficiency of motor vehicle production in Brazil has now improved to a point where disadvantages of small scale no longer exert a strong negative influence on the international competitiveness of the industry¹. If the hypothesis can be upheld this will have important implications for any assessment of the overall performance of the industry and of its potential contribution in the long run to raising the country's export earnings. Given that Brazil is the largest motor vehicle producer among developing countries with exports in the order of one fifth of production, the conclusions from this analysis can also be expected to be relevant to the motor vehicle industries of other newly industrializing countries.

An analysis of scale efficiency ideally should be based on manufacturers' data on their cost structures. As such information is not available, data on production by manufacturer and model are compared with estimates of the minimum efficient scale of production and of the long-run average cost function² in motor vehicle manufacturing. The following chapter reviews such estimates and their applicability to conditions of production in Brazil. Chapter 3 surveys the development of the scale of motor vehicle production in Brazil and attempts to establish to what extent economies of scale have been realized and what scope exists for further improvements. Chapter 4 compares the scale of production in Brazil with that of its major international competitors. Chapter 5 discusses some implications of the findings for firm strategies and the role of government policies. Chapter 6 presents a summary and the conclusions.

¹ Economies of scale are of course only one out of several factors that determine the competitive status of an industry in the world market. For a more general analysis of the international competitiveness of the Brazilian motor vehicle industry see Nunnenkamp (1987).

² The long-run average cost function relates average total costs to installed productive capacity at normal capacity utilization.

2. Economies of Scale and Per-Unit Costs in Motor Vehicle Production

2.1. The Concept of Economies of Scale

Economies of scale may be defined as reductions in per-unit costs achieved by expanding the scale of production, which is represented by installed productive capacity (as opposed to capacity utilization). In microeconomic theory this idea is commonly expressed through a downward-sloped, long-run average cost curve, relating per-unit costs (with full utilization of productive capacity) to changes in capacity. The long-run curve may be thought of as the 'enveloppe' of an infinite number of short-run, U-shaped average cost curves that relate per-unit costs to changes in capacity utilization (Rhys, 1972a, pp. 266-8).

This rather loose definition of economies of scale, which is commonly used in the empirical analysis of industrial market structures, contrasts with the more stringent notion of 'increasing returns' to scale in the theory of production. 'Increasing returns' are usually associated in the literature with a homogeneous production function of degree $r > 1$, where a proportionate increase in the quantities of all inputs yields a more than proportionate increase in output (see, for example, Henderson, Quandt, 1981, p. 79). However, the strict assumptions employed in the definition of increasing returns (such as homogeneous factors of production, identical technology, and constant factor prices over the full range of scales analysed) are usually relaxed for the purpose of empirical studies. The corresponding concept of economies of scale assumes only that essentially similar products are made with essentially similar inputs, while allowing for changes in production technology (such as a higher degree of mechanisation) and, consequently, variations in factor intensity¹.

¹ For an extended discussion of the two concepts and the underlying assumptions see Gold (1981). Giersch (1986, pp. 18-19) cautions against some of the more naive views of economies of scale that fail to take into account the very high capital expenditure to be incurred on the initial investment before any of the benefits associated with decreasing costs can be reaped.

Although this definition of economies of scale lacks theoretical rigour it has nevertheless become a standard tool in the empirical analysis of industrial market structures, particularly in relation to the motor vehicle industry (see, for example, the literature cited in Chapter 2). This provides the justification for employing this concept in the present study. Economies of scale, thus defined, may arise from a variety of sources in the areas of technology, procurement, marketing, and finance. A further distinction is between economies at the firm, plant, or product level.

As concerns technology, significant economies of scale may be achieved in motor vehicle manufacturing in line with the workings of the 'law of mass production' (Kern, 1980, pp. 58-9), which states that average total per-unit costs tend to fall with an increasing division of labour and specialization of the manufacturing process. A firm that produces a certain commodity at a large scale using for example specialized machinery and flow techniques of production (such as an assembly line) can thus expect to enjoy lower per-unit costs than another firm making a smaller quantity of the same product with general-purpose machinery, shop assembly, and little division of labour. This may be true even if the small firm produces efficiently in the sense of not wasting any resources and achieving the same degree of capacity utilization as the large firm. The most famous early application of the 'law of mass production' in automobile manufacturing was the Ford Motor Co.'s Model T car, which consisted of a relatively small number of standardized components and was the first automobile to be mass-produced on a continuously moving assembly line. The reduction achieved in unit costs, due largely to economies of scale, can be gauged from the fact that the car's retail price in the US had fallen by 1925 to less than a third of its initial 1909 level (White, 1977, p. 173).

Apart from technology, significant economies of scale in motor vehicle production can be achieved in the areas of procurement, marketing (due to indivisibilities in advertising, the setting up

of a dealer network, etc.), and finance (involving, amongst other things, the ability to undertake costly research and development efforts, with the attending risk of failure, and to fund large-scale investment projects). Economies in finance and marketing cannot meaningfully be analysed in a Brazilian context only, because almost all the country's motor vehicle production is accounted for by the subsidiaries of large multinational enterprises (Fiat, Ford, General Motors, Mercedes-Benz, Saab-Scania, Toyota, VW, Volvo; see Table A1). In addition to their own resources these firms rely on their parent companies' facilities for research and development with respect to both models and production technology, as well as for support with the marketing of exports. Therefore economies of scale in marketing or finance are not discussed further. Economies in procurement may result either from cost savings on the part of suppliers due to higher order volumes, or from increased market power of the vehicle manufacturers. However, conditions of production in the component industry as well as the relationships between suppliers of components and vehicle manufacturers are too diverse to be covered here in sufficient detail¹. The resulting limitations to the validity of the findings of this paper are discussed in section 2.3.

2.2. Estimates of the Minimum Efficient Scale and Long-Run Average Cost Function in Motor Vehicle Manufacturing

This section surveys the available empirical studies that provide estimates of the minimum efficient scale of production in the motor vehicle industry (Table 1) or of the relationship between per-unit costs and the scale of production (long-run average cost function; Table 2). All studies relate to conditions of production in industrialized countries. More recent estimates² or ones

¹ The limited evidence available suggests that Brazil does not suffer from a competitive disadvantage in this respect (Stevens, 1987).

² A recent OECD publication relies on many of the same studies as this paper (OECD, 1983, Table 29, p. 76).

