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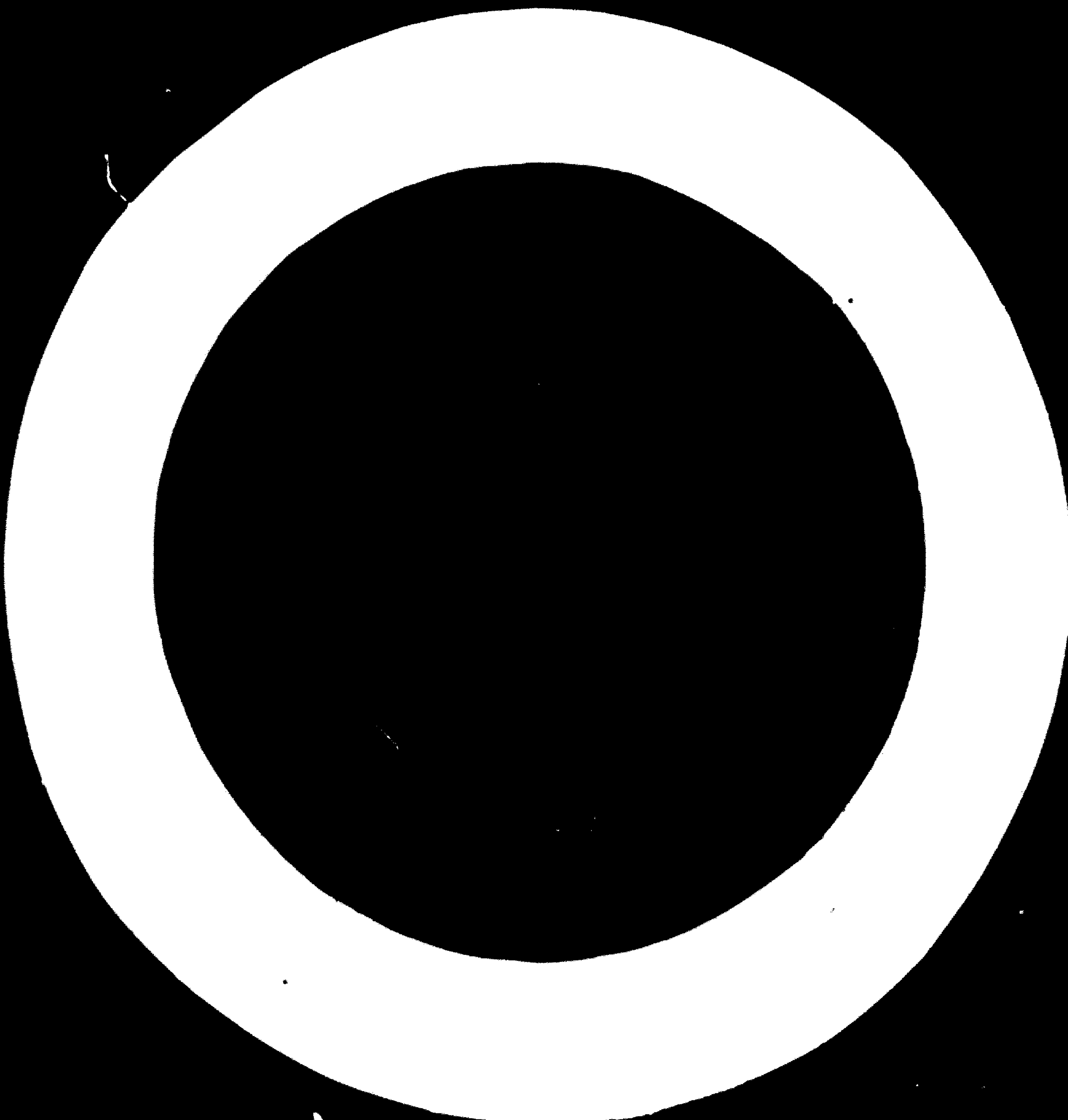
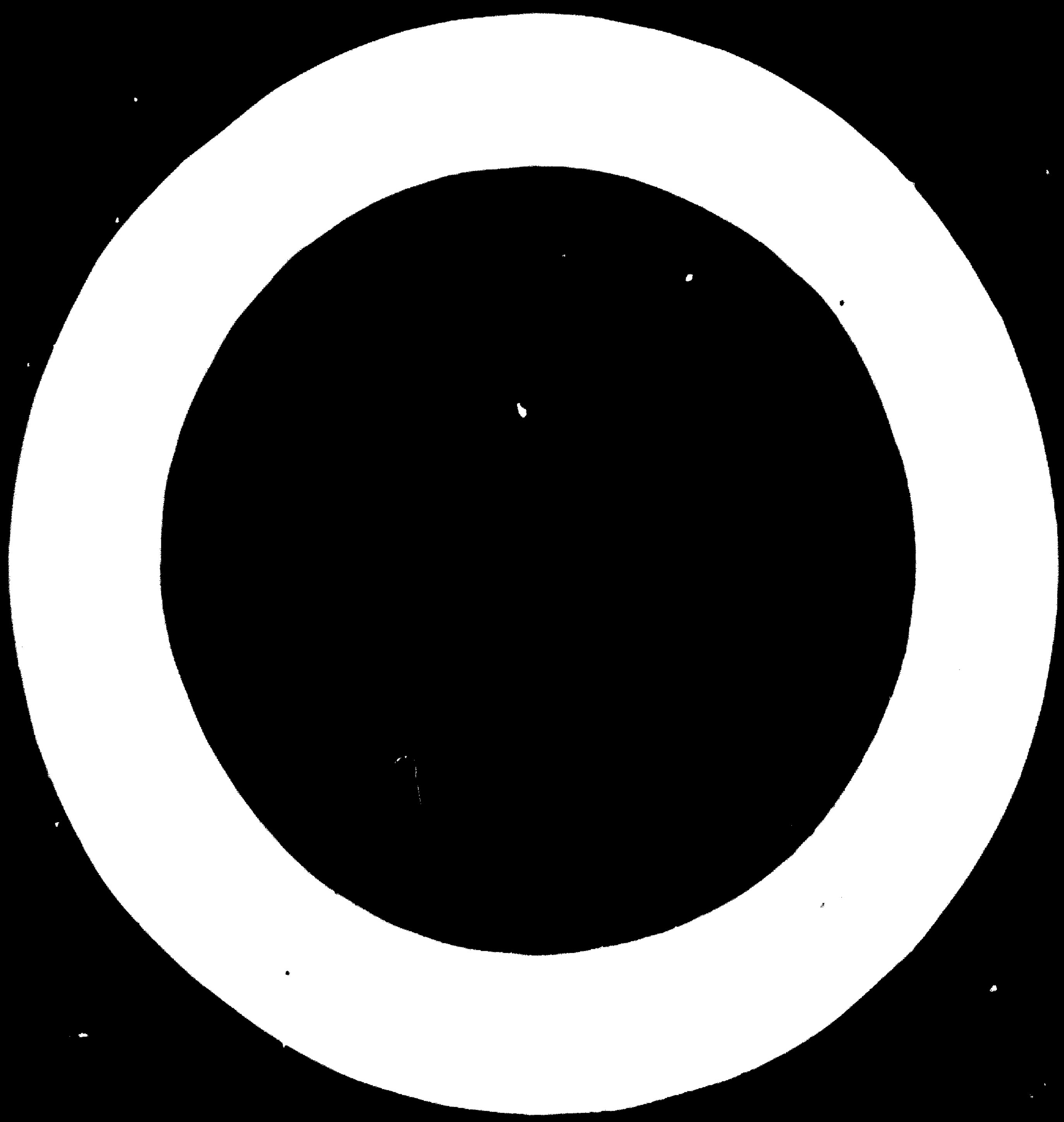
ESTABLISHMENT AND DEVELOPMENT OF AUTOMOTIVE INDUSTRIES IN DEVELOPING COUNTRIES

Report and proceedings of seminar held in
Karlovy Vary, Czechoslovakia
24 February-14 March 1969

Part II PROCEEDINGS OF THE SEMINAR

UNITED NATIONS





ESTABLISHMENT AND DEVELOPMENT OF AUTOMOTIVE INDUSTRIES IN DEVELOPING COUNTRIES

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION, VIENNA

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Preface

PART I OF THIS PUBLICATION (ID/36, Vol. I) contains the report of the seminar on the establishment and development of automotive industries in developing countries, held in Karlovy Vary, Czechoslovakia in February/March 1969. The seminar was arranged by UNIDO in collaboration with the Government of Czechoslovakia as host. The report includes chapters reviewing the following subjects considered by the seminar:

1. Elements of preliminary planning
2. Vehicle service plans
3. Intermediate assessment of vehicle demand
4. Technological problems
5. Cost implications, capital and expense, profitability
6. Training requirements and timing
7. Problems of launching new facilities
8. Personnel relations
9. Regional co-operation
10. Completion of motor-industry planning
11. Summary of discussion
12. Recommendations of the seminar

The annexes to Part I present the agenda, the list of participants, the list of documents presented to the seminar, a description of the factories visited by the participants in Czechoslovakia by arrangement of the host country and statements made to the opening meetings by representatives of the host country and UNIDO. In addition there are the following annexes:

Comment by C. Moore on the paper on "The Work of the ILO in Relation to the Metal Trades", by the ILO Secretariat.

Summary of the paper "The Motorcycle, its Present and Future", by V. Jansa.

Part II, the present volume (ID/36, Vol. II) consists of six of the papers presented to the seminar; the selection of these papers is based upon the principle that they present a broad cross-section of views and problems related to the development of the automotive industry. The annex to Part II gives data on the import and assembly of motor vehicles in seven developing countries, as presented to the seminar at Karlovy Vary.

[redacted]

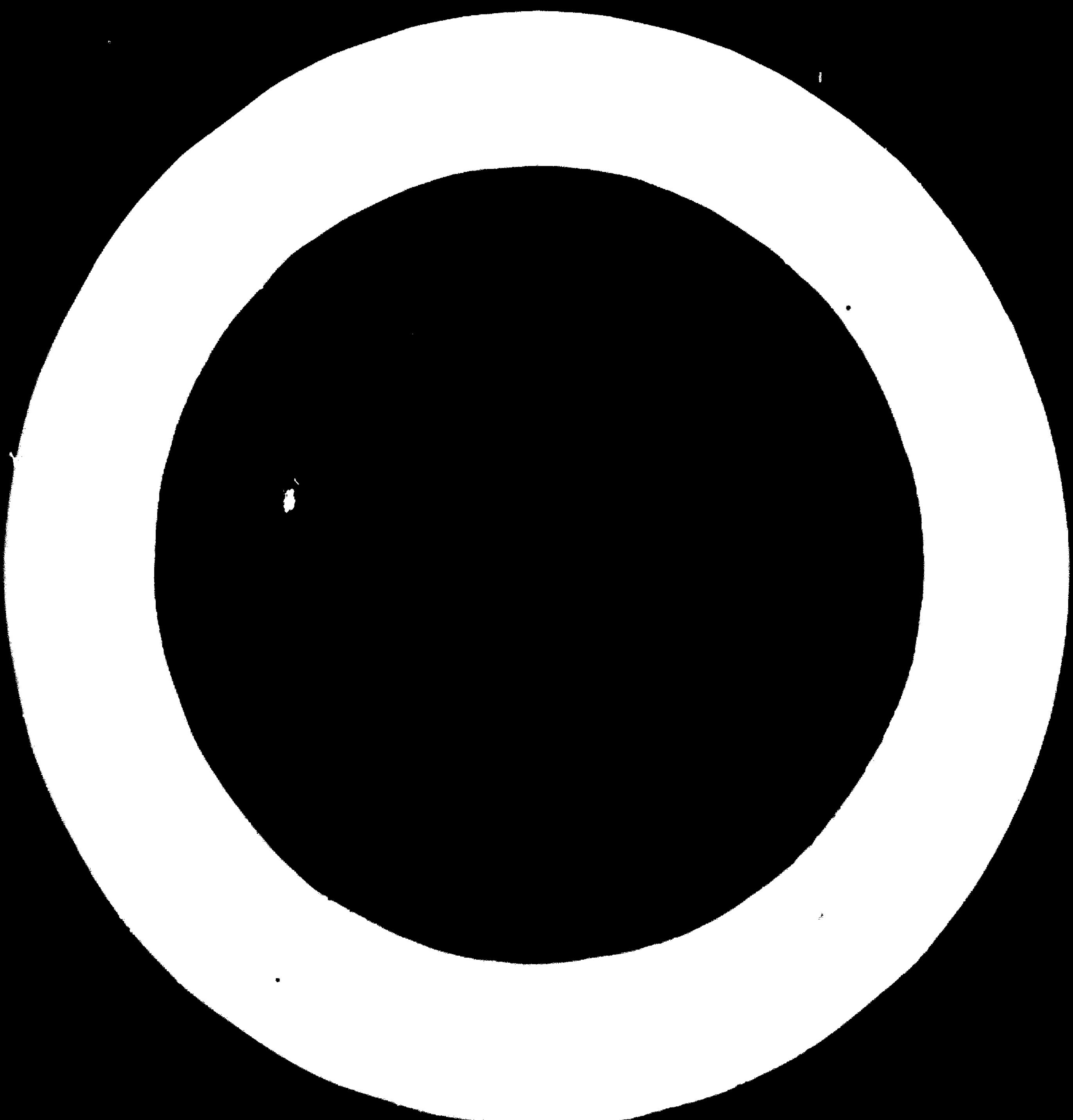
EXPLANATORY NOTES

"Dollars" ($) refers to United States dollars unless otherwise indicated.
"Billion" signifies a thousand million.

ABBREVIATIONS

CBU	Completely built up
CKD	Completely knocked down
MKD	Medium knocked down
SKD	Semi knocked down
PM	Preventative maintenance

CONTENTS



IMPORTANCE AND PRACTICAL ASPECTS OF TECHNICAL CO-OPERATION IN THE ESTABLISHMENT OR DEVELOPMENT OF A MOTOR-VEHICLE INDUSTRY IN FOREIGN COUNTRIES

*G. L. Malleret**

Introduction

A country that wants to establish or rapidly expand a motor-vehicle industry generally consults manufacturers of motor vehicles with good international reputations. This paper attempts to explain how Citroën S. A. visualizes the co-operation that must be established between the local authorities and the manufacturer.

Dealing with a complex product of several highly diversified technical fields, the aim must be the optimum mobilization of the host country's scientific and technical resources, both human and material. The co-operation between the motor-vehicle manufacturer and the host country must begin with the preliminary talks and continue up to the mass production and marketing of the vehicle—indeed throughout the life of the vehicle. The two parties should co-operate at all levels, particularly in the technical and industrial fields.

Among the more specifically industrial problems involved are the following, which will be examined in this paper:

Choice of vehicle adapted to the country;
Stages of production;
National production and integration programmes;
Investment programmes;
Establishment of the factory;
Cost and retail price of the vehicle.

1. Choice of vehicle adapted to the country

Whether the object is to establish a motor-vehicle industry or to expand one that has already been established by widening the range of existing models, the situation discussed in this paper is one in which a country decides to produce a vehicle for the widest use, a vehicle for the masses, generally designated as the "popular car".

What is a popular car? It should be economical to purchase and operate, practical, comfortable and safe to secure a wide market. It should meet the following standards:

It must be inexpensive so that it could be bought by the largest possible number of people;
It must have low consumption of fuel and lubricants;
It must be of sturdy and simple construction;
It must be able to be driven on all terrains;
It must be versatile, in particular suitable for rural regions, transportation of passengers, light loads etc.;
Maintenance must be simple and low-cost;
A long lifetime must be assured;
It must offer maximum comfort;
It must not be a mini-car, for its body must be able to accommodate four passengers and their luggage;
It must be easily transformable, without too much additional cost, into functional derivatives such as light vans and jeep-like models which can be used in industry, agriculture and commerce.

The essential characteristics of this vehicle are:
Sturdy and simple engine;
Engine in front to allow for luggage space in the back;
Independent suspension adaptable to bad roads;
Front wheel drive, an important road-holding factor;
Spacious but not cumbersome, with four side doors as well as a fifth door giving access to the luggage compartment;
Removable seats to allow transportation of cumbersome loads;
Efficient interior ventilation and heating;
Comfort ensured by interior fittings and by driving safety;
Vulnerable parts of the body must be removable, facilitating repairs and lowering their cost;

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Minimum maintenance, thus ensuring safety even when experienced maintenance service is not available;

To assist in the proper choice of the type of vehicle to be produced, the manufacturer should provide the following information:

Commercial description of the models manufactured and sold on the home market;

Technical description of engine and transmission (clutch, gear-box, transmission shafts and joints), suspension and shock absorbers, steering, brakes, tires, electrical equipment (engine, visibility, signalling) chassis and body;

Operational details, dimensions, weight and performance (speeds, acceleration, consumption of petrol and oil);

Advantages of a chassis which permits the combination of the features of several types of bodies.

It is the responsibility of the manufacturer to provide models for testing in the host country, to examine the test results and to issue a specifications book. The manufacturer should not rigidly impose the same models as those currently sold on the home market.

The models produced in the host country will be built somewhat differently from those of the mother country, thus:

Special anti-dust equipment, e.g. a special air filter;
Anti-frost devices for cold countries;
Supplementary heating for cold countries;
Reinforced ventilation or air conditioning for hot countries;
Special tires;
Other modifications required by local regulations.

The technicians of both countries, particularly the commercial staff, must develop specifications for the different models, i.e.:

Private vehicles;

Commercial vehicles such as vans, jeep-like models and the various types of vehicles used in agriculture, industry, the crafts and commerce.

The commercial personnel of both countries must also study the market in order to plan the production programmes.

A popular vehicle which meets the conditions enumerated above—in particular, reasonable price and low-cost maintenance—presents few problems. The sales possibilities are usually directly related to a country's population density, standard of living and *per capita* income.

2. Stages of production

The production of vehicles in a factory to be built or expanded in a developing country must be based on a methodical and detailed plan adopted by both parties.

The local manufacture of the bodywork and the mechanical structure by the factory and by local suppliers must follow a succession of stages.

National integration consists in assembling vehicles from imported parts and then gradually replacing them with locally manufactured parts. In each successive stage, the percentage of locally manufactured parts and the total output will increase according to plan.

If the stages are spread over a given period, the investment can be spread in parallel fashion, and thus be amortized progressively. In addition, the initiation of local production is facilitated, since problems can be solved as they arise. Furthermore, reductions in cost can be included in the initial planning.

For the bodywork, Citroën offers its partners a production plan with a preliminary stage followed by six main stages:

In the *preliminary stage*, a few vehicles are assembled entirely from imported parts; the external parts have already received a final coat of paint. The aim is to familiarize the factory staff with the vehicle and its assembly. At the end of this preliminary stage the degree of national integration will be about 4 per cent.

It is possible to begin in the *first stage* during which the external parts of the bodywork are imported with only an undercoating of paint. The parts are then lacquered and the vehicle assembled; the degree of national integration is about 8 per cent. Some of the wiring, upholstery and sheet metalwork must be installed in the factory. The local suppliers will deliver the materials, which have been approved by the manufacturer.

In the *second stage*, all the coatings (surface treatment of the sheet metal, undercoating of paint and lacquer layers) must be applied in the factory. The following processes will commence during this stage:

Assembly of the body;
Manufacture of various components (units) of the body;
Manufacture of the pressed parts by external suppliers.

During the *next three stages*, the body panels, doors and chassis will be progressively assembled with a consequent increase in the volume of pressings and sheet metal. The manufacture of the body must be completed by the end of the fifth stage, since the object of the sixth stage is a maximum output.

For the assembly of the mechanical structure, Citroën proposes eight stages:

1. Engine and gear-box together with the carburettor and fuel pump (the two latter parts can usually be made quickly in local factories);
2. Suspension;
3. Rear axle;

4. Front axle and steering;
5. Gear-box;
6. Engine;
7. Transmission joints;
8. Inertial dampers (which are unique to Citroën's popular cars).

These eight stages provide a framework for the corresponding stages of the manufacture of the components of these parts. From the beginning of the assembly of a unit, the parts produced in the host country by the factory or by local suppliers can be incorporated in the unit.

The stages in the manufacture of the bodywork are basic. They and the stages in the manufacture of the mechanical structure can be ordered in various combinations depending on the particular local situation. Consequently, the stages outlined for the two principal components of a car need not be followed rigidly. Two examples will suffice:

In Spain, a local gear manufacturer made it possible for Citroën to begin manufacturing the gear-boxes during the second stage;

In Argentina, a factory built by Citroën, which had competent managers and proper equipment, quickly began to manufacture inertial dampers.

What forms should co-operation in this field take? On the one hand, the local authorities should permit visiting experts to study the industrial possibilities of the host country. On the other, executives, engineers and technicians of the host country should attend lectures and training courses in the factories of the manufacturer and also in the factories of his suppliers. They will thus become familiar with the vehicle to be built and with the manufacturer's techniques and engineering concepts, especially those of advanced engineering. These courses lay the foundations of a supply service managed by technically and industrially trained personnel, who can increase their knowledge under the auspices of the manufacturer. This aspect of co-operation is especially important as it can lead to reductions in the cost of supplies that accounts for about 65 per cent of the unit cost.

All the technicians must then agree on the division of production tasks in the host country with special reference to the following points:

Manufactured items, which might include a small bodywork shop (with stamping facilities if future production volumes justify them);

Mechanical items which can be produced completely or partially in he factory, although a few such as the gear-box, can be made in existing factories of the host country which then must be expanded;

The manufacture of semi-finished parts (castings and forgings) may eventually require the construction of a new shop or the extension of an existing one.

Technical co-operation for optimum utilization and development at minimum cost of the available industrial facilities in the host country must be the constant aim and concern of both parties.

3. National production and integration programmes

After technicians of the host country have become familiar with all models of the cars to be built and after the determination of the specific parts to be manufactured by the new or expanded factory and by external suppliers, the following goals must be set in co-operation with the local authorities:

Maximum annual output;

Time limit for attainment of maximum output;

Tempo of national integration.

The maximum annual output depends essentially on the results of the market study. If the hourly output corresponding to this maximum is greater than six, the operations will be divided into two shifts or about 4,200 working hours a year (the precise number of working hours will of course depend on the local labour regulations).

National integration at any given time is expressed as a percentage. In general, the technical percentage of national integration is obtained by multiplying by 100 the ratio of the value of the locally produced parts to that of the completed vehicle; however, weight is sometimes substituted for value, e.g. in Brazil.

When planning the production and national integration programmes, the personnel of both parties should benefit from the experience acquired by the manufacturer in establishing and operating factories abroad and within the prescribed time limits. As an example of the time limit, Citroën established two factories in Spain and in Argentina; both of them attained an hourly output of six vehicles and a national integration of 90 to 95 per cent within five years.

After production has begun, the quality, output and price must be controlled for two related reasons:

The output cannot be maintained if the quality is poor because, as is shown in section 4, no financial provision is made for the manufacture of a large volume provision is made for the manufacture of a large volume of rejects;

The price cannot be maintained if the quality is poor with an accompanying decrease in output. Industrial experience in all countries shows that quality and prices depend on high outpout.

Quality is often uncertain when the hourly output is less than six vehicles, because the production facilities are necessarily limited and on a small scale. Depending on the output and the degree of national integration, the prices of these vehicles may exceed three times the prices of mass-produced vehicles.

High quality is easier to obtain with an hourly output of six vehicles (12,500 vehicles annually with one work shift or 25,000 vehicles with two work shifts) and 90 per cent national integration. The price may not increase but it may be twice the price of mass-produced vehicles. At this rate of output, the 10 per cent of imports are those manufactured items for which the necessary investment would permit a greater output; consequently, they are not easy to amortize (crank and cam shafts in popular Citroën models).

With an hourly output of twelve vehicles (50,000 vehicles annually), the national integration is almost 100 per cent but the price may be 1.4 times that of a mass-produced vehicle. National integration is 100 per cent with an hourly output of 50 vehicles (200,000 vehicles annually). The prices are competitive in world markets. With an hourly output of 75 vehicles (300,000 vehicles annually) the factory has reached European standards.

These summary facts and figures are based on the experience of Citroën. They vary from one country to another and indicate the importance of a market study. (A discussion of price is given in section 6 below.)

Other factors which must be studied in close co-operation by both parties and taken into account in the initial planning are the following:

Importance and duration of the training courses given under the manufacturer's auspices and the creation of a supply department;

Opportunities for the factory to expand the physical plant and for local suppliers to obtain financing, especially when currency exchange is necessary;

Time limits for delivery of the necessary machinery for production, especially those items which must be imported;

Time limits for the completion of buildings and installations;

Sufficient time to obtain manufacturing licences from the suppliers of the electrical and special mechanical parts;

The long-term, continual necessity to import certain components which are unobtainable in the host country (for example thin sheet steel).

Quality must be a constant concern. Vehicles produced in the local factory must satisfy the same technical and performance standards as the vehicles manufactured in the home factory.

All the staff will thus have to take into account the time needed to reach this standard; it depends partly on the host country's level of industrialization.

In general, all the parts produced in the host country must be approved by the manufacturer and the local factory managers before they are assembled. Account must be taken of the time needed to obtain these approvals; the parts may be tested in the home plant or in the local plant, but always according to the established norms.

When the parts have been approved, the next step is to ensure uniform quality through the adoption of the manufacturer's modifications, which are the results of continuous advances in engineering and of improvements in the vehicle itself, to produce a modern vehicle.

When establishing or expanding a motor-vehicle industry with a large expected output, it is a grave mistake to assume that there will be a rapid increase in hourly output and slow progress in national integration; the necessary foreign exchange to pay for the imported parts is not available in most countries.

It has been shown that in some countries where the motor-vehicle industry was initially at a low stage of development, 90 to 95 per cent integration has been achieved in five years. The length of the integration process depends on the factors previously outlined and particularly on the industrial development of the host country.

In many countries, when the hourly output exceeds twelve vehicles, 100 per cent national integration can be attained in five years. The progression is not linear; 100 per cent integration in five years assumes about 80 per cent integration at the end of the third year. During the fifth year, the vehicle is almost 100 per cent integrated; the small per cent of imports represents temporary local failures in either quality or production.

When planning a national integration programme, provision can be made for compensation procedures between the host country and the manufacturer's country. This form of co-operation could enable the host country to play an important role in international trade. The manufacturer can buy raw materials and locally manufactured parts in the host country.

Two examples of this type of co-operation are:

Citroën Hispania ships daily from Spain to Citroën France 20 tons of finished products, as well as certain parts to Citroën subsidiaries in Portugal and in Chile for use in their production;

In return for car parts bought from Citroën France, TOMOS in Yugoslavia exports finished products for use in vehicles manufactured in France.

This kind of co-operation is especially advantageous to the host country throughout the period of incomplete integration. It partially compensates the foreign exchange for imports; it also makes it possible to increase production.

Even though the vehicle may not be wholly manufactured in the host country, as in Spain, the value of the imports can nevertheless be balanced by the value of other exports to the manufacturer's country from the host country. These exports must meet certain standards of quality, delivery period and price; they are indicative of a country's industrialization.

The extensive industrial and commercial co-operation indicates the factors which must be taken into consideration in planning the programmes, thus:

General programmes

National production and integration,

Planning and subsequent installation of the pro-production facilities;

Initial programme for each stage of the production;

Complementary regional programme (see the discussion in section 6).

4. INVESTMENT PROGRAMMES

The investment programmes for the overseas manufacture of Citroën vehicles at various hourly output rates are given below. This information may assist the local authorities and the co-operating manufacturer to plan investment programmes for the establishment of a factory adapted to the conditions of the host country or for the expansion of an existing factory.

A complete automobile factory will comprise a bodywork unit, a mechanical unit with facilities for heat treatment and a semi-finished parts unit (castings and forgings).

The bodywork unit is composed of the following shops:

Manufacture of body sections;

Sheet metal;

Chassis and bodywork assembly;

Coatings

Surface treatment of sheet metals,

Painting (chassis, body, wheel rims and other parts),

Electrolytic coating (polishing, zinc coating, cadmium coating and chromium plating);

Wiring and upholstery;

Assembly lines for vehicles.

When the hourly output exceeds twelve vehicles, a stamping shop is added to the bodywork unit. With a smaller hourly output, a stamping shop is difficult to amortize: thus, until the output reaches this level, the stamped parts must be made in another shop.

The mechanical unit consists of shops for manufacturing the different parts of the vehicle with one or more heat treatments, depending on the hourly output. This unit can be combined with the bodywork unit.

The raw materials unit is composed of a forging shop, a casting shop for ferrous metals and a casting shop for non-ferrous metals (aluminium alloys). This unit can be combined with the bodywork or mechanical unit.

Citroën not only provides hourly output estimates for each manufacturing unit and for the ancillary departments, but it also provides detailed data of the areas covered (basement area and the ground floor area, which is with or without rolling cranes). These data are accompanied by standard diagrams of the individual buildings.

The ground area can be six to ten times that of the covered portion. This ratio depends on the ground available, the individual conceptions of the layout of the buildings, the size of the "green areas" and the anticipated development of the factory. Experience has shown that the following characteristics of the proposed building site must be considered: its physical geography, the nature of the underlying soil, the availability of water and electrical power, and the accessibility by road and rail. Estimates for purchasing and developing the ground are not given, since they depend on the particular local circumstances.

The building structure (reinforced concrete and metal framework), particularly that of the shops, depends on the facilities and costs in the host country. For the shops, a metal framework which offers greater flexibility is preferred. The estimates are based on this kind of structure.

Estimates of utilities include hourly consumption of compressed air, water, gas, electricity and steam, and installation costs for the gas and electric power from the country's networks.

The estimates for the general ancillary departments include shops (maintenance, tooling, professional training etc.), reception control for external supplies, chemical and metallurgical laboratories, handling, transportation and storage and ancillary (offices, cloak rooms, restaurants, infirmary, fire service etc.).

Estimates for each shop include expenditures for manufacture of tools, purchase of materials, purchase of tools, installation of the manufacturing facilities, and testing and tuning the manufacturing facilities.

Thus, for each shop, separate estimates are given for the buildings, fluids, general and ancillary departments and manufacturing units. Lists of materials used and the technical data of various manufacturing processes are also provided to the host country.

The investment is estimated on the same basis as in the mother country and includes all expenditures which must be amortized for a given number of vehicles.

The estimates relating to the manufacturing facilities include those for:

Manufacture of vehicles;

The same percentage of rejects as in the manufacturer's factories. However, rejects are very rare in mass production;

Manufacture of the spare parts needed for maintenance and repair of the vehicles.

The hourly capacity of the manufacturing facilities is thus greater than the hourly output of vehicles.

In addition, there are various expenditures that must be incurred concomitantly with the investment expenditure, for example:

"Primary equipment", which includes consumable materials (for example cutting tools); the cost is included under "shop expenditures";
Special equipment (charged to the distribution network) for maintenance and repair of the vehicles.

Thus the necessary total investment for a complete factory is itemized. This investment must be carefully evaluated in terms of the particular local situation. During this extremely important period of technical co-operation, before the actual beginning of operation of the factory, all parties should be constantly aware of the necessity to keep the total investment to a minimum. The investment must be amortized through a given number of vehicles, for this factor affects the retail price of the vehicle. It may therefore be necessary to modify the plans of the manufacturing stages with respect to the machinery and raw materials.

