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MOTOR MANUFACTURE IN UNDERDEVELOPED COUNTRIES

By

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This paper sets out to comment on the desirability or undesirability of establishing a motor vehicle-producing industry in the less developed countries. As has been pointed out by many analysts,[1] it appears questionable on economic grounds for developing countries to attempt to establish fully integrated motor vehicle manufacturing facilities using techniques more appropriate to the scale of operations in Detroit, or in Vokswagen's Wolfsburg complex, or in Toyota's Tsutsumi plant. When it is considered that motor firms in the developed countries working on a two-shift basis can have a plant optimum of as much as two million units a year, and comparing this with the total available market in a less developed country, it would appear that vehicle manufacture is a highly questionable way for such a country to use its scarce resources. However, it is our purpose here to show that by carefully choosing the right technology, the efficient scale of production in relation to the size of the market available can be lowered and the 'cost penalty' of establishing a motor industry in a low per capita income economy reduced.

The nature of the problem confronting the establishment of an efficient motor industry in an underdeveloped country can be seen by taking Indonesia as an example. In terms of income per head in 1969 Indonesia's figure of $100[2] was among the lowest in the world as was its average annual growth rate in real per capita income of 0.8% over the decade 1960-1969[3]. Given the close relationship between

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[1] For instance, see J.R. Hansen. "The Motor Vehicle Industry" in the *Bulletin of Indonesian Economic Studies*.

[2] *Finance and Development* No. 1, 1972. Clearly this figure can only be compared approximately with income levels in developed countries. Differences in costs, in the basket of goods consumed, in the size of the subsistence sector, the exchange rate problem, and the cheapness of non-traded goods all make international comparisons difficult.

[3] *Finance and Development* No. 1, 1972.

[redacted] ndonesia would almost
[redacted] on earth to establish a
[redacted] cars to people, or 'car
[redacted] the foot of the world

[redacted] Use[5]

[redacted]	People per vehicle[7]		
	1967	1969	197[illegible]
[redacted]	461	379	359
[redacted]	9.8	9.4	4.7
[redacted]	4.2	3.8	3.4
[redacted]	126	99	(30.0)
[redacted]	3.2	2.7	2.8
[redacted]	82	72	44.0
[redacted]	15	15	9.9

[redacted] ries in 1967 and 1969, [redacted] n Indonesia.[9] Over this [redacted] relative ranking vis-à-vis [redacted] g able to surpass Haiti's [redacted] was little indication that [redacted] activeness' as a motor [redacted] otal Asian figure for car [redacted] and 1969, Indonesia's

[redacted] s, *The Motor Industry: An* [redacted] 1972.

[redacted] tain", *SMMT*, London 1968,

[redacted] ation.

[redacted] plus commercial vehicle

[redacted] Canadian data. The model [redacted] South America (e.g. Brazil, [redacted] tina and Venezuela, 14 for [redacted] ile and Paraguay, figures are figures increased by just 17%. However, if Japanese data from the total Asian figures were omitted, the figures would indicate that Indonesia performed better than the average and was catching up with the rest of Asia.[10] Thus, given Indonesia's low ranking in the income per head league, its position in the car and vehicle density table is where one would expect it to be.

In terms of the country's car density, Indonesia's position can be looked at in two ways — either as an area of very great *potential* expansion, or as an area where the car market is moribund and static. If the claimed success of the last Stabilization Plan[11] is taken as a sign that Indonesia is ready to embark upon steady growth, then the first interpretation may have some basis. However, this is far from showing that Indonesia, or any other underdeveloped country for that matter, would be well advised to establish a motor industry. Any such conclusion can only rest on further analysis, much of which has general application to the entire underdeveloped world.

There are a number of points which need clarification before the efficacy of establishing a motor industry in an underdeveloped country can be established. Firstly, the optimum production levels of a 'Detroit-style' operation needs discussion. Secondly, the cost disadvantage of copying, or alternatively the cost advantages of avoiding, 'Detroit-style' methods needs analysing. Thirdly, the possibility of making vehicles which are both 'designed-down' to a low price, and made with materials and techniques best suited to the needs of small markets, must be considered. It could be that methods are available which may impose higher unit costs than are experienced by Detroit but which nevertheless give lower unit costs than those incurred by the sub-optimum working of Detroit, West European, or Japanese-type production facilities.