Table 1 - Estimates of the Minimum Efficient Scale of Motor Vehicle Production in Industrialised Countries (1000 units per year)

Stage of Production				One Model	One Firm (complete model range)	Source
Casting	Machining	Stamping	Assembly			
<u>Passenger Cars</u>						
1000	250 (engines) 400 (transmission)	500	300	500	1000 (3 basic models)	Pratten, 1971 ^a , pp. 138-49
"Efficient operation over most other-wise feasible scales of production seems likely"	260-80 (with use of automatic transfer devices)	400 (identical components; press capacity is in the order of 2500)	200-250	400	800 ^e (2 models)	White, 1971 ^b , pp. 20-29, 44-50
Varies according to product; production of up to 200000 cars involves "no cost disadvantage"	1000 (engines); 300 - 1000 (transmission, depending on technology)	2000	200	-	2000; less in case of out-buying of components	Rhys, 1972a
100 ^{c,d} (engine block)	500 (engine ^c and transmission)	-	250 ^c	-	-	Central Policy Review Staff ^a , 1975, p. 16
1000 - 2000	400 - 1000	500+	200-400	200+	1000+ with small economies thereafter	Bristol University Motor Industry Research Group (reported by Bhaskar, 1980, p. 55)
1000 (engine blocks) 100-750 (other parts)	600 (power train) 500 (axle)	1000-2000	250 (painting and final assembly)	-	-	Rhys, 1980
<u>Commercial Vehicles</u>						
-	-	- ^f	70 (for standardized vehicles produced on a continuous line); as little as 5 if labour intensive, simple flow techniques are applied ^a	- ^g	- ^g	Rhys, 1972a
200 (engine castings for large diesels)	100 (power train)	similar to car body pressings	30 (max.weight) 50 (8-24 t gross weight)	-	-	Rhys, 1980

^aBased on conditions in the U.K. - ^bBased on largely US conditions. - ^cIdentical Units per plant per year. - ^dThis is apparently not a printing error. This author finds himself unable to offer an explanation for the discrepancy between this and the other estimates. - ^eFirm optimum to allow compensation for the risk of changes in consumer preferences, and, therefore, demand. - ^fGlass fibre rather than pressed steel may be efficiently used in the construction of body parts for annual volumes of up to 20 000 vehicles (Rhys, 1972c). - ^gOut-buying of components is particularly common in commercial vehicle production and may reduce the model optimum to the size of the assembly optimum.

Table 2 - Estimates of the Relationship between Per-Unit Costs and the Scale of Production

Annual production (1000 units)	Pratten (1971) ^a		White (1971) ^d	Rhys (1972b) ^e		Rhys (1977)		Doz (1981) ⁱ
	1 model ^b	Range of models ^c	1 model ^b	Range of models	Firm	1 model-annual production ^g	1 model-model life volume ^h	1 model
	(Index of per-unit costs; 100 000 units = 100)		(Index of per-unit costs; 400 000 units = 100)		Price/lb	(Index of per-unit costs; 100 000 units = 100)	(Index of per-unit costs; 300 000 units = 100)	(Index of car variable, per-unit manufacturing costs; 200 000 units = 100)
1				434.4	Aston Martin			
25				175.2	Jaguar			
50			120	128.4	Rover			
70				127.5	Saab			
100	100	100	110-115	-	-	100		
125				144.0	BMW			
150				96.0	Volvo			
190				111.6	Vauxhall			
200			103-105	-	-			100
210				106.8	Hillman			
250	89	83		-	-			
300				-	-	85	100	
400			100	100.8	Citroen			
500	84	74		99.6	Ford (U.K.)	73	93	92
700				73.2	BMC (Austin Morris)			
800			99+ (production of 800 000 or above)	74.0	Opel			
900				74.4	Renault			
1000	81	70		-	-		89	
1300				74.4	Fiat			
1500				74.4	VW			
2000		66		-	-		86	
3000				42.5 ^f (85.0)	Ford (USA)			
5000				40.2 ^f (81.4)	G.M. (USA)			

^aBased on U.K. prices in 1968. Apart from technological economies of scale the estimates also include economies in the purchase of materials and components. - ^bAssuming a production run of 4 years. - ^c3 basic models with variants, 5 basic engines. Pratten's estimate does not take into account the effects of certain scale economies at the firm level, such as greater opportunities for introducing new plant of the optimum size and fully utilising it quickly, or a greater incentive to incur expenditure on innovation as the costs of research and development can be spread over a larger volume of production. - ^dProduction economies only. - ^ePrice per pound-weight (average derived from the best-selling models of each firm) is used here as a proxy for average cost, assuming long-run competitive equilibrium in the market with no supra-normal profits, where price equal both marginal and average cost. In interpreting these data as a long-run average cost function there remains of course the problem of product heterogeneity (a pound of a Jaguar car is a different product from a pound of a Volkswagen Beetle). - ^fPrices are derived by deflating US car prices in the U.K. by an indicator which reflects the difference in the overall cost of living in the US compared with the U.K. The figures in parentheses represent the original data before correction for the difference in general cost levels. - ^gData supplied by one British firm, based on 1974 budgeted costs. - ^hBased on data from one British firm. - ⁱAverage per-unit cost decrease generated by a doubling of annual production in the 200 000 to 500 000 units per year range.

Source: Doz (1981, Exhibit 1); Pratten (1971, pp. 141-1); Rhys (1972b, p. 96; 1977, p. 314); White (1971, p. 39).

for developing countries¹ do not seem to exist.

2.2.1. Passenger Car Production

Table 1 presents estimates of the minimum efficient scale in each stage of production, as well as overall figures for one car model and a complete model range. In some categories (especially casting, machining, and stamping) the estimates vary widely. Summarizing the results it seems reasonable to assume that engine block castings may be efficiently produced in quantities of about one million units per year, while the minimum efficient scale for other castings, which are often supplied by independent foundries, is rather lower. In engine and power train machining cost savings can be realized through production volumes of up to half a million units per year, with some further economies at higher volumes. In stamping the minimum efficient scale seems closer to 2 million units per year, which need not be identical, but have to be stamped on the same set of presses. However, the ensuing batch production with time-consuming changes of dies carries a cost penalty, as compared with continuous production of identical panels; the excess cost increases along with the number of different types of panels produced.

The studies agree broadly that the minimum efficient annual rate of final assembly is in the order of at least 200 000 vehicles on a five-day-week/two-shift basis. The recent increase in the degree of automation and robotization of assembly operations in industrialized countries is likely to have two separate effects on minimum efficient scale. On the one hand assembly lines can be operated at higher speed, increasing the minimum efficient rate of assembly per line. On the other hand, while traditional as-

² Some studies have been undertaken on the feasibility of newly establishing a motor vehicle industry in a typical developing country (e.g. El Darwish, 1970; a brief survey is provided by Maxcy, 1981, p. 214). While these studies provide rough estimates of the minimum level of annual production needed for overall efficiency, the data are not specific enough to serve as a basis for an assessment of the scale efficiency of the motor vehicle industry in a particular country.

sembly technology makes it difficult to produce more than one basic model on one line without expensive changes in the set-up of the machinery, the greater flexibility of recently installed equipment allows several similar models to be assembled on the same line¹. The minimum efficient rate of assembly per model may therefore be reduced.

The minimum efficient scale of assembly operations can also be considered as the minimum efficient scale of production for one basic passenger car model (of which several versions may be made with a high proportion of interchangeable components), if both the engine and the transmission (each with a minimum efficient scale of production of about half a million units per year) are also used in other models. Otherwise, the model minimum rises accordingly. Similarly the minimum efficient scale of production for a firm making a range of three to four models, to cover the 'mini', 'small', 'medium', and 'large' segments of the market, can be assumed to lie between one and two million units per year, depending on the number of basic engines and types of power train used. Some economies at the plant level may be achieved at volumes of up to two million units per year in line with the capacity of the large presses used for stamping body panels.