The mechanical parts can only be partially manufactured in the factory to be built or expanded. It may indeed be more economical to build installations for manufacturing gear-boxes and engines, for example, to an existing factory.

The semi-finished parts (castings and forgings) can be ordered from existing factories which will thus have an incentive to expand. Only one light metal foundry shop will be needed, since an existing factory will already have one for ferrous metals.

The layout of the factory should be planned through the co-operation of both parties in accordance with the relief of the building site. The locations of the buildings should permit future expansion with minimum dislocation and expense. If a factory is not developed rationally, it will stagnate and ultimately fail. The expenditure for the plant site can be estimated within the framework of the host country's economy. Then both parties can plan an investment expenditure programme and fix the sums to be amortized annually.

After all the programmes have been co-ordinated, both parties must follow them closely if production is to begin within the prescribed time limits and if the desired goals are to be reached.

The manufacturer must provide all the necessary technical data within the prescribed time limits of the general programme, including:

Plans and blueprints from his design department;
Norms and specifications;
Scales and operation sheets for each vehicle part;
Plans and technical data of the production facilities and installations for the particular vehicle in his factories;
Norms of control and approval, and control scales;
Similar technical data for other suppliers of manufactured products.

Basic studies should investigate the following:
Physical features of the plant site;
Buildings;
Installations for utilities;
General and ancillary departments;
Production facilities.

These studies can be carried out either by the engineering manufacturer who can deliver a fully equipped factory to the host country or by the host country's technicians on the basis of technical data furnished by the manufacturer and with the assistance of technicians from the main factory. The latter situation produces the maximum technical co-operation between the two parties.

Since one of the objects is to train the technicians of the host country as fully as possible, Citroën prefers the situation in which the studies are undertaken in the host country in "on-the-spot" collaboration with the manufacturer's technicians. However, there could be supplementary courses of instruction at the manufacturer's establishments for the host country's technicians during their training periods.

Indeed, if the manufacturer issues a manufacturing licence to the host country, and if he sets quality and engineering standards, Citroën considers the choice of means of production is largely a matter for the host country to determine.

For example, for the production of mechanical parts, the host country must decide whether to use a succession of standard machines which must then be adjusted or to use a system of automatic transfers. This decision depends on the local wages and on the purchase prices and operational costs of the machines to be adjusted as compared with the costs of transferring items.

The same conclusions are valid for forging (choice between hammers and presses), casting (choice of means of fusion), pressing (type of press and degree of automation) and coatings. The choice must be one that is most suitable to the development of the existing factory.

The object is not to operate spectacular plants and equipment but rather to produce a quality vehicle at the lowest cost by the most appropriate means.

5. Beginning factory operations

The co-operation between the manufacturer and the host country assumes a permanent character while the factory is under construction, the equipment is being installed and of course when production begins. Before production begins, there should be training periods in the manufacturer's factories for the shop managers, foremen, shift foremen and certain skilled workers.

The technical and manufacturing personnel of the manufacturer assist in the building of the plant, the installation of equipment and the manufacture of vehicles. They should also provide supplementary information whenever new problems arise.

The technical assistance of the manufacturer should continue during the lifetime of the vehicle; the results obtained by his research and development departments should be shared with the factory in the host country to ensure continuous improvement in methods of manufacturing and control and in the testing of all products and raw materials used in the manufacturing process.

During the period when the factory was under construction and the equipment was being installed, Citroën's experience was that the local suppliers were reluctant to produce parts which were not immediately used to produce a demand for a new order, even if the output rates were low.

In Spain and then in Argentina, Citroën did produce vehicles during the initial period of factory construction, with simple equipment in shops which later were used for different purposes. The term "pilot shop" describes an installation which permits operations during the preliminary, the first and part of the second stages, which are then regarded as transitional phases while the factory is being built and equipped in final form.

One of the principal tasks of the pilot shop is to plan the use of locally produced items. As soon as parts can be obtained from the local suppliers, they are fitted to the cars. The vehicles thus assembled in the pilot shop are tested and immediately delivered to selected customers in the host country. In this way performance of the locally produced items can be determined and necessary modifications introduced.

The pilot shop itself is an example that could convince the manufacturer's suppliers that technical and commercial co-operation parallel to the basic co-operation between the manufacturer and the host country would be in their interest. This stage provides a concrete framework for discussions and facilitates the conclusion of licence agreements and compensatory financial transactions between the host country and country of the manufacturer.

The pilot shop also has a time-saving function, since:

All technicians will gradually speak a common technical language; the terms are understood clearly and are not subject to misinterpretation or dispute under the conditions of mass production;

The processes of approval and the methods of quality control can be perfected in the pilot stage; and

The assembly labour force can be trained.

The results achieved in the pilot shop make it possible to begin mass production in the completed factory even though a percentage of national integration is not very high but is by no means negligible; or when there are some unsolved problems.

The investment in the pilot shop is small compared with that required for the construction of the completed factory. In any case, certain expenditures are actually investments. For example, the painting section of the pilot shop usually becomes the retouching shop of the completed factory

Moreover, the non-redeemable investments can be partially balanced by the savings in foreign exchange that result from beginning mass production with a certain percentage of national integration as compared with the assembly of vehicles from wholly imported parts.

In Spain, the pilot shop produced 1,410 vehicles in 16 months and achieved 12 per cent national integration in cost and 17 per cent in weight. The low percentages reflect difficulties with the local suppliers in 1958–1959. Very strict quality standards were set. The necessary effort was made to meet Citroën requirements by the Spanish factory and its suppliers.

In Argentina, the pilot shop produced 395 vehicles in 9 months; the degree of national integration was 20 per cent.

6. COST AND RETAIL PRICE OF THE VEHICLE

The technicians of both sides will have to estimate the industrial costs for the manufacture of a vehicle in the host country, since this is the basic prerequisite for all decisions which must be made by the local management.

Incidentally, Citroën has had to justify price/kilogram comparisons of its vehicles and other models; however, the vehicles have not always been of comparable types. A price/kilogram comparison of vehicles of different weights is generally to the disadvantage of the lighter vehicles.

When a country is importing complete vehicles, price/kilogram comparisons are valid between vehicles with similar characteristics and of approximately the same weight. (The particular qualities of each vehicle are unimportant to the estimate.)

On the other hand, when the vehicles are manufactured locally, comparisons of the retail prices are meaningless. A manufacturer's retail price in any country depends on his price policies and on the profit which he must realize on each vehicle, particularly in respect to the costs of research and development. This is extremely important because one of the basic premises of the technical co-operation between the manufacturer and the host country is that the host country will not have to include the costs of research; studies and tests in the retail price for these costs are assumed by the manufacturer.

On the basis of Citroën's experience, the average industrial cost includes:

Costs of finished parts from local suppliers (about 40 per cent of the total);

Costs of the necessary materials for the manufacturing processes (about 25 per cent);

Wages for forging, casting, machine operations, stamping and assembly (about 35 per cent).

These are the mean percentages prevailing in France.

In accordance with the list of parts bought from the suppliers by the manufacturer, the estimate of costs in the host country must be the result of consultations between the competent local sales organizations, the external suppliers and the personnel of the manufacturer's purchasing department, who would be assisted by the personnel of the organization selected by the host country to study the project.

The planned output rates and production timetable should be the basis of the negotiations of the costs of the following raw materials:

Casts and aluminium alloys;
Steels used in forging and screw cutting;
Sheet metals for bodywork and mechanical parts;
Tubes;
Coating materials and other manufacturing materials;
Textiles and plastic materials for the seats and trimming;
Wiring and other materials for the electric bundles.

The estimates would be facilitated if the prices in the host country are negotiated with the competent sales organizations on the basis of the planned output rates and production timetables.

For the locally manufactured parts, the labour costs must be estimated. The manufacturer provides the following information:

Time per work section;
Total personnel required in the factory;
Production personnel (including shop annexes);
Personnel included under general shop expenses;
Personnel included under general administrative expenses;
Shop expense percentages.
Indirect labour utilities;
General shop expense percentages (including expenses common to several shops). When local wage scales are known, the plant's manufacturing costs can be determined.

By adopting the same basis of calculation for different types of vehicles, it is possible to establish valid comparisons. The "factory price" is based on:

Amortization of technical equipment;
General administrative expenses;
Interest on borrowed capital;
Marketing expenses;
Fees for licences and technical assistance;
Factory profit;
Taxes.

To obtain the retail price, the remuneration of the salesman (dealer) must be added.

It has been shown how costs can evolve in relation to output. It has also been shown that a popular vehicle must be a quality product sold at a reasonable retail price; this objective can be achieved with a high hourly output.

In many countries it is understood that in order to industrialize, it is necessary to establish a motor-vehicle industry. However, the production of a small number of 100 per cent locally made vehicles is not industrialization but merely the use of limited facilities to obtain an expensive product. Nevertheless, a high output of certain vehicle parts is the beginning of industrialization.

It therefore appeared logical to Citroën to try to interest two or more countries in the same geographical area in manufacturing the same type of vehicle; certain parts would be produced on a co-operative basis in these countries in a complementary regional agreement.

A brief description is given below of the experiences of Citroën in Chile and in Argentina within the framework of bilateral agreements concluded by the Governments.

In 1964, Citroën began the fourth year of the integration plan in Argentina. Since it was necessary to achieve 92 per cent integration in costs by the end of 1965, provision had been made for appropriate investments.

Chile had achieved about 35 per cent national integration. The Chilean Government had predicted 85 per cent national integration in ten years, but the prospects for a popular vehicle (one to two vehicles an hour) in the Chilean market were not such as to permit the investment needed to ensure a high percentage of national integration.

The Chilean Government then stated that it would consider a part imported from Argentina to be of local origin (for the purposes of their integration plan) if Chile could export an equivalent value to Argentina.

Argentina currently produces five times as many cars as Chile, while the combined hourly output of the two countries exceeds six vehicles. The breakdown in percentages is shown in table 1.

TABLE 1. IMPORTS AND COMBINED OUTPUT RATES IN ARGENTINA AND CHILE

(percentage)

Argentina (hourly output *a*)	
European imports	5
Chilean imports	4
Production in Argentina at the combined output rate of the two countries (*a* + *c*)	20
Argentina (*a*)	71
	100
Chile (hourly output *c*)	
European imports	40
Argentine imports	20
Production in Chile at the combined output rate of the two countries (*c* + *a*)	4
Chile (*c*)	36
	100

The vehicles produced are 60 per cent of South American origin in Chile and 95 per cent of South American origin in Argentina. In calculating the percentage of South American origin, Chile assumes that any component imported from Argentina is 100 per cent South American in origin, since the consequent understatement of expenditure on foreign exchange is small. Chile's investment pertains to only 40 per cent of the vehicle. The experiment is continuing; the goal for Chile is a 90 per cent South American vehicle and perhaps even 100 per cent if the production facilities of the two countries permit.

The financial agreement between the Citroën plants in Argentina and Chile began with a number of restrictions which have been progressively eliminated, in particular those pertaining to local suppliers, who have been carefully selected.

The exchanges of vehicle parts are effected as follows:

At the European list prices in $;

Without customs duties or taxes;

With strict payment in $.

The attendant packing and transportation costs must be compensated by higher output, fewer amortizations, better quality, and, consequently, a smaller number of rejects.

Two countries in the same geographical region can thus agree to produce jointly 100 per cent of a vehicle, each country contributing:

A non-exportable percentage of local origin;

An exportable percentage of local origin produced at a high output rate (the sum of both countries' output rates);

A percentage of imports from the other country.

In table 2, these percentages are shown for two countries A and B whose annual production capacity is 25,000 and 175,000 vehicles respectively.

TABLE 2. PRODUCTION AND BREAKDOWN OF IMPORTS AND EXPORTS BETWEEN COMPLEMENTARY COUNTRIES A AND B

	A	*B*	*A+B*
Annual production (vehicles) ..	25,000	175,000	200,000
Hourly output (vehicles)	6	42	48
Ratio of productions	1	7	8
		percentage	
Non-exportable percentage of local origin	20	20	20
Exportable percentage of local origin	10	70	
Imported percentage	70	10	80
Total	100	100	100

The non-exportable percentage of local origin includes:

Items which can be purchased locally and need not be imported from the other country (tires, batteries etc.);

Partial or total assembly of mechanical parts to permit the incorporation of local items which need not be imported from the other country;

Assembly of the bodywork and subsequent application of coatings;

Assembly of the vehicle.

This percentage can range from 10 to 30 per cent. In table 2, 20 per cent was assumed.

The respective percentages of the exportable local percentage and the percentage imported from the other country are inversely proportional to the output of each country. The percentages should include items which can be supplied by one or the other country in such a way as to permit financial adjustments in accordance with possible variations in the output of each country.

A close study of table 2 shows that to produce vehicles in both countries without currency outflows, country A must provide up to 30 per cent of the investment and country B up to 90 per cent. In general, the investments of country A to produce 30 per cent of the vehicle are less than 30 per cent of the investments needed to produce 100 per cent of the vehicle at the output rate of country B. Generally, the country with the higher output assumes the more costly investments.

In manufacturing 80 per cent of the vehicle, country A benefits without any foreign exchange burden from the reduced componen. price levels made possible by a total scale of production which is eight times its own. In both countries, the production costs decrease when making 80 per cent of the vehicle at a higher output rate, while depreciation charges decrease.

The operation is especially advantageous for the country with the smaller output, but then the more developed countries should aid the less developed ones in the same geographical area to enable them to industrialize and produce vehicles without currency outflows. Of course, these principles are applicable to more than two countries.

CONCLUSION

The main problems in technical and industrial co-operation between a manufacturer and a host country which desires a motor-vehicle industry, as discussed above, indicate that this co-operation can take different forms depending on the degree of industrial development in the country, and depending on whether the object is to create a motor-vehicle industry or to expand an existing industry.

The world needs cheap transportation to help solve many problems, for example, the mobility of the labour force. This demand for transportation indicates that the motor-vehicle industry is an industry of the future. It can be a pilot industry which provides employment for many persons in all sectors of economic activity.

It is natural for present-day manufacturers to wish to pass on their experience and know-how to other countries. The harmonious progress of the complex venture, whose purpose is to produce a vehicle at the lowest cost consistent with a predetermined quality standard is indissolubly linked to the achievement of close and continuous co-operation between the host country and the foreign-based manufacturer.

The framework within which this co-operation must take place has been defined in this paper with a view to stressing its international importance in the development of mutual understanding between all peoples.

THE RATIONALE OF THE GRADUAL DEVELOPMENT OF THE AUTOMOTIVE INDUSTRY FROM ASSEMBLY OF IMPORTED PARTS TO COMPLETE LOCAL PRODUCTION

*Fernand L. Picard**

Introduction

Prior to a consideration of this study, some basic questions must be answered. Is it wise for a developing country to expend a large part of its human and financial resources to create an automotive industry, when all kinds of vehicles can be supplied more cheaply by industrialized countries? Is this the best possible use of human and financial resources?

It is not possible to give a general affirmative reply that is valid in all circumstances, traditions and economies. All these factors deserve careful consideration in each particular case. In fact, it would be dangerous to give a categorically negative reply, based either on logic or on economic principles.

The automotive industry is an integrated industry that is accompanied by other basic industries; their development enriches the economy of a country. The automotive industry requires large supplies of raw materials and manufactured goods such as steel, castings, light alloys, plate glass, textiles, paint, chemical products and electrical equipment. To obtain these supplies, mines and quarries must be opened and new processes adopted; factories must be built, which could also manufacture parts for other industries, in particular domestic appliances such as refrigerators, stoves and washing machines.

The industry creates a large demand for trained personnel: skilled workers such as smiths, welders and tool-makers, and technicians and managers. National technical and teacher-training colleges are necessary for their education. Other industries would also benefit from the availability of trained personnel.

The strict requirements of the automotive manufacturing industry generate a feeling for quality combined with quantity. Quality is difficult to achieve in a developing society and even more difficult to maintain. It requires great mental and physical discipline and a firm adherence to rules at every stage. Such virtues are rare in people who have not been trained in such restraint. They must stop doing things approximately and "almost good enough".

However, this new mental attitude, once acquired, tends to spread. A workman or foreman will take it outside the factory into his daily life at home. Social life is likely to become more methodical. Similarly, in relations between labour and management, this attitude helps management to see situations more clearly and to refrain from constantly modifying its decisions. The beneficial effects of industrialization are especially evident in the automotive industry with its rigid requirements, its complex manufacturing processes, and the manifold uses and popularity of the finished products.

1. Conditions for the establishment of an automotive industry

The currently available resources and the immediate and long-term prospects of economic development must be assessed carefully to ascertain the existence of a sufficient market. The automotive industry would be a part of the national economy from which it would buy raw materials, hire qualified and experienced personnel and obtain capital to finance its operations and investments.

Market

The market potential must be defined. The data from other countries may suggest the nature of the market, but an intensive study of the national market must be undertaken.

The study should embrace not only the market potential for private vehicles but also the complete national transport requirements. Every developing country should have a well co-ordinated transport system that will move both passengers and goods cheaply over all its territory.

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In organizing such a system, important determinants are the geography and terrain of the country and the distribution of natural resources and population. Although it is relatively easy to enumerate these factors, it is essential to project their evolution for a period of ten to fifteen years by a research survey and not merely by mathematical extrapolation. For example, it would be a serious error to disregard either the continuous decrease of the rural population or the expansion of industry and services in the urban centres.

The growth of transportation precedes growth of the industrial and commercial sectors. The research study should determine whether the existing transport systems (seaports, railways, roads, navigable waterways and airports) can bear an increase in traffic or be sufficiently developed to meet increased transport needs. The potential role of road transport—either long-haul (heavy trucks with semi-trailers) or delivery and cargo-transfer vehicles—should be included in the study.

In the initial phase of development there is usually an increase in collective passenger transport, primarily inter-urban buses, since tramways are not feasible. Small buses suitable for short-distance routes are advantageous: they can adapt to traffic increases during transitional periods; and they do not require large investment in the infrastructure. Moreover, buses are usually manufactured from the same mechanical components (engines, transmissions, bearings, gears and brakes) as heavy trucks. Coach-building requires the same skills as the building of horse-drawn coaches in the past.

Collective passenger transport is a transitional phase pending the development of private transport. It would be unwise to concentrate investment in the manufacture of the equipment needed during this period. The vehicles should be manufactured quickly and in sufficient quantity to satisfy the demand. Subsequent manufacturing will be of replacement vehicles only at the annual rate of 10 per cent. This percentage should be borne in mind when contemplating the construction of automotive factories.

A very interesting study of the number of the private vehicles and national *per capita* income was carried out by Henri Hondermarcq.[1] The results indicate that in 1960 the vehicle density per thousand inhabitants in relation to the *per capita* income of the countries selected was distributed in logarithmic co-ordinates almost along a straight line (figure 1). Another statistician expressed the vehicle density in an equation and concluded that the number of vehicles per thousand inhabitants varies proportionally with the exponent 1.8 of the national *per capita* income (number of vehicles per thousand inhabitants = *per capita* income exp. 1.8).

The maximum number of potential vehicle owners in a given country and the increase of potential owners

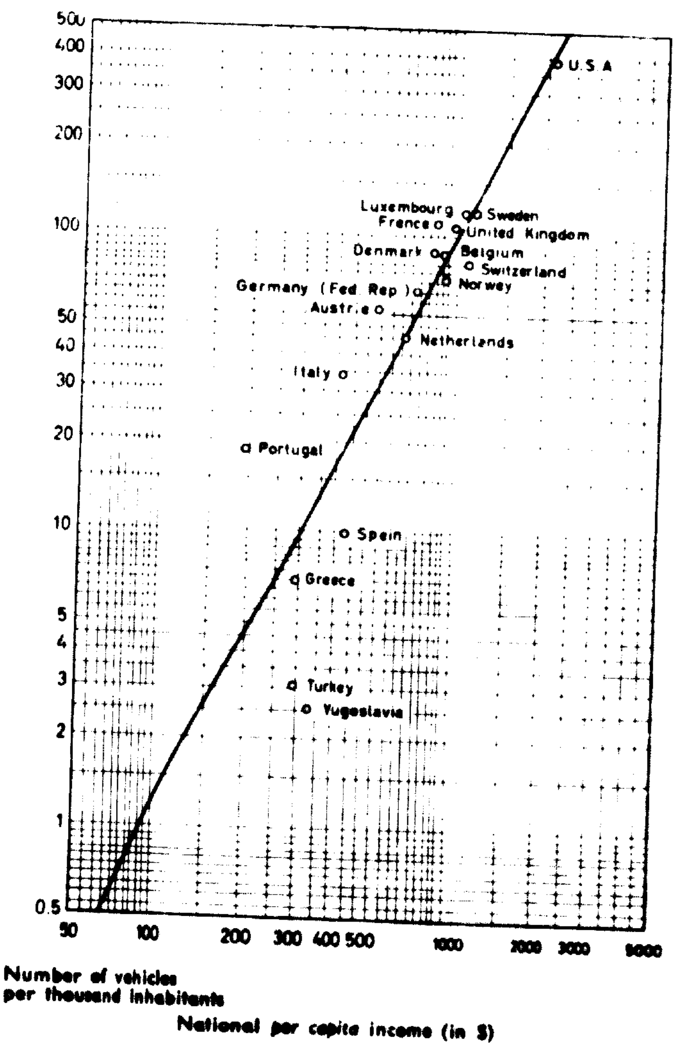


Figure 1. Hondermarcq graph of the number of vehicles per thousand inhabitants in relation to the national per capita *income in 1960*

in proportion to the growth of *per capita* income can be calculated from these studies. However, the calculated figures are approximations that must be interpreted in accordance with the social structure and political system of a particular country. It must also be borne in mind that these figures include private vehicles regardless of their size and weight. In certain developing countries, the socio-economic structure of the vehicle-owner population is quite different from that found in more advanced countries where the tendency towards relative equalization of income has resulted in a homogeneous structure of private car ownership.

Nevertheless, it remains true that, for a country with, for example, 10 million inhabitants and an annual *per capita* gross national product of about $400, it would be unreasonable to plan on the basis of 500,000 private vehicles, whereas the Hondermarcq graph indicates only sixteen vehicles per thousand inhabitants, that is a total of 160,000 vehicles.

From these considerations it is possible to plan a general programme for ten years with a forecast (on the basis of anticipated growth in population and gross national product) of the annual increase in the number

[1] H. Hondermarcq (1960), "Le programme routier belge", *Transports*, July—August issue.

of utility vehicles, coaches and buses, and private vehicles.

The annual maintenance and renewal of the existing vehicle fleet necessitate the production of a number of vehicles that is roughly equal to one tenth of the current population.

The Government of the country must determine the proportion of the total number of vehicles to be imported and the proportion to be locally manufactured. The Government must then modify the country's laws and customs regulations accordingly.

If the domestic manufacture of vehicles is to be encouraged for the reasons enumerated in the introduction, the Government must determine the number of vehicle manufacturers permitted to operate in the country and the number of different models they may manufacture. In view of the technical and financial requirements for the establishment of an automotive industry and the consequences of failure, the development of the industry should be closely supervised in developing countries. The position is quite different in economically developed countries, where a liberal policy, with all its risks, may be followed without danger of serious damage to the national economy.

Road system

A network of roads is essential for the development of a motor industry, even though initially it may be disproportionately large in relation to the actual traffic. The system must cover the entire country and not be restricted to cities and their immediate suburbs.

An accurate assessment of the present state of the road system must ascertain: the number of kilometres of paved highways, dirt highways, unpaved secondary roads and mere tracks; the maximum gradients of the roads in hilly country; the nature of ancillary facilities—for example, maximum width and load-bearing capacity of bridges, dimensions and slip-way gradient of ferries; the actual conditions of the roads—for example, are there holes, open transverse gullies or pot-holes in them? Are they dusty or muddy during any season?

These data are vital to the selection of the type of vehicle (i.e. whether utility vehicle, bus, coach, or private passenger vehicle) most suited for the country in question, and of a method for adapting it to ensure maximum efficiency and minimum expense in its use.

Active implementation by the Government of plans for the development and financing of the road system, would give added impetus to the motor-vehicle construction programme and to the necessary financing of it.

Ancillary industries

If the long-range goal is a local automotive manufacturing industry capable of satisfying the normal motor-vehicle requirements of a country, other industries must be developed to supply the basic materials; of these, the most vital are the steel and petroleum industries. The establishment of these industries can be postponed to fit the country's over-all development plan; however, this must be taken into account in the scheduling of the future use of locally produced materials.

The steel industry must produce high-quality steel because the manufacture of motor vehicles requires considerable quantities of carbon and alloy steels. The quantity of steel needed to manufacture one unit varies from 800 to 1,500 kg; 50 per cent of this is high-quality sheet steel for bodywork and 25 per cent special steels for transmission gears, steering gear, and engine and suspension parts. The quality of steel is quite different from that for beams, rails or reinforcing bars, that are generally produced in large quantities. Special steels alloyed with metals such as nickel, chromium or manganese must meet a number of strict standards.

An order of priority must be established for the delivery of these steels by local steel works that is consistent with the plans for using locally produced components. Highly specialized steels that are used in small quantities, such as valve steel and stainless steel, can be imported for several years without seriously affecting the cost of components. The thin sheet steel used in the manufacture of vehicle bodies requires highly skilled technicians and heavy investments in very specialized equipment; it should be imported until the quantities required for local industries—and possibly also those of neighbouring countries—are sufficient to warrant the full use of such equipment and to amortize its cost.

The petroleum industry supplies the necessary fuels and lubricants. However, the possibility of domestic refineries must be carefully studied. The fuel specifications must meet international standards, particularly the octane rating, to avoid complications in the lengthy period during which engines must be imported.

Apart from the primary materials, almost one quarter of the cost of a motor vehicle represents the costs of parts and units usually produced by other specialized industries. Most countries today, even those not highly developed, produce sufficient glass and textiles for domestic use. An inventory of the production capacities of these industries is vital to determine their potential to meet the quality and volume requirements of a local motor-vehicle industry.

Specialized firms must manufacture additional parts that are not usually manufactured by the motor-vehicle industry. These include expendable components such as tires and tubes, brake and clutch linings; electrical equipment such as batteries, dynamos, starters, coils, distributors and sparking-plugs; specialized parts such as carburettors and fuel injection pumps; accessory equipment such as windshield-wipers and dashboard instruments; body parts such as locks, hinges and window mechanisms, headlights and other lamps.

Such equipment is generally manufactured in accordance with national and international standards with very little variation. Therefore these accessories should be produced by competent local firms with the technical assistance of specialists from the country of the co-operating manufacturers. The production facilities required for these accessories are generally smaller than those needed for the manufacture of motor vehicles and therefore production can begin more rapidly.

In order to reduce imports, it is generally advisable to establish parts-producing firms requiring only limited capital before the actual assembly-line production begins. These firms can then provide good-quality accessories during the CKD (completely knocked down) assembly. Local industrialists must seek their foreign partners from among the most highly qualified and best known in the field, follow their advice and avoid makeshift methods, improvising or using untested techniques. Experience shows that these are very serious mistakes that may be primarily responsible for the poor reputation of locally produced vehicles.

Technical staff

The very future of the industrial and economic life of the country is dependent upon an adequate labour force. A firm can organize an apprentice school to train young recruits to become skilled mechanics, or it can provide advanced instruction for skilled workers. But the firm cannot educate engineers and technical personnel. Because a long-term reliance on the assistance of foreign engineers and technicians is usually undesirable, a technical and professional training system on all levels must be developed within the country to provide all of its industries with educated personnel. This is a governmental responsibility. A Government that wishes to stimulate industrialization must seek aid and assistance to plan curriculum requirements and to obtain experienced teachers for its technical schools. The lack of qualified men who are capable of adapting themselves to new methods must be overcome.

If there are existing local universities to provide scientific training, technical schools could be established within the existing framework to use their teaching staff. The staff should, however, possess the proper qualifications because the education of technicians and engineers differs from a liberal arts education. Economics, commerce and industrial psychology are important subjects in the education of engineers and technicians.

Special training programmes for other adults should provide the general mathematical and scientific knowledge necessary to understand the new techniques. The engineers seconded from the co-operating manufacturer could participate in this programme if they share a common language. This collaboration could also have a very favourable psychological effect on the over-all co-operation within the enterprise. It will lend an experimental tone to the training and make it more attractive for adults by showing them its advantages.

The co-operating manufacturer and the vehicle to be produced

The selection of the manufacturer with whom to enter negotiations for the local production of motor vehicles is affected by several conditions.

The choice will obviously be influenced by the pattern of historical ties, particularly those of a common language, for close links must be established between the local factory and the co-operating manufacturer. The technical experts who are recruited for the particular country may wish to teach or study at local universities and technical schools. If two languages are involved, the basic documentation must be translated and even the units of measurement may have to be converted, for example from the foot-pound system to the metric system.

Community of interest is also a fundamental prerequisite for the proper solution of the many financial and commercial problems. The common interest may include factors such as membership in the same monetary bloc, current trade agreements and relations, and similar political systems and international policies.

The foregoing would suggest that relations would be easier between the United Kingdom and the countries of the British Commonwealth or between France and its former dependencies and territories than between other countries. However, these are not absolute conditions, since the currents of trade fluctuate as much as those of political relations and, indeed, affect them.

Commercial considerations are as important as technical data in the final selection of the specific vehicle to be manufactured. Financial considerations, especially credit terms, can lead to the selection of a vehicle which may not be technically altogether suitable. Likewise, the commercial policy of manufacturers will have a great influence at this stage of the negotiations; some manufacturers are more attracted to international co-operation than others who concentrate primarily on their own national markets.

The vehicle must then be adapted to the particular local conditions before the planning of operations. It is seldom that the original model of a vehicle is well adapted to overseas conditions. The climate, the terrain and the local cultural patterns may require modifications (see appendix 1). These modifications are authorized after investigations and tests in the country itself by the expatriate technical experts and the decision-making staff of the licensee's commercial, sales and service departments who would gain detailed knowledge of the product that is to be marketed in a competent and confident manner.

Financing

Financing may assume different forms depending on the degree of financial collaboration between the local manufacturer and the co-operating manufacturer. Both parties must candidly study the question of financing during the initial planning of the project. All items on the investment and operating budgets must be taken into account.

At the very least, the study must include:

A financial plan for several years that specifies as precisely as possible the amounts and schedules of all expenditures and ways to fulfil them. The rate of integration of local industry must be in accordance with the means available for financing the necessary investments to permit operation of local industry (for example construction of foundry, forging shop, machine shop, press shop etc.);

Manufacturing cost data that indicate the expected reductions from the proposed measures.

No expenditure must be omitted from these forecasts. Thus, account must be taken of:

Investment in the purchase of land, the construction of factories, and in the purchase, transport and installation of machine tools;

Costs of shipping, manufacturing and storage of parts in order to maintain stocks. These stocks must be large enough to cover any short-term difficulties in manufacturing (for example strikes in the suppliers' factories) or shipping (for example inclement weather and customs delays);

Costs for the establishment of sales and service facilities and, in particular, of stocks of spare parts throughout the area in which the vehicles are to be sold;

Large scale credits to dealers in the sales network and to the customers. This point is of particular importance in order to stimulate purchases in countries where *per capita* national income is low. Financing the purchase of a vehicle is a difficult matter; therefore credit assistance is essential.