During the 1960s, European, Japanese, and U.S. producers indicated that the optimum output of vehicles at the assembly stage, and of items cast at the foundry stage, was around 200,000 units a year on a two-shift basis. However, with increased automation Toyota and General Motors Corporation (GMC) had by 1970, pushed the assembly optimum up to 400,000 units a year. At the same time they had introduced even more specific equipment, that is,

[10] Unfortunately, due to a significant change of coverage the 1972 figures for 'Asia' *cannot* be compared directly with those of 1969.

[11] "Indonesia: Economic Stabilization 1966-69" by Gunnar Tomas, in *Finance and Development.* Vol. 7, No. 4, December 1970.

equipment suitable only for one repetitive job. This means that the optimum has moved up from 200,000 cars of any type to 400,000 units of very similar models. Increased automation in foundries is increasing the optimum output level to an excess of 300,000 units a year. However, these are still relatively small figures compared with those needed for optimization in the machining and forging of major components, such as engines, axles, transmission units, and so on. Depending on the component involved, the two-shift output figure needed for the optimum use of manufacturing equipment here lies between 750,000 and 1,250,000 units a year. Even on the basis of the latter figure, U.S. manufacturers retain the same basic engine design for anything between ten and fifteen years in order to fully amortize the expensive equipment used and to control unit costs; that is, to keep the fixed cost element per engine to the minimum. Even given these astronomical figures, an even greater optimum output level exists in the pressing and stamping of sheet metal used in body panels. The lowest cost are experienced by using equipment at its designed optima of between one and two million units, the precise output figure depending on the kind of pressing involved. Such output levels would allow firms to move on to their lowest short-run cost curves and to reach the lowest point possible on their long-run average cost curves. In the U.S.A. domestic car production exceeds nine million units; in W. Germany and Japan figures of around 3½ million are reached. These are output levels in the realms of fantasy as far as less developed countries are concerned. The sub-optimum use of equipment used by mass-producers in the developed countries would lead to substantial unit cost penalties. For instance, a fall in output of 25% from the planned volume would lead to an increase in unit costs of 6.5%;[12] the output volumes in a country such as Indonesia can be as low as 1/2500ths of the overall optimum! However, output methods can be used which are more appropriate to much lower output levels than those experienced by firms in developed countries. These methods, although technically inefficient, are nevertheless economically efficient for producing the output levels involved. Neither the type of production nor the nature of the productive process need be those associated with high cost and high price producers such as Aston Martin or Ferrari. Instead, they could be much more in line with the requirements of the market for basic motoring. For instance in Chile, British Leyland joined forces with its local distributor in establishing a plant to manufacture glass-fiber bodied models of the BLMC Mini Saloon in place of the usual steel bodies. Glass fiber is cheaper to use than steel when only

[12] See D.G. Rhys, *The Motor Industry, An Economic Survey*, Chapter 8, Butterworths, London, 1972.

small output volumes can be anticipated.[13] In addition, this enabled British Leyland to conform to 'local content' regulations with the minimum cost penalty; that is, as the optimum level of output is so high, the greatest degree of sub-optimality and the largest cost penalty would occur in this area. Therefore, by avoiding the use of metal bodies, a major step is taken to minimize the cost penalty of producing vehicles in countries with small markets.

In the developed countries, motor industry bodywork and major components account for over 60% of total unit costs:

Table 2: Cost Structure of Typical Mass-Produced Car
(Cost of materials but excluding direct labor)

	Proportion of Total Costs
Engine	20
Other major components (e.g. gearbox)	12
Body	33
Electrical items	8
Castings and Forgings	6
Suspension	5
Brakes	3
Other items	13

The most costly investment in equipment matches the most costly units incorporated in a single car.[14] Although the optimum output of tools and transfer machines that make engines, gearboxes, transmission units, axles and so on is lower than that for presses used in making metal body sections, the investment is higher. A new engine plant, for instance, costs in the region of £30 million compared with around £25 million for facilities to press out a complete car body.