These conclusions are broadly in agreement with the estimates presented in Table 2 of the long-run average cost function in motor vehicle manufacturing. The data from Pratten (1971), White (1971), Rhys (1977), and Doz (1981) all indicate that per-unit costs fall considerably as annual production per model increases from 100 000 units to about a quarter of a million, but decrease rather more slowly as production rises further to half a million vehicles. Similarly at the firm level reductions in per-unit costs (see data from Pratten, 1971) become small beyond a production volume of one million vehicles per year. However, a de-

¹ Volkswagen's manufacturing system at the Wolfsburg plant for the Golf II model is capable, for example, of producing not only several body styles of the Golf but also the three-box Jetta without changing tools or interrupting production (Altshuler et al., 1984, pp. 135-6).

crease in unit costs as small as 4 per cent due to a doubling of firm production from one to two million units per year (as suggested by Pratten, 1971) can significantly influence a firm's profitability and, therefore, competitiveness in an industry where profits are often less than 5 per cent of turnover (Rhys, 1980, p. 184)¹.

2.2.2. Commercial Vehicle Production

Data on the minimum efficient scale of commercial vehicle production are comparatively scarce (Table 1). Since engines and transmissions are often used in several models, the minimum efficient scale of production for one basic model can be assumed close to the assembly minimum, which varies very considerably according to weight class and manufacturing technology. While the estimates of minimum efficient scale for standardized vehicles produced on a continuous line (30 000 to 70 000 units per year, depending on weight group) are useful in delimiting the scope of potential cost savings through an expansion of the scale of production, it should be noted that of the many firms operating world-wide in the commercial vehicle sector only very few actually reach these 'minimum' levels. Partly this is explained by the fact that customer preferences in the commercial vehicle sector tend to vary relatively more widely than among buyers of passenger cars. Small firms have been able to survive in the commercial vehicle sector by catering for the particular preferences of small groups of customers and buying in major components (including bodies, engines, and transmissions) from outside sources, mostly independent suppliers, but also some of the large vehicle manufacturers. Even the large producers offer many different versions of their

¹ The figures in Table 2 from Rhys (1972b) also demonstrate that specialist (as opposed to volume) producers that do not aim at covering all four main segments of the car market (such as Jaguar, Saab, BMW, Volvo) may still operate profitably at comparatively low production volumes, as they can afford to charge relatively higher prices. Even in the case of volume producers skillful marketing may create consumer preferences in favour of a particular model and allow it to be priced higher than its competitors, thus compensating for a disadvantage in unit costs.

models to cover a variety of market segments. Thus the diversity of models required by customers restricts the degree of standardization, which would be a precondition for realizing economies of scale at the model level. The greater flexibility consequently required of the manufacturing system is achieved by applying relatively more labour-intensive technology, which may reduce the minimum efficient scale of production to as little as 5.000 units per year (Rhys, 1972a, as reported in Table 1).

While customer preferences in the commercial vehicle sector are more diverse than in the case of passenger cars, they also change more slowly. Model runs therefore can be longer¹, with the possibility that larger model life volumes may compensate for some of the cost increase due to the relatively low degree of product standardization.

2.3. Methodological Limitations and Data Problems

Two separate problems arise in relying on the estimates presented in the previous section for an analysis of the scale efficiency of the Brazilian motor vehicle industry. Firstly it needs to be investigated whether current conditions of production in Brazil are sufficiently similar to those on which the estimates are based (i.e. industrialized countries in the late 1960s and 1970s). Secondly, some data problems need to be considered.

In all countries the motor vehicle industry is highly capital-intensive; the technologies used in Brazil do not differ substantially from the industrialized countries in spite of differences in relative factor prices. Labour intensity in Brazil tends to be somewhat higher; robotization, which has only occurred to a limited extent, has resulted from quality control consideration rather than high labour costs (Stevens, 1987, p. 36). Thus the estimates of minimum efficient scale based on conditions in industrialized countries in the late 1960s and 1970s can be expect-

¹ For example, Ford's main truck cab first introduced in 1964 was still being made in 1980 (Rhys, 1980, p. 185).

ed to reflect reasonably well the current position of the Brazilian motor vehicle industry.

As regards international comparisons, more severe problems may arise concerning the adequacy of the data used in this study. The analysis is based on data on production per firm and, in the case of passenger cars, per basic model. A basic model is defined to include all different versions of each model, irrespective of engine, body style, etc. When this concept is applied in a cross-country analysis (see Chapter 4), the diversity of statistical sources for such a variety of firms and countries renders it difficult to consistently group individual models (for which production data are often available) according to the basic model criterion. However, the resulting margin of error is rather unlikely to invalidate the use of this concept for an assessment of the scale efficiency of final assembly operations, provided that international differences are considerable¹.

Firm-specific data can only capture the scale efficiency in the areas of casting, machining and stamping (which play an important role in determining overall efficiency) if the degree of vertical integration does not differ among firms. While in the passenger car sector in Brazil such variations are apparently limited, they are rather pronounced in the case of commercial vehicles (Stevens, 1987, p. 29); accordingly, firm-specific production data should be interpreted carefully with respect to conclusions on scale efficiency especially in the commercial vehicle sector. Moreover, little information is available on the extent to which components are shared between models or even firms. Gains in scale efficiency resulting from joint use of components are thus not captured by the available data.

¹ An alternative approach could consist of using data on production per model family, which is commonly defined to include several models that share a high proportion of components, including major ones, and are sometimes even produced on the same assembly line. Unfortunately available data have not been sufficient to allow the grouping of all relevant models into 'families'.

3. The Scale Efficiency of Motor Vehicle Production in Brazil

The integrated manufacture of motor vehicles in Brazil started in 1956 as a result of a government programme aimed at substituting domestic production for imports. Eleven firms, many of which had previously assembled vehicles in the country, committed themselves to setting up integrated production facilities and achieving, within four years, local content levels of more than 90 per cent for all locally made vehicles. Incentives granted by the government included duty and tax-free imports of capital equipment as well as the effective closure of the Brazilian market to motor vehicle imports. While some concentration has since taken place, there are still four large firms producing both passenger cars and commercial vehicles (Volkswagen, General Motors, Ford, Fiat) as well as several other firms that limit their activities to the commercial vehicle sector (Mercedes-Benz being the most important)¹.

3.1. The Passenger Car Sector

This section analyses the development of the scale of production in the passenger car sector since the inception of the industry and assesses the extent to which scale efficiency has been achieved, compared with the estimates of minimum efficient scale reviewed in Chapter 2.

Table 3 presents the information on which this analysis is based. The data on average production per firm and per basic model only relate to those models whose annual rate of production exceeds 5 000 units, because the inclusion of 'specialist' models with even smaller runs (in whose production scale efficiency does not play an important role) would bias the findings by leading to an underestimation of overall scale efficiency. To give a rough approximation of installed capacity in the passenger car sector,

¹ Table A1 summarizes the firm structure of the industry, with mergers and new entries since 1956 as well as production data for 1985.