Location of the factory

The location of the factory is of the greatest importance for it affects the entire future of the enterprise. It affects the quality of the vehicles produced and their manufacturing cost. Conditions will vary with the phase of industrialization: Will the factory only assemble vehicles or will it completely manufacture them? The choice is determined by the long-term plans. If the ultimate objective is complete local manufacture, the possible advantages that the choice of a particular situation would provide in the first phase may have to be sacrificed, as the first stage will be completed in only a few years.

A suitable location for an assembly plant would be the vicinity of a port that is equipped to handle heavy and cumbersome crates and to dispatch vehicles throughout the country. The creation of a free port may have certain advantages if a large number of assembled vehicles are to be exported to neighbouring countries. Distribution is always difficult and expensive, particularly in areas where the road and railway systems are poor or unreliable.

A port location also has the advantage of facilitating contacts with the customs administration. This is by no means a negligible consideration in the initial production period when many administrative problems arise. It may be necessary to reduce the stocks of imported parts by leaving them within the customs area, thus avoiding the immobilization of financial resources. Proximity to the customs administration may also reduce the time required to begin the production of finished vehicles.

In the case of complete local manufacture, the choice of the ideal location is more complicated; the various optimum conditions may be contradictory. However, the economic considerations will be the primary factors in this decision; they will determine the success or failure of the enterprise, since the final objective is the economical production of high-quality vehicles.

The local manufacturing plant must be adjacent to a junction of rail, road and, if possible, river transportation, so that the raw materials and products purchased abroad or in other parts of the country can be economically transported to the factory and the finished vehicles shipped to the dealers. An operational study should assess the future needs: Where will the main suppliers be located? Where will the major customers be located? Delimit the optimum area for economical distribution of finished vehicles in all seasons.

The plant should be located in a large population centre where sufficient personnel can be recruited by the automotive industry. This problem will not be the same in all countries but will differ according to local history and tradition. A country with traditional handicraft production will be in a better position to provide an automotive labour force than a country that specializes in agriculture or particularly, in animal husbandry, one whose population consists largely of nomadic groups.

The demographic situation must also be taken into account. Young workers who are not entrenched in occupational habits and practices will be easier to train and to adapt to industrial routines. The plant should be near a university and technical schools so that professionally qualified technicians and engineers can teach basic and advanced courses to the managers and supervisors. Ideally, there should be a dynamic relationship between the factory and the university. The expatriate engineers who provide the initial technical assistance to the factory may also teach at the university and technical schools that in turn provide the factory with newly trained engineers and technicians.

It should also be remembered that foreign engineers will not be willing to settle in a country unless it provides attractive cultural facilities and educational opportunities for their children.

The terrain should be as level as possible and not subject to flooding. Adequate supplies of water and electricity must be available. The climate should be as temperate as possible to provide optimum working conditions without expensive heating or air conditioning installations. It should also be as dry as possible, since humidity causes oxidation of parts and thus necessitates costly special treatment. The site should be free from sand-bearing winds, as dust shortens the working life of machine tools and impedes painting.

Finally, the site must be consistent with the existing national development plans. However, care should be taken not to over-emphasize the importance of choosing a site in a region qualifying for the maximum government subsidy. The immediate benefit might mortgage the future indefinitely. Even temporary relief in the form of credit might place a heavy burden on future net production costs.

After the site has been chosen, plans for designing and building the factory must be made. As a basic principle, the management of the undertaking must have complete freedom of decision regarding the choice of the site, the architect and the contractor; it must not yield to local pressures.

The surest way to reach the right decisions quickly is to obtain assistance from the manufacturing firm granting the licence. Experts should indicate the ideal site for the immediate programme and subsequent expansion and contract the design of the installations and the supervision of the operations to an experienced engineering firm. An optimum site can thus be chosen with a view to future expansion and to stockpiling when, for economic or climatic reasons, deliveries are delayed. The overseas experiences of Renault indicate that the area of the ideal site should be at least three (preferably ten) times the area of the initial project.

The layout should provide optimistic, but not over-ambitious, opportunity for subsequent extensions of the assembly shop at minimum expense and without demolition of the original installations. The paint shops in particular, which are needed from the very beginning, are very costly and could not subsequently be moved without halting production.

Solutions that appear to be time-saving and easy, such as the purchase of a vacant factory from another business, should be avoided. Economical and high-quality production requires plants specifically designed for the automotive industry.

2. The phases of integration

The laws and regulations to which automotive manufacturers are subject in developing countries are not discussed here; the actual process of establishing and developing an automotive industry is studied.

There are three principal phases in this process:

Assembly, during which most of the components are imported;

Incorporation of locally made items in the production while still using imported tooling until production is almost wholly local;

National autonomy in tooling and vehicle research. This is the ultimate objective.

The assembly phase

The assembly phase can be divided into two logical stages. In the first SKD (semi knocked down) stage an imported vehicle is assembled, that is, the bodywork (a completely welded shell that already has been painted), complete units of mechanical components and the interior trim and fittings are only assembled to produce a complete vehicle.

In this most satisfactory temporary solution, expensive welding and paint shops are not necessary. As a take-off point for a more thorough integration, it facilitates the recruitment and training of the labour force for the final assembly line. It demands the establishment of an organizational nucleus and a quality-control department. It also provides the opportunity to organize sales and service departments and to train repair and maintenance workers throughout the country.

After paint shops are operative, unpainted bodies can be imported. Since customers often equate the quality of a vehicle with its finish, painting should begin only when there is certainty that the resins used for priming and finishing coats will be of good quality, and that the labourers are able to perform the task satisfactorily. The decision to import unpainted bodies must be approached with caution. Terms and products must not be confused. Light gauge sheet metal in transit requires protective greasing. It is difficult afterwards to remove the protective greases, which penetrate the welded joints and mar the finish. The term "unpainted" therefore pertains to sheet metal with a first coat of primer that is not liable to additional customs duty as untreated sheet metal.

In the second CKD (completely knocked down) stage, the following components are imported as units: bodywork without welding, in more or less complete units (platform frames, body panels, dashboards, hoods, bonnets and wings); mechanical parts in complete units that have been assembled and tested (motors, transmissions, steering gears, front and rear suspension), and fittings and trim.

However the CKD stage progresses to the import of subassemblies or even sets of pieces to be assembled. Consequently, small sheet-metal items can be produced locally with simple tooling or by craftsmen using their traditional hand tools. This CKD stage requires the installation of welding and body-building shops with more skilled workers than are required for simple assembly.

The imported assembly and welding equipment should be sturdy and simple with no regulating equipment accessible to the workers, who may attempt adjustments without knowledge of the proper methods and mechanics.

In incorporating locally made items, priority should be given to those already being manufactured within the country, that is, parts subject to wear and tear in existing vehicles such as glass, tires, tubes and batteries and to standard components already utilized by other manufacturers and produced under their technical assistance programmes such as dynamos, starters, windshield wipers, headlamps, radiators, door handles and steering wheels.

This is a delicate phase. High-quality articles are difficult to obtain, as most producers do not have the necessary tooling to ensure quality. A quality-control section for outside supplies must have the necessary apparatus to check incoming articles against specifications. Technical experts should visit the suppliers; the initial deliveries should be controlled in the laboratories of the co-operating manufacturer.

Extensive preparations are now essential in the co-operating manufacturer's home factory. After the items to be forwarded have been specified, they must be assembled, packed and shipped. The methods vary according to the size of the consignments, the number of models to be built simultaneously and the distance between the manufacturing and assembly plants. If these two plants are on the same continent, the goods can be shipped in specially fitted wagons. If an ocean separates them, as is almost always the case, then expensive packing suitable for maritime shipment and protection against impact and oxidation is needed. (For example, CKD packing for 50 Renault 8 models comprises 45 crates with a total volume of 306.7 m^3.)

It is not always easy to reconcile a "lost" expense and the need to deliver the parts to distant shops in the same condition as they would arrive at the manufacturer's own assembly line. For instance, the packing materials and labour for a Renault 10 model cost as much as complete assembly in the manufaturer's own factory. This explains the high cost of SKD or CKD assembly when progressive development of integration of locally produced accessories and parts is not included in the plan. This tendency is bound to become more pronounced in the future since assembly operations are easier to mechanize than selection and packing. The CKD method is, however, still recommended for very distant destinations because of the savings in freight charges, particularly during periods of intense business activity.

Obviously, the items transported with such care must be unpacked and carefully and methodically stocked in sheltered premises.

Technical expertise is indispensable during the assembly phase. Welding and paint specialists should assist the local management in beginning operations in the new plant. Similarly, specialists should also train the assembly staff.

An engineer seconded by the co-operating manufacturer should provide technical liaison, control the quality of locally purchased accessories and equipment and also supervise any necessary modifications and adaptations. Similarly, a service technician should assist the local management in planning stocks of spare parts and in training mechanics in maintenance and repair procedures and techniques.

Incorporation of locally made components

The gradual incorporation of components of local origin must be planned by experts as soon as the first contract for co-operation is signed to ensure that vehicles built or assembled abroad meet the quality standards of the co-operating manufacturer at the lowest possible net cost.

The substitution of imported parts by locally made items will be necessary for several reasons:

- Some parts or products may be difficult to transport or may deteriorate during transportation, such as batteries, paints, stoppings and adhesives;
- Freight charges for the transportation of large-dimension parts considerably increase their price. This applies to tires, wheels, seats (frames and upholstery), petrol tanks and air filters;
- Heavy customs duties may be levied on certain parts or accessories, particularly in countries where protective tariffs shield an established local industry against foreign competition;
- The cost of materials or labour may permit the manufacture of certain parts locally, even on a small scale, at smaller costs than the shipping costs and customs duties for imported parts. Seat coverings very often are in this category;
- The legitimate desire of the Government for the employment of as much local labour as possible in craft occupations such as the manufacture of seat coverings, electrical wiring etc.;
- Two or more of the above reasons may favour local manufacture, although it is not possible to identify the decisive factor.

Other factors which must be taken into consideration are the financial relationship between the licensee and local industrial groups, or the insistence of the Government that the final product contain a given percentage of locally manufactured components.

The selection and schedules of the parts to be made locally require detailed study. If an automotive industry is already established, there may be local factories of foreign manufacturers which produce accessories and equipment; these factories could produce standard or special parts as is the case with ball- and roller-bearings, propeller-shaft and connecting-rod bearings, inlet and exhaust valves, valve springs, engine pistons and rings, steering wheels and items moulded in rubber or plastic. Such factories are usually well equipped and staffed. Co-operation has made it possible for them to attain the requisite quality.

It would not, however, be appropriate to contemplate the incorporation of locally produced basic parts (pistons, ball bearings or plain bearings) in assemblies for which the main parts (engine and transmission), are produced in the co-operating manufacturer's shops because it would require the import of these mechanical assemblies as seperate parts and thus substantially increase the volume and costs of packing and shipping. It would also lead to shifts of responsibility for quality and thus inevitably to conflict between the co-operating manufacturer and the licensee.

In some cases local plants manufacture clutches, brakes or transmissions to European or United States standards under licence. These parts can be adapted to the vehicles to be built; however, these parts cannot be regarded as standard. The incorporation of vital parts such as cylinder blocks, cylinder heads, crankshafts, gear-boxes and bodywork raises highly complex problems and requires very large-scale technical and financial resources.

Local production of these items requires substantial capital investment; the difference in volume as compared with that of the co-operating manufacturer would entail a less technically advanced production line from the standpoint of mechanization and automation and consequently higher net costs. Indeed, local production of basic parts should not be contemplated unless the law requires the inclusion of a minimum percentage of locally manufactured parts.

The initial studies prior to the planning of local production must be undertaken by the co-operating manufacturer or by a qualified engineering company under his direction. In most cases, standard or special machine tools must be imported as well as special equipment for production and testing. Special problems arise in the case of castings and forgings. If there are existing local foundries and forging plants, the supply of rough parts may be subcontracted after a technical investigation to ensure that the facilities can produce parts of the requisite quality. The production shops can begin operations with imported blanks; then the manufacturing plans would not be delayed. Local production of parts will progressively increase as additional subcontractors meet the quality standards. Facilities for producing blanks of advanced design involve pressure casting in light alloys and foundry precision work with ferrous metals; they will not be immediately available. If blanks cannot be imported, special designs must be made for the crankcase or mechanical parts. Crankshafts made in Europe in special cast steel will inevitably have to be forged locally because, as a rule, very few foundries in developing countries have reached the required level of technology. Special studies and endurance tests will be necessary.

Other difficulties arise in connexion with the use of special steels made in local works. High-quality steels, such as alloy steels, that meet rigid standards, are required in vehicle construction. These steels can be produced locally according to the required specifications, but their use will call for the greatest circumspection. In fact, these steels will have to be imported until the quality of the local product can be fully guaranteed. During this phase the role of the test laboratory and of its quality-control facilities will be vital. The test laboratory should be under the direction of an engineer seconded by the co-operating manufacturer.

The locally approved samples should be sent to the co-operating manufacturer's laboratory to undergo shape and dimension tests, as well as endurance tests for each part separately or the complete vehicle. The basic materials and the effects of heat treatment should be analysed. Only after the laboratory approval of the sample should the locally manufactured part be used. The local quality-control section must also ensure that the series production conforms strictly to the standards.

Manufacture of the bodywork also entails heavy capital investment. Present-day techniques of shell construction with electrical welding of pressed sections require very costly equipment and special tooling for pressing, stamping and assembly. If this equipment is to be amortized over a reasonable period, large-scale series production will be necessary.

As sheet metal of the required quality is very difficult to obtain locally, local production of the pressings should not be attempted in most cases. A more attractive financial proposition, from the standpoint of capital investment and net cost, is to continue to import them and complete the shell and sub-units locally with tooling supplied by the co-operating manufacturer. Moreover, in contrast to mechanical units, the packed volume is reduced, and thus also the costs of packing and shipping.

A press shop should not be built until the volume of production warrants its operation.

National autonomy in tooling and vehicle research

The phase of national autonomy in tooling and vehicle research is very difficult to predict as it depends much more on external circumstances, on expansion of the industry and on the general prosperity than do the preceding phases. It will extend over a period of many years. Actually, its first manifestation occurs at the beginning of the SKD stage, and it then assumes more definite form during the phase in which locally manufactured products are used in the production.

Local autonomy in methods of producing equipment is a natural result of the development of the maintenance and service shops; they gradually manufacture more complex equipment as qualified staff increase their experience and competence with the help of foreign personnel. Some of the most sophisticated plant equipment can be built locally in accordance with the methods and designs supplied by the co-operating manufacturer.

The problem centres on the availability of local technicians. Technical training as well as production planning is the responsibility of the foreign engineers. For the most capable trainees, on-the-job training should be supplemented by courses in the shops and offices of the co-operating manufacturer. In the interest of maximum efficiency, language training should also be provided at school and later in the factory.

There should be provision in the investment budget for expansion of the facilities for production of tooling and inspection equipment in order to increase the capacity for precision work. Basic training and advanced courses will enable the most able workers to improve their skills.

The achievement of national autonomy in vehicle research follows a parallel course, but its origin is in the quality-control and testing departments. A modest beginning may be made through technical liaison with the co-operating manufacturer in developing equipment specially adapted to local conditions and in the implementation of modifications that are suggested by his laboratories.

The management should recruit young engineers and technicians from local technical colleges and further their contact with expatriate engineers to increase mutual respect and co-operation. They would also be stimulated by study tours and in-service training at the headquarters of the co-operating firm. This training should be highly specialized to cover only a single department (engines, transmission or bodywork). A general course could be given later.

The research office is initially a classification and nomenclature registry, but later it must suggest modifications, improvements and adaptations to suit their customers. Soon both the local office and the research office of the co-operating manufacturer will work on the same problems; the merits of their respective solutions would then be discussed.

In the evolution of new models, the local research office could suggest changes in a new vehicle, for example retaining the same engine or transmission when the manufacturing installations have not yet been sufficiently amortized. It may also develop components suggested by a local supplier.

To be fully effective, this work of research and development must be carried out with the whole-hearted support and collaboration of the co-operating manufacturer. It is in the interest of the local firm to maintain close relations with the co-operating manufacturer, and thus benefit from his experience and profit from his research.

There is the psychological difficulty that the pupil will eventually want to shake off the tutelage of his master but with mutual goodwill, both parties will be rewarded.

3. EXAMPLES

Since 1946 the principal United States and European manufacturers have collaborated with overseas countries to establish local automotive industries. The situation of 30 June 1966, with respect to factories or assembly lines working under licence (Part III of this publication) is summarized statistically in table 1.

TABLE 1. LICENSED AUTOMOTIVE INDUSTRIES

	Number of assembly lines in operation	*Number of countries in which these assembly lines have been installed*
Federal Republic of Germany (excluding Ford and Opel)	55	22
France	62	26
Italy	25	22
Japan	49	22
Sweden	10	8
United Kingdom (excluding Ford and Vauxhall)	64	27
United States (including German, Australian and British subsidiaries)	122	41

The important automotive manufacturing countries control (completely or technically) almost 400 factories or assembly lines in 55 countries. There are, however, wide differences in the status of these concerns, which may be classified in three main groups:

- Subsidiaries in which the parent company's holding is more than 50 per cent;
- Concerns in which the co-operating manufacturer has a minority financial interest;
- Concerns wholly dependent financially on domestic companies engaged in assembly or manufacture with the technical co-operation of a foreign manufacturer.

The local manufacturing or assembly units were established primarily because of the customs duties and taxes imposed in many countries on imported vehicles. Argentina, Brazil, Mexico and Spain now manufacture 95 per cent of various models and, in some cases, the entire vehicle.

The Régie Nationale des Usines Renault, for instance, has set up 22 factories or assembly lines which delivered 158,000 vehicles in 1965. The three countries with the largest production of vehicles are Spain—47,300; Belgium—46,100 and Argentina—23,400.

The data from four countries are presented as examples of the different phases of national integration:

- Ivory Coast (a minimal use of locally produced items);
- Portugal (40 per cent national integration);

Argentina (95 per cent national integration);
South Africa (100 per cent national integration).

The Ivory Coast

An analysis of the market in the Ivory Coast is given in table 2.

TABLE 2. ANALYSIS OF THE MARKET FOR PRIVATE VEHICLES IN THE IVORY COAST

	1964	*1965*
	vehicles	
Annual registrations	4,074	3,356
Distribution of private vehicles according to cylinder capacity	*per cent*	
Less than 1,100 cm³	57	53
1,150 to 1,750 cm³	39	43
Greater than 1,800 cm³	4	4

Legislation concerning entry of vehicles

Built-up vehicles may be imported under a quota system and are subject to duties. Quota and customs advantages are granted for local CKD assembly. There are no penalties, since local integration is not yet legally compulsory.

Existing CKD plant

The Régie Nationale des Usines Renault has built a factory at Abidjan, which is under the management of the Société Africaine de Fabrication des Automobiles Renault. The covered area is 9,300 m². The daily output of 10 to 12 units includes the passenger models R4, R8, R10 and R16; light vans in the R4 range; and Saviem lorries and transport tractors. The production figures for 1964 and 1965 are:

Vehicles assembled	*1964*	*1965*
Renault 4 L	300	330
Renault 4 B	150	120
Renault 8	250	103
R. 1132	—	150
Renault 10	—	42

The completed sets for assembly are imported; a few items are purchased locally (tires, batteries, paints and materials). The first Renault 4 model was assembled in April 1962. The main items integrated are paints and materials.

Prior to the CKD stage, paint and material plants had been established. The Government is now considering the establishment of regulations that would encourage the development of other industries related to the automobile industry.

Portugal

An analysis of the market in Portugal is given in table 3.

TABLE 3. ANALYSIS OF THE MARKET FOR PRIVATE VEHICLES IN PORTUGAL

	1964	*1965*
	vehicles	
Annual registrations	19,896	33,885
Distribution of private vehicles according to cylinder capacity	*per cent*	
Less than 1,100 cm³	34	31
1,150 to 1,750 cm³	61	69
Greater than 1,800 cm³	5	—

Each assembly firm was authorized to import 75 built-up vehicles annually (this may include several models) beginning 1 January 1963. In CKD assembly, a minimum of 25 per cent local integration is required. Local integration includes any expenditure in Portugal (costs of assembly, locally produced parts, packings and domestic transport). If more than the minimum percentage is incorporated, partial exemption from customs duties is granted. The local integration attained by Régie Nationale des Usines Renault is 40 per cent. If the degree of integration is below the statutory minimum, the factory must not only pay the improperly waived customs duty but also a fine equal to thrice that sum.

Existing CKD plants

About twenty manufacturers have entered the Portuguese market. Sites have been purchased and assembly operations assigned to subsidiaries or to importing firms (see Part III of this publication). The assembly plants could not be established at Lisbon or Oporto or in the immediate vicinity of either city. The "threshold of profitability" for an assembly line in Portugal is 400 passenger vehicles annually; the necessary minimum investment is 25 million escudos. A number of manufacturers have therefore formed associations for joint operations.

Position of the Régie Nationale des Usines Renault

The Renault subsidiary Industrias Lusitanas Renault SARL has a covered area of 3,500 m². The Renault 4, Renault 8 and Renault 10 passenger vehicles and R4 light vans are assembled at Guarda. The annual planned production capacity of the assembly lines is 1,250 passenger vehicles and 250 utility vehicles. The production figures for 1964 and 1965 are:

Vehicles assembled	*1964*	*1965*
Renault 4	722	1,198
Renault 8/10	352	964

Integration has been concentrated on parts produced by established local industries to obtain parts of good quality. The first Renault 4 model was assembled in 1963. At the end of the second year, 40 per cent integration was achieved. The main parts integrated were tires, batteries, seat coverings, glass, electrical equipment, and small sheet-metal and packing items.

Prior to the CKD stage, tire, battery manufacturing and light engineering plants had been established. After the CKD stage, the expansion of existing industries and the development of accessory-producing plants were encouraged.

Argentina

An analysis of the market in Argentina is given in table 4.

TABLE 4. ANALYSIS OF THE MARKET FOR PRIVATE VEHICLES IN ARGENTINA

	1954	1959	1964	1965
		vehicles		
Annual production	173	18,290	114,619	131,800
Distribution of private vehicles according to cylinder capacity		*per cent*		
Less than 1,100 cm³	—	—	48	43
1,150 to 1,750 cm³	—	—	14	17
Greater than 1,800 cm³	—	—	38	40

Legislation concerning entry of vehicles

Since 1956, when Argentina began to implement a CKD policy with mandatory integration of local parts, very few built-up vehicles have been imported. In exceptional cases however, a very few built-up vehicles are imported under licence and are subject to customs duties as high as 300 per cent.

The Argentine Government* requires submission of an assembly and manufacture plan for new vehicles. Registration is not accepted unless the firm undertakes to manufacture 93 per cent of the vehicle locally in the first year and 95 per cent in subsequent years. Prior to 1966 the percentages were based on value; now they must be based on tonnage.

If the percentage is not attained, the issuance of import licences for the 5 per cent non-integrated parts is curtailed. In exceptional cases, authorization may be granted to import parts under a special tariff heading "supplementary parts" subject to a 200 per cent duty.

Existing factories

At the beginning of 1966, twelve factories produced 15,000 to 18,000 vehicles monthly—23 passenger models and 20 utility models (see Part III of this publication). Six of the twelve factories are Argentine. Industrias Kaiser Argentine (IKA) produced about 30 per cent of the total output in 1966. In 132 months, IKA built 210,000 m² of factory space and manufactured 320,000 vehicles of 20 different American and European models.

Twelve manufacturing shops have been set up or incorporated as a result of agreements concluded with other industrial plants. This has strongly encouraged the development of other Argentine industries. there are now 1,500 factories and workshops supplying IKA with over 15 billion pesos worth of materials and equipment annually. At present IKA manufactures vehicles similar to those produced by Kaiser Jeep Corporation and American Motors Corporation, United States, and by the Régie Nationale des Usines Renault, France. The production figures for 1964 and 1965 are:

Vehicles manufactured	*1964*	*1965*
Renault 4	11,122	10,099
Dauphine	8,456	13,317

Vehicles are now manufactured locally. The imported parts are only 5 per cent of the vehicle in cases where local suppliers cannot meet the requirements of IKA plants.

The first Dauphine model was assembled in 1961. In two years, 95 per cent integration of locally produced components was achieved. New vehicles are now required to reach the 95 per cent content at the end of the year following Government approval of the contract.

Prior to the CKD stage, the automotive industry was supplied by iron and steel works, chemical firms, foundries and general engineering firms.

Existing industries have expanded in line with the demand created by the automotive manufacturers. All the other subcontractors were established in response to the need for their products.

South Africa

An analysis of the market in South Africa is given in table 5.

TABLE 5. ANALYSIS OF THE MARKET FOR PRIVATE VEHICLES IN SOUTH AFRICA

	1964	1965
	vehicles	
Annual registrations	140,254	123,753
Distribution of private vehicles according to cylinder capacity	*per cent*	
Less than 1,100 cm³	19	19
1,150 to 1,750 cm³	65	61
Greater than 1,800 cm³	16	20

Legislation concerning entry of vehicles

There is a complete prohibition of imports of series vehicles in built-up form. Luxury vehicles may be imported under a quota system but are subject to very high customs duties.

A prospective manufacturer is required to submit a proposed operational plan for local manufacture. Until 1965, the requirement was that 55 per cent of the total weight must be produced locally; local machining of the engine was mandatory. The requirement is now 75 per cent, but the Government realizes that an interim period—perhaps as long as three years—may be needed before this result can be achieved. When the prescribed percentage is attained, the product can be declared locally "manufactured" and will benefit from supplementary quotas. However, quotas are reduced in proportion to any delay in the approved schedule for integrating locally produced components.

Existing factories

Seventeen models of private cars stamped "Made in South Africa" were produced between July 1964 and March 1966 and marketed in 57 variants. Others have recently appeared on the market. Broadly speaking, the large foreign firms established in South Africa aim at the status of "manufacturer" (see Part III of this publication).

Position of the Régie Nationale des Usines Renault

The Renault vehicles are assembled in the East London (Cape Province) factories of the Car Distributors Assembly Company, which also builds other passenger vehicles (Alfa Romeo, Auto-Union, Jaguar and Mercedes) and utility vehicles (Hino, Price and Renault). This is a wholly South African enterprise.

The first Renault 8 model was assembled in South Africa in 1964. By the end of 1967, 55 per cent integration was to be achieved and 75 per cent by 1970. The production figures for 1964 and 1965 are:

Vehicles assembled	*1964*	*1965*
Renault 4	439	211
Dauphine	251	100
Renault 8/10	1,770	2,041
R. 1134	—	100

Integration is applicable mainly to relatively heavy parts which do not entail very substantial capital investment. The main parts integrated were tires, batteries, seat coverings, wiring, glass, external accessories, mechanical parts of the front and rear suspensions, castings of cylinder blocks and mechanical parts of the engine.

Prior to the CKD stage, steelworks, foundries, glass factories and textile mills were established. After the CKD stage, the following facilities were established: tire factories, industrial rubber plants, factories manufacturing seats, seat coverings and accessories, light-alloy foundries, factory-equipment plants and general engineering shops.

Conclusion

This study has examined factors in the establishment of an automotive industry in a developing country. This endeavour calls for a competent staff (managers, engineers, technicians and skilled workers) and a high degree of discipline in both organization and execution.

None of these conditions can be improvised. Much patience and time are needed, since financial resources are limited; waste cannot be tolerated. However, the most difficult and time-consuming task is education, especially of the managerial and supervisory staff, who must learn their individual specialities and also the art of management.

The Régie Nationale des Usines Renault has found that the methods outlined yield satisfactory results in a number of countries. Nevertheless, time is needed, and the stages cannot be rushed. The quality of the product should never be sacrificed, even temporarily. It is better to delay the transition to the next stage of industrialization than to risk a reduction in quality. Consistency of quality is vital to the success of the undertaking and to the morale of the production and sales staff.

The Government can be of great assistance to the manufacturer, but it must exhibit moderation in its plans and decisions. A prime necessity is an absolutely consistent policy. This is difficult, especially in countries where there is not always political stability.

The legal requirements must therefore be moderate. The programme must be feasible. The production capacities of the automotive and supplying industries should not be over-estimated.

Finally, the developing industry must be protected by duties on finished imported vehicles. A reasonable profit for national investment must also be ensured. It is necessary to offset the rise in net costs which is the inevitable consequence of the modest scale of series production, the need to train manpower and all the uncertainties in starting production. The industry will never really justify itself until it is in a position to export, that is, until its prices are competitive. The question of net costs is therefore of vital importance. A solution must be found if the country is to avoid entering a state of structural inflation.

APPENDIX 1

EXTERNAL CONDITIONS AFFECTING THE USE OF MOTOR VEHICLES

Climate

In maritime regions temperatures seldom fall below − 20° C, but they can register − 40° C or under in continental regions such as Siberia or Minnesota. At these temperatures, starting the ignition is a serious problem (which can be aggravated by humidity or wind), especially for cars that normally cannot be parked in a garage. Interior heating, and window demisting and defrosting equipment are essential.

In contrast, tropical regions experience temperatures up to + 45° C in the shade during the summer; in maritime regions, temperatures rarely exceed + 30° C. These extreme conditions lead to vaporization of the petrol in the carburettor, that makes it difficult to start the ignition and causes vapour locks that may result in stalling.

The engine cooling system must therefore be designed to maintain water and lubricating oil temperatures within moderate limits. Contrary to general opinion, engines with liquid-cooling systems are the most widespread and the best able to cope with extreme conditions. By its very structure, the air-cooled engine is unsuitable for any but temperate regions, since starting in extremely low temperatures is problematical, and cooling in high temperatures is difficult.

Reasonable comfort for passengers in sultry regions can be ensured by an efficient ventilation system or by air conditioning.

Atmospheric humidity in temperatures between 0 and 5° C may lead to icing in the carburettor and also cause fog in regions with a maritime climate. Special lighting equipment will be necessary.

Around 0° C, humidity often leads to the formation of ice on the road surface; motor travel is then difficult and even dangerous. Under these conditions, the basic road-holding qualities of the vehicles are tested, especially the adhesion of the driving wheels.

At lower temperatures, humidity will cause precipitation in the form of snow. A properly designed vehicle can be driven with a reasonable degree of safety. However, in countries where snow is frequent and abundant, the city streets are often cleared by the scattering of salt. The paint work, chrome plating and underbody, if regularly exposed to such conditions, are likely to suffer serious deterioration; special protection is therefore needed against corrosion.

When the vehicle is likely to be exposed to heavy rain and violent storms, especially in tropical regions during the wet season, the body openings (doors, hoods and bonnets, and opening roofs) must be watertight. The engine and ignition system must be protected against water splashed from the wheels so that the vehicle can move in all weather conditions.

Wind can also have dangerous effects on the road-holding ability. Wind-tunnel tests must not only produce model with low resistance to forward movement at high speed in order to save petrol; they must also ensure that the vehicle is reasonably stable in windy weather. The weight of the vehicle and its shape are important factors in this connexion.

Relief

Relief is more important than altitude. In level country a three-speed gear-box can be quite satisfactory, and an automatic gear change system can be used even with a low-powered engine; but in mountainous regions, more power is needed and a four-speed gear-box is preferable if the weight-power ratio is high.