This means that production facilities are especially costly when a manufacturer makes the decision to manufacture for himself items which account for over 40% of total unit costs. It is relatively easy for the manufacturer to domestically produce items which make up

[13] In 1972 General Motors Corporation calculated that only at output levels in excess of 50,000 units a year was there no tooling cost advantage from working in fiber glass rather than steel.

[14] The new Alfasud plant in southern Italy cost £200 million. This included the foundry, machining, pressing, and assembly facilities of a completely integrated plant.

almost 40% of the costs of a single car.[15] This covers the costs of assembly and of parts which are easily supplied domestically. Beyond this point the costs of providing engines, transmission units, rear axles, radiators, stampings and pressings are very high. This is the result of using equipment which is both specific and very expensive; equipment which is needed for efficient production; equipment with very high optimum output levels. Thus, any sub-optimum use of this equipment leads to significant cost penalties.[16] Where commercial vehicles are concerned, press work is less significant and the crucial figure becomes 60% of total costs made up by items which are relatively easily supplied domestically. However, the cost penalties involved in commercial vehicles, especially car production, can be minimized by the utilization of alternative techniques to produce the items making up the 'final' 60% of unit costs.

Mechanical and moving assembly lines are readily replaced by other methods, such as manually pushing vehicles on simple carts or 'dollies' past a line of components stacked in sequence. After all, this was the way Henry Ford developed his first flow line during the first decade of the 20th century. Expensive jigs and automatic welding are equally dispensable. Such methods help to reduce the already relatively small cost penalty involved in small scale assembly, while general purpose flexible machines and tools are used to make certain components. However, it is the elimination of 'high technology' engine and transmission production lines and pressing facilities which can provide the greatest aid to minimize the problems involved in establishing a motor firm in small markets. This kind of technology is available in developed countries. For instance, the use of a small partly automated transfer line to produce (complex) Jaguar V12 engines has an optimum of 1,000 units a week. The capital expenditure involved was £3 million which compares with £10 million plus for a full-size transfer machine facility to mass-produce engines. Lotus introduced a line based on modern multi-purpose equipment which involved using standard machines to batch produce 15,000 engines a year. The same equipment could also perform other tasks, such as machining gearbox components. The capital outlay was

[15] See J. Baranson, *Automobile Industries in Developing Countries*, Washington D.C., International Bank for Reconstruction and Development, 1969, pp. 29-32.

[16] Baranson shows (Ibid) that in underdeveloped countries, the cost penalties stemming from engine and gearbox facilities were around 45%; that for body-making, 65%. In contrast the penalties in assembly were 17%. Figures refer to operations conducted in Brazil. For other countries the penalties were even higher.

£500,000 which, if amortized over ten years, meant a fixed cost recoupment per engine of some £3. Although there are no available precise comparisons of the costs involved in producing the same engine on a mass-production basis with different equipment, it is interesting to note that the Jensen-Healey car using the Lotus engine costs 30% more than British Leyland's MGB sports car which uses an engine made on a high volume mass-production basis.

On the body-building side, savings are also possible when only relatively small output volumes are feasible. These are mainly achieved by using techniques which avoid steel bodies and the attendant need for expensive dies and stamping machines. At output levels, which require less than 20,000 bodies a year of a particular type, it appears that open mold glass fiber methods are the most efficient.[17] Given that steel construction requires capital intensive methods while glass fiber is labor intensive, this figure should be increased in labor abundant economies. The mass-production of glass fiber bodies pushes the 'break-even' point up to 45,000 units a year.[18] In terms of tooling and material costs for a truck cab, the following picture emerges:

Table 3: Cost of CV Cab Production

	Steel	Aluminium	Mass-produced Plastics	Open-mold hand made Plastics
Tooling Costs	£1.4 M	£.630 M	£.130 M	£.025 M
Material Costs per cab	£100	£120	£128	£163

Where relatively few numbers are needed, fiber-glass units are cheaper. Even where hand-building methods are used in metal work, the really expensive pressings and stamping processes are those involved in bending and shaping the metal. The use of fiber-glass panels where bending is required can reduce unit body costs by 10% even at low output levels; for instance, where the production of steel and aluminum bus or coach bodies is concerned.