Table 3 - Production^a of Passenger Cars and Light Multiple-Usage Vehicles in Brazil, 1960-1985

Year	Total pass. car produc- tion (1000 units)	Number of mass- producing firms	Number of mass-produced basic models ^b	Volume of mass production (1000 units)	Average number of basic models per firm	Average production per firm (1000 units)	Average installed capacity per firm (1000 units)	Average production per basic model (1000 units)	Average installed capacity per basic model (1000 units)
1960	46	2	4	39	2.0	20	n.a.	10	n.a.
1965	118	3	7	109	2.3	36	n.a.	16	n.a.
1970	305	3	7	290	2.3	96	n.a.	41	n.a.
1975	706	3	12	690	4.0	230	244	58	61
1976	747	3	12	731	4.0	244	260	61	65
1977	719	4	13	711	3.3	178	214	55	66
1978	858	4	11	839	2.8	210	221	76	80
1979	900	4	12	891	3.0	223	235	74	78
1980	927	4	14	918	3.5	229	254	66	73
1981	585	4	15	581	3.8	145	227	39	61
1982	673	4	17	668	4.3	167	287	39	67
1983	749	4	19	743	4.8	186	284	39	60
1984	679	4	21	674	5.3	169	268	32	51
1985	759	4	21	752	5.3	188	266	36	51

^aOnly includes basic models with an annual production of more than 5.000 vehicle. - ^bA basic model is defined here to include all different versions of one model irrespective of the number of doors, or type of engine, etc. - ^cData from Table 4 on capacity utilization for the whole industry have been used in the calculation of this column.

Source: Unpublished ANFAVEA data; Table A2; own calculations.

data on the overall degree of capacity utilization in the motor vehicle industry (Table A2) have been combined with the figures on actual production in the passenger car sector (Table 3). Even such a rough measure of installed capacity should provide a more reliable basis for an assessment of scale efficiency than actual production, which was subject to considerable short-term fluctuations.

The reference case corresponding to scale-efficient production may be defined, on the basis of the estimates presented in Table 1, to involve installed capacity of one million units per year for a firm producing a range of three to four basic models. Similarly, minimum efficient installed capacity per basic model may be assumed to be 200 000 units per year. By comparing these figures with the corresponding data from Table 3 and using the estimates of the long-run average cost function in motor vehicle manufacturing from Table 2 an estimate can be obtained of the extra cost per unit produced that results from a lack of scale efficiency¹.

Concerning the scale of production per firm Table 3 reveals that average installed capacity per firm amounted to roughly a quarter of a million units annually throughout the 1980s. Using Pratten's estimate of the long-run average cost function, this involves extra per-unit costs of 19 per cent compared with scale-efficient

¹ The question arises whether an analysis of firm specific data could not yield a more reliable estimate of the scale efficiency of each manufacturer, and therefore of overall efficiency. However, many of the conceptual and data problems discussed above (grouping of models into 'families', degree of vertical integration of production, degree of capacity utilization) are likely to have less of a distorting effect on an estimate of the extra cost due to low scale efficiency if the estimate refers to the whole passenger car sector (where distorting effects can 'average out' to some extent) rather than an individual firm. A firm-specific analysis of scale efficiency is therefore not attempted in this study. Table A1 conveys an impression of the difference in size between the Brazilian car-makers; Table 8 lists the number of basic models produced by each firm.

production¹. With respect to the development over time it becomes apparent that the scale of production per firm (measured by average production in the absence of data on capacity utilization before 1975) grew more slowly until the mid-1970s than total passenger car production due to the emergence of new mass-producing firms. Thus the increase in the volume of total production was only partly translated into improved scale efficiency at the firm level.

A similar picture emerges from an analysis of the development of the scale of production per basic model. Average installed capacity per basic model reached a maximum of 80 000 units per year in 1978 and has since fallen to 51 000 units annually (Table 3). On the basis of White's estimate of the long-run average cost function (see Table 2) the latter figure is found to imply an extra cost per unit produced of between 13 and 14 per cent, compared with scale-efficient production of 200 000 units annually. The continuous increase over time in the number of basic models has meant that the scale efficiency of production at the basic model level actually deteriorated.

Summarizing the findings of this section, it is seen that there remains considerable scope for improvements of the scale efficiency of Brazilian passenger car production, both in terms of production per firm (relating to economies of scale in the production of major components, e.g. engines, transmission, etc.) as well as in terms of production per basic model.

3.2. The Commercial Vehicle Sector

The diversity of products as well as differences in the structure of individual firms in this sector make it difficult to draw firm conclusions on scale efficiency (for an overview of the distribu-

¹ This estimate is likely to be on the low side as the individual firms produced between four and seven basic models each, rather than a maximum of four as assumed in the reference case (see Table 8).

tion of production among firms and types of vehicle see Table 4). Installed capacity in this sector has not been calculated from the data on capacity utilization for the whole of the Brazilian motor vehicle industry (as presented in Table A2) because information received from two large manufacturers involved in different segments of the market indicates that idle capacity in the commercial vehicle sector after 1980 was significantly above the average for the whole industry.

Moreover, vertical integration in the commercial vehicles sector varies widely, with Mercedes-Benz and Saab-Scania showing a high degree of integration, Volkswagen and Volvo at the lower end, and Ford and General Motors somewhere in between (Stevens, 1987, p. 29). Production of bus chassis is dominated by Mercedes-Benz with Saab-Scania and Volvo playing only a minor role; bus bodies are often made by independent suppliers.

Table 5, summarizing the development of production since the inception of the industry, shows that in each of the three broad categories of commercial vehicle production tended to rise, with some fluctuations, until about 1980. Production of medium and heavy trucks as well as buses then fell off significantly without regaining its 1980 level, whereas the light commercial vehicle sector expanded further, with setbacks in 1981 and 1983, to a historical high in 1985. For an assessment of scale efficiency it therefore seems appropriate to compare firm-specific production data for 1980 and 1985 from Table 4 (depending on which year is likely to yield the closest approximation of installed capacity) with the estimates of minimum efficient scale (Rhys, 1972a and Rhys, 1980; see Table 1)¹.

On the basis of these estimates it seems reasonable to assume that the minimum efficient scale of production for the two categories of light commercial vehicles in Table 4 (which are often

¹ Information provided by one large manufacturer indicates that its capacity in 1980 was in fact fully utilized, while in 1985 idle capacity was in the order of one third of total capacity.

Table 4 - Production of Commercial Vehicles in Brazil by Firm and Type of Vehicle, 1980 and 1985

Firm	Light commercial vehicles (2-4 tons)	'Utilities' (pick-ups, vans)	Light	Trucks Medium, medium heavy	Heavy, very heavy	Buses	Total
(1000 units; 1980 figures in brackets)							
Agrale	0,8 (-)						0,8 (-)
Fiat Automoveis		36,6 (15,0)					36,6 (15,0)
Fiat Caminhões (ex FNM/ Alfa Romeo)			0,0 (1,3)	- (1,9)	0,1 (1,4)	- (0,1)	0,1 (4,7)
Ford	14,8 (15,4)	14,3 (3,7)	7,4 (11,2)	6,0 (11,8)		0,0 (-)	42,6 (42,1)
General Motors	17,6 (29,3)	8,1 (-)	2,5 (-)	3,0 (14,3)		- (0,0)	31,4 (43,7)
Gurgel	0,1 (0,4)	1,2 (1,6)					1,3 (2,0)
Mercedes Benz			4,9 (8,0)	19,1 (34,8)	2,0 (4,1)	6,9 (13,0)	33,0 (60,0)
Puma			- (0,6)				- (0,6)
Saab-Scania					3,5 (3,8)	0,9 (0,7)	4,4 (4,5)
Toyota	2,1 (3,5)	0,5 (0,8)					2,6 (4,3)
Volkswagen	24,7 (46,8)	13,8 (-)					38,5 (46,8)
Volkswagen Caminhões (ex Chrysler)			6,0 (3,8)	6,0 (2,9)			12,0 (6,8)
Volvo					3,1 (0,1)	0,5 (0,6)	3,6 (0,7)
Total	60,2 (95,4)	74,5 (21,1)	20,9 (24,9)	34,2 (65,8)	8,7 (9,3)	8,4 (14,5)	206,9 (231,1)

Source: Unpublished ANFAVEA data.