In economically advanced countries with well-developed road networks, mountain roads are usually designed with slopes of less than 10 per cent with high attendant engineering costs. In other countries, slopes of 20 per cent or more are quite frequent.

A vehicle must be modified for use in mountainous country according to the severity of the conditions and, if necessary, speed is sacrified in favour of hill-climbing ability.

Continuous use of a vehicle at high altitudes may require special modifications. On the high plateaux of Central and South America in particular, light-weight cars with larger-than-standard engines can compensate for the loss of power caused by lower atmospheric pressure. Carburettors will often need a mixture regulator to prevent an over-rich fuel mixture that reduces cylinder life.

The road network

In countries that are well developed for motor vehicles, natural obstacles have been modified to ensure optimum conditions for vehicles. The road network is dense and well surfaced. There are roads suitable for heavy traffic and even special highways where intersections have been eliminated and there are only gradual inclines. Road surfaces are even; concrete or bitumen surfacing ensures smooth non-skid driving conditions. Vehicles can be fitted with soft, comfortable suspensions. Normal tires are adequate. There is no great distance between petrol stations and the capacity of the petrol tank of the vehicle suffices for a range of 400 to 500 kilometres.

In developing countries, however, the road network has not yet been adapted to motor traffic. Roads are often narrow and hilly. The surfaces may be stony and sometimes poorly maintained with frequent pot-holes. In the absence of top-surfacing, they are dusty in summer, and muddy or waterlogged in winter. Strong cars with heavy suspension and special shock absorbers are necessary. The dusty atmosphere requires highly efficient air-filters to protect the engine against premature wear. Larger petrol tanks are also needed, as there are large distances between the few petrol stations in operation.

A high ground clearance is essential (at least 20 cm). Vehicles must be fitted with special tires with inner casings and treads that will endure the rough roads. There must be a reserve of power to enable the driver to overcome difficult situations. Sheet-metal guards or grills can protect the vital components (crank case, transmission and petrol tank) against shock or moving stones. Traffic may cause the formation of a dangerous "corrugated-iron" surface on dirt tracks· therefore a special suspension system is necessary to prevent excessive vibrations. At the ferry crossing of a river, there may be steep access ramps; then vehicles will need adequate forward and rear clearance.

Dust roads may create even more serious problems than old stone roads. The protective equipment, especially the air filters for the engine, must withstand all kinds of dust from red laterites (mainly iron oxides) to the pure silica of desert sands.

Legal requirements

Each country has its own approach to traffic problems and road safety. The steering wheel is sometimes on the left and sometimes on the right. The highway codes governing signalling and safety vary. Number plates, lighting and signalling apparatus are of different types and dimensions and are placed on different points of the vehicle. The regulations regarding brakes also vary. Regulations for the protection of third-party interests, such as restrictions on exhaust noise, suppression of radio and television interference, or the prohibition of dangerous projections likely to injure pedestrians or cyclists in a collision, differ in scope and magnitude.

The motor fuel characteristics differ from country to country. Examples are the octane number, that governs the engine compression ratio; and volatility, that may entail pre-heating for carburettors. Moreover, these differences may require modifications of the engine.

APPENDIX 2

INCREASE IN THE COST OF VEHICLES IN PROPORTION TO THE PERCENTAGE OF LOCAL INTEGRATION

There are many reasons for the higher cost of vehicles manufactured in developing countries; some of them pertain to problems of assembly and others to problems of local manufacture.

Problems of assembly

Assembly operations in developing countries do not necessarily entail cost increases. It is necessary to compare prices and indicate the excessive cost (resulting from the relatively small production) of local assembly in comparison to the transport cost of built-up vehicles. The results depend upon:

Relative distance of the country from the co-operating manufacturer's factories;

Rate of output of assembled vehicles in relation to the size of the local market;

Wage rates for local labour;

Productivity of local labour.

The data may justify local assembly. The difference in freight costs for built-up vehicles and CKD transport may be a sufficient margin to absorb price increases resulting from local assembly of parts.

For this reason some United States manufacturers installed assembly lines in developing countries many years before they were legally required to do so. For example, the Ford Motor Company installed an assembly line in Mexico in 1925.

The incorporation of locally made parts entails increased costs. Prior to the basic decision, it is useful to consider the proportionate increase in net costs of the whole set of imported parts in relation to the cost of integrating items manufactured locally.

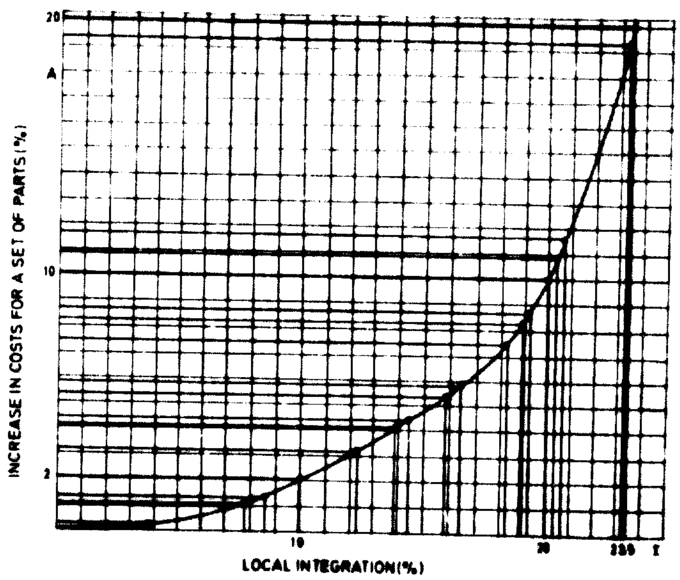


Figure 1. Variation of the increase in vehicle costs with the percentage of local integration

Figure 1 shows the variation in *A* per cent increase in the costs of a set of parts with a local integration content ranging from 0 to 24 per cent for a factory in a North African country, where *A* per cent is the proportion $(Pr/Pd) - 100$, where *Pr* is the net cost of the set of parts delivered to the assembly line plus the parts purchased locally; *Pd* is the net cost of the set delivered to the assembly line when all the parts are imported from France. The percentage of integration I is the ratio of the price of locally integrated parts to that of the complete set.

Figure 1 shows that for the country in question:

With 10 per cent local integration, the set costs 2 per cent more;

With 20 per cent local integration the set costs 10 per cent more;

With 23.5 per cent local integration, the set costs 20 per cent more.

Problems of local manufacture

Mass production is very important in the automotive industry; the relationship between cost and volume is very marked. The larger manufacturers, who produce for world markets under strong competition, have lowered costs by concentrating on mass-production techniques (for example, conveyor machinery).

However, the advantages of mass production are not identical in the different automotive manufacturing processes. The "critical volume" varies in foundry operations, forging and bodywork.

The guideline for any manufacturing policy in developing countries should therefore be to begin local incorporation with parts for which the "cost-volume" effect is least; and then to include those for which this effect is substantial. It is an implicit assumption that parts can be classified by the relative increase in net costs for a given rate of manufacturing that is compatible with the local market.

A further assumption is that an operational plan can be drawn up for local integration on the basis of the classification of parts and the effect of each stage in local integration on other operations. For example, it would be absurd to consider the net cost of manufacturing gear-box pinions without also examining the problem of assembling the gear-box. In this connexion, therefore, it would be necessary to establish a system of priorities through research on time studies and methods (Programme Evaluation and Research Techniques).

If the correct approach is used, the result will be the increase in net costs shown in figure 2 that is based on an annual output of 8,000 vehicles.

The percentage increase in costs is calculated on the basis of the price of a complete set "ex-works".

Figure 2 shows that three phases can be identified in the cost-increase curve in relation to the degree of local integration:

Phase *A*, in which costs increase disproportionately to the increase in local integration;

Phase *B*, in which costs rise more or less in proportion to local integration;

Phase *C*, which is a recurrence of phase *A*.

In Argentina and Brazil vehicles are built with a very high proportion of locally manufactured parts. The figures for the Renault Dauphine are:

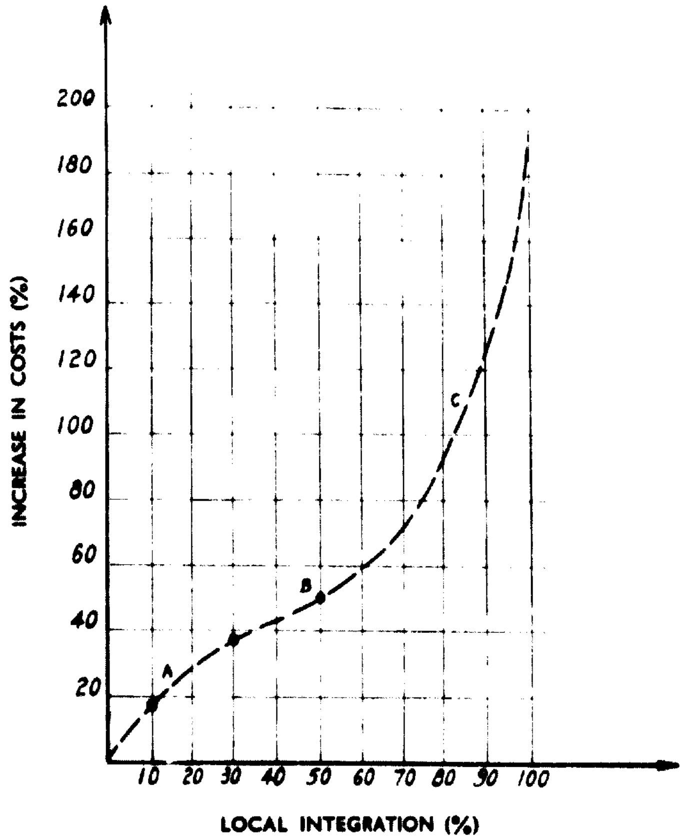


Figure 2. Increase in net costs per vehicle for 8,000 vehicles annually in relation to the degree of local integration

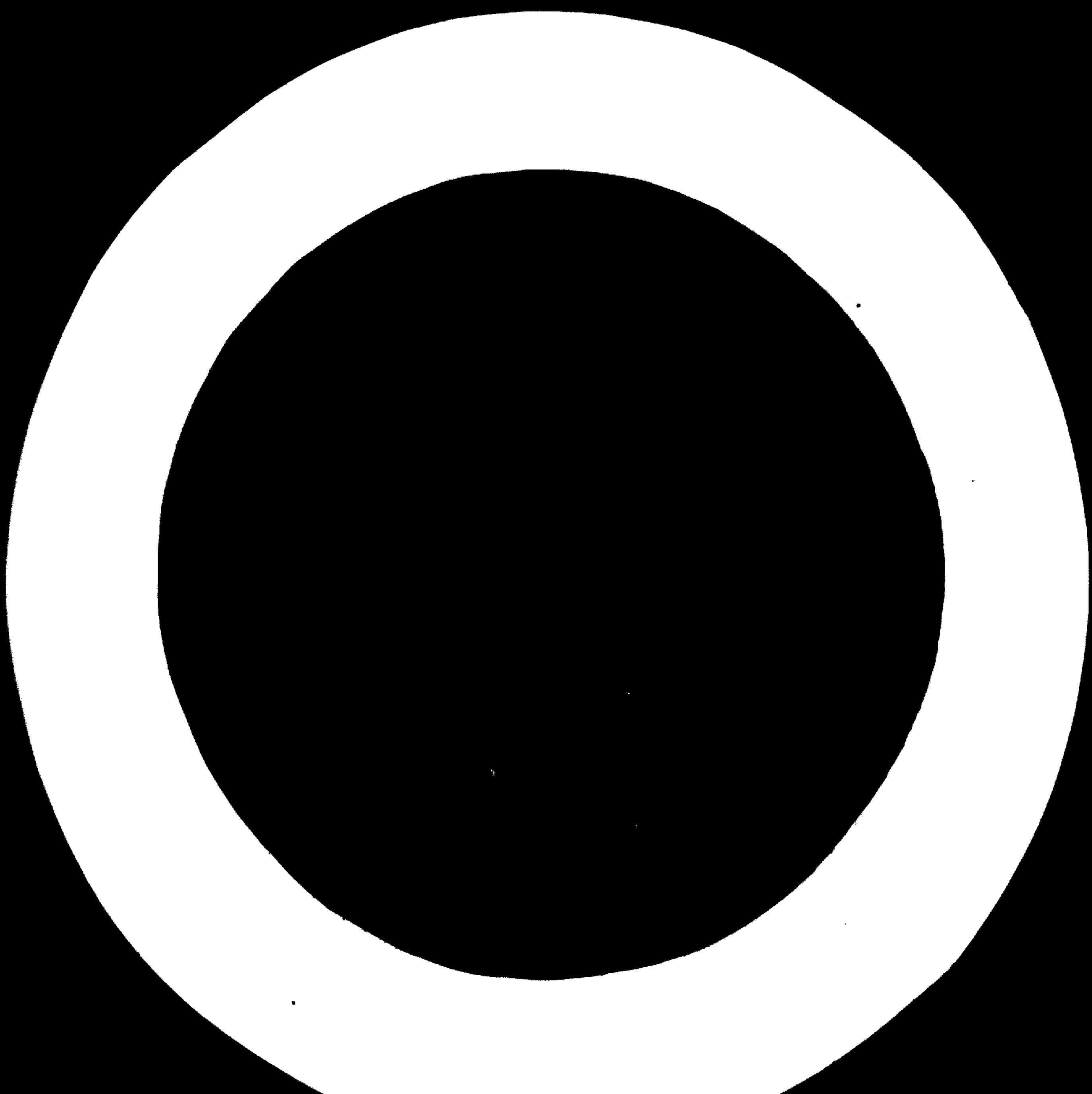
Selling price of the Renault Dauphine model (Base 100 = price on the French market):

	Argentina	*Brazil*
Rate of local integration	85%	92%
Price index	297	210

Account must be taken of the volume of production, which is not exactly the same in Argentina as in Brazil; furthermore the official exchange rates are not an altogether sound basis for calculating price indices in view of the rapid inflation in both countries.

The slope of the curve in its exponential portion *C* is because the parts concerned are portions of the bodywork. Manufacture of such parts in small series results in heavy amortization charges since the necessary press tools are designed to produce a much larger volume of parts than is practical in a developing country.

Each country must therefore consider the local market and decide the extent to which it should follow the curve. It can place a limit on the rise in net costs per vehicle. On this basis, the extent of obligatory incorporation of locally manufactured parts should be decided.



MAINTENANCE OF HEAVY-DUTY COMMERCIAL VEHICLES

*W. F. Eaton**

INTRODUCTION

The industrialization of a nation can be measured by its transportation system because industrial growth depends on the movement of persons and materials. The discussion of this paper concerns one small sector of a highly complex system of transportation and communications. The maintenance and repair of vehicles is crucial, because when mechanical failure occurs, previous plans are to no avail unless the vehicle functions properly.

Basic features of the establishment and operation of an efficient repair and maintenance service for heavy-duty commercial vehicles can also be adapted to passenger cars because truck maintenance requirements are far more stringent and complicated than those for passenger cars.

The organizational set-up is outlined to show that, although a service and repair shop may begin with only a few mechanics and a head mechanic (who may also be the owner), qualified personnel can be hired as the need arises. The selection of productive workers requires thorough testing and appraisal prior to employment.

The layout and construction of the maintenance shop is vital to its efficiency.

Emphasis is placed on methods and schedules for training mechanics, who are key factors in the efficient operation of any shop. A training programme should reward achievement, and offer incentives to the apprentice.

The basic shop tools and equipment are usually acquired by an established shop as the need arises. Management should purchase any tool that meets a need provided that the volume of work warrants the expense. Repair and service shops must have proper tools to function efficiently.

Maintenance procedures and schedules will be discussed although each maintenance set-up is unique; therefore, experience is vital in planning the proper maintenance programme. A well-planned and well-supervised maintenance programme should be based on experience, records and appropriate tests.

A simple method of inventory control is given that can easily be enlarged, improved and changed to satisfy any unusual demands. The basic idea is to have a par when it is needed; however, parts that are seldom used should not be stocked in abundance. Parts issued from inventory must be constantly replaced, and obsolete parts should be returned to the suppliers under an established agreement.

Records are essential for mechanical decisions, warranties, future equipment specifications and cost control. This paper suggests how such records may be compiled. If the shop provides service and repairs to the general public, certain records are not necessary, such as the mechanical history of the vehicle; this is the responsibility of the owner of the vehicle. However, records of the current condition of vehicles and of costs are indispensable in any shop.

Existing methods and procedures of automotive maintenance will be compared. The tried and proven practices should be acknowledged, although owners of maintenance firms must be flexible and willing to accept new tools and methods.

Many persons tend to avoid the responsibility for problems related to mechanical equipment due to an ignorance of the basic principles of how it functions and of the necessary maintenance for trouble-free operation without costly repairs. An owner may drive his vehicle without any thought of preventive maintenance. He will justify his position, "Why should I spend money on my vehicle when it is running well and in fact doesn't need maintenance?" The relatively small costs of basic maintenance could prevent a costly major breakdown. These same individuals raise their voices loudest when a breakdown does occur and express a complete lack of understanding of why or how it occurred. They did not remove the vehicle from service for preventive maintenance, but when a major mechanical repair is necessary, they are compelled to do so.

Maintenance shops are often referred to as a necessary evil, a drain on profits, heavy spenders, non-contributors to revenue etc. However, the wise owner of an automotive fleet knows that vast sums of money can be saved by a well-organized and efficiently operated maintenance

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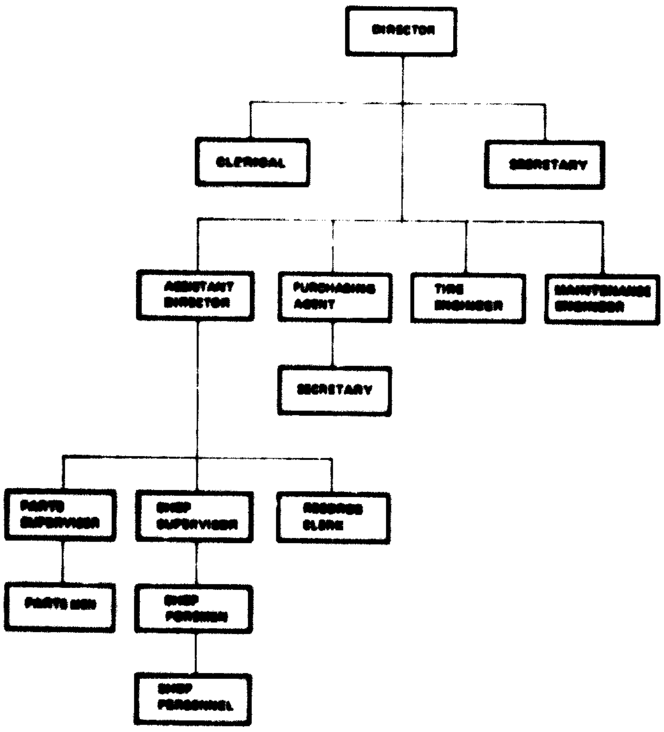
system. The efficient maintenance of vehicles could effect the difference between profit and loss. Vehicles that await major repairs or are parked due to mechanical failure do not contribute to the success of an enterprise.

An efficient maintenance shop depends on a team of well-trained personnel who are willing to accept responsibility and authority. The table below is a manning table for a maintenance shop.

Organizational structure



1. Organization of a commercial fleet maintenance department

Director or superintendent of maintenance

He reports to the owner or administrator. His primary responsibilities are to:

Establish policies and procedures for proper and economical maintenance of all vehicles;

Recommend standards for the purchase of vehicles, shop equipment and replacement parts;

Manage and direct subordinate personnel in the development of goals, performance standards, training methods, scheduling and all activities within the maintenance department.

Other responsibilities include:

Attendance at lectures and meetings; study of the current literature relative to vehicles and their maintenance;

Administration of the personnel safety programme;

Control of costs by daily reports and spot checks;

Approval of requisitions for purchase of shop equipment and material;

Liaison with owners or senior management, manufacturers' representatives and salesmen and other shops within the organization.

Assistant director or superintendent of maintenance

He reports to the director or superintendent. His primary responsibilities are to:

Assist the director;

Supervise and direct the operations of the maintenance facilities.

Other responsibilities include:

Preparation of schedules to carry out policies and procedures;

Review and plan future material and parts inventory needs;

Co-ordination of the procedures of the shop foremen;

Promotion of harmony between supervisors and workers;

Constant review of costs and recommend saving measures;

Supervise and direct training of shop personnel.

Shop supervisor

He reports to the assistant director. His primary responsibilities are to:

Schedule, supervise and direct the work during his assigned shift;

Make decisions on mechanical problems and conduct spot inspections of vehicles before and after repairs;

Advise and consult with the director and assistant director on mechanical and organizational procedures.

Other responsibilities include:

Distribution of the repair orders to the mechanics;

Approval of requisitions for replacement parts and material;

Supervision of on-the-job training;

Supervision of the flow of repairs in the shop.

Parts department supervisor

He reports to the assistant director. His primary responsibilities are to:

Direct and control the receipt, storage and issue of automotive parts and related materials;

Maintain records of outgoing and incoming shipments in the parts department.

Other responsibilities include:

Prompt handling of requisitions for priority parts;

Accurate accounting of the rebuilt components and control of the return of defective units;

Parts-storage methods and systems to ensure optimum utilization of space and personnel;

Planning the number and type of replacement parts to be regularly stocked and secures special parts;

Supervision of the subordinate personnel in the parts department.

Purchasing agent

He reports to the director or assistant director. His primary responsibilities are to:

Direct and assist in the procurement of automotive parts and all other material;

Negotiate annual motor fuel, lubricants and anti-freeze contracts.

Other responsibilities include:

Expedites delivery of parts and materials of the proper quality at suitable prices;

Good relations with suppliers, meeting salesmen to know current prices and new products.

In addition, secretaries and clerical staff are needed for the correspondence, records, files, reports etc.; their number would depend on the size of the service shop. If the shop is responsible for a fleet of 500 power units plus trailers, a tire engineer and/or a maintenance engineer should be hired.

Tire engineer

He reports to the director. His primary responsibilities are to:

Conduct critical investigations of procedures and methods for tire maintenance and of tire costs;

Control the distribution of tires for recap and requisition new tires from the purchasing agent.

Other responsibilities include:

Control of all tire records;

Adjustment and discard of tires in agreement with manufacturers and recappers;

Approval of all invoices relative to tire expense and all correspondence about tires.

Maintenance engineer

He reports to the director. His primary responsibilities are to:

Perform assignments within the shop as supplementary training;

Develop procedures and practices to expedite mechanical tasks.

Other responsibilities include:

Designing automotive and shop equipment for maximum life and efficiency;

Planning and supervising any modifications to automotive and shop equipment;

Any other duties assigned by the director.

The shop personnel are as important as the managers and supervisors. Manual skill and mechanical knowledge are their necessary qualifications because inexperienced personnel would produce faulty repairs with resultant failures.

There are different levels of mechanical work in any shop; each justifies a different rate of pay based on knowledge and skill. Unless the shop has a very large volume of mechanical work, there are few phases of the operations that can be organized on an assembly-line basis. A mechanic repairs a vehicle in the usual daily work schedule. The nature of the repairs varies and does not fall into enough of a pattern to allow an assembly-line approach.

The following are basic requirements for shop personnel:

Class A mechanic

His tasks include, but are not limited to, the following:

Rebuilding and overhauls (major and minor);

Engine tuning-up, including testing with dynamometer (if shop has one);

Frame straightening and alignment;

Body and fender repairs;

Painting;

Welding.

He is the most skilled man of all and if he is truly class A, he can do any task in the shop. However, he may be class A only in certain areas such as tuning-up, rebuilding, overhaul, and body and fender. The class A mechanic is the backbone of any repair shop. With his knowledge and skill, he can diagnose a fault, carry out repairs and restore the vehicle to service, while a less skilled mechanic only attempts to find the fault.

Class B mechanic

His duties are general service and repairs. While this employee may carry out all the class A tasks, he is of lesser skill and requires closer supervision. He is in fact a class A trainee. Depending on the variety of tasks in a shop, he may constitute more than 50 per cent of the labour force.

Service mechanic

His duties are to:

Change oil and filters;

Lubricate chassis;

Service batteries;

Maintain and repair tires;

Carry out other routine tasks not requiring great skill.

Utility man

His duties are to:

Clean the shop;

Empty trash bins;

Wash parts.

Parts man

His duties are to:

Receive, store and issue parts to mechanics;

Record all transactions that affect the procurement and dispersement of parts;

Increase his rudimentary knowledge of equipment and repairs.

Washer

His duties are to:

Clean vehicles with both water and steam.

2. Recruitment

A maintenance shop will only be as efficient as its employees. Therefore, proper selection of personnel and a progressive training programme are not only desirable but mandatory in the administration of the shop.

It is extremely important to employ the right people; their selection is very difficult. The unknown and changing human characteristics cannot always be recognized. There is no foolproof way to be sure the right people have been hired or to predict accurately how an applicant will develop as an employee. However, precautions can be taken: investigations conducted, tests and appraisals help eliminate the marginal-to-poor applicant in such critical areas as physical and mental health, ability, general character and integrity. The time and effort spent in a complete and thorough investigation of every applicant will give high dividends.

The method for recruiting maintenance personnel would, of necessity, vary with the degree of development of the automotive industry in a given area. One would not expect to find any degree of experience in a country that has no such industry; in such a case, the obviously undesirable applicants would be eliminated. The interest of a new mechanic should be appraised very carefully. Basically, if a person is mechanically inclined, educated sufficiently to understand instructions and willing to apply himself, he can learn maintenance repair.

The first step in personnel recruitment is a written application for employment. The primary object is to learn everything possible about the applicant. The next step is interviews, and check and appraisal of references. The entire history of the applicant is investigated to determine his suitability.

It is not absolutely essential for a mechanic to be literate because there are very many good mechanics that are not. Literacy is advantageous to understand sophisticated engines, transmission and electrical systems, and changing vehicles and their components. A mechanic must be able to use service and repair manuals, read micrometers, set tolerances. etc. The illiterate applicant can be taught, but he does not learn new concepts very rapidly. Therefore, it is desirable for a mechanic to have at least a high school education.

There are various kinds of tests that can be given to job applicants. They are not all conclusive and should only be used as a guideline and to establish a norm. Some recommended tests are:

(*a*) Test No. 1 (warm-up test)
Aptitude Test Service, Swarthmore, Pennsylvania;

(*b*) Perceptual Speed
Industrial Relations Center, University of Chicago, 1225 East 60th Street, Chicago, Illinois;

(*c*) Traffic and Driving Knowledge
Institute of Public Safety, Pennsylvania State College, State College, Pennsylvania;

(*d*) Mechanic's Job Knowledge Test.

The particularly important test (*d*) is given in appendix 1. The 92 multiple-choice questions will very quickly indicate whether the applicant has any mechanical experience. The total score on the test is not as important as the type of questions that are answered correctly. From this test it is easy to judge the applicant's knowledge and experience of petrol or diesel engines, electricity, air systems, shop tools etc. The questions could be grouped by mechanical classifications and only those pertaining to the type of work to be carried out by the applicant need be assigned to him, although a discussion of the other questions with the applicant can also be very fruitful. It is always possible on a multiple-choice test for the applicant to merely guess and still make a respectable score; however, the lack of previous experience and basic knowledge would be revealed in the interview and discussion of the test. This test should be treated as confidential for if it is in circulation, the testing results would be meaningless.

Physical examinations are of great importance in the employment of mechanics. In view of the lifting and straining required of a mechanic, it is most important to have an X-ray of the spine and lower back to control the absence of congenital defects or previous injuries.

3. Shop construction

Details of the design and construction of a repair and service shop are not given because there are too many variables. In order to cope with these variable factors in an efficient manner, each shop must be built in accordance with the owner's particular needs and circumstances. It is important to visit existing shops, to gain ideas by observing their operations and by discussing the experiences of their owners to avoid mistakes.

The location and design of a maintenance facility are almost as important as the personnel. Unnecessary movement of equipment, visits to the parts room or other wasted motion should be avoided for the mechanic is a valuable production man and must therefore be kept on repair tasks as much as possible. With this in mind, careful consideration must be given to the traffic pattern, that is, movement into, out of and within the shop. It would be impractical to move a vehicle in order to bring another job into the shop. Such movements are costly and can be eliminated with proper shop design. The parking area should be convenient and readily accessible to avoid further wasted motion.

A few pointers in the building of a repair and service shop are briefly discussed:

Locate and design for growth. The expanding economy and changing vehicle dimensions may cause a shop to become too small in a few years. Therefore, each area of the building should be so located and designed that it can be easily expanded with minimum interruption of the existing traffic pattern and of daily operations. Prefabricated steel buildings lend themselves very readily to quick and economical expansion. There can be no expansion if a building is crowded into the corner of the property or against a natural barrier;

Plan good artificial and natural lighting. Skylights in the roof will save electricity;

Design for maximum heating if the location is in a cold region. Consider the number of times the doors will be opened. Insulate fully. Position the doors so that the prevailing winter winds will not directly hit a large door;

Floors should be of reinforced concrete and thick enough to carry heavy loads. They should be smoothly finished and specially treated for hardness, otherwise they will become chipped and rough and are then difficult to clean and unsuitable to roll such shop tools as floor jacks, transmission jacks and creepers;

Entrance and exit doors should be of top quality as they will be opened and closed frequently. Vehicle design changes, so doors should be wide and high. Overhead doors driven by electric motors are highly desirable for ease of operation and speed. These can also be controlled with automatic, actuating devices and timers so that the driver of the vehicle does not have to leave the cab. In addition to the time saved and the convenience, automatically controlled doors also save heat by closing themselves instead of remaining open until someone finds time to close them. Such doors should have heavy guards spaced slightly narrower than the door opening to protect them from damage by moving vehicles. A good guard can be made with a 6-inch, concrete-filled steel pipe that is embedded in concrete;

Roof vents will improve working conditions in hot weather;

Noisy areas should be located away from the parts room, offices and other departments where noise would create tension and retard production. A dynamometer should be placed behind a partition in an extreme area of the shop. Soundproof as much as practical;

Exhaust removal systems are a necessity. These may be placed in the ceiling or under the floor;

Design for cleanliness. Shops accumulate dirt by their very nature. Locate continuous drains in the floor, cover them with removable grating and slope the floor towards them. This will permit self-draining of the floors and will allow the floors to be scrubbed and hosed off. The interior walls must be of a material that will allow them to be scrubbed with a brush and detergent. The drains must be large enough to be cleaned with a shovel;

Ceiling height is important for maintenance of trailers, since a mechanic must be able to stand on top of a trailer for inspection and repairs without interference from structural objects. Height also improves working conditions in hot weather.