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[17] Statist, February 10th 1967. Open mold techniques produce 350 units a year from one set of dies. Duplication brings no cost disadvantage and only at output levels in excess of 20,000 a year are steel producing methods more efficient. In a labor-cheap economy the break-even point should be higher.

[18] *Motor Transport*, November 8, 1963.

Even when all this is said, it is still true that an attempt by less developed countries to produce a multitude of models by the methods used in developed countries is wasteful of scarce resources. Essential components such as forgings, electrical items, and wheels, are all most efficiently produced at output levels in excess of one million units a year. Nevertheless, underdeveloped countries could *minimize* the cost disadvantage of making vehicles by restricting activities to: (i) vehicle assembly and/or (ii) producing parts easily supplied in underdeveloped countries, and (iii) (more questionably) making machined items such as engines by using multi-purpose equipment and using fiber glass in body manufacture. If manufacture is limited to the items which account for less than 40% of total costs, the policy of establishing a motor industry becomes more realistic. An example of what is possible in terms of choosing the right technology can be seen in the British motor industry. The profit earning price of the glass fiber bodied Reliant 'Rebel', which is made at an annual output volume of some 1,000 a year, is only £100 (or 16%) more than that of the steel bodied BLMC Mini produced at an output volume of around 150,000 a year. Although the latter is a complicated and costly car to make and assemble, (estimates of the extent of 'over-engineering' are placed at between £30 and £50) the comparatively small price difference shows what can be done. However, apart from choosing a more appropriate technology, attention should also be paid to designing-down vehicles to a particular cost and price. This has been the policy of all mass-producing manufacturers in order for them to tap the widest possible market. It does seem that the ability to produce and market a car at a price roughly equivalent to a country's annual per capita income figure, assuming a relatively 'equitable' distribution, signals a take-off in car ownership.

In Asia and Africa the vast majority of countries have per capita incomes of between $100 and $300 a year. At this time Ford and GMC are developing the simplest cars yet devised, which the companies hope will revolutionize transport in less developed countries. These vehicles were designed to be just one step up from the bullock cart or bicycle. Both companies are using their smallest British-made engines with straightforward controls. At the same time a single power take-off was used so that the vehicle could be used for such tasks as cutting wood and pumping water. Ford, for one, found it impossible to strip and adapt the Escort, its existing U.K. small car, for the role as a significant part of this car's price lies in the initial capital costs of tools and assembly-line.[19] As a result a stripped

[19] It is only when a mass produced car is built in large numbers equivalent to its output target that fixed costs per unit are a small proportion of total costs.

down British Ford Escort for the bush, built in relatively small numbers, would be little cheaper than a fully trimmed European car. This illustrates the important point that where European metal-bodied cars are concerned, the introduction of unitary or chassisless construction greatly increases the optimum size of motor firms. Ideally, therefore, a car designed for use in underdeveloped countries should be constructed with a separate body and chassis to allow the use of a simple cheap body, with the engine and other major components imported from a foreign low cost source. In developed countries the optimum output for production techniques needed in making vehicles with separate bodies and chasses is, by the nature of things, a little lower than those used in unitary construction; but it is still well in excess of what is feasible in underdeveloped countries. The Ford and GMC utility vehicles are designed for use in relatively poor agricultural economies where Western vehicles fit neither people's needs nor their incomes. Therefore, their price had to be low and to be bought by the people, the vehicles had to cost little more than the bullock team they were intended to replace. To keep labor assembly costs to a minimum, Ford's vehicle was assembled in the Philippines. However, the prices set to cover costs turned out to be in the range of $600 to $700, cheap by Western standards but way beyond the typical per capita income figures in Asia and Africa,[20] so it is doubtful whether even these cut-price vehicles can achieve very large output figures in the forseeable future. In the U.K., even an ultra-utilitarian and spartan Reliant chassis-cab costs £582 exclusive of tax. It would appear that if less developed countries wish to establish an industry making transport equipment, they may be better advised to study the economics of moped and motorcycle production.