Table 5 - Production of Commercial Vehicles in Brazil, 1960-85

Year	Total production (1000 units)	Light commercial vehicles ^a			Medium and heavy trucks ^b			Buses ^c		
		Number of firms	Production (1000 units)	Average production per firm (1000 units)	Number of firms	Production (1000 units)	Average production per firm (1000 units)	Number of firms	Production (1000 units)	Average production per firm (1000 units)
1960	82	4	44	11	5	33	7	3	4	1.3
1965	60	3	36	12	5	19	4	4	3	0.8
1970	101	3	62	21	6	34	6	3	4	1.4
1975	210	5	135	27	6	64	11	4	10	2.5
1976	216	6	136	23	6	68	11	3	12	4.0
1977	186	7	91	13	6	81	14	3	14	4.6
1978	190	8	110	14	6	66	11	4	14	3.6
1979	213	8	131	16	6	69	12	3	13	4.3
1980	231	9	141	16	6	75	13	4	14	3.6
1981	194	8	123	15	7	58	8	3	13	4.4
1982	186	8	142	18	7	32	5	4	10	2.4
1983	148	8	117	15	6	24	4	3	6	2.0
1984	184	7	142	20	6	32	5	3	7	2.4
1985	207	8	155	19	6	43	7	3	8	2.7

^aIncludes only firms producing more than 1000 units per year. - ^bIncludes only firms producing more than 500 units per year. -

^cIncludes only firms producing more than 100 units per year.

Source: Compiled from unpublished ANFAVEA data.

derived from car models) is in the order of 70.000 units per year for one model. The corresponding figure for light trucks (which are usually highly standardized) can be assumed to be 50.000 units annually per model, which may go down to about 30.000 units annually for medium-weight trucks and as little as 5.000 units per year for heavy trucks and buses. Inspection of Table 4 reveals that with the possible exception of Mercedes-Benz all firms are apparently far from reaching a volume of production that approaches the minimum efficient scale of operations. This remains true even if one considers the 1980 production figures which in many cases appear to provide a closer approximation to installed capacity than 1985 data. Thus it may be concluded that in the commercial vehicle sector (as in passenger car production) per-unit costs could be reduced considerably through an increase in the scale of production¹. Without an estimate of the long-run average cost function in the production of the various types of commercial vehicles, however, the potential cost savings cannot be quantified.

4. An International Comparison of Scale Efficiency in Motor Vehicle Manufacturing

In order to assess the impact of scale efficiency on the international competitiveness of the Brazilian motor vehicle industry, the scale of production in Brazil has to be compared to that of its competitors (rather than the hypothetical optimum value). This chapter therefore surveys the scale of production in eight important producer countries including Brazil, both newly industrializing and industrialized ones. Since comparable information on capacity utilization is not available, this cross-country analysis has to be based on data on actual production.

¹ The more important problem in the short run is of course the underutilization of existing capacity.

4.1. The Passenger Car Sector

Table 6 summarizes the empirical evidence with respect to the scale of production per firm as well as per basic model. Among newly industrializing countries production in Brazil is clearly more scale-efficient than in Mexico and India, and comparable to Spain. South Korea, however, by concentrating its much smaller volume of total production on a very limited number of models, has managed to achieve a slightly greater degree of scale efficiency at the basic model level as Brazil. In fact a distinct advantage on the part of South Korea may arise in the near future since the 1984 data in Table 6 do not fully reflect the Hyundai firm's recent success in introducing its Pony 2 model in the North American markets. Economies at the firm level (relating mostly to the production of components common to several basic models), where Brazil is in a better position than South Korea, may compensate somewhat for the relatively small scale of Brazilian production per basic model¹.

Turning now to the industrialized countries, the volume of production per basic model in the USA, the Fed. Rep. of Germany, and Japan was about four times as large as in Brazil. On the basis of White's estimates of the relationship between per-unit costs and the scale of production (see Table 2) this can be assumed to imply a difference in per-unit costs in the order of 10 per cent². In relation to the U.S. this estimate is likely to be on the low side, given that the three large firms in the U.S. often produce very similar or almost identical models in their separate divisions³. Economies of scale resulting from the interchange-

¹ The scale inefficiency resulting from model proliferation becomes even more obvious in the Mexican case. Possible firm strategies to overcome inefficiency due to model proliferation are discussed in the next chapter.

² A decrease in the scale of production from 100 000 to 50 000 is reported by White to carry a cost penalty of between 4 per cent and 9 per cent.

³ For example, General Motors' 'J Car' is sold in the US in 5 different versions, corresponding to the GM Car divisions: Cadillac Cimarron, Pontiac J 2000, Buick Skylark, Oldsmobile Firenca, Chevrolet Cavalier (Waymark, 1983, pp. 138-9).

Table 6 - Production of Passenger Cars and Light Multiple-Usage Vehicles in Brazil and Selected Countries, 1984

Country	Total passenger car production (1000 units)	Mass-produced cars ^a			Average number of basic models per firm	Average volume of production per firm (1000 units)	Average volume of production per basic model (1000 units)
		Number of firms	Number of 'mass-produced' basic models	Volume of 'mass' production (1000 units)			
Brazil	679	4	21	676	5.3	169	32
Mexico	232	6	17	216	2.8	36	13
South Korea	159	2	4	156	2.0	78	39
India ^b	86	4	4	85	1.0	21	21
Spain	1 225	6	n.a.	1 254 ^c	n.a.	209 ^c	n.a.
USA ^d	7 952	4 ^e	64	7 742	16.0	1 935	121
Fed. Rep. of Germany	3 754 ^f	4 ^e	24	2 819 ^g	6.0 ^k	705 ^j	117 ^{g,k}
Japan ^h	7 771 ^j	5 ^j	n.a.	7 071 ^{i,j}	18 ^k	1 414 ^j	134 ^{g,k}

^aOnly includes basic models with an annual production of more than 5 000 vehicles. - ^bIncluding jeeps. - ^cProduction figures are not available for individual models. Figures relate to the firms' total production. - ^dRetail sales of domestically produced cars. No data are available relating to individual models of Volkswagen or Honda. - ^eAmerican Motors, Chrysler, Ford, General Motors. - ^fB.M.W., Mercedes Benz and Porsche have not been included as these firms cater for particular market segments with only limited relevance to Brazilian conditions. - ^gExcludes completely - knocked - down kits, for which no data are available at the model level. - ^hProduction figures for individual models are only available for Toyota. - ⁱIncluding knock-down sets. - ^jRelates to total production by Honda, Mazda, Mitsubishi, Nissan, Toyota. - ^kToyota only.