Shop plans can include features that permit a mechnical task to be completed more quickly:

Hydraulic floor lifts for both empty and loaded vehicles will expedite numerous maintenance tasks such as engine frame overhaul, clutch replacement, tire change and brake repairs. In addition to allowing a mechanic to work at a convenient height, they also permit more effective inspection;

Pits in the floor for inspection, greasing and oil changing should have good lighting and pipes to drain used oil into an underground storage tank outside the building;

Overhead travelling joists can be utilized for many tasks and serve several work bays in the shop. A hoist can be installed on a travelling monorail system and thus serve a greater area;

Design a dock or ramp for loading and unloading parts near the parts room;

A central storage system for oil, grease, air and water will ensure that all these very important items are readily available to the mechanic. Underground storage tanks facilitate large-volume purchases. Chassis grease can be stored in 55-gallon drums in a central pump room. It can be piped to all shop areas and dispensed through overhead, automatic hose reels with metering nozzles. If this method is chosen, the hose and nozzles must never be on the floor. The air should be provided from more than one compressor, so that the volume can be increased if necessary, and a supply is assured in the event of the mechanical failure of one compressor. If a 20-hp compressor will meet the air requirements, it is better to install two 10-hp compressors. Economy is achieved because there is a point in compressor ratings where the price greatly increases, so that two compressors will cost less than one. The central air system will also remove the moisture from the compressed air. This moisture is very detrimental to air tools;

If the oil, grease, air and water are not dispensed through overhead reels, wall outlets can be used. These outlets, electric welding outlets and general service electric outlets should be plentiful and strategically located;

If trailers are to be rebuilt in the shop, alignment and straightening can be expedited by means of tie-down rings embedded in the concrete floor. The rings can be tied to embedded structural steel and spaced so as to serve main frames and subframes. Further advantages can be obtained by installing wells spaced outside a frame member, into which 9- to 10-inch steel "I" beams can be dropped for pushing or pulling with hydraulic tools. The wells on one side should be connected to those on the other side by structural members embedded in the concrete. These arrangements should be strong enough to support any straightening job.

It is difficult to determine the ideal size of a maintenance facility. The dimensions of the vehicles to be repaired and serviced, as well as the anticipated volume, are the basic factors. It should be remembered that vehicles change and generally increase in size. In planning the size of a shop, it is sound reasoning to assume that all vehicles are higher, wider and longer than they actually are: this will prevent possible errors and also create a shop that will be functional in the future. Space for the vehicle itself is not enough because a mechanic must work on, around and under it. The mechanic should have a work bench with a mounted vice near his working area and also a trash bin. There must be sufficient space for him to remove wheels from the vehicle with a wheel dolly and to roll portable equipment such as transmission jacks and floor jacks around the vehicle. The work bay or area itself must be large enough for quick entrance and exit of vehicles; consider the time wasted over a 25-year period if a vehicle has to be pulled or backed continually in order to enter or leave a repair area. This waste of time and motion can be eliminated with careful planning. There is also a safety factor in the number of times vehicles must be moved, especially in maintenance facilities with a high volume of operations.

A stock of small, relatively inexpensive, quickly used parts within the working area is helpful if the shop is to service and repair a large fleet of more or less standardized vehicles. Then the mechanic can devote all his skills and time to the vehicle and need not walk to the parts department for one of these parts. For example, bolts, nuts, washers, filter cartridges, light bulbs, electric terminals etc. can be stocked in the mechanic's work area; he can then obtain the needed item with little movement or lost time. Although some of these stocks will be lost, this will be more than balanced by the additional time the mechanic will devote to his assigned tasks. The parts department can stock the area with material from the main parts room; space for a parts bin will therefore have to be planned in the working area.

The size of the repair and service area in a typical commercial firm should be taken into consideration. For example, a three-axle tractor is 96 inches wide and 20 feet long. There are many possible designs for this area, but the most functional design would be a rectangular building with a door at one or both ends. The building should be 90 feet wide with a 12-feet wide door. The minimum working space on each side of the tractor should be 4 feet, which provides a 16-feet wide service bay. The building has a common driveway in the middle which can channel vehicles into service bays on each side. This driveway should remain open to traffic at all times and provide a quick and easy entrance and exit of vehicles. Parking within the service bay can be angular or perpendicular. Each has its advantages and disadvantages. Angular parking is better for entry, but it requires additional space, so that a longer building will be needed for the same number of 16-feet wide bays. Perpendicular parking is less convenient and may need a wider building in order to eliminate one pull-up or back-up or both; but there is less wasted space at the ends of the building. Vehicles should not be parked closer than 6 feet from the wall. This provides enough wall space for work benches, trash bins, small parts bins and movement of mechanics. If money is no object, the interior common driveway can be eliminated and a door installed for each service bay. This makes a very convenient entrance, but overhead electric motor driven doors are expensive for they require maintenance and also cause loss of heating in the shop. If service pits are included in this facility, they should have their own entrance doors. Vehicles must enter or leave a pit in a straight line.

There are variations to this type of vehicle service and repair area: for instance, the parts room and offices can be located either at the end of the building or in the centre. A central location involves less walking; however, if there are several wings in the building, the end becomes the centre and is thus the most convenient location. This building complex in the form of a cross with the parts room and offices conveniently located in the centre can be expanded in the future.

The total length of tractors and semitrailers varies; the over-all length may be 50 feet or even 65 feet. The most functional service and repair areas for combinations should have pull-through bays with entrance and exit doors. It is not practical to plan that these rigs can be backed into place. The length of the bays should be at least 80 feet to allow free passage and a work area at each end. The width of the combination is 8 feet. The mechanic needs a minimum work area of 4 feet on each side. Quickly used parts, tires, portable tools, welders, work benches and portable work platforms for repair jobs can be stored on top of the bay The bay width should be about 22 feet; the height should be approximately 20 feet so that a mechanic can work on top of the trailer without interference from fixed objects.

There must also be an area for major repairs on trailers: this can include space for repairs and a painting booth or an enclosed area for painting. A pull-through repair bay is useful too. However, since the traffic flow is usually light here, a back-in bay will suffice. One satisfactory method is to back in from each side with enough bay length to provide a working space behind each trailer and also the storage of small parts, trash bins etc. To accommodate 40- to 45-feet trailers, the ideal length for the back-to-back method is 140 feet, which is also ample space for longer trailers. Bay width is important, since it is time-saving and convenient to store items such as flooring, plywood, lengths of iron and steel etc. between bays. If this area is to be used for storage, there must still be enough space for scaffolding and free movement of the mechanic. Therefore the recommended bay width is 22 to 24 feet.

Thorough planning must precede every shop construction. Too many builders rush through the preliminaries and later regret it. A shop must be functional. The immediate requirements should be analysed very carefully, and the long-term requirements should also be projected. The imported factors must be taken into account regardless of cost. Saving is a long-term process and not merely a matter of low construction costs. Ten minutes spared in the completion of each task over a period of years will produce a considerable saving in labour and costs.

4. PERSONNEL TRAINING

The training of personnel is as important as any other part of the firm's operations. An improperly trained employee is a potential problem. His inadequate training may cause him to feel discontented and to resign. If he does not resign, he may be discharged for incompetence. Morale is closely connected to the training of personnel. It may be possible to hire an outstanding person but if he does not feel that he is wanted and needed, his interest will subside. Every effort must be made to know him as an individual: his first name, his interests and his family. His ability must be assessed and recognized to utilize his skills in the most rational manner. He must be publicly praised and privately disciplined. He must be informed of his progress or lack of progress.

Training can take many forms; each maintenance firm will have its own starting points, methods and goals. Consequently training programmes vary As was stated in section 2, any person with mechanical aptitude and a desire to learn can become an apprentice in a training programme.

In the United States and other countries, various courses in mechanical subjects are given both in industrial technical schools and in private schools. They all provide excellent basic instruction in subjects such as fuel systems, electrical systems, engines and transmissions. However, it has been proved that these courses require supplementary practice on the vehicle itself. It has never been fully explained why an individual who has excelled in mechanical courses and obtained extensive knowledge of the maintenance and repair of automotive components in the laboratory and classroom cannot take a chassis with all components assembled and make it run. Trial and error, and much hard work, are needed to find the answer to a repair problem; moreover, the mechanic must remember the knowledge gained in this way and be able to use it again when the same problem occurs. Why should a mechanic who has thoroughly studied a 12 V electrical system have trouble detecting the cause of an electrical fault in a tractor and semitrailer? This is a frequent occurrence and indicates the necessity of actual work experience with proper instruction and supervision.

Once in a long while, there appears a rare individual who has all the talents of a mechanic. He is a joy to watch for he has that "sixth sense" which will enable him to approach a vehicle, listen to it, smell it, feel its vibrations and diagnose the trouble almost immediately. (I once thought these rare individuals were only born with this ability, but now I feel that some of them are the results of hard work and training.) Such a man is easy to recognize and is worth three average mechanics.

Four years are necessary to train a class A mechanic to service and repair a vehicle. He does not become a specialist on engine rebuilding, transmission rebuilding or any specific component. The training programme is carefully planned and is not erratic work on vehicles. If there is no planned training, a mechanic may be assigned the same task day after day because it is easier to continue employing him at a task he knows than to take time and effort to train him in other skills. This approach is not fair to the individual or the company. The individual could become redundant through technological changes in the industry and lose all chances of promotion, while the company would lose the services of one who might have become a valuable class A mechanic. Since a thoroughly trained man is not available, vacancies cannot be satisfactorily filled and substandard repairs result. The truly valuable mechanic is the one who can do all tasks.

An apprentice should be as young as possible but still mature. (An elderly employee will retire after a few years of service.) This is not discrimination against older employees; it is simple economics for considerable time and money are required to train a mechanic. A firm does not fully benefit from an apprentice during his years of training; therefore he must work in the shop as many years as possible after he becomes a valuable and skilled mechanic to repay the investment with dividends.

A good apprentice training programme should comprise 8,000 to 9,000 hours. With the aid of the nineteen sample work processes given in appendix 2, a programme can be drawn up to meet the needs of the maintenance firm. These suggestions can of course be tailored to shop requirements; some items would not be applicable to the vehicles to be maintained while others might have to be added. It is important to follow a planned programme, review it regularly and change it if necessary. A classification such as painter or body and panel beater involves 8,000 hours of work processes by itself and has very little relation to the other requirements.

It is a poor policy to employ more apprentices in a shop than can be absorbed upon completion of their apprenticeship. Proper supervision and training cannot be given if there are too many apprentices. The apprentice should receive progressive increases in his earnings as he completes each part of the course. The first increase could be given after completion of 500 hours, and subsequent, corresponding increases until he becomes a full-fledged mechanic with the wages of a journeyman.

Attendance should be required in approved classes of related instruction for at least 150 hours (but not more than 600 hours) annually during the four apprentice years. These classes should be attended at night or at least outside normal working hours. A firm might feel that this is too demanding, but it should remember that it is not only investing in its own future efficiency, but it is also training an individual for his life's work. He is acquiring a skill that will afford him and his family a better-than-average standard of living. The apprentice owes the firm more than just a fixed number of working hours per week.

The best classes are those conducted on the premises with supervisors acting as instructors. However, instructors can be engaged from companies manufacturing vehicles or components. These men are usually specialists in their particular fields and can provide valuable instruction. A closer relationship between mechanic and supervisor is formed if the latter plays a major role in an apprentice programme; moreover, the supervisor gains valuable experience that will be beneficial in the shop.

Some of the subjects that can be taught in the classroom are:

Wiring and ignition diagrams with emphasis on schematics;
Fundamental hydraulics and Ohm's Law;
Elementary blueprint reading;
Fundamentals of mathematics;
Precision measurements;
Power transmissions;
Theory and application of transmissions, clutches, steering, carburetion etc.;
Business management;
Safety measures;
Labour problems.

A written test should be given at the end of each lesson and the results recorded. It is very important to record the number of hours each apprentice has completed in specific work processes and in the total apprenticeship course. There is a tendency to keep an apprentice on a particular phase of training after he has completed the required hours because of a heavy workload. This should not be done, as his progress may be doubted. Of course, he may repeat a work process that he has not mastered, but this should be discussed so that the apprentice knows his performance and failures.

There are many valuable training aids that can be used in classes for apprentices and in advanced courses for journeymen. On- and off-premises training classes can be provided by manufacturers of equipment and components. Many manufacturers have fully equipped mobile units that are highly successful because the instructor uses drawings, pictures, slides and sectioned parts and components that can be stripped and reassembled under his supervision. All manufacturers offer service manuals, rebuilding manuals, service bulletins etc., which are always useful in a training session. Excellent films and slides can be shown on portable equipment, for instance, during lunch or rest periods. Correspondence or home study courses are available in almost any subject. Written examinations test the knowledge that has been learned from printed material and drawings. The mechanic pays the complete fees, or sometimes he receives a partial or total refund upon successful completion of the course. The Interstate Training Service, Portland, Oregon, is one of several institutions that provide courses of this type.

When a problem arises and is eventually solved, one of the most useful and simple training aids is to pull up a work bench, lay out all the parts and call everyone together. This will normally take only a few minutes, but the problem and the solution can be thoroughly explained and illustrated by the mechanic who discovered the fault. He becomes a part of the training process and feels a sense of pride. Otherwise, the next mechanic who faces the same problem a week later may spend twice the time trying to solve it. Communication is difficult but very important; it is highly desirable that every mechanic be aware of all solutions to maintenance and service problems or time-saving methods and procedures.

It cannot be over-emphasized that on-the-job training means learning by doing: the apprentice should not merely watch the skilled mechanic and hand him tools. The apprentice will, of course, need assistance and instruction in many maintenance procedures and problems. This kind of assistance must be given by a skilled mechanic, but the apprentice must carry out the task himself, for in that way he will learn much faster. Most of the process of becoming a skilled mechanic consists in finding the solution to a problem. No amount of talk or observation can compensate for the knowledge obtained by carrying out the task with one's own hands and tools. The apprentice will make mistakes, some of them costly. The training programme must ensure that he learns from his mistakes and does not make the same mistake twice. Any training course is more fruitful if the trainee is exposed to the vehicle or component. For example, if the mechanic has been only trained on generators and the fleet is switched to alternators, a basic training course should be given before he comes in contact with an alternator; a more extensive and detailed course should follow after he has developed sufficient interest. The mechanic who has been exposed to the alternator and encountered some problems will have many questions to ask.

5. SHOP TOOLS AND EQUIPMENT

Nut and bolt maintenance is on the wane, but the old familiar tools and equipment will be needed for some time. As long as the nut must be turned and the bolt held, tools will be needed. The only change is that tools must be supplemented regularly in order to repair and service modern vehicles. Electronic and highly specialized tools and test equipment are essential for a precise and rapid diagnosis of faults.

There are many special tools and test equipment. Their purchase must be governed by the volume of operations in the shop. The comparative costs of using another firm's services should be taken into consideration. The ability of another shop to carry out a specific task, the possible delay involved when using its services and the available skills in one's own shop are other factors which should be borne in mind. Tools are a basic prerequisite. A shop without the proper tools is inefficient. Any tool that will do a job better and faster should be purchased if the volume of operations warrants it.

It is normal practice in the industry for a mechanic to supply standard hand tools up to one-half inch drive size and often a three-fourths inch size. These include ratchets, sockets, box and open end wrenches, hammers, screwdrivers, extensions, flex drives, pliers of all types, punches, chisels, set screw wrenches, feeler gauges, measuring tape, hacksaw etc. Consequently, a mechanic will often have an investment of $1,200 to $1,500. As a rule, mechanics take pride in good tools and will look after them properly. They are usually eager to add a new tool to their collection. They know that the right tool may save an hour of toil and trouble and help to complete a task in five minutes.

Special tools and equipment are usually furnished by the company and supplied from a tool room or the parts room. Often a mechanic has to be convinced of the usefulness of a new tool, even after the management has decided that it is needed. The new tool often gathers dust after the first few days. The mechanic will say it takes too long to hook up, or that the task can be done faster the old way. This is true enough initially, but with training and practice the mechanic will soon learn to carry out the task more efficiently and quickly with the new tool. Mechanics do not always accept changes readily.

Appendix 3 lists tools and shop equipment for a repair and service shop. This is neither a complete list nor should every single item be purchased before a new shop is opened. The type of work and the volume of operations are the determining factors in the purchase of tools and equipment. It is more economical to find a need for a tool and then purchase it than to purchase the tool and never find a need: even the minimum tool requirements will constitute a considerable investment.

In the future vehicles could be connected to a computer which would produce a tabulation of all malfunctions, parts needed and adjustments required. Even then, the mechanic and his tools will still be needed.

6. MAINTENANCE PROCEDURES AND SCHEDULES

Maintenance procedures and schedules vary with the type of vehicle, climate, monthly mileage, terrain, speeds, loads and road conditions. Maintenance procedures and schedules must always be tailored to the requirements and conditions of the firm. Often the requirements can only be ascertained by experience and from the firm's records; procedures and schedules must be fixed accordingly and confirmed by tests. First and foremost, the management must be flexible in its thinking and planning. Necessary changes should be introduced to correct a weakness. The procedures, methods and plans should be reviewed monthly because they may be faulty and therefore need to be changed.

It is entirely possible to over-maintain as well as under-maintain. A middle-of-the-road course is best. With proper procedures and schedules, the first and most important aim is to secure the value of a dollar for each dollar spent. Not too many years ago, it was considered a good maintenance practice to remove components after a fixed mileage that was based on experience in order to avoid a failure. While this is right and proper in aircraft maintenance for safety purposes, it is not necessary for ground vehicles. In a fleet of 200 commercial vehicles purchased at the same time, 25 per cent of them fail at 150,000 miles, so the decision is made to remove the remainder from service and rebuild them before they also fail. While the latter might fail in the next 25,000 miles, the chances are good that many of the alternators will exceed 350,000 miles. Parts and components are too costly to waste mileage by removing them from service for rebuilding on a fixed schedule. Of course, an engine should not be kept running after oil pressure drops, or a differential kept in service after the slack becomes excessive. To ignore such obvious signs and wait for the failure to occur might well increase overhaul costs. Low oil pressure could ruin the crankshaft before the engine fails, and excessive slack in the differential might cause a seizure if prompt remedial action is not taken. There is no substitute for good test equipment and skilled mechanics to examine each component and judge when maximum mileage has been obtained.

Basically, maintenance is closely connected to the types of vehicle and components purchased and to the skill and responsibility of the driver: stopping leaks; keeping the air clean; lubricating the vehicle with clean fuel and then leaving it alone provided that it operates normally. When the procedures and schedules demand too many adjustments, there is always room for error, and as a consequence mileage can be reduced. For example, fixed mileages for adjustment of valves and injectors on modern diesel engines can be a source of trouble. The original adjustment might be better than subsequent re-adjustment. If the vehicle is operating normally, it should be left alone; this saves many work hours.

The heart of a maintenance programme for commercial vehicles is preventative maintenance (PM). As mentioned previously, there is no magic formula for the mileage at which a vehicle should be sent to the shop for preventative maintenance. For example, a diesel tractor accumulating 100,000 to 120,000 miles annually has a PM schedule set for 10,000 miles with chassis lubrication at 5,000 miles. With the brands of grease available today, it is often possible to eliminate the 5,000 mile lubrication and retain only the 10,000 mile maintenance schedule. The latest automatic chassis lubrication systems, in addition to furnishing timely and effective lubrication, also keep the tractor in service and out of the shop. Any design, component, procedure or schedule that will keep the vehicle out of the shop is well worth the time and money spent on it. It costs money to bring a vehicle into a shop and take it out again, even though no mechanical work is done. All aspects of a commercial vehicle maintenance programme should be focused on the foremost aim to keep the vehicle in a satisfactory operating condition.

The tasks and inspections carried out on PM schedules will vary since anything connected with maintenance inevitably varies. As a rule, a PM check sheet is given to the mechanic along with the shop repair order. The regular repair order will list faults reported by the driver and also any special maintenance checks that current conditions dictate. The PM check list can be drawn up in several ways and have several results. The PM sheet can be a very useful training aid, for it draws the attention of mechanics to points on the vehicle that require care and inspection. It can be modified in order to train the mechanics on a new and different model. It can contain check items applicable to the first year of vehicle operation and be expanded to cover the second year as further items need attention. The PM inspections of older vehicles should be changed accordingly. The PM checks can also include different items at different mileages. There are tasks that need to be done in 50,000 mile inspections that are not necessary in the four preceding inspections.

The PM check lists should be as brief as possible and still give the desired results. A mechanic should not have to waste time reading lengthy lists. Once the mechanic is trained in the routine items, he should be expected to cover them automatically without having to read a check list. As a rule, mechanics have an aversion for reading and writing, and it may not be easy to get them to make written entries for the record. Most shops assign a mechanic a number which he uses to mark off any item he repairs. He should also be required to list anything he finds needing mechanical attention and mark it off if he makes repairs. It is necessary that the man carrying out a mechanical task put his name on the work order and the PM sheet, so that the individual responsible for a faulty job can be identified and his mistakes brought to his attention. Moreover, another mechanic that might be assigned to the task would know what work has already been done.

All PM inspections should comprise the following tasks:

Change oil and oil filters;
Lubricate vehicle completely;
Check all gear-box oil levels;
Check clutch adjustment;
Clean all filters and replace if necessary;
Check coolant level;
Check and gauge tires;
Check all lights;
Check water level in batteries;
Check and stop all oil, water, fuel and air leaks;
Inspect operation of all instruments;
Adjust brakes;
Check the condition and tension of the belts;
Check engine for knocks or unusual noise.

These basic items are essential for long and trouble-free mileage. Often it is practical to carry out a short PM for 10,000 mile inspections, another for 20,000 mile inspections or more, and then a more extensive one for one scheduled inspection. A shop repair order and PM inspection list can have several forms. It can be one sheet with entries on both sides; carbon paper can be used for additional copies. Several copies are often necessary for the records and book-keeping purposes. For effective labour and cost control, it is necessary that a mechanic record the time spent on a task. Time data can also be used to fix a normal time for completion of a particular task and will readily reveal the promising apprentice or the inefficient mechanic. There will always be mechanics who can carry out their tasks much more quickly than others because they work harder and more steadily, have more mechanical ability and are better trained. Also, there are mechanics who are good at a particular task and may even halve the normal time for the task they like and do best. It is the supervisor's responsibility to know the mechanic's special skills and to use them whenever possible.

A PM inspection list that is changed at intervals will prevent the mechanics from falling into a set pattern and make them more alert. Otherwise, it may become so much of a routine that they only make a pencil check which is merely to check items without a thorough inspection.

A 10,000 mile service and inspection for a diesel tractor has been mentioned. Petrol-powered vehicles will require more attention and, while they can be purchased more cheaply and their engine overhaul is less costly, their out-of-service time will be much greater. This is also true of vehicles engaged in local pick-up and delivery work in a stop-and-go operation, whether they are gasoline- or diesel-powered. The idling time and the starting and stopping frequency are very detrimental to engines, transmissions, clutches, universals etc. The maintenance on such vehicles must be fixed on both a mileage and a time basis; for example at 2,000 miles or sixty days. As a rule, these are low-mileage vehicles but the service required of them is very demanding.

The following are some accepted maintenance practices:

With the cost of tires, it is false economy to install steering tires without balancing them and checking camber, caster and toe-in of the front axle. New vehicles should receive the same attention. Assembly-line production does not turn out vehicles with the steering and front axle correctly aligned. No two sets of tires are alike;

Dual tires should be matched to a one-quarter inch diameter with the larger tire on the outside;

A transmission replacement should not be made without checking the clutch condition, otherwise the transmission may have to be removed again shortly afterwards for clutch trouble;

Old bearings should be replaced;

Doubtful bearings should not be used;

When an engine is scrapped, the rings, rod and main bearings should not be re-used no matter how good their outward appearance;

Whenever the head must be removed from an engine, the valve seating should be checked;

If the wheel is removed for any reason, thorough inspection and maintenance should be carried out on the brakes and components;

In the rebuilding of components or the repair of parts such as sheet metal, the material and labour costs as compared with a new item should be evaluated. Parts purchased individually and assembled will cost more than a ready-to-use assembly from the manufacturer;

Patch-up maintenance may occasionally be required on an exposed component, but if time and trouble are expended on mechanical repairs, the task should be done properly and the component restored to its original condition as fully as possible. Repeated failures are costly;

Water and oil should be checked, and a visual inspection for leaks made whenever a vehicle is in the maintenance shop. It is also helpful for the driver to check them regularly;

Commercial fleets that maintain their own stocks of fuel should also fix their own specifications to ensure fuel economy and efficient engine performance. Engine manufacturers' specifications are broad and can be easily met by fuel suppliers, but they will not necessarily do justice to the engines or the requirements of economy. In order to be certain of quality, spot testing is necessary. Oils and greases should likewise be tested. Appendix 4 gives sample specifications for No. 2 diesel fuel, petrol, oil and grease. These can be modified in line with operating conditions. Economy, horsepower, starting properties, minimum sludge etc. should all be taken into consideration. An all-purpose chassis grease can be used on all items, including bearings, water pumps etc;

Most maintenance operators agree it is good practice to change the filter element at the same time as the crankcase oil. Oil change mileage can be ascertained by laboratory testing. The expense of the oil itself is not too important as oil purchased in bulk is not costly. However, the necessary labour, the time not in service and the price of the filter element are factors to be borne in mind when scheduling oil changes. The oil change mileage should always be set within a safe range. One cannot afford to take chances; often the oil is not changed exactly on time due to operational needs or to the circumstance that the vehicle is far from its regular service station when the scheduled mileage is reached;

In cold climates, diesel vehicles require starting aids. Engine warmers have proved very satisfactory, both in the cooling system and in the crankcase. Insulated battery cases with heating elements have their advantages as the efficiency of a cold battery is very low. If either is used in the air intake system, it must be used properly. Improper use will fill the combustion chamber and stall the engine, or if it does fire, head gaskets will blow, valves be damaged, heads cracked, head studs loosened etc. Neither should be used with petrol engines because of the danger of an explosion.

7. PARTS ROOM AND INVENTORY

The parts room and the inventory of parts are very important because they represent a large investment. The inventory itself is an idle asset; therefore only those parts that are likely to be needed should be stocked. An expensive vehicle that is idle for lack of a one-dollar part indicates poor planning. It is no less idle than it would be for lack of a $2,000 engine. Of course, no one can predict the parts which will be needed or those parts which will not be needed. It is better to have the part when it is needed and thus enable a vehicle to be operative than to decide against its initial purchase with the result that a vehicle is idle until the part arrives.

A maintenance shop requires a capable and alert parts supervisor, a competent purchasing agent and well-trained parts men. The size of a parts inventory is governed by several conditions:

The availability of a part at a supplier, his location, the transportation time and his stock practices. If engine parts are available in the same city as the repair shop, none will be needed in the parts room. The supplier should invest in the parts, and orders can be placed when the need arises;

The number of different models serviced by the maintenance shop directly affects the inventory. Therefore, it pays to standardize;

The age of the vehicles directly affects the value and number of items in inventory. As a rule, while vehicles are operating at low mileage after purchase, the expensive items used in rebuilding engines, transmissions, differentials etc. will not be stocked;

A component rebuilding programme should be practiced. If a component is replaced every time it fails, the items in inventory will decrease in number but rise in value. Moreover, this will greatly increase over-all maintenance costs. Little skill is required in a "parts replacement" shop, as most components are not very difficult to remove and replace. The parts room must contain rebuilt components such as engines, transmissions, differentials, clutches, alternators, starters, control valves, injectors, fuel pumps etc. Such items, if rebuilt with high-quality parts and tested properly, will give additional mileage. If the rebuilt item is in the parts room, the vehicle can return to service almost immediately;

The replacement or trade-in schedule of vehicles is a relevant factor, for the inventory can be phased out accordingly. After all the vehicles of a particular model have been sold, traded or scrapped, the parts that pertain only to that model will not be needed in the inventory.

The parts room is under the control of the parts supervisor. It must be conveniently located to receive and issue parts. It must also be easily accessible to the entire shop area—in other words, in a central position. Within the parts room itself, the arrangement of the various items requires careful study. Neither a mechanic nor the parts man should have to walk a great distance to get an item from the parts room. If the shop is a complex structure, and the parts are issued from more than one point, the parts should be stocked in accordance with the type of work for which they will be used. Quickly used items should be conveniently located.

Parts can be stocked in a variety of ways. First, all parts coming from the same manufacturer can be grouped together—or, alternatively, all parts belonging to the same component, thus, engine parts in one section and transmission parts in another. Parts can also be stocked numerically, either by the supplier's part number or by a numerical cross-reference system. It is important that the system is thoroughly understood by supervisors and parts men. It is not always easy to find a needed part unless the system is followed closely. If the parts cannot be located, the mechanic and the vehicle are idle and thus increase costs. The parts bins and shelves should be numbered to form an accurate system to locate any item. Each section must have enough room for expansion; otherwise the sections will overlap, and eventually the entire system will be in hopeless confusion.

The number of items in the parts room is the most important factor in a system of control and records. A simple, permanent inventory record system will contain a card for each item, listing the part number and all cross-reference numbers. On this card must be posted the dates of receipt from the supplier and the dates of issue so that the current balance is always shown. The card should also show bin location, current price, most recent supplier, quantity number on order and not received, and the maximum and minimum stock requirements, which will be determined by usage, availability and the duration of the stock supply period (for example, 60-day supply). When the inventory card shows a minimum, an order should be sent to the purchasing agent for sufficient items to have the maximum stock. Maxima and minima must be flexible to meet current conditions; since parts usage will increase on various items with increased mileage, the maxima and minima stocks must be raised accordingly.

The inventory record should be constantly scrutinized for parts that are not being used and for obsolete parts. An arrangement should always be made with the supplier for the return of such items; often a handling charge of 10 per cent will have to be paid, but this is preferable to keeping the useless items in the parts room year after year. A parts room should always reflect the current situation, otherwise it will not meet the needs of the service department.

Some systems require daily accounting so that all parts used on a given day will be entered in the record. In other systems no entries are made until the shop repair order is completed, thus indicating that the task is finished. The objection to the latter practice is that often the shop may have tasks requiring several days with the result that the parts used are not re-ordered to replenish the stock on a current basis.

The above method of inventory control is the oldest and the most basic. In many large shops all information is fed into an accounting machine which in turn tells what is being used, what to order and what is not being used. If this service is available, it is highly recommended.

The responsibility of the purchasing agent is to secure the item requisitioned by the parts room at the cheapest possible price within an acceptable time limit; moreover, he must not accept less than the best quality. There is always a supplier with a cheaper price; this is good if the quality is good. Maintenance shops cannot accept any poor-quality item. Too much time and effort it spent on repairs of poor-quality parts—and then the repairs only have to be repeated shortly afterwards. Money spent for quality is always money well spent.

8. RECORDS

A repair and service shop responsible for all the maintenance on a fleet of vehicles should have a system of records that will reveal the past history of the maintenance. The system can be very detailed, but actually it should contain only sufficient detail to enable a shop supervisor to make a quick decision.

All repair orders from the shop, invoices or particulars of a given item can be attached to a two-part record if applicable. The record lists PM inspections, filter changes, engine repairs, component replacements and accidents. No costs should be entered, merely the date and mileage. This information will often enable the supervisor to pinpoint the trouble for the mechanic immediately. It will also identify repeated maintenance where the vehicle has had the same component replaced more than once and yet is still not operative because the source of the trouble was never discovered. Also, if a vehicle is released with doubtful repairs, this can be entered in the record so that the condition can be rechecked the next time the vehicle is in the shop.

The service mileage of important components can also be entered in the record. This information is very useful in connexion with warranty claims, specifications of new equipment and shop work forecasts.