Thus, although the attempt to produce a specially designed vehicle can contribute to cost saving, it is unlikely that even this would allow motoring to spread to the mass of the population. Clearly, however, it is possible to design a vehicle down to a price and then to produce it by methods which, although putting firms on short-run average cost curve above the minimum possible, allows underdeveloped countries to avoid some of the cost penalties involved in sub-optimum working. All this gives them the chance to develop a small labor intensive motor industry; that is, labor intensive methods would be used in assembly, in the making of parts, major components, and bodies. The last two items involve the largest

[20] Even if exchange rates underestimate the real wealth of a country — say, because of the cheapness of non-traded goods — it is unlikely that the error is sufficient to greatly modify the conclusion reached here.

output levels for optimality and can therefore impose the greatest cost penalties when production is undertaken in less developed countries. Thus, where car bodies are concerned, the use of glass fiber using techniques open up great possibilities for cost saving.

In conclusion, it is germane to indicate the importance of the car density figures in the less developed countries. Although these countries have large potential markets, these can only be realised with a growth in per capita income. Obviously, if a cheap vehicle could be built-down to present per capita income levels, then it would top a tremendous demand. However, it appears that in order for this approach to succeed relatively large increase in incomes is needed. At present, it would be impossible to build a vehicle down to a price which is equal to the present typical Asian and African per capita income figures. Furthermore, vehicle manufacture in underdeveloped countries presupposes a drastic reduction in the number of models, a fact recognized by governments in South Africa, Mexico, Chile, and elsewhere where the number of firms permitted to operate is being reduced. In the less developed countries low cost production presupposes the replacement of competitive assembly and manufacture by a single "no choice" peoples' car or bullock cart. Proliferation of models only aggravates the existing problem of sub-optimal production. The production of CVs may be less costly in terms of resource-use as the optimum output levels are lower than those involved in car production. Furthermore, as the period of economic development calls for a capital investment-based rather than a consumer-based economy, the market for CVs is large in comparison to that for cars. Therefore, the production of a bullock cart chassis which could use either a car or a small truck body would be the ideal. At no stage however can it be argued that technological change is likely to reduce the world wide optima in the motor industry.

What is suggested here is that either technological change or the choice of the correct existing technology can reduce the cost penalty of operating at sub-optimum levels. Hence, ways can be found of reducing the waste of resources involved in establishing a motor industry in less developed countries. This is especially so if a country does not attempt to become fully self-sufficient in the parts needed for vehicle production, and continues to import the key components which are made on expensive machinery with high optimum output levels. Ideally, this would mean the importation of engines, gear boxes, and transmission units on the one hand, and body panels for local assembly on the other. Finally, if the real opportunity cost of capital is greater than the financial cost to an underdeveloped country, then labor intensive production methods may be called for. If labor is sufficiently cheap, then the real cost of vehicle manufacture can approach the low levels experienced in developed countries. Attempts to copy 'Western' methods would preclude countries enjoying this possibility.

Appendix One
Overall Optima (e.g. in Detroit)
(Output on a two-shift basis over a period of one year)

Assembly	200 — 400 thousand units
Foundering	200 — 400 thousand units
Machining	500 — 1250 thousand units
Pressing	250 — 2000 thousand units

Appendix Two
Lifetime of Equipment (e.g. in Detroit conditions)

Body dies: Up to two years
Presses: Indefinite
Transfer lines: Ten to fifteen years

Appendix Three
Alternative Technologies (Most efficient up to following production levels:)

Assembly

BESPOKE	BATCH	MASS-PRODUCTION
Up to 7,000	7,000-40,000	40,000+

Body building

Open Mold	Mass-production	Mass-production
Glass fiber	Glass fiber	Steel: Up to million
Up to 20,000 units	Up to 50,000	Aluminum : Up to 750,[illegible]

Engines

Aluminum and iron: Up to 20,000
Iron Casting: 20,000+
Aluminum : 100,000+