Source: Compiled from World Motor Vehicle Data, 1986 Edition.

ability of components in such cases are not reflected by the data on production per basic model, because sufficient information on constructive similarities between models has not been available.

Summarizing the findings of this section one may conclude that Brazil enjoys a clear advantage in scale efficiency compared with the other newly industrializing countries, with the exception of South Korea which is rapidly improving its position especially at the basic model level. Brazil continues to find itself at a disadvantage relative to the large industrialized countries. However, given the conceptual limitations of the methodology applied in this study (in the absence of practical alternatives) not too much weight should be placed on the precise figure obtained of an average 10 per cent extra per-unit cost due to low scale efficiency on the part of Brazil. The general conclusion of this section is that Brazil's international competitiveness is unlikely to be so seriously affected by its relative small scale of production that the resulting disadvantage cannot be compensated for by other factors (e.g. lower wage costs)¹.

4.2. The Commercial Vehicle Sector

As far as the commercial vehicle sector is concerned, the diversity of products and firm structures in an international context again makes comparisons difficult (Table 7). Relative to the other newly industrializing countries Brazil appears to enjoy an advantage in terms of scale efficiency in the production of light vehicles². In the field of medium and heavy trucks as well as buses production per firm in Brazil was only about one fourth that of India, whose Telco and Ashok-Leyland firms are important exporters to developing countries of trucks and buses, respectively (Maxcy, 1981, pp. 265-6). Compared with the industrialized

¹ This assumes that the distortions that result from the limitations of the methodology applied tend to 'average out' rather than lead to a clear-cut bias in the findings.

² This may not apply to production by the South Korean firm of KIA with its fairly large volumes for individual models; see Table 7, footnote d.

Table 7 - Production of Commercial Vehicles in Brazil and Selected Countries, 1984

Country	Total production (1000 units)	Light commercial vehicles ^a			Medium and heavy trucks ^b			Buses ^c		
		Number of firms	Production (1000 units)	Average production per firm (1000 units)	Number of firms	Production (1000 units)	Average production per firm (1000 units)	Number of firms	Production (1000 units)	Average production per firm (1000 units)
Brazil	185	7	144	21	6	32	5	3	7	2.3
Mexico	112	6 ^d	95	16	5 ^d	14	3	2	1	0.6
South Korea	107	2 ^d	13	6	2 ^d	4	2	5	26	5.3
India	95	4	32	8	2	40	20	2	21	10.7
Spain	54	4	43 ^l	11	3	7 ^f	2	4	2	0.4
USA ^g	3 475	5	3 208 ^h	642	8	266 ⁱ	33	n.a.	n.a.	n.a.
Fed Rep. of Germany	255	4 ^j	169	42	3 ^j	57	19	4	9	2.3
Japan	4 392	11 ^j	4 239	385	n.a. ^j	65	n.a.	8	72	9.0

^aUp to 8 t gross weight; only includes firms producing more than 1000 units per year. - ^bOver 8 t gross weight; only includes firms producing more than 500 units per year. - ^cOnly includes firms producing more than 100 units per year. - ^dTruck production by KIA could not be split into the 'Light' and 'Medium and Heavy' categories, and has therefore been excluded from the analysis. Production figures are available for individual models: E 2200: 35 624; E 3000: 11 306; E 2500: 3840; E 4100: 4743. - ^eUp to 9 t gross weight. - ^fOver 9 t gross weight. - ^gRetail sales of domestically produced vehicles. - ^hUp to 14 000 pounds gross weight. - ⁱOver 16 000 pounds gross weight. - ^jNo data are available on production by individual firms and weight groups. It has been assumed that all major firms producing 'trucks' are involved in the production of light vehicles, while no similar assumption could be made in the case of medium and heavy trucks.

Source: Compiled from World Motor Vehicle Data, 1986 Edition.

countries, the scale of production per firm in each category is smaller in Brazil than in the major producing countries. Without a much more detailed analysis of individual market segments and firm structures, which is beyond the scope of this paper, it is impossible to determine the extent to which the international competitiveness of commercial vehicle production in Brazil is affected by scale inefficiency.

5. Implications for Firm Strategies and the Role of Government Policies

The deterioration of scale efficiency in the Brazilian passenger car sector in recent years, especially at the basic model level, indicates a major area of concern. Therefore this section discusses some possible firm strategies to improve scale efficiency in this respect, as well as the role of government policies in this context. The emphasis is on the passenger car sector, but some of the conclusions also apply - *mutatis mutandis* - to commercial vehicle production. The following options are considered:

- reducing the number of basic models;
- lengthening model runs;
- inter-firm cooperation, including mergers;
- increasing exports.

A reduction in the number of basic models produced would increase the scale of production per basic model, provided that production per firm can be maintained at its previous level. With three of the four large Brazilian car-makers mass-producing only four to five basic models each (see Table 8), such an approach would probably force some firms to stop serving particular segments of the market. Such specialization could, however, turn out to be counter-productive, because the nature of oligopolistic competition in the Brazilian domestic market makes it important for each volume car-maker to cater for first-time buyers of automobiles as well as for customers who are moving up-market, in order not to lose market shares and, consequently, scale efficiency in

production. The alternative of importing certain models from abroad instead of inefficiently producing them domestically does not exist in Brazil because of the effective closure of the domestic market to imports. The protection of domestic motor vehicle manufacturing has thus contributed to the recent deterioration of scale efficiency through encouraging model proliferation, rather than allowing the industry, as suggested by the infant industry argument, to grow up to become scale-efficient.

The marketing strategies currently pursued by firms in the Brazilian domestic market tend to emphasize style and appearance rather than, for example, practical usefulness or ease of maintenance (Macchione, 1986, p. 42). That approach apparently plays an important role in preventing a lengthening of model runs, which could otherwise reduce per-unit costs through the spreading of certain model-specific fixed costs over larger model life volumes (see Table 2 for an estimate by Rhys, 1977 of the relationship between per-unit costs and model life volume). The traditional notion that model runs are distinctly longer in newly industrializing than in industrialized countries cannot be upheld (in spite of examples to the contrary) as a comparison between the average period of production of 1984-produced basic models in Brazil and the Federal Republic of Germany demonstrates (Table 8). This may be a result precisely of the need to limit the number of basic models to the minimum required to cover the main segments of the market. With changes in consumer preferences demanding the frequent introduction of new models, the production of older models has to be terminated (even if there is still significant demand for them) once their replacements are introduced. By contrast, the larger markets in the industrialized countries apparently allow each firm to have a somewhat greater number of models in production simultaneously, and still take advantage of economies

Table 8 - Average Length of Production of Mass-produced^a Basic Passenger Car Models in Brazil and the Federal Republic of Germany, 1984

<u>Brazil</u>			<u>Fed. Rep. of Germany</u>		
Firms	No. of basic models mass-produced in 1984	Average period of production (years)	Average period of production (years)	No. of basic models mass-produced in 1984	Firms
4 large firms	21	7.5	11.6	24	4 mass producers (Audi, Ford, Opel, Volkswagen)
3 large firms (excluding Fiat, which only started production in 1977)	16	8.7			
Ford	4	8.5	11.2	5	Ford
General Motors	5	8.0	17.2	5	Opel
Volkswagen	7	9.3	9.6	10	Volkswagen
^a Only includes basic models with a 1984 production volume of less than 5000 units					

Source: World Motor Vehicle Data, 1986 edition; Verband der Automobilindustrie, Tatsachen und Zahlen aus der Kraftverkehrswirtschaft, various issues; Latini, 1984, p. 100; own calculations.

of scale. Some examples of the early withdrawal of still popular models in Brazil are the replacement of Volkswagen's Brasilia and Beetle models with the BX family (Gol, Voyage, Parati), the substitution of General Motors's Monza for the Opala, and the replacement of Ford's Corcel II with the Escort (Crissiuma, 1986, pp. 85- 86)¹.