No maintenance firm can function properly without records. Parts inventory records and maintenance vehicle records have been discussed. There must also be cost records, otherwise the efficiency of the shop cannot be assessed. The hourly shop labour rate must be used to compute the labour cost on each task—whether the shop sells labour to the general public or maintains a company-owned fleet. The labour rate can be calculated in a variety of ways depending on how it is to be used. If it is used only for comparative purposes as in a company-owned fleet, it can be computed on the basis of the actual rate paid to the mechanic plus insurance, vacation and other fringe benefits. In this method all other costs are listed as overhead. Probably the best method is to include the total cost—in addition to the items in the other method—supervision, heat, water, light, rent, parts room cost, depreciation of shop equipment, taxes, insurance, miscellaneous supplies not in inventory etc. These items should all be computed separately so that they can be checked for inaccuracies. The shop labour rate will decrease whenever the volume of operations demands additional labour, as the larger number of productive hours will absorb the fixed costs.

If a fleet of commercial vehicles is maintained, it is useful to have a unit cost system. This will permit the evaluation of different vehicle models, indicate the cost factor of important components and reveal the costly items immediately. If such a record is kept for several years, cost normals can be established and costs controlled effectively. It is a very valuable aid in the preparation of specifications for new vehicles or components. It establishes the parts-labour ratio which is an important factor in determining when to trade or sell used vehicles or parts.

If, however, the breakdown of costs is too detailed, the copious records may never be significant or useful. Records that give no information and are not used are pointless and a waste of money. The only records needed are those which facilitate costs control and provide guidance in mechanical decisions and specifications.

CONCLUSION

Vehicle maintenance is a highly interesting and ever-changing field. Transportation is vital to the progress of any country. The future is bright, and many highly interesting innovations such as petrol turbine engines will soon appear. Maintenance operators must be flexible, progressive and always ready to accept better equipment and methods.

APPENDIX 1

MECHANIC'S JOB-KNOWLEDGE TEST

(Circle the letter you think represents the correct answer)

1. Which of the following is the best to use for proper gauging of spark plug gaps?
   a. Flat feeler gauge
   b. Square feeler gauge
   c. Round feeler gauge
   d. Tension gauge

2. The instrument used to check ignition timing is:
   a. Neon timing light
   b. Voltameter
   c. Distributor clamp
   d. Low voltage tester

3. A torque wrench measures:
   a. Number of threads per inch
   b. Size of nut
   c. Strength of bolts and nuts
   d. Pull in lb-ft

4. In threading a hole, use:
   a. Die
   b. Bit
   c. Reamer
   d. Tap

5. When making a compression test on an engine, it is very important to:
   a. Have the engine running
   b. Turn on the ignition switch
   c. Remove all spark plugs
   d. Remove one spark plug

6. Resistance is measured in terms of:
   a. Volts
   b. Ohms
   c. Amperes
   d. Watts

7. Which unit protects a generator?
   a. Coil
   b. Radio supressor
   c. Voltage regulator

8. The colour of the "nose" of a spark plug after operation, if it is in the proper heat range, should be:
   a. White
   b. Brown
   c. Dark blue
   d. Black

9. When a distributor has one set of points on a six-cylinder engine, the cam has:
   a. One lobe
   b. Three lobes
   c. Six lobes
   d. Twelve lobes

10. When the timing light flashes before the timing marks line up with the pointer, the timing is:
    a. Too late
    b. All right
    c. Grounded
    d. Too fast

11. When installing spark plug wires in the distributor cap, you must know both the firing order and:
    a. Piston displacement
    b. Rotation
    c. Venturi action
    d. Throttle action

12. The segments of a switch are insulated by:
    a. Friction tape
    b. Rubber
    c. Tinfoil
    d. Mica

13. A cold-running engine indicates:
    a. Ignition timing incorrect
    b. Radiator filled to the top
    c. Open thermostat

14. A common check that can be quickly made for too rapid wear on tires is:
    a. The angle of steering knuckle arms
    b. Camber
    c. Toe-in
    d. Caster

15. A differential is needed in order to:
    a. Increase the power of the truck
    b. Allow one wheel to turn faster than the other
    c. Increase the speed of the truck

16. Where would you attach the tie-rod?
    a. To the front wheels
    b. To the Pitman arm
    c. To the steering knuckle arm
    d. To the drag link

17. What is the purpose of the manifold heating device?
    a. Maintain an even engine temperature
    b. Provide heat for the driver
    c. Preheat the gases in the intake manifold
    d. Warm the oil so it will flow sooner

18. Vacuum of a well tuned engine should be:
    a. 22 to 24 inches
    b. 10 to 24 inches
    c. 18 to 21 inches
    d. 24 to 32 inches

19. An increase in compression when oil is put into a cylinder indicates:
    a. Head gasket is "shot"
    b. Rings faulty
    c. Piston loose

20. The sequence of tightening the cylinder head should be:
    a. From one side of head to the other
    b. From either end
    c. From the middle towards each end

21. What is the firing order of a six-cylinder engine?
    a. 153642
    b. 152643
    c. 153624
    d. 142536

22. If valve springs are too strong:
    a. The valve remains closed too long
    b. The valve breaks
    c. The valve opens too soon
    d. The valve does not open at all

23. When the exhaust valve on # 5 cylinder has just closed on a six-cylinder engine, which of the cylinders is to fire next?
    a. # 4
    b. # 6

c. # 1
d. # 5
e. # 2
f. # 3

24. Too much clearance between the oil pump body and the gears would reveal a tendency for the:
    a. Oil relief valve to stick
    b. Oil pump to overheat
    c. Back pressure to build up
    d. Oil pressure to drop

25. A half-charged battery, although the vehicle is in normal use, indicates:
    a. Coil shorted
    b. Armature grounded
    c. Voltage regulator

26. Poor oil mileage may be a result of too much:
    a. Intake valve guide clearance
    b. Camshaft end play
    c. Exhaust valve guide clearance
    d. Valve tappet clearance

27. Low carburettor bowl level would cause:
    a. Rich mixture at high speed
    b. Rich mixture at low speed
    c. Lean mixture at high speed

28. Low fuel-pump pressure will result from:
    a. Spring too strong
    b. Leaking diaphragm
    c. Mounting bolts loose
    d. Valves not seating properly

29. Poor vehicle performance (carburettor) caused by rich mixture is due to:
    a. High fuel level or float setting
    b. Low fuel level or float setting
    c. Restricted main fuel passage
    d. Accelerating pump stuck

30. A piston's size is measured at the:
    a. Skirt
    b. Below ring grooves
    c. Top

31. Which condition would cause unequal caster?
    a. Twisted axle
    b. Bent steering knuckles
    c. Unequal air pressure in front tires

32. Worn main bearings may be indicated by:
    a. Engine stopping
    b. High oil pressure
    c. Low oil pressure
    d. Engine running hot

33. The breaker points are connected to:
    a. Secondary coil
    b. Primary coil
    c. Distributor rotor
    d. Spark plugs

34. If the engine is idling at 300 rpm, how fast is the distributor turning?
    a. 150 rpm
    b. 100 rpm
    c. 600 rpm

35. How would you release the brakes on a trailer after an emergency application?
    a. Bleed the reservoirs on trailer
    b. Disconnect the emergency or charged line
    c. Equalize the pressure in truck and trailer system
    d. Rotate the brake shoe adjusting nut counter-clock-wise

36. Which of the following would cause the carburettor to flood?
    a. Too small jets
    b. Low fuel pump pressure
    c. Bent main nozzle
    d. Pinhole leak in the float

37. A cracked intake manifold causes:
    a. A noticeable rise in oil pressure
    b. Piston slap
    c. Carburettor to give too rich mixture
    d. Engine skips and misses

38. Where would you start bleeding a vacuum hydraulic brake system?
    a. Brake line to left rear wheel cylinder
    b. Vacuum-hydraulic
    c. Line furthest from the master cylinder
    d. Master cylinder

39. "Kickback" in engine starting is caused by:
    a. Defective vacuum advance
    b. Carbonized engine
    c. Bad points
    d. Spark advanced too far

40. What is adjusted by the eccentric nut on the worm and sector type steering gear?
    a. Back lash
    b. Cross shaft end play
    c. Worm end play

41. A vacuum hydraulic unit is installed for the purpose of:
    a. Equalizing output on brakes
    b. Retarding brake action
    c. Increasing line pressure

42. Possible cause for clutch slippage is:
    a. Flywheel housing misalignment
    b. Incorrect pedal free travel
    c. Burned-out clutch release bearing

43. Hopping or shimmy is caused by:
    a. Loose front wheel bearings
    b. Over-inflated tires
    c. Zero camber setting
    d. Boot in tire

44. If battery and connections are in order, the most probable starter failure is:
   a. Bent starter shaft
   b. Grounded field
   c. Loose bushings
   d. Bad starter switch

45. A "hard" brake pedal on hydraulic brakes indicates:
   a. Shoe retracting springs broken
   b. Shoes not centralized
   c. Too much clearance between shoe and drum

46. The hand lever in an air brake system:
   a. Controls the amount of pressure applied to trailer brakes
   b. Controls the amount of air entering compressor
   c. Controls the reservoir pressure

47. Weak breaker point spring tension is indicated by:
   a. Ping on acceleration
   b. Miss at high speed
   c. Crossfire

48. A transmission interlocking device is used to:
   a. Make shifting easier
   b. Prevent shifting into more than one gear at a time
   c. Eliminate transmission noise while driving

49. Do reground or honed cylinders need to be cleaned?
   a. Yes
   b. No

50. If yes, with:
   a. Soap and water
   b. Solvent, such as kerosene
   c. Dry rag

51. The smallest allowable voltage of a fully charged battery under load is:
   a. 6 volts
   b. 3.5 volts
   c. 5 volts

52. The marks on crankshaft and camshaft gears should be lined up to:
   a. Insure a proper fit of meshed teeth
   b. Time valves correctly
   c. Prevent excessive wear on gears

53. Sludge in the engine oil pan can be caused by:
   a. Valves sticking
   b. Leak in the oil pan
   c. Dirty oil
   d. Misfiring

54. Which cleaning medium would you recommend for cleaning hydraulic parts?
   a. Alcohol
   b. Lead-free gasoline
   c. Kerosene
   d. Benzene

55. Where should the relief valve on universal joints be located?
   a. Between trunnion shaft and bearing cup
   b. In the end of bearing cup
   c. In the centre of the cross

56. A good fuel pump should show pressures:
   a. 14 to 16 lb
   b. 2 to 4 lb
   c. 10 to 12 lb
   d. 6 to 8 lb

57. To clean regulator contacts, use:
   a. Petrol
   b. Fine-cut file
   c. Non-metallic sandpaper

58. What, besides carbon, would cause a valve to stick open?
   a. Light valve springs
   b. Bent rocker arm
   c. Insufficient clearance

59. An important function of the condensor is to:
   a. Decrease coil intake
   b. Prevent arching at points
   c. Decrease the voltage at points
   d. Increase the voltage at points

60. Which of the following would happen if the accelerator pedal hits the floorboard before the throttle valve is wide open?
   a. Poor idle adjustment
   b. Low top speed and no power
   c. Lean mixture at all speeds
   d. Choked condition and poor mileage

61. The primary purpose of a turbocharger or blower on a diesel engine is to:
   a. Increase fuel mileage
   b. Gain rpm
   c. Increase horsepower

62. On a two-cycle engine the crankshaft turns how many times to fire one cylinder?
   a. Twice
   b. Once
   c. Four times

63. On a four-cycle engine the crankshaft turns how many times to fire one cylinder?
   a. Twice
   b. Once
   c. Four times

64. Which of the following items is found on a diesel engine?
   a. Distributor
   b. Spark plug
   c. Fuel pump
   d. Condensor

65. If a diesel engine "runs away" you should:
    a. Turn off the ignition switch
    b. Break the intake fuel line
    c. Put transmission in neutral

66. Which items below could cause speedometer to be "too fast"?
    a. Wrong adapter
    b. Worn front tires
    c. Engine out of tune
    d. Drive line bent

67. Radiator shutters on a tractor control:
    a. Fuel pressure
    b. Intake air pressure
    c. Water temperature
    d. Air conditioner

68. A diesel engine fires with:
    a. Compression
    b. Spark plug
    c. Glow plug

69. Oil in the air system of a tractor indicates:
    a. Overfilled crankcase
    b. Faulty oil pump
    c. Low cylinder compression
    d. Worn compressor rings

70. Restriction in air breather of diesel engine would cause:
    a. High engine temperature
    b. Low oil pressure
    c. Excessive smoke
    d. Faulty air brakes

71. What is meant by "free play" in a clutch?
    a. The travel of the clutch pedal
    b. The wear in the clutch disc
    c. The distance from the throw-out bearing to the clutch fingers
    d. The tension of the clutch springs

72. The camshaft is used to:
    a. Open the valves
    b. Control the compression of the engine
    c. Regulate the clutch travel
    d. Steer the vehicle

73. Compression ratio of a diesel engine is:
    a. Higher than petrol engine
    b. Same as petrol engine
    c. Lower than petrol engine

74. Correct rod bearings to use with a .010 reground crankshaft are:
    a. .010 undersize
    b. Standard
    c. .010 oversize
    d. .020 oversize

75. Air pressure in the air system is controlled by:
    a. Air compressor
    b. Air tank
    c. Safety valve
    d. Air governor

76. Fuses are used in electrical system of tractor to:
    a. Make lights brighter
    b. Extend life of bulbs
    c. Break the circuit when needed
    d. Increase speed of wind-shield wipers

77. Under-inflated tires cause:
    a. Centre of tire to wear fast
    b. Outside shoulder of tire to dip out
    c. Both outside edges of tire tread to wear excessively

78. What is correct water level in a storage battery?
    a. Half full
    b. Completely full
    c. Three-eighths of an inch above plates
    d. Three-fourths full

79. The rate at which a battery is charging depends upon:
    a. Amp meter
    b. Generator output
    c. Day or night driving
    d. Gauge of wire from battery to junction box

80. A 12-volt generator is controlled by:
    a. 12-volt positive ground regulator
    b. 6-volt positive ground regulator
    c. Dash amp meter
    d. Speed of the engine

81. Thrust washers are used to:
    a. Control stroke of piston
    b. Time engine
    c. Regulate end play of crankshaft
    d. Align driveline

82. In order to run, diesel engines must have:
    a. Battery current
    b. Coil
    c. Injectors
    d. Shutter control

83. The air tank on a diesel tractor serves to:
    a. Inflate tires
    b. Unhook fifth wheel
    c. Store air
    d. Filter the air system

84. How many pieces of brake lining does each trailer wheel contain?
    a. One
    b. Two
    c. Four
    d. Six

85. A turbocharger on a diesel engine is driven by:
   a. Belts
   b. Gears
   c. Exhaust gases
   d. Self-driven

86. Average cooling system pressure is:
   a. Five pounds
   b. Ten pounds
   c. Twenty pounds
   d. Fifty pounds

87. On a tandem axle trailer the axle weight is equalized by:
   a. Springs
   b. Spring hangers
   c. Equalizer
   d. Torque arms

88. Trailer axle alignment is adjusted by:
   a. Torque arms
   b. Hangers
   c. Tie bolt
   d. King pin

89. Which differential ratio will produce the highest speed?
   a. 5:25 –1
   b. 7:17 –1
   c. 4:11 –1
   d. 5:00 –1

90. Air chambers are used to:
   a. Activate the slack adjusters
   b. Inflate tires
   c. Operate air windshield wipers
   d. Regulate air pressure

91. A dynamometer is used to:
   a. Rebore cylinders
   b. Line bore block
   c. Check horsepower
   d. Time engine

92. To make upward adjustment of air brakes on trailer, how would you move adjusting device?
   a. Vertically
   b. Counter-clockwise
   c. Clockwise
   d. Horizontally

APPENDIX 2

APPRENTICESHIP COURSES

Work processes	*Approximate hours*
1. Cleaning and inspecting parts	500
Instruction on all parts and accessories	
Requisitioning and acquiring parts	
2. Cylinder heads	750
Cleaning and inspecting	
Replace valve guides	
Remove and replace valve seats	
Ream valve guides	
Grind valve seats with grinder	
Lap valves	
Check valves with dial indicator	
Install injector tubes or brass	
Replace welch plugs and water test head	
Rebush rocker arms and ream bushings	
Check and replace rocker arm rollers	
Torque cylinder head bolts	
Install cylinder head and gaskets	
Torque injectors and adjustments	
3. Cylinder blocks and liners	1,200
Remove and install cylinder sleeves, wet and dry	
Clean and check water passages	
Check counter bores for sleeves	
Recut and straighten counter bores	
Remove and replace cylinder studs	
Clean piston ring grooves, fit pistons and rings for clearance	
Install and fit piston pin bushings and piston pins	
Check piston rod weight, alignment and rod bores	
Hone and bore cylinders	
Clean and inspect oil passages and lines	
Check, remove and install timing gears	
Check main bearing saddles, crankshaft wear and radius area	
Reasons for magnafluxing	
Check clearances and install main and rod bearings	
Proper torquing of main and rod bearings	
Ream lines and install camshaft bearings	
Pressure test oil systems	
Dial indicating run out on flywheel, housing and dampener	
Repair of accessory drive gears	
Check and set timing	
Check and repair oil pump	
Install crankcase pan and gasket	
4. Clutch	600
Remove and replace clutches	
Check and adjust clutches and linkages	
Rebuild pressure plates	
Reline clutch discs	
5. Transmission	1,000
Remove and install transmissions	

	Approximate hours
Adjust linkage, shift cylinders etc.	
Rebuild transmissions	
Inspect gears and bearings	
Clearances and tolerances	
Power take-off	
6. Drive axle	500
Removing and replacing	
Complete rebuilding	
Inspect, adjust and replace all gears, bearings and seals	
Remove and replace axles	
Rebuild or replace universal joints, yokes, splines etc.	
7. Cooling system	500
Checking and cleaning, internal and external, including reverse flush	
Remove, repair and replace water pump	
Inspect and replace fans	
Check and replace thermostats	
Minor repairs to radiator tubes	
Gasket replacement on radiator tanks	
Cooling system pressures	
Use of anti-freeze	
Inspect and replace hoses	
Inspect and adjust belts	
8. Front end steering	850
Remove, repair and install steering box adjustment	
Replace front springs	
Set camber, caster, toe-in and turning radius	
Replace wheel seals	
Check shock absorbers	
Replace and repair tie rod ends	
Replace front axle, king pins and bushings	
Balance front wheels	
9. Brakes	700
Minor and major adjustment	
Bleed hydraulic systems	
Replace and turn drums	
Reline brake shoes	
Rebuild wheel cylinders and master cylinders	
Check and repair brake power system	
Repair and adjust parking brake	
Repair and reset automatic adjusters	
Rework or replace backing plates	
Rebush cams and repair slack adjusters	
Rebuild brake chambers	
Trace and have knowledge of all lines, valves and adjustments	
10. Electrical systems	950
Use of equipment to check electrical systems	
Repair and adjust alternators, starters, generators and voltage regulators	
Make and install replacement wiring systems	

	Approximate hours
Repair and trouble shooting series parallel switches	
Test and charge batteries	
Coils, condensors, distributors—repair and replace	
Trace circuits for shorts on all lights	
Install and test electrical accessories, including wipers, gauges, horns etc.	
11. Fuel systems	2,500
Parts identification	
Injectors—remove, repair, flow-rate and install	
Assemble and disassemble diesel fuel pumps	
Calibrate fuel pumps	
Repair and test fuel pumps and carburettors	
Install fuel lines	
Check, repair or rebuild governors and correct all governor functions	
Service air cleaners and fuel filtration system	
12. Lubrication	250
Use of various oils and greases	
Clean and replace all filtering elements	
Greasing—front axle, drive shaft, brake components, steering accessories, clutch bearings, universals etc.	
Changing lubrication—crankcase, transmission, differential, air cleaners etc.	
Lubricate and adjust wheel bearings, seal replacement	
Lubricate water pump, distributor, alternator	
Inspect and correct all lubricant leaks	
13. Engine tune-up and trouble-shoot	1,500
Use timing devices, analysers, compression gauges	
Clean and test spark plugs, ignition wiring, distributor adjustment	
Check firing order and timing	
Adjust valves and injectors	
Use of vacuum gauge and tachometer	
Dynamometer testing	
Use of fuel flowrater	
Complete analysis of engine operation and detailed listing of repairs needed	
14. Welding	800
Acetylene—cutting, brazing and welding	
Electric—cutting and welding	
Special—stainless steel and aluminium	
Knowledge of metals and welding supplies	
15. Air system	160
Removal and overhaul air compressors	
Rebuild all air application valves; relay valves etc.	
Trouble shooting on air system	

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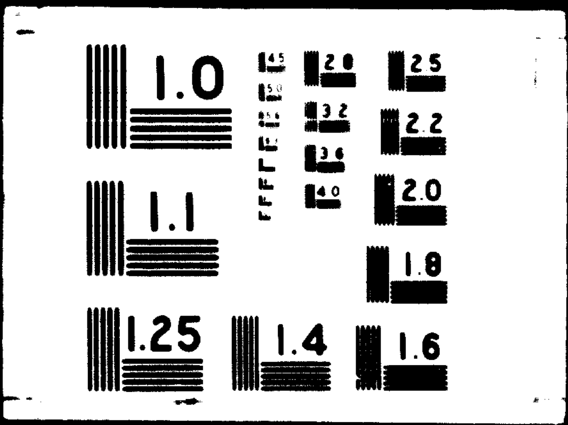


	Approximate hours
16. Bench work	500
Hydraulic test equipment	
Rebuild hydraulic cylinder, valves, power steering etc.	
Operation of various machines:	
Valve refacer	
Armature lathe	
Brake drum lathe	
Portable drills	
Boring bars	
Arbor press	
Brake tester	
Grinders	
All test equipment	
17. Automatic transmissions	450
Repair, rework or replace all types of automotive transmissions	
Analyse and test procedures for trouble shooting automotive transmissions	
Function and knowledge of torque converters	
Repair and rebuild industrial type torque converters	
Test and evaluate torque converter functions	
Adjust and rebuild steering clutches	
Reline clutch bands	
Adjust and install bearings and seals	
18. Painting	6,000
Prepare body and fenders for painting	
Sanding and rub down preparation	
Use of spray gun, spray booths, regulators and their maintenance	
Mix paints and knowledge of paints, primers and thinners	
Touch up brush	
Colour matching	
Air sanding	
Masking and taping	
19. Truck and trailer body mechanic	8,000
Strip wrecked trucks	
Straighten frames and miscellaneous parts—2,500 hours	
Rebuild cabs, doors etc.	
Layout and fabrication	
Riveting	
Welding	
Chassis assemblies	
Use of body fillers	
Change springs and axle assemblies	
Install fifth wheels	

APPENDIX 3

Tools and shop equipment for a repair and service shop

Wheel dolly to pull dual wheels
Floor jacks
Hand jacks
Transmission jack which can usually be adapted to differential jack
Bearing and gear pullers
Seal seating tools
Wheel nut wrench
Axle tread chaser
Power hand drills
Power impact wrenches and sockets
Power hand chisel
Compression gauge
Pressure and vacuum gauges
Water and/or mercury manometers
Heli-Coil set
Tire changing equipment
Brake drum lathe
Brake shoe grinder
Brake shoe relining machine
Battery test equipment
Battery charger
Distributor test machine
Valve spring tester
Valve refacing machine
Valve seating vacuum tester
Valve seating tool
Valve lapping tool
Volt ampere tester
Spark-plug cleaner and tester
Armature tester
Armature lathe
Electric welder
Acetylene-oxygen welding equipment with hoses, valves and gauges
Welding equipment for stainless steel and aluminium
Air compressor
Torque wrenches, inch-pound and foot-pound
Tap die set
Micrometers—inside and outside
Depth gauges
Telescoping gauges
Wire gauges
Feeler and thickness gauges
Calipers—inside and outside
Dial indicators
Cylinder gauges
Bench grinders
Portable grinders
Vices
Sander
Surface grinder
Honing equipment

The example selected here describes the introduction of the automotive industry in Brazil, the long-range plan developed by governmental agencies and the important role of the manufacturers of automotive components. Brazil had a modest number of vehicles before the Second World War, mostly imported from the United States. A few trucks were assembled locally from American components; 90 per cent of all replacement parts was imported from the United States. During the Second World War, however, this source of replacement parts was lost, and the stocks of the distributors were soon exhausted, thus creating the need to produce repair parts domestically. Several enterprises were organized for their manufacture. Unfortunately, these components had poor quality frequently because the original drawings and specifications were not available. Furthermore, they were often fabricated on primitive equipment from inferior substitute materials. These parts were initially costly and perhaps had a short life but at least they kept the trucks and cars operative. Although the new plants were rather primitive, they provided a training ground for management and workers; they grew in size, number and efficiency and became an essential nucleus for post-war growth.

The post-war growth of the automotive-component industry may be attributed to several key factors. The import of many trucks created a large demand for components. Several local parts makers invited well-known foreign parts manufacturers to participate in the growth through licensing, technical-assistance agreements or the creation of partnerships that provided technical assistance, equipment and capital. The intensive import of trucks caused a drain of Brazilian foreign-exchange funds; therefore the Government severely restricted the import of automotive components and finally prohibited the import of certain parts manufactured in Brazil. This action served as a further stimulus for foreign manufacturers to counteract the loss of this export market by participating in the creation of the Brazilian automotive industry.

However, the main contributing factor to the successful establishment and growth of the Brazilian automotive-component industry was the thorough planning of several governmental offices. The planning was formalized, centrally directed and supervised by the executive governmental body, Grupo Executivo da Industria Automobilistica (GEIA) which was formed on 16 June 1956. The "father" and capable director of GEIA Admiral Lucio Meira initiated the programme for the establishment of a Brazilian automotive industry and carried it through successfully. This programme was part of a national economic development plan, the Plan of Targets *(Plano de Metas)*, in which the automotive section was Target 27. The history of the first two years of GEIA and Target 27 is described in a booklet published in 1959 by the Office of the President under the title *Meta 27: Industria Automobilistica*. The author of the present report uses the data of this publication and his own experience to summarize the salient features of the GEIA plan and its realization.

Within the Plan of Targets, the Government gave the highest priority to the automotive industry and granted special preferential treatment of the necessary machine tool imports to establish the automotive plants. GEIA was able to function effectively because its members were high officials of various departments. Thus GEIA decrees represented, simultaneously and automatically, the decisions of participating governmental organs, such as the Ministry of Public Works, the Finance Ministry, the Bank of Brazil, the National Bank for Development and the Customs Office. The planned development of the automotive industry was stimulated by GEIA through the following general incentives:

Graduated foreign-exchange taxes to give most favourable concessions to the import of equipment needed in the manufacture of components;

Fiscal incentives, particularly in the form of a waiver of import duties on authorized equipment and on components not yet produced in the country;

Credit regulations for foreign exchange and loans from the National Bank for Development for the construction of automotive factories;

Commercial stimuli by establishing protective exchange and customs tariffs against the import of foreign vehicles and components already available from domestic producers.

The result of these incentive decrees was an amazing response from domestic and foreign manufacturers which put GEIA into the difficult but pleasant position of selecting the best projects from the many submitted for approval. A significant result was the interest of domestic and foreign companies in the manufacture of components not previously produced in the country. The GEIA plan (Target 27) envisaged a horizontally integrated automotive industry. The regulations of GEIA therefore divided the companies applying for participation in the plan into two categories: the producers of complete vehicles, and the manufacturers of automotive parts or subcontractors to the vehicle industry. The importance of the latter category in the realization of the entire plan is detailed in the above-mentioned publication.

Under the GEIA plan, the Brazilian automotive-parts industry underwent a transition from its original aim to serve the replacement market to the status of an original-equipment supplier or subcontractor to the national automobile manufacturers. According to a GEIA statement, the role of the parts industry in the establishment of a national automotive industry was decisive; its superior ability to adopt modern manufacturing techniques and the extraordinary capability of its management implemented progressive increase of the local content of the vehicles produced under the GEIA plan. The same incentives as those offered to the motor-vehicle manufacturing industry were also available to promote the growth and improvement of the sub-contracting industry.

The GEIA report states that, in December 1956, the investment in automotive-parts plants was estimated at $117,100,000 whereas, on the same date, the total investment in the motor-vehicle manufacturing plants reached $90,500,000. When the 1960 target was reached, the investment (as planned and approved by GEIA) increased to approximately $400,000,000 in the parts industry as against $300,000,000 in the motor-vehicle manufacturing industry. It is interesting to note that, unlike the early automobile industries in the United States and in Europe, the Brazilian automobile industry at its start already had a flourishing parts industry developed mainly by local capital and management. The GEIA plan strove to preserve this trend while encouraging technical assistance from abroad and welcoming foreign capital and technical assistance. The vehicle-manufacturing sector of the automotive industry needs foreign capital because of its large financing needs; the component-manufacturing sector is still primarily financed by local capital.

While the plan for horizontal integration was generally followed, certain natural obstacles were encountered that had to be overcome. It may be useful to list them here, because it is reasonable to assume that they are typical and could occur in any future plan for a domestic components industry.

A manufacturer of international reputation naturally wishes his subsidiary in a developing country to merit the same prestige. He would therefore prefer to use the reliable, established suppliers of many precision components for the subsidiary. This difficulty was often resolved favourably when the manufacturer induced his component suppliers to produce the same parts in Brazil or to license their production by local firms, always with adequate technical assistance. An even more favourable condition was created when these new parts makers could also produce components for other vehicle manufacturers; the increased volume and experience contributed to a more economic operation.

Another difficulty resulted from the justifiable demand by the vehicle manufacturers that the parts furnished to them by local firms should meet their rigid specifications and tolerances, whereas many local producers of automotive parts had been accustomed to work to less rigid standards when they had been supplying their products to the replacement market only. Often these suppliers needed not only retraining in their attitudes towards quality control and procedures, but they also needed better manufacturing equipment and methods. Some vehicle manufacturers preferred to make such parts themselves rather than purchase them from sub-contractors.

A financial obstacle to GEIA's horizontal integration concept lay in the very nature of capital sources. The foreign manufacturers, with their long-established ties with international sources of capital and their knowledgeability about the financing of new enterprises, had easier access to capital funds than did the new national firms.

Possibly the greatest obstacle to horizontal integration in the automotive industry, and therefore a threat to the components manufacturers, was the existing fiscal regulations of Brazil which imposed sales taxes at the state level, as well as a federal consumer tax. The state sales tax was applied to every transaction as materials or semi-finished products moved from one firm to another, and the federal consumer tax was levied on the finished components as well as on the vehicle itself. This cumulative taxation would have been prohibitive; therefore GEIA had to advocate fiscal reforms.

To ensure the success of the plan, other general measures, while designed to further the entire automotive industry, were essential to the success of the parts manufacturers. Foreign exchange had to be provided, and the plan called for $510,000,000 to cover the period from 1957 to 1960. Of this amount, $100,000,000 was allocated to pay the principal and interest spent abroad by vehicle and parts manufacturers for machine tools. The remaining $410,000,000 was allocated towards the purchase abroad of automotive components not yet produced in Brazil but which would be needed during the first three years of the plan while domestic production was starting. Incidentally, the major portion of the equipment imported from abroad was acquired without payment as a direct investment by foreign firms and thus did not require foreign exchange. Equipment worth about $200,000,000 was thus imported with GEIA's authorization, and the parts industry received about 25 per cent of this amount.