Economies of scale in the manufacture of parts can also be achieved through increasing the degree of interchangeability of components among models. This is already being done to a great extent², and within individual firms the process may in fact be approaching its limits, as cars of different sizes (to cover different market segments) each require their own body parts, engines, and, possibly, transmissions. There remains, however, ample scope for increasing scale efficiency through inter-firm co-operation in the procurement or production of components, which seems to be the main thrust of the collaboration agreement covering the operations of Volkswagen and Ford in Brazil and Argentina ('Autolatina'; see Stevens, 1987, p. 60).

Finally the possibility of increasing exports needs to be considered. The South Korean example demonstrates that even with much smaller total production, concentration on a few models together with determined efforts to expand exports may considerably improve scale efficiency. In the case of Brazil several obstacles to such an approach appear to exist. Firstly, in the past the pressure to export is likely to have been smaller than in South Korea given the much larger size of the (protected) Brazilian domestic market. Secondly, being subsidiaries of multinational

¹ It may be noted that the introduction of new models in Brazil tends to follow with a lag of several months the appearance of the equivalent model in the home markets of the parent companies. Thus the experience of the parent company may be relied upon in the setting-up of production in Brazil to avoid certain starting-up (i.e. model-specific fixed) costs. This cost saving may be set against any unit cost disadvantage resulting from relatively short model runs.

² Volkswagen's BX model family, for example, accounted for 47 per cent of the Car Division's 1985 output (Stevens, 1987, p. 45).

firms the Brazilian car-makers are not entirely free to choose their export markets if their decisions conflict with the interests of other parts of the corporation. This appears to be one important reason why exports to the North American and West European markets have remained limited, although these would seem the most natural targets for an export expansion strategy aimed at increasing the scale of Brazilian production (deliveries by Fiat to Western Europe and by Ford to Scandinavia being obvious exceptions)¹. Thirdly, legally binding local content requirements which apply to all cars produced in Brazil (Prud'homme, 1984) appear to represent an obstacle to a fuller integration of the Brazilian subsidiaries into the global production networks of the parent companies², even though they are relaxed somewhat for cars destined for export under BEFLEX agreements: 85 per cent for passenger cars and around 80 per cent for most types of commercial vehicles instead of the usual 95 per cent (Stevens, 1987, p. 31). Local content requirements and similar restrictions such as the new law on information technology also necessitate design changes in parent company models in the course of their adaptation for production in Brazil that may impair the Brazilian versions' suitability for sale in developed country markets (Stevens, pp. 33 and 42)³.

¹ Volkswagen's current export drive in the US, if successful, may alter the picture somewhat.

² For a discussion of the 'World Car' strategy, involving ideally a global integration of production, see Black (1981). Stevens (1987, p. 33-4) describes the problems encountered in applying that strategy in Brazil.

³ For example, in transforming the Parati/Voyage into the Fox for the US market Volkswagen had to make alterations to 30 per cent of the components.

6. Summary and Conclusions

This paper has surveyed empirical studies on the impact of the scale of production on per-unit costs in motor vehicle manufacturing. On this basis the validity of the hypothesis has been investigated that the scale efficiency of motor vehicle manufacturing in Brazil has now improved to the point where the remaining disadvantage no longer seriously affects the international competitiveness of the industry. The analysis has been limited to scale efficiency in the area of manufacturing technology, which in the case of Brazil can be assumed to exert a stronger influence on relative cost advantages than scale efficiency in the fields of management, marketing, or finance.

The empirical studies on economies of scale in motor vehicle manufacturing all indicate that per-unit costs decline substantially as the scale of production increases. However, scale represents only one out of several important determinants of per-unit costs. Lower prices for inputs or the adoption of less capital-intensive technology (within the limits set by quality requirements) may therefore compensate for a competitive disadvantage due to small scale. Furthermore, the concept of economies of scale lacks theoretical rigour in that it is unable to distinguish clearly between different sources of cost savings associated with large scale. Therefore the findings from the empirical application of the concept should be approached with caution. This is also true for the numerical estimates that have been presented of the minimum efficient scale in motor vehicle manufacturing, and of the relationship between per-unit costs and the scale of production in the passenger car sector.

Bearing in mind these qualifications the available estimates have been used to assess the scale efficiency of the Brazilian motor vehicle industry. First they have been contrasted with the development of the scale of production since the inception of the industry. It has been found that there remains some scope for improving scale efficiency, both in the passenger car and the commercial vehicle sector. The scale of motor vehicle production

in Brazil has then been compared to seven other selected producer countries, including newly industrializing as well as industrialized ones.

In passenger car production scale efficiency in Brazil exceeds that of the other developing countries with the exception of South Korea. In the latter country a policy of concentrating production on a very limited number of models and a determined effort to expand exports have increased production per basic model to a level above that achieved by Brazil, in spite of a much smaller volume of total production. In relation to industrialized countries Brazil apparently still finds itself at a disadvantage in terms of scale efficiency, which, however, seems to have become so small that it no longer seriously affects the country's relative position in production costs.

An assessment of the scale efficiency of commercial vehicle production is rendered difficult by the diversity of products and firm structures. It appears that, in general, the scale of production in Brazil tends to be low in this sector, not only in relation to most industrialized countries but also to South Korea and India. It is impossible, however, within the scope of this study to determine the extent to which this disadvantage affects the international competitive position of commercial vehicle production in Brazil.

Finally, various firm strategies aimed at improving scale efficiency as well as different policy options for the Brazilian government have been considered. The main alternatives (not mutually exclusive) are to curb model proliferation or to raise exports, both of which are difficult to implement under present government policy. Model proliferation is at least partly a result of the closure of the domestic market, where oligopolistic competition makes it desirable (and protection makes it profitable) for each major firm to offer a whole range of models, all of which must be manufactured in Brazil. An easing of restrictions on imports of vehicles and components would help to improve

scale efficiency by facilitating international specialization. Models now produced domestically in small numbers could then be imported; vehicle exports, particularly to developed country markets, would benefit from less stringent local content requirements and controls on imports of technically advanced components.

Thus it must be concluded that the continuing protection of the Brazilian motor vehicle industry does not help to improve the industry's scale efficiency in relation to its major international competitors (as would be suggested by the infant industry agreement). On the contrary, much of the remaining competitive disadvantage is likely to be a result precisely of the closure of the domestic market and could be reduced substantially by a less protectionist policy.