Other foreign-exchange funds were earmarked for purchases of raw materials and for the remittance to foreign investors of royalties and technical assistance fees. However, it is significant that the total amount of foreign exchange allotted to the development of the national automobile industry can be considered, in effect, as a saving of foreign exchange since, without the domestic production on which this outlay depended, either more foreign exchange would have had to be expended to import the same number of vehicles or, with foreign-currency outlay held at the same level, fewer motor vehicles would have been added to the Brazilian economy.

In the provision of adequate manpower for the automotive industry, the plans of GEIA were concerned not only with channelling about 100,000 additional workers into the new industry during the first three years of the plan but also with the training and education of supervisors, engineers, technicians and managers. Other governmental agencies, industry groups and institutions of higher learning collaborated in this important task.

The ever-present problem of quality was also of concern to GEIA, and its efforts in this field were mostly directed toward the parts industry. As mentioned previously, the Brazilian parts industry initially had to fill a void in the supply of replacement parts during the Second World War. With a few exceptions, the standards of quality in an industry created under such conditions left much to be desired when compared with the rigid quality standards of the foreign parts makers. With the first Brazilian assembly plants and the later manufacturing plants, adherence to standards and tolerances became not only a requirement demanded by the customer but also a matter of prestige for the national product. Inasmuch as the promotion of quality was primarily the responsibility of the industry, GEIA undertook to support such efforts by arranging with qualified schools to give assistance to the parts makers, particularly the smaller ones who needed it most. The motor vehicles produced at that time in Brazil were of seven national origins, each employing its own standards. This was a handicap for the parts manufacturers and posed considerable problems of quality. However, GEIA initiated a programme to develop Brazilian national standards to supplant the various foreign standards, leading it was hoped, to common components for several makes of vehicles.

This very condensed case history should be understood not as a plan to be copied by other countries but as an illustration of basic problems to be expected in developing an automotive parts industry and the particular solutions devised in Brazil, where the results seem to indicate that long-range planning achieved success. From 1956, when 6,087 vehicles with only about 40 per cent local content were assembled in Brazil, the parts industry grew in volume and quality, enabling it to supply a practically 100 per cent local content to the more than 185,000 vehicles built in 1965, and to produce all the parts required to maintain 1,900,000 registered vehicles.

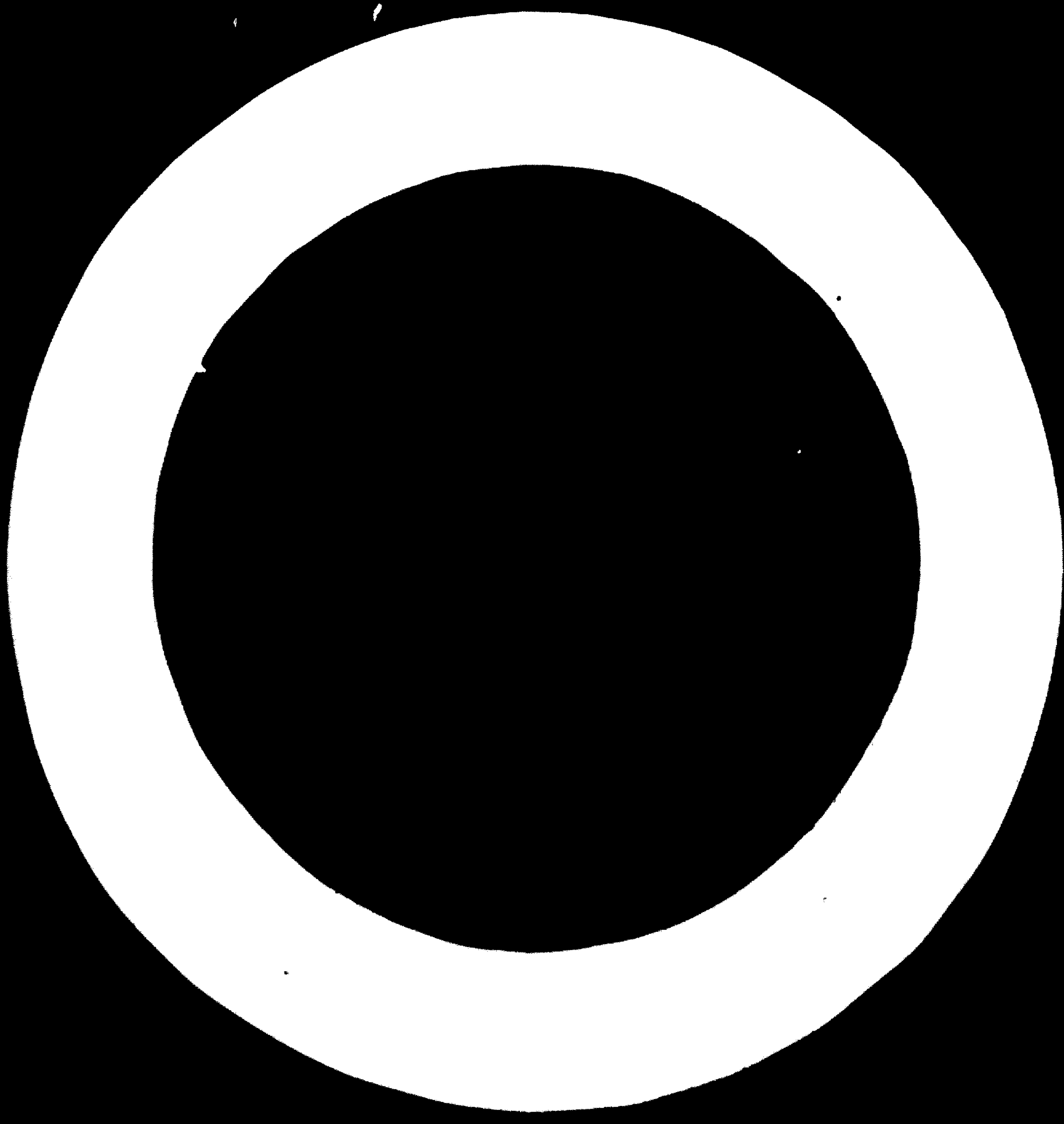
7. The future

The automotive parts manufacturers who supply the fully developed automobile industries of their own countries will, for a long time, provide replacement parts to developing countries. While they compete for a place in the export market, they will also collaborate with developing countries by providing capital and technical assistance to build plants for the production of automotive components. The inducement for this participation must come from a sufficiently large demand and from governmental measures offering an incentive to foreign companies to share in the industrial development of the country.

The questions may be asked: How large is the potential of the automotive-component market? How can it be related to the demand for original equipment and for replacement parts? Some statistics are available which make it possible to arrive at a rough estimate. For instance, a study of the Japanese automobile parts industry undertaken by a German engineering group[1] in 1964 states that suppliers to the Japanese automobile factories of raw materials, semi-finished products and finished parts share 55 per cent of the manufactured value, of which 30 per cent is represented by products which tend to increase their share. (In the Federal Republic of Germany the suppliers' share was at that time 60 to 65 per cent.) Furthermore, 76 per cent of the value of the total Japanese parts production went to new vehicles and 24 per cent to replacement parts. By relating these ratios to Japanese motor-vehicle production figures and the number of registered vehicles, it appears that the parts industry furnishes approximately $500 worth of original parts per manufactured vehicle and an average of $100 worth of replacement parts for each registered vehicle. Because the proportion of trucks manufactured and registered is higher in Japan than in other automobile-producing countries, these estimates may be applied to developing countries where the demand for trucks and buses is relatively higher than the demand for passenger cars. Thus, a country with 200,000 registered vehicles provides a market for a volume of repair and replacement parts valued at approximately $20,000,000. A country assembling and manufacturing 200,000 vehicles annually may support a domestic parts industry with a yearly production value of $100,000,000.

The steadily increasing demand for automotive vehicles in the developing countries will generate pressures to create or expand domestic automobile parts industries. It is hoped that this paper furnishes guide-lines to determine the feasibility or advisability of such plans, and shows how to avoid errors and how to tailor these undertakings to the needs of particular regions and markets.

[1] Verband der Automobilindustrie (1964), *Die japanische Automobil-Teile-Industrie*.



THE ESTABLISHMENT OF AN AUTOMOTIVE INDUSTRY IN DEVELOPING COUNTRIES*

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Introduction

This report seeks to point out the main factors that affect the establishment of an automotive industry in a developing country and the problems that arise during the different stages of its growth. It emphasizes the contributions that established automotive corporations can make and suggests careful selection of a suitable licenser from among them. The paper also indicates the rewards licensers expect for their assistance.

The report describes the manifold conditions obtaining in developing countries and the significant differences in technologies for the manufacture of passenger cars, tractors, trucks and buses. It also discusses the various policies of the automotive corporations that grant manufacturing licenses in developing countries.

In this report, manufacturing is taken to include machining parts from raw and semi-finished materials, buying components and materials from suppliers and assembling sub-groups and final vehicles. Since 50 to 70 per cent of automobile production cost pertains to raw materials, semi-finished parts and finished components purchased from other manufacturers, the development of the supplier industry is discussed in a separate chapter.

Many statements in this paper apply as well to other industries, such as those manufacturing major domestic appliances and textile machinery.

1. The manufacture and marketing characteristics of various vehicles

The present study deals with the production of passenger cars, trucks, buses and tractors, including the manufacture of the parts or groups of parts incorporated in these vehicles.

The level of design, technology of manufacture and economic scale of production are dictated by competitive international corporations. These factors vary greatly according to product, i.e. passenger car, truck, bus or tractor. Since these are all classified as automotive products, it is important to review their significant features and differences before drawing conclusions which might not apply to the production of all vehicle types.

Passenger cars

Design, production technology, automation and mass production have developed more rapidly with respect to passenger cars than any other vehicles because of the large increase in world demand and the keen price competition in this field—as is borne out by the increasing volume of passenger cars on the road today. Consequently, the passenger car industry is a major factor in road construction, the establishment of service and filling stations, the demand for fuel etc. It is also a major customer of many industries, including the steel industry.

Passenger car design is of great importance to the consumer, and styling is therefore one of the major concerns of the manufacturer. The functional aspect of the passenger car is taken for granted, while appearance, comfort, luxury, and special features and accessories are becoming the distinguishing features of each model.

The increases in production costs of similar passenger cars have been small over the past twenty years by comparison with increases in wage rates, costs of materials and equipment, and the continual improvement in safety standards and styling of passenger cars. The small increase in production costs was a result of the progressively more efficient utilization of materials, labour and equipment through better production technology and design, together with mass production and automation. An explosion in the scale of production has also made it possible to reduce the cost of purchases from other industries by increasing the sizes of orders and standardizing them. In addition, the design of passenger cars has been heavily revised to limit costs by a reduction in the number of unnecessarily high safety factors (imposed in the past by the limited knowledge of metallurgy) and by development of materials and manufacturing techniques. This trend has been most marked in the production of passenger cars and

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has consequently had greater influence on their design than on that of any other type of vehicle.

The producers who have survived are those who were able to exploit more intensely their domestic markets and diversify, merge and extend their operations internationally. This group consists of a limited number of companies, known by name to anyone associated with the industry. This development has been accompanied by new problems in all fields, especially in marketing. The last twenty years have witnessed a shift from how to make enough cars to meet demand, to how to sell what must be produced if costs are to be kept at competitive levels.

Trucks and buses

The increase in world demand for trucks and buses has also been great, although it cannot be compared with that for passenger cars. The typical truck- or bus-chassis producer has expanded, many of the smaller ones have vanished, and design and production technology has advanced. Competition has been quite fierce, but much less so than in the passenger-car industry. This difference is illustrated by the fact that the largest truck producers in Europe make about 50,000 medium-sized units of varying types and models per year. This is less than the smallest passenger car producer in the developed countries.

In addition to the small, highly specialized truck-makers, who cater to special requirements at special prices, producers with a profitable output of about 10,000 standard trucks per year still exist in Europe. This situation in truck production is likely to change, but at a slower rate than in passenger car production. As a result, the need for automation and mechanization in the former has been less than in the latter. The marketing of trucks overseas has been limited by variations in road regulations and usage (differences in types of cargo, length of trips etc.). Bus-body production includes operations which are more difficult to mechanize; consequently, many body-builders in Europe produce bus bodies only in small quantities.

The transport costs of buses and trucks sold overseas increase in proportion to the size of such vehicles. This has discouraged the mass production of commercial vehicles, since products manufactured on a large scale must ultimately be transported greater distances.

Passenger cars have been regarded in the past as luxury articles rather than transport equipment like trucks and buses. This view may be changing rapidly in many countries, even in those where utilitarian doctrines and philosophies predominate.

Tractors

Tractor production is discussed in this study because its principal features are similar to those of other automotive products. In the 1950s, competition in tractor sales was less fierce than in the case of trucks. Tractor design underwent relatively few changes during that period, but this may be attributed to the lack of need for development of this product.

Growing competition in tractor production over the last three years has curtailed the number of producers and decimated the firms that were making only tractors. However, tractors are still produced in developed countries in somewhat greater quantities than trucks, though in much smaller quantities than passenger cars.

2. Local conditions and problems

Suitable conditions for automotive production

The factors that must be considered in determining whether demand in a country is enough to justify domestic vehicle production are: population; *per capita* income; financial resources; volume of road traffic pertaining to goods transport; area of cultivable land; existing sub-suppliers of raw materials, semi-finished and finished parts and components; availability of skilled labour and management personnel; relations with neighbouring countries and markets; attitudes of local authorities etc. The feasibility of setting up an automotive factory in a developing country further depends on the state of vehicle production in developed countries, where passenger cars are being produced and sold on a much larger scale than tractors, trucks or buses. As against that, the demand for commercial vehicles in many developing countries is as great as that for passenger cars. Consequently, developing countries should begin their automotive production with assembly and gradually progress to the manufacture of parts, first for buses and trucks, then for tractors and, ultimately, for passenger cars.

Generally speaking, an automotive factory should not be planned until the short-term market potential has reached the following levels:

	Annual sales		*Remarks*
	Assembly	*Manufacture (1 type)*	
Bus bodies		300	Cheap labour
Truck and bus chassis	2,500	6,000	5 tonners
Tractors	3,000	10,000	30—65 hp
Passenger cars (medium)	20,000	50,000	Excluding production of body panels
		200,000	Including production of body panels

In any event, local conditions must be considered in each individual case. The number of vehicles registered (vehicle population) and annual production in some developed and developing countries are given for

TABLE 1. EXAMPLES OF WORLD CAR POPULATION AND PRODUCTION

Country	Vehicle population—registered 1966[a] (in thousands)			1965 production (in thousands)					Approx. domestic content (per cent)
	Cars	Trucks	Buses	Cars	No. of makes	Commercial vehicles	No. of makes		
United States of America	76,000	15,000	311	9,300	4	1,800	11		
Federal Republic of Germany	9,800	940	39	2,800	8	255	9		
United Kingdom	9,100	1,700	98	1,700	5	455	5	(Great Britain)	
France	8,800	1,900	48	1,400	4	217	6		
Italy	5,500	640	26	1,000	1	66	3	(Fiat cars only)	
Japan	2,200	4,500[b]	103	700	10	1,170[b]	13		
Australia	2,900	870	17	300	5	47	5		90[c] (Australia, Brazil, Spain, Argentina)
Brazil	1,060	760	85	100	4	79	9		
Spain	960	440	24	140	3	70	10		
Argentina	930	607	20	130	8	65	7		
Mexico	760	380	32	126	7	89	7		70[c]
Union of Soviet Socialist Republics	...	...	...	201	...	450	...		
Democratic Republic of Germany	...	...	...	103	...	13	...		
Czechoslovakia	...	...	...	84	...	32	...		
Poland	...	...	...	29	...	27	...		
India	370	265	80	23	3	46	5		90[c] (India, Yugoslavia)
Yugoslavia	180	79	8	35	1	12	4		
South Africa	1,200	333	23	129	8	47	11		under 50 (South Africa to Algeria)
Venezuela	380	140	10	38	7	16	7		
Portugal	240	85	3	30	9	7	15		
Philippines	160	97	32	9	7	6	9		
Algeria	210	92	4	6	1	2	2		
Malaysia	164	48	4	11	5	...			under 50 (planned) (Malaysia to United Arab Republic)
Pakistan	70	35	10	6	3	4	3		
Morocco	160	60	3	6	2	2	4		
Peru	135	92	9	1	2	1	2		
Colombia	115	94	21	—	2	2	2		
United Arab Republic	100	33	12	6	1	6	2		

Source: World Automotive Market Survey, McGraw-Hill (save for production in Malaysia, Pakistan and the United Arab Republic).

[a] New registrations are usually about 8–15 per cent of these figures.

[b] Including small and midget trucks, which are used extensively in Japan.

[c] In most cases, this includes manufacture of large body panels.

... Not available.

purposes of comparison in table 1. This table illustrates the differences in demand with respect to types of vehicle. It also shows that countries with a small car population tend to produce a relatively large number of makes, thereby increasing the handicap resulting from the smaller size of their markets.

Defining the structure of the industry

Local authorities should define the structure of the automotive industry in accordance with local conditions. This involves the decisions described in detail below.

Vehicles must be selected which meet domestic requirements, with emphasis on utilitarian models and a limitation of the number of different types and sizes. The same models should be retained long enough to amortize the special tooling. This type of programme leads to standardization with the focus on utility as compared with a wide range of consumer choice. The local authorities must also decide whether the production of buses, trucks, tractors and cars should commence one after the other or simultaneously. Another important decision is whether all vehicles should be made in one factory or whether each type should be manufactured in a separate factory. The production of various vehicles in one factory may result in better utilization of equipment and facilities and in standardization of technology and purchases from the supplier industries. Because of the ensuing expansion it may also be possible to attract foreign firms and build strong ties with them. However, the intricate organizational and management problems which are likely to arise from such centralization can outweigh these advantages. Finally, the local authorities must decide whether working with one licenser for all vehicles is preferable to working with a different one for each vehicle or, even, more than one for the same vehicle.

Selecting the licenser

Neither the licensee nor the local authorities in a developing country will initially have much experience in planning and setting up viable automobile factories. They must rely to a great extent on the help of a licenser until they acquire a working knowledge of the industry. Their selection of a licenser from among the firms that produce vehicles suitable for the needs of the country should be guided by the following factors:

Certain licensers, such as General Motors and Fiat, produce a wide variety of models, while others, such as Volkswagen and Massey Ferguson, specialize within a narrow range;

Large firms such as Ford and General Motors may be less interested than smaller companies (e.g. American Motors, Simca, Citroën or Volvo) in minor licensing operations;

Firms such as Fiat and Renault are anxious to move into developing countries, while others (e.g. Mercedes and Volkswagen) are sometimes more reserved;

Japanese, Spanish and Yugoslav firms are also offering licences, although their own industries were established only recently. They are more willing and flexible, though less experienced in overseas operations, than the older United States and European firms;

Distance, language differences and the political, commercial and social relations between their respective countries all affect the prospects of smooth collaboration between licenser and licensee.

The attitudes of companies depend on their management, ownership and general policy. It should also be noted that some firms are currently undergoing changes. Chrysler Corporation has bought shares in Simca and Rootes, while Mercedes-Volkswagen and Renault-Peugeot mergers could be in the offing. Consequently, the attidutes of these firms towards the granting of manufacturing licenses in developing countries might change.

Local regulations

The automotive industry in developing countries depends on local regulations for guidance and support. For example, the number of licenses granted for assembly of vehicles should be limited. The assembly of numerous types and makes is feasible, but this often delays local integration, because of the resulting lack of standardization. In addition, the government should set reasonable time-tables in respect to domestic content; ensure that foreign licensers have a meaningful over-all stake in the business; promote local supplier industries to provide the automobile industry with products of adequate quality at reasonable prices; and help the industry to extend its sales into neighbouring countries by means of export subsidies and special agreements. Also important to the developing automotive industry are: duty-free imports of equipment and materials; tax rebates; reasonable protection from imported vehicles; support in raising the required funds, in both local and foreign currencies; and continuity of government policy on matters affecting the industry.

3. The role of international firms in the establishment of the industry

Technical assistance and know-how

Transmitting manufacturing technology

Automotive production in a developing country should begin with the manufacture under license of an existing type of vehicle and with the purchase of technical assistance and know-how. In this way the difficulties of design, development and technology that are typical of the initial years of manufacture of a prototype can be avoided and management can concentrate on its other problems.

Licensers must simplify their documentation for use in developing countries. They should modify their production technology in line with the scale of production and the local conditions of their licensees and allow for the use of available raw materials and cheap labour. Licensers can achieve this by reducing automation, simplifying tooling and introducing manual operations to save on investment costs. In short, the licenser must do much more than merely provide the type of information that is relevant to his own factories.

Licensers are usually willing to make the necessary adjustments in technology, but they frequently underestimate the work and effort that such changes require of their executive and management personnel. Experienced international corporations are aware of the expenses involved and consequently insist on adequate compensation. This is ultimately to the benefit of the licensee, because a licenser who has underestimated his costs may try to make up for it by reducing the quality of his services.

Ensuring satisfactory product quality

Vehicles produced under licence in developing countries tend to be inferior in quality for a wide variety of reasons. For one thing, there is little competition from imports in protected markets; in certain cases there is no competition between local makers because only one type of car is produced. In addition, local traffic authorities do not use proper tests to control quality prior to registration, while there is a lack of uniformity in the raw materials and the semi-finished and finished components supplied by local industries. Another reason for the lower quality of these vehicles is the need in developing countries to rely more on the human element because production is less mechanized. Unfortunately, it often happens that workers and supervisors are not sufficiently reliable and conscientious. Finally, there is the unhappy tendency to buy the cheapest goods and underpay workers and employees, combined with an emphasis on quantity at the expense of quality, in order to make up for delays.

The licenser should ensure product quality by instituting strict inspection procedures and recommending minimum standards for purchased goods and finished vehicles.

After-sales servicing

The 25 or 30 firms that export built-up cars to developing countries also assume responsibility for their servicing. Local garages carry out simple repairs under the supervision of these firms and local dealers who also supply them with spare parts. Once local assembly and manufacture begin, servicing becomes the responsibility of the local car-makers. The market is then usually shared between about five makers, a number which makes it possible to dispense with imports.

One result is that some of the existing garages close down or change from servicing cars to other lines of business. The remaining garages, which had originally been designed to service a limited number of any one make, cannot cope with larger numbers of that make, especially since they are no longer supported by the licensers.

The licensee is often unaware of the fact that his reputation depends as much on the life-long performance of the car he sells as on its condition when the buyer takes delivery. As part of the know-how they contribute, licensers should help their licensees to set up a central service organization to keep complete records of sales, supervise use of vehicles, control and provide assistance to garages carrying out repairs, and enforce maintenance schedules. The licensers could also help by equipping authorized garages with service tools and special equipment, thus ensuring a supply of spare parts in the area where the vehicles are in use; by training repairmen to work in branches throughout the country; and by handling guarantee claims and customer complaints.

Product design

Once a licensee is able to manufacture an existing vehicle with technical assistance from his licenser, he can then focus his attention on modifying or redesigning it in line with local conditions. Moreover, such modifications may well be justified by special customer requirements and the small scale of production.

In general, a licensee cannot in the initial stages bear the costs of a design and development department. His licenser can help here by using his own research facilities to modify the vehicle so that it is suitable for local conditions and its manufacture in accordance with the technology of small-scale production.

Local conditions can affect many of the principal parts of the vehicle. For example, road conditions would affect car design with respect to ground clearance, suspension, steering and axles, while temperature and dust would affect the plans for the cooling and lubricating systems. Other modifications might be necessary to allow for the type of terrain (mountainous or flat), because this affects the amount of power required and the choice of gear ratios. The size of families and the amount of luggage determine the dimensions of the passenger and baggage compartments of the car, just as the design of a commercial vehicle body is affected by the type and volume of cargo it will transport.

When the vehicle is modified in line with the technology of small-scale production, changes in design should also be made. Such changes should make it easier for the licensee to manufacture parts economically in small quantities; to use less expensive, manually operated or semi-automatic equipment, even if this requires a greater labour input; and to use locally available materials whenever technically and economically feasible.

Appropriate changes in design may include using bent instead of pressed (with dies) sheet-metal parts; replacing pressed or forged parts with cast parts; using fibre-glass instead of sheet-metal bodies; replacing a one-piece body side panel with a number of welded pieces; substituting flat glass for curved; and reducing the variety of sizes and types of nuts, bolts, screws, wires and raw materials used.

Licensers recognize the importance of introducing such modifications and have even shown willingness to redesign a vehicle completely when necessary. Major automotive companies are equipped for this as they are continuously changing their own models. Chrysler has redesigned a truck to meet local conditions in Turkey, in line with the requirements of rational production technology. Renault has recently redesigned the Dauphine in accordance with conditions in Brazil, and the firm expects that costs will fall if it is made there. In addition, the sales of this car would then increase to an extent that would compensate for the benefits that would otherwise be derived from its interchangeability with models produced by Renault in France.

Marketing

The small market for automotive products in a developing country limits sales and increases the fixed costs per unit (as compared with large car-producers) and the price of materials, parts and supplies.

Developing countries need to expand their home market by exports, especially to their neighbours. However, several problems are involved. First, neighbouring developing countries have little confidence in each others' products, especially motor vehicles. They all want their own plants and do not want to import from another developing country. Second, it is difficult for a developing country to establish a reputation for its products in international markets. For example, Volkswagens made in Brazil and priced competitively met with sales resistance from Dutch and Swiss Volkswagen dealers, although the parent Volkswagen company vouched for the quality of the Brazilian product.

Other expansion difficulties in developing countries include high operating costs, which make it difficult for new companies to compete pricewise with the big established firms; lack of experience in negotiating export transactions and in delivering cars and parts abroad; lack of skill in servicing and maintaining vehicles and supplying spare parts; and the need to keep abreast of innovations and developments in design.

The many ways in which a licenser can help expand his licensee's restricted domestic market will now be described in detail.

The licenser can purchase certain parts for his own production from his licensees and organize the exchange of different parts among the latter. This helps curtail a licensee's costs by extending the scale of production of certain items. He can then export these products to balance his imports of those components which it is difficult for him to make competitively.

The licenser can suggest that his licensees specialize in parts more suited to their local conditions; moreover, he can control and guarantee the quality and reliability of the wares exported by his licensees, and himself use parts made by them in order to build up confidence in their products. However, this type of programme involves a number of problems, such as determining the parts most suited to each licensee, subdividing parts production among different licensees all wanting to make the same item, determining the quality and continuity of products from a developing industry, persuading the licensee to absorb initial cost disadvantages, and adjusting the licenser's own purchasing methods.

These problems are not insurmountable. A Yugoslav concern, TAM (Tovarna Autor. obila Maribor—"Maribor Automobile Factory"), has been exchanging truck parts with its German licenser, Magirus-Deutz, for the last five years. TAM has also supplied parts to Magirus-Deutz' licensee in the United Arab Republic and is trying to organize, with its licenser's help, exchanges of parts between licensees in India, the United Arab Republic and Yugoslavia.

The licenser can also help expand his licensees' restricted home markets by ordering from them certain spare parts for older models and special accessories for his world markets. Such parts are produced on a relatively small scale with little mechanization in developed countries, and their prices are consequently high. This type of transaction is particularly convenient if the older model is still being produced by the licensee.

The licenser can help in the export of built-up vehicles by allowing his trade name to be associated with his licensee's products; by assuring his overseas distributors that the quality of his licensee's products is equal to that of his own; by using his overseas marketing experience and contacts to assist the licensee in concluding export transactions; and by using his dealer and service organizations overseas for after-sales servicing of his licensee's products.

Specialization in one type, size or tonnage of vehicle helps improve a licensee's economy of scale. However, this one type may not suit all customers in his domestic market, who invariably have different requirements. Rather than diversify, licensees could exchange different vehicles between themselves and complement each others' product lines. Fiat's 600D, 124, 125 and 1300 are to be produced in Yugoslavia, the Union of Soviet Socialist Republics and Poland; this may well lead to exchanges among these countries. This type of specialization could, with advantage, be extended to Latin American and African countries, although it might be more difficult to organize there.

Another policy the licenser could follow would be to direct one of his licensees to supply a model which he himself has ceased to sell in his home and world markets. Certain models (e.g. the Fiat 1100 and 600D) have retained a fair portion of their original markets, even after being superseded by newer models of a similar size (the Fiat 1300/1500 and 850, respectively). Fiat is giving thought to the possibility of halting production of the 600D in Italy and ordering any cars which can still be sold in Italy and abroad from Spain and Yugoslavia, since current annual demand for this model is now about 80,000 cars, a figure that is likely to decrease rapidly. This would still leave a considerable volume of business for Yugoslavia's CZ (Crvena Zastava—"Red Star") factory (1965 production: 35,000 Fiat cars) or Seat in Spain (1965 production: about 80,000 cars).

A licenser could similarly entrust to his licensee the complete production of special vehicles or special variants of current models (sports cars, tourist buses, special purpose truck chassis such as tippers), which are produced on a smaller scale than standard commercial vehicles or passenger cars. In this connexion, Volvo is considering the advisability of making one of its special trucks in Argentina for the world market. Truck-makers in the Federal Republic of Germany order their special models from small firms which "tailor-make" them, but economies in labour costs, which are high in such cases, could be effected if these vehicles were made in developing countries.

The licenser plays an essential part in guiding such Marketing schemes to success. Very few new automotive industries have been able to achieve recognition in world markets without backing from a large established corporation. A possible exception is the Japanese automotive industry, which is now winning world-wide markets. However, this industry has lagged considerably in recognition, as compared with other Japanese in-

Reamers, various sizes
Tubing cutter
Tubing flaring tool
Bolt cutters
Sockets, above 1 inch
Thermometer
Ring glan gauges
Ring glan cleaner tool
Hole saw sets
Vacum pump
Ohm gauge
Tubing bender
Metal shear
Magnifying glass
Ridge reamer
Liner puller, wet and dry
Liner and block boring tool
Line boring bar
Chain wrench
Piston-ring compressor
Heavy duty C clamps
Heavy duty cabinet clamps
Metal cutting bandsaw
Drill press
Heavy duty press, 50–60 tons
Engine rebuilding stand
Transmission and differential rebuilding stand
Engine shutter control test equipment
Degrease tank
Steam cleaning equipment
Adjustable safety stands
Lubrication equipment
Painting equipment, including gun, hose, regulator etc.
Tobin arc bar

The special items below should only be purchased in volume in order to warrant the investment:

Magnaflux machine
Crankshaft grinder
Balancing equipment for clutches, drivelines, crankshafts etc.
Diesel fuel pump test equipment
Injector tester and flow-rate equipment
Wheel balancer and aligner
Heavy duty frame and axle straightening machine
Front end machine for setting caster and camber
Dynamometer
Ignition oscilloscopes
Ultra-high frequency sound detectors for leaks and friction

APPENDIX 4

SAMPLE SPECIFICATIONS ON DIESEL FUEL, PETROL, OIL AND GREASE

Diesel fuel

This is an all-purpose fuel intended for use in all automotive diesel engines under normal conditions. It must be a straight run petroleum distillate, free of water, grit, acid and fibrous or other foreign matter likely to clog or injure pumps, nozzles or valves. It must conform to the following chemical and physical requirements:

Distillation test

Cetane number	*Min. 45*
50 per cent point	Max. 520° F
End point	Max. 650° F
Flash point	Min. 125° F
Pour point	Max. 15° F
Viscosity S.U. at 100° F	30–45 secs.
Carbon residue on 10 per cent bottoms	Max. 0.15 per cent
Sulphur	Max. 0.50 per cent
Water and sediment	Max. 0.05 per cent
Corrosion	Pass
Ash	Max. 0.01 per cent
API gravity	Max. 36

Petrol

Regular petrol must consist of blends of refined hydrocarbons derived from petroleum, natural gasoline or blends thereof with synthetic or aromatic hydrocarbons or both. Regular petrol shall be free of water, sediment and suspended matter.

Requirements

The distillation ranges of the minimum percentages to be evaporated are:

75° C – 10 per cent;
140° C – 50 per cent;
200° C – 90 per cent.

Distillation residue should not exceed 10 per cent. Gum shall not exceed 4 mg per 100 ml. The maximum vapour pressure should be in pounds per square inch, based on temperature and location. Copper strip corrosion must fit classification 1 of the ASTM Test. The octane number is checked by the minimum 92 research method. The sensitivity should not exceed 10. The sulphur content should not exceed 0.2 per cent. Testing should conform to the ASTM specifications D-439-60T.

Lubricating oil – internal

One type of heavy-duty oil should be suitable for crankcase lubrication of reciprocating internal combustion engines (spark ignition *and* compression ignition) under all conditions.

dustries, which shows how difficult it is to market vehicles internationally without the support and collaboration of an established firm.

Many licensers do not seem to be fully aware of the benefits to be derived from co-operation with their licensees in marketing arrangements. Others are aware of the possibilities but may be reluctant to proceed for fear of indirectly hurting their reputation in markets where they are already established. Although encouraging exchanges among their licensees, they themselves stand aloof. Firms who assist their licensees by buying components from them enjoy a clear advantage over competitors in the same country.

Certain firms use such arrangements as "bait" to gain access to markets in developing countries where the authorities permit the local production of only a limited number of makes of vehicle. Massey Ferguson is trying to enter the Mexican tractor market, where there are already two established tractor-makers, by offering to make additional axles in Mexico for shipment to Detroit. The Mexican authorities are using this proposal to bring pressure on the existing tractor producers (Ford and John Deere) to do the same. Special efforts of this kind cannot be expected from the international firms save in exceptional circumstances, for instance, when they are trying to enter an already crowded market. Nevertheless, the advantages they offer to a developing country may be greater than the harm which could result from adding another producer to a limited domestic market.

Operating costs

The complicated nature of the automotive industry makes it particularly difficult to measure and allocate costs. Unwise purchases, excessively large stocks, or stoppages in production resulting from short stocks can increase costs considerably. Only experienced management personnel can locate abnormal expenditure and prescribe the quickest and most appropriate remedy. The licenser must emphasize the importance of cost analysis and control in a growing automotive enterprise and help his licensee set up an adequate costing system. Cost allocation and accounting, together with continuous inventory and stock control, should be introduced at the very outset, since these procedures become more intricate once the factory is actually in operation.

Generally speaking, fixed costs per unit and prices of materials and supplies are high in the relatively small plants that are commonly found in developing countries. Furthermore, despite the lower capital investment cost due to the smaller degree of automation, the cost of depreciation per unit in developing countries is often as high as, or even higher than, that in plants which are more automated but also produce a larger number of units. Labour is the only cost element that might give the producer in a developing country the edge. However, the advantage in wage rates is often nullified by the low productivity of labour in developing countries. Moreover, direct labour accounts for only 3 per cent of the manufacturing costs of passenger cars, and not more than 15 per cent in the case of buses. Therefore, the small-scale producer is invariably at a disadvantage in the significant cost areas such as purchase of materials (50 to 70 per cent of total production costs), general overhead and expenses (15 to 20 per cent) and depreciation (7 to 15 per cent). Consequently, the unit cost of vehicles manufactured in small quantities is usually significantly higher than that of mass-produced vehicles.

Apart from expanding its licensees' markets, the automotive corporation can also help them by modifying its designs, as mentioned earlier; by reducing materials and labour overhead and costs with the aid of modern management methods, time-and-motion studies, critical-path techniques, cost controls etc.; and by defining the feasible sequence for manufacturing parts locally to increase domestic content.

The licenser can direct his licensee to schedule production and domestic procurement of parts in such a way as to limit increase in costs. In line with this policy, the licensee could begin with those parts and tasks which lend themselves to small-scale production. Alternatively, he could begin with simpler parts and tasks which do not call for much skill or supervision but are expensive enough to make a meaningful domestic contribution. He could also schedule his procurements from the domestic supplier industry in accordance with the same rationale.

Domestic contribution can be further encouraged if parts made locally are exported to pay for the import of other parts which are particularly expensive to make and less often mass-produced (e.g. body panels and ball bearings). Spain for example, imports body panels from the United Kingdom and exports castings to them. Yugoslav car-makers import nuts, screws and washers cheaply from the Federal Republic of Germany and export castings. Countries such as Argentina, Brazil and India, which produce over 90 per cent of their car components locally, may be able to reduce their costs by importing such parts and paying for them by exporting others.

Labour and management training

Management

The role of management is of crucial importance in the automotive industry, owing to the complex nature of this industry. Certain automobile firms in developing countries manufacture many types of vehicles under various licenses. Each of these vehicles has over 10,000 parts whose production involves a large variety of operations, which in their turn call for a wide range of equipment and skills. Store-keeping, purchase transactions and cost controls require a combination of technical, commercial and administrative expertise. In addition, technicians are needed for the work of planning, design and development. Furthermore, the local executives and managers must be capable of learning from the staff of their licensers while still commanding their respect.

There are many specific problems involved in the training of supervisors and managers, including, *inter alia*:

The limited number of recruits of the right background, personality and character;

The selection of executives is no easy matter;

Unnecessary personal competitiveness frequently develops among local executives and supervisors, thus reducing interdepartmental co-operation;

The need to teach leadership, co-operation, discipline and decision-making;

Differences in language, academic training, past experience and social and cultural background, as between the licenser's staff and the local executives

The automotive corporations can solve some of these problems by carefully selecting the individuals they send to train local supervisors and managers on the job; by sacrificing key men from their own staff to serve as supervisors and managers until the local group can take over; and by helping the local group to screen and select senior officers.

Labour

Trained labour is often not available in developing countries. Training methods for skilled workers on the job or in the licenser's factory have been standardized and are effective, provided that recruits are carefully selected and suitable instructors provided by the licenser. Keeping trained workers is a problem, however, as they tend to migrate or move to other industries.

It is more difficult to train workers to be reliable and conscientious than it is to help them acquire professional skills. Good foremen, supervisors and inspectors are hard to find and difficult to train quickly in developing countries.

Another problem is the inability of the new industry to establish piece rates soon after the start of operations. This is common in developing countries because of the immaturity of the industrial system and labour force. The scales fixed by the management are usually inadequately planned and balanced; the workers are suspicious of the system, and their output is often reduced by factors beyond their control. This leads to a postponement of the setting of piece rates, a situation that inevitably contributes to lower labour productivity in developing countries and usually nullifies the cost advantages anticipated from lower wages.

Foreign-exchange requirements

The manufacture of vehicles is usually established stage by stage over a number of years, the same holding good for the supplier industry. Consequently, fresh funds in local and foreign currency are required for capital investment throughout the build-up period.

Receipts from sales in local currency finance operating expenses. The latter include the cost of imported materials and component parts, royalties, fees etc. which must be paid in foreign currency. This requires a considerable supply of foreign exchange until most of the materials and components are available locally.

The local manufacturers and authorities should estimate the funds required during the build-up period and make sure their resources cover their needs. Underestimation of requirements or inability to find the necessary funds, especially foreign exchange, can impede progress in local integration and production of vehicles.

One item which is usually underestimated is the requirement for imported materials. A first reason for this is that the start-up time needed to establish a manufacturing concern on a solid basis is itself often underestimated, with consequent lengthening of the assembly period. Second, the savings in foreign exchange resulting from assembly with about 5 per cent domestic content are negligible, as shown in table 2, which also shows the financial burdens arising from packing and from increases in freight costs when importing semi-knocked-down vehicles.

Table 2. Savings in foreign exchange resulting from assembly of vehicles with minor (about 5 per cent) domestic content
(in dollars)

	Import assembled	*Semi-knocked-down*	*Completely knocked down*
Ex-factory price	1,000	980	950
Minor deletions		— 50	— 50
	1,000	930	900
Packing and f.o.b. charges	40	110	100
Freight and insurance		80	
Total	1,040	1,120	1,000

A third reason for underestimating the amount of imported materials required is that the number of vehicles produced locally cannot be restricted in the initial years of manufacture, as the local authorities hope, until the domestic content rises to an appreciable level. In fact, demand has been known to rise sharply with the establishment of a local car industry. Fourth, local manufacture (domestic content) often does not progress as rapidly as planned.

An example of miscalculation of foreign currency requirements is given in table 3, which shows both the theoretical and actual requirements. The same miscalculation is shown graphically in the figure on p. 68. In this example, the foreign exchange that had been estimated

TABLE 3. FOREIGN-EXCHANGE REQUIREMENTS FOR IMPORTS NEEDED BY A NEWLY ESTABLISHED AUTOMOTIVE INDUSTRY

	Theoretical											*Actual*			
Year	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*0*	*1*	*2*	*3*
A. Quantity of vehicles produced															
Per year (in thousands)	—	3	5	6	8	10	12	15	15	18	20		5	8	10
Cumulative (in thousands)	—	3	8	14	22	32	44	59	74	92	112		5	13	23
B. Domestic content (%)															
In factory	—	10	14	20	25	30	35	40	43	43	43	—	5	7	10
Local purchases from suppliers	—	15	20	30	35	40	45	48	50	52	54	—	5	10	12
Extra packing and freight	—	—	—	—	—	—	—	—	—	—	—	—	−14	−6	6
Total (domestic content)	—	25	34	50	60	70	80	88	93	95	97	—	−4	11	16
C. Imported components/unit (%)	—	75	66	50	40	30	20	12	7	5	3	—	104	89	84
D. Annual currency requirements For imports (A × C) (in cost per thousand complete vehicles)	—	2.3	3.3	3.0	3.2	3.0	2.4	1.8	1.1	0.9	0.6	—	5.2	7.1	8.4
E. Cumulative currency requirements For imports (in cost per thousand complete vehicles)	—	2.3	5.6	8.6	11.8	14.8	17.2	19.0	20.1	21.0	21.6	—	5.2	12.3	20.7
Foreign exchange for investment in fixed assets for domestic content in factory only, excluding investment for supplier parts and material production (converted into costs per thousand complete vehicles)	1	3	4	4	6	2	—	—	—	—	—	1	——3——		—

to be sufficient to cover the import of materials and parts for the production of 112,000 cars over a ten-year build-up period (to reach 97 per cent domestic content) was used up in three years to make only 23,000 cars (reaching a net domestic content of 16 per cent). The example also shows that the cost of fixed assets for manufacturing car parts (excluding the supplier industries) is small compared to the amount of foreign exchange required for importing materials and parts.

An assembly or manufacturing plant cannot be subjected to ups and downs (depending on how much currency is available) similar to those involved in the importation of built-up cars. Theoretically, an increase in local content will result in a reduction in over-all foreign-exchange requirements despite increases in the number of vehicles produced. In actual practice, there is an initial peak in foreign-exchange requirements which often causes a subsequent shortage. Consequently, the industry is unable to import enough materials to operate at maximum capacity. This leads to a reduction in volume and an increase in operating costs per unit, and, subsequently, in sales price as well. Customs duties must then be increased to provide protection from imports. It may be beyond the power of local authorities to remedy the difficulties that can result from this situation, so it should be predicted and avoided.

The licenser can help his licensee avoid foreign-exchange problems by making realistic estimates of requirements; by directing him to manufacture components from local materials and to use locally made supplier parts; by permitting him to purchase standard items such as bearings and electrical and fuel-system components from international manufacturers who will allow him to pay in "soft" currency; by expanding his licensee's export market; by extending meaningful credit facilities (three to five years) for the supply of materials and parts delivered by the licenser; by helping him to procure suppliers' credits for the purchase of machinery; and by making meaningful equity participation directly in the licensee's firm.

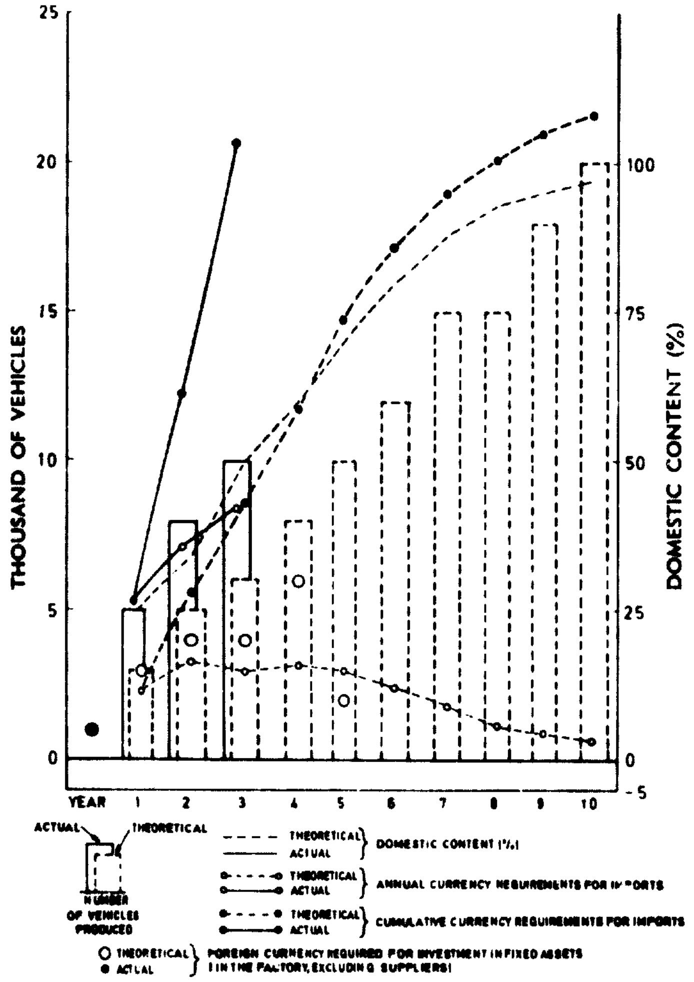
4. DEVELOPING THE AUTOMOTIVE SUPPLIER INDUSTRY

Products made by the supplier industry

About 10,000 different supplier parts and materials per model are purchased by a vehicle producer in a developing country, accounting for 50 to 70 per cent of his total costs. These parts and materials can be subdivided into three main groups—raw materials, semi-finished parts, and finished components and parts.

Raw materials

This group consists mainly of steel strips, bars, tubes, light alloy materials etc., which are machined into finished parts in the automotive factory itself. These materials are made general standards and are also used in other industries.



Foreign exchange requirements for imports needed by a newly established automotive industry

Semi-finished parts

Included here are cold-rolled steel sheet; various iron castings; steel, aluminium and other metals; steel forgings. These parts are manufactured by the metallurgical industry from raw materials but require further machining or processing in the automotive factory itself. Similar semi-finished parts, manufactured with the same basic equipment, are used by other industries.

Finished components and parts

This group includes pistons, rings, bearings, springs, starters, dynamos, auto-electrical equipment, carburettors, fuel pumps, steering units, clutches, brake cylinders etc.; in other words, the parts that are directly incorporated into the vehicle. Such items are used only by the automotive and allied industries. The finished group also includes items such as crankshafts, valves, gear-boxes, propeller-shafts etc., and even complete engines from specialized factories, if these happen to be available on the market at suitable terms.

The lack of any supplier part or late delivery of a raw material or semi-finished part will halt vehicle production and cause severe losses. This accounts for the fact that large car-makers in developed countries control many of the firms that supply them with essential raw materials and parts; it could also serve as an incentive to increase domestic content in developing countries at a more rapid rate than would be justified in the normal course of events.

Sequence of growth of supplier industries

The supplier industries described below are usually already in existence in developing countries before the automotive industry is established.

Spare and replacement parts industry

Car components such as tires, batteries, V-belts, plastics, matting and fast-moving spare parts, have short lives (more than four changes per car) and are consumed in larger quantities as spare parts than as original components in new vehicles. The demand for spares could well develop to a point that would justify their domestic manufacture before the establishment of an automotive industry. Such parts can be used later by the car industry if their quality improves. However, they do not usually account for more than about 5 to 10 per cent of the price of a vehicle.

Other supplier industries

In many developing countries there are industries that manufacture simple materials and parts similar in technology and form to those used in the car industry, e.g. grey castings, small dye castings, cables, glass, light bulbs, upholstery, woodwork and rubber products. These industries can be helped to improve their specifications and technology, with the result that they will eventually be able to produce parts for the car industry.

Other materials and components industries are seldom economically feasible until they can supply parts directly to an automotive factory, and they are therefore unlikely to be in existence before such a factory is built. These industries can be subdivided into three groups, as described below.

The first group consists of industries that manufacture materials and components common to the automotive and other industries, e.g. high-tensile steels, steel castings, electrical components, chains, engine parts and oil seals. Similar parts are used in other engineering industries, such as those manufacturing domestic and electric appliances, industrial engines, pumps, motor cycles and spare parts and wagons for the railways, which appear in developing countries at about the same time as the automotive industry. Once automotive production begins, the need for these products rises to a level which may justifiy the construction of a factory. However, the specifications for materials and components and the production technology would call for the conclusion of a licence and know-how agreement.

The second group consists of those industries that produce materials and components essentially for the automotive industry. Included in this assortment of products are forgings, malleable castings, cold-rolled steel sheet, and items such as clutches, brake components, linings etc. These are used mainly in the car industry in developing countries, but also in other industries in developed countries. Some of these materials and components may be produced for a visibly growing automotive industry. Their design and technology are specialized and they can only be produced satisfactorily with a foreign licence and know-how.

The third group includes industries producing typical "mass production" items. Certain products manufactured by the first two groups of industries, e.g. ball bearings and diodes for alternators, may be manufactured at such a high level of mass production in developed countries that they cannot be produced under licence in smaller quantities at competitive costs. Such products presently account for only about 10 per cent of the cost of a complete vehicle and should be imported until the demand for them is large enough to justify their domestic production.

It is probable that components accounting for about 10 per cent of the price of the vehicle will be almost immediately available from suppliers. With further development of the industry and an increase in the demand for vehicles, more parts can be produced to replace imported components, but only when this is economically viable.

Planning new supplier industries

There are two alternatives to be considered in connexion with the timing of automotive production in relation to the supplier industries, most of which do not exist in developing countries when car manufacture is first contemplated. First, automobile production should only commence when most of the required common raw materials, semi-finished and finished parts are already being produced satisfactorily for other consumers in the country. Second, automobile production should begin with the import of materials and components until a demand is created which, combined with that of existing consumers, will justify the gradual establishment of supplier industries.

It is improbable that adequate automotive supplier industries will exist in a country before the car industry is established there, because the industries which precede automobile manufacture (e.g. construction, textiles) rarely utilize the materials and components needed for making vehicles. The advent of automobile production standardizes requirements for materials, components and spare parts and creates a general interest in them. Through the suppliers of the licenser, the industry also becomes a source of know-how for the local supplier industries. Therefore, the second alternative is inevitable, and the resultant problems should be tackled as vigorously as possible.

The following are typical problems that arise in connexion with the import of materials and components:

Because of the difference in transport costs, certain finished parts may be cheaper to import than their raw materials or semi-finished blanks;

The import price of components and semi-finished parts, especially forgings, will be very high if the licenser modifies his products and discontinues his orders of the same parts;

The problems involved in packing, conserving and in defining responsibility for damages (supplier, shipper, port storage facilities). Returning faulty parts or materials to the supplier is expensive;

The parts and materials imported are in relatively small quantities and comprise a large variety of specifications and dimensions. Only dealers and small wholesalers are interested in such small orders, and they will raise their prices accordingly;

Long delays before delivery of the required materials make it necessary to tie up funds in large inventories;

The shortage of, and the restrictions with respect to, the foreign currency needed to import materials and components make it difficult to co-ordinate production and can cause stoppages.

Role of local entrepreneurs and authorities

The growth of a local supplier industry depends on the quality of the local licensees, on the local regulations and on the attitude of the local authorities. Several important contributions can be made by the latter. For one thing, they can exert judicious pressure on the licenser, at the proper time, to increase domestic content by developing the supplier industry in the country. This has its drawbacks, but it has proved to be the most effective way of setting up supplier industries in countries that are ready for them. Second, the local authorities can assist in procuring the funds, including foreign currency, required to finance the purchase of investment goods, materials and tools; they should refrain from giving their support to premature projects fraught with financial, economic, administrative and technical difficulties. Finally, the local authorities can provide subsidies and incentives and give appropriate protection to the infant industry from imports within reasonable time limits.

Sources of know-how for the supplier industries

Raw materials

The know-how required for the production of raw materials and some of the semi-finished materials (e.g. sheet metal) must be procured by the developing countries for their metallurgical industries from suitable foreign collaborators.

Semi-finished parts

The manufacture of semi-finished parts (e.g. grey and steel castings, light metal and aluminium castings, malleable and die castings, forgings) lies within the domain of the metallurgical industry. However, the production of the machined vehicle part is so dependent on that of the semi-finished part that the necessary know-how should be obtained from the vehicle licenser himself. Semi-finished components are made in a separate factory which has entered into agreements with the car factory and other buyers of castings and forgings, e.g. railways and various local industries. The technology should correspond to the requirements of the market as a whole.

Finished goods

The technology for the manufacture of finished goods is usually in the possession of the suppliers of the vehicle licenser, rather than the vehicle licenser himself. Thus, the suppliers can only be brought to transmit this know-how if the vehicle licenser, who is one of their most important customers, exerts pressure on them.

Specific problems may arise when several firms are licensed for the production of trucks, tractors and passenger cars in one country. For example, these vehicles may have electrical components of different firms, e.g. Lucas, Bosch, Marelli and Autolite. Electrical equipment would then have to be produced in a small market under four different licences, unless the licensee can combine them or one of the licensers modifies his equipment for use in all vehicles. The vehicle licensers must approve such measures and might have to modify their vehicles so that they could be fitted with makes of electrical appliances different from those they purchase in their home markets. This could lead to ill feeling between the automotive manufacturers and their suppliers, who may be reluctant to see a competitive item built into a car which they have traditionally equipped at home.

Femsa, a company making electrical components in Spain, has licence agreements with Marelli, Lucas and Bendix, among others, and supplies parts to the Fiat, BMC (British Motor Corporation) and Citroën factories in Spain. Some of its products are an ingenious adaptation of the various licences; for example, the generator has been redesigned for use, with slight alterations, in more than one make of vehicle. In this way, a certain degree of standardization and economy is achieved without friction with the car or electrical-component licensers.

Firms providing technology for the production of supplier articles will help their counterparts in developing countries to retain the goodwill of the vehicle licenser and prevent competitors from gaining access to his market through his overseas licensees. They will receive larger royalties, know-how fees and dividends than at home. They will secure indirect market access for some of their other products. Finally, they will supply a limited quantity of components to the licensee until local production is under way.

In the final analysis, suppliers enter into licence operations overseas as a result of the pressure brought on them to do so by their clients, the vehicle producers, who have already started licensing operations abroad and are obliged by local regulations as a condition of doing business in the country, to procure more parts locally.

5. The licenser's rewards and obligations

Rewards

Direct marketing of components

Licensers want to extend their penetration in an important market or to introduce their products into an area which can absorb a large quantity of vehicles. They realize that their sales must take the form mainly of exports of parts for assembly by the local industry, rather than shipment of complete vehicles. This reduces the volume of delivery per unit but ensures for them a larger share of the market than for makers delivering complete units. Consequently, a firm's sales usually show a considerable increase when it undertakes a licensing operation, despite the decrease in parts supplied per unit of the products made under licence. This is illustrated in table 4.

The parts and operations which in the initial stages are handled locally by the licensee are of less interest to the licenser. He is more concerned with increasing his sales of those mass-produced parts that have a long setting-up time and a short piece-time and require expensive tooling. He will therefore postpone the local manufacture of parts such as large body panels. Although the principal gainer here is the licenser, the licensee does not suffer either, as such parts do not create any direct conflict of interest between licenser and licensee. Seat (Spain) has wisely postponed local manufacture of body panels for some models of the cars made under Fiat licence. However, European car licensers are irked by the regulations in Iran which lay down that body panels must be made in the early stages of production. This will merely discourage potential licensers without bringing much benefit to Iran.

A licensing operation ensures sales for the licenser and makes his volume of business more predictable. Some European firms do 15 per cent of their total business in sales of components, which often accounts for half their exports.

Licensers are particularly interested in growing markets or those that provide access to still other markets through racial, commercial or political ties. Yugoslavia has been attractive to firms for the access it provides to other East European countries.

TABLE 4. LICENSERS' DELIVERIES BEFORE AND DURING THE BUILD-UP OF A LOCAL INDUSTRY

	Imports	*Assembly*	*Manufacture (actual)*			*Goal*
Year	*1*	*2*	*4*	*6*	[illegible]	*12*
A. New registrations[a]	6,000	6,300	7,000	7,700	8,500	10,000
B. Number of suppliers	30	4	2	2	2	2
C. Average share of licenser (A ÷ B)	200	1,600	3,500	3,800	4,200	5,000
D. Percentage of vehicle supplied by licenser	100	80	[illegible]	40	30	10
E. Percentage of vehicle manufactured by licenser[b]	50	40	30	20	15	5
Average volume of business handled by the licenser (C × D)	200	1,280	2,100	1,520	1,260	500
Licenser's sales of parts manufactured by him (C × E)	100	640	1,050	760	630	250

[a] In a specific range of vehicles, assuming an increase of about 5 per cent per year.
[b] Assuming that approximately 50 per cent of the parts supplied by the licenser are purchased by him from his suppliers.

Indirect marketing advantages

Licensers can often sell more of their other vehicles or products, excepting those made under licence, as a result of the access which they gain to the market in a country where they have a licensee.

Supply of equipment and raw materials

Licensers profit indirectly when they supply machine tools, special equipment and raw materials and semi-finished parts to their licensees. Most automotive factories built under licence are equipped with machinery of the same make as that used by their licenser. Special tools, dyes and jigs may be supplied by the licenser's own tool shop, while accessories, raw materials and semi-finished parts come from his subsidiaries or associates. The licenser's reward does not necessarily consist only in commissions from the suppliers who get the business, for he may also acquire influence and bargaining power with those firms. Fiat may well expect to reap such benefits as a consequence of supplying equipment worth about $100 million for production of the Fiat 124 in the Union of Soviet Socialist Republics at an annual output of about 600,000 cars.

International skills and image

The skills acquired in doing business overseas have a propaganda value that promotes sales and makes for international recognition. It is no coincidence that the large automotive corporations are now subdivided into those having an international licensing organization (firms with up to 40 different licensees throughout the world) and those having none. The latter are, of course, finding it difficult to retain their export business.

Royalties and fees

In view of the mounting costs of technological research and product development in most automotive firms nowadays, the licenser must receive adequate royalties, licence and know-how fees if he is to cover the expenses of transmitting his know-how and still be able to contribute towards his own research and development costs.

Obligations

Automotive corporations must often undergo changes and make sacrifices for the sake of their licensees. For instance, the licenser should develop the ability to transmit know-how successfully through capable officers who are fully conversant with the problems of developing countries and have the special personal approach required. He should also simplify the documents sent to developing countries, all the while ensuring that the right kind of information is given. The licenser should select efficient and energetic executives from his own factories to assist the licensee and to train local technicians on the job.

Another of the licenser's obligations is to adjust his own system at home so that it can handle licensing operations involving the economical packing and shipment of car parts all over the world. He should bear in mind the problems that will be experienced by his licensee in the event of short shipments or damage during transport.

The licenser should invest in overseas manufacturing ventures that are economically sound, even if this means depriving his own projects of part of their resources. He may have to make a choice between safe but marginally profitable projects at home and investments abroad. The latter are more risky but provide marketing privileges and can be more profitable. In addition, the licenser should buy parts from his own subsidiaries to make up in part or in full for shipments to them. He must tackle the problems that arise from such transactions as if they were his own, since this type of compromise is an essential sales technique.

The licenser should expend effort and resources to help his licensees to export vehicle parts, although this will place an additional burden on his own marketing and servicing organizations. He should also use his influence to persuade his suppliers to enter into licensing operations abroad.

Conclusions

A country must have a suitable industrial background before it establishes an automotive industry; there must also be a demand for vehicles. The local authorities should then decide how many factories are to be set up to make vehicles, select the appropriate types and models, and fix the production capacity and the extent of incorporation of local parts. They must also select the licensers best qualified to assist the industry. The local authorities must be prepared to give adequate support to the industry throughout its relatively long start-up period.

Automotive corporations should not allow competition among themselves to lead to the establishment of too many small factories in a country with a limited market. However, the primary responsibility for preventing uneconomic duplication lies with the authorities in the developing countries.

Generally, the industry should be built up gradually and progress through the following phases:

Assembly of imported components;

Manufacture of parts from imported materials, initially for buses and trucks, later for tractors, and ultimately for passenger cars;

Purchase of components and materials from local factories to replace imports;

Exchange of parts with the licenser;

Exchange of parts with other licensees;

Sharing of export markets with the licenser;

Production of certain vehicles exclusively for the licenser's home and world markets;

Membership in an international group of licensees guided by the licenser and assisted in marketing and design by him.

International automotive corporations can play a leading role in this development by:

Providing production know-how and assistance in design, and establishing cost and inventory control systems;

Assisting in management and in the training of supervisors and workers, and inducing their suppliers to do the same for their counterparts in developing countries;

Helping the licensee overcome problems of scale and foreign exchange by providing export opportunities through their world-wide organizations;

Indicating the best uses of the available foreign currency;

Participating in financing.

Some of the large car-producers are interested in setting up manufacturing subsidiaries in developing countries in order to increase their share of the market in these countries. They are encouraged by the progress made in countries such as Brazil, Spain and Yugoslavia. In exchange for their efforts, they expect special marketing advantages; profits from supplying equipment and raw materials through their subsidiaries, associates and suppliers; and royalties and know-how fees that will cover their expenses and also yield them a measure of profit.

AUTOMOBILE DEMAND IN DEVELOPING COUNTRIES*

A. G. Nowicki

INTRODUCTION

This desk study was undertaken to find a sound approach to the problem of projecting automobile demand in developing countries. It surveys demand in developed and developing countries, draws attention to the difficulties of forecasting demand in developing countries and suggests that demand projections based on a market saturation concept should be used in developing countries. Market saturation, its measurement and some of its implications for economic policy are outlined.

Although only a small proportion of the population in developing countries owns automobiles, automobile purchases are important in the total consumer spending. Since such purchases have a very high import component, they are usually very much the concern of governments. Automobile industries in most developing countries are still at an embryonic stage, but they are given high priority, and tariff and other industrial policies are frequently based on them. A knowledge of automobile ownership trends is also necessary in planning the supply of joint consumption goods such as gasoline, in road use projections, and in other aspects of regional and urban planning.

Forecasting the demand for automobiles is vital to the formulation of consumption, production and other policies in developing countries, but the forecasting methods used in developed countries are inappropriate