Table A1 - The Firm Structure of the Brazilian Motor Vehicle Industry, 1956-1985

Firms involved in the industry			Production in 1985				Exports in 1984
1956	1970	1985	Passenger cars (1000 units)	(per cent of total)	Commercial vehicles (1000 units)	(per cent of total)	(per cent of production)
Volkswagen (Fed. Rep. of Germany)))					
Vemag (Brazil; joint venture with Auto-Union, Fed. Rep. of Germany)	) Volkswagen))					
))					
))					
Simca (France)	)	) Volkswagen	307	41	51	24	16
	) Chrysler))					
International Harvester (US)	) (US)))					
))					
Ford (US)))					
	) Ford	Ford	146	19	43	21	18
Willys Overland (US)))					
FNM (Brazil)	Alfa Romeo (Italy)	Fiat (Italy; joint venture with state of Minas Gerais)	114	15	37	18	56
General Motors (US)	General Motors	General Motors	191	25	31	15	14
Mercedes (Fed. Rep. of Germany)	Mercedes	Mercedes	-		33	16	27
Toyota (Japan)	Toyota	Toyota	-		3	1	3
Scania Vabis (Sweden)	Saab-Scania	Saab-Scania	-		4	2	4
		Volvo	-		4	2	17
		Others ^a	0	0	2	1	3
		Total	760	100	207	100	23

^a Agrale, Gurgel, Santa Matilde.

Source: Maxcy, 1981, p. 259 (1956 and 1970 data); World Motor Vehicle Data, 1986 Edition (1984 export data); unpublished ANFAVEA data (1985).

Table A2 - The Brazilian Motor Vehicle Industry: Total Capacity, Capacity Utilization, and Exports, 1960-1985

	Unutilized capacity (per cent) (1)	Total motor vehicle production (1000 units) (2)	Total productive capacity (1000 units) (3)	Total exports (per cent) (4)	Share of exports in production (per cent) (5)
1960	n.a.	133	n.a.	n.a. ^a	n.a.
1965	n.a.	185	n.a.	0 ^b	0.1
1970	n.a.	416	n.a.	0 ^c	0.1
1975	5.7	930	986	73	7.9
1976	6.2	987	1052	80	8.1
1977	17.0	921	1110	70	7.6
1978	5.2	1064	1122	96	9.0
1979	5.2	1128	1190	106	9.4
1980	9.7	1165	1290	157	13.5
1981	36.0	781	1220	213	27.2
1982	41.7	859	1474	173	20.2
1983	34.7	896	1373	169	18.8
1984	37.0	865	1372	197	22.7
1985	29.2	967	1365	208	21.5

^a1961 export were 380 buses. - ^b1965 exports were 120 buses, 9 trucks. - ^c409 units.

Source: ANFAVEA, Anuario Estatístico 1957/1986, Tables 4.1.1 (2), 5.1 (4); Macchione, 1986, Table 26 (1); own calculations.

References

- Altshuler, Alan, et al., The Future of the Automobile; The Report of MIT's International Automobile Program, Cambridge, Mass. 1984.
- Bhaskar, Krish, The Future of the World Motor Industry, London/New York 1980.
- Black, Andrew, Trends in the International Trade in the Automobile Industry: a Comparison of the "World Car" and "Market Specialization" Strategies. International Institute of Management/Industrial Policy, Wissenschaftszentrum Berlin, Discussion Paper 82-39, Berlin 1982.
- CPRS (Central Policy Review Staff), The Future of the British Car Industry, London 1975.
- Crissiuma, Maria Cecilia Borghi, Restruturacao e Divisao Internacional do Trabalho na Industria Automobilistica: o Caso Brasileiro, Dissertacao de Mestado apresentada ao Curso de Pós-Graduacao da EAESP/FGV, São Paulo 1986.
- Doz, Yves L., The Internationalization of Manufacturing in the Automobile Industry - Some Recent Trends. Research Working Paper No. 81/18, Institut Européen d'Administration des Affaires, Fontainebleau 1981.
- El Darwish, A.S., "The Establishment of an Automotive Industry in Developing Countries". Establishment and Development of Automotive Industries in Developing Countries, Report and Proceedings of Seminar held in Karlovy Vary, Czechoslovakia, 24. Feb. - 14 March 1969, Part II: Proceedings of the Seminar, pp. 59-72; ed. by United Nations Industrial Development Organization, New York 1970.
- Giersch, Herbert, Internal and External Liberalisation for Faster Growth. Kiel Working Paper No. 275, Institut für Weltwirtschaft an der Universität Kiel, Kiel 1986.
- Gold, Bela, "Changing Perspectives on Size, Scale, and Returns: An Interpretive Survey". Journal of Economic Literature, Vol. 19, 1981, pp. 5-33.
- Henderson, James M., Richard E. Quandt, Microeconomic Theory; A Mathematical Approach, 2nd ed., Tokyo etc. 1971.
- Kern, Werner, Industrielle Produktionswirtschaft, Stuttgart 1980.
- Latini, Sydney A., Suma Automobilistica, Vol. 1, Rio de Janeiro 1984.
- Macchione Saes, Maria Sylvia, A Indústria Automobilistica Brasileira, IPEA, São Paulo 1986.

- Maxcy, George, *The Multinational Motor Industry*, London 1981.
- Nunnenkamp, Peter, *The Brazilian Automobile Industry within the International Division of Labour*, Kiel 1987 (mimeo).
- OECD (Organization for Economic Co-operation and Development), *Long Term Outlook for the World Automobile Industry*, Paris 1983.
- Pratten, C.F., *Economies of Scale in Manufacturing Industry*, Cambridge 1971.
- Prud'homme, Remy, "Les Investissements des Multinationales de l'Automobile dans le Tiers-monde". *Revue d'économie industrielle*, Vol. 29, 1984, 3ème trimestre, pp. 62-77.
- Rhys, D.G. (1972a), *The Motor Industry: An Economic Survey*, London 1972.
- (1972b), "Economies of Scale in the Motor Industry". *Bulletin of Economic Research*, Vol. 24, 1972, pp. 87-97.
- (1972c), "Heavy Commercial Vehicles: The Survival of the Small Firms". *The Journal of Industrial Economics*, Vol. 20, 1971/2, No. 3, pp. 230-52.
- , "European Mass-Producing Car Motors and Minimum Efficiency Scale: A Note". *The Journal of Industrial Economics*, Vol. 25, June 1977, pp. 313-20.
- , "Motor Vehicles". *The Structure of British Industry*, ed. by P.S. Johnson, pp. 179-206, London etc. 1980.
- Stevens, David, *The Brazilian Motor Industry: Change and Opportunity*. Automotive Special Report No. 8, Economist Intelligence Unit, London 1987.
- UNCTC (United Nations Centre on Transnational Corporations), *Transnational Corporations in the International Auto Industry*, New York 1983.
- UNIDO (United Nations Industrial Development Organization, Global and Conceptual Studies Branch, Division for Industrial Studies), *International Industrial Restructuring and the International Division of Labour in the Automotive Industry*. Working Papers on Global Restructuring, Vienna 1984.
- Waymark, Peter, *The Car Industry; A Study in Economics and Geography*, Bath 1983.
- White, Lawrence J., *The Automobile Industry Since 1945*, Cambridge, Mass. 1971.
- , "The Automobile Industry". *The Structure of American Industry*, ed. by Walter Adams, New York/London 1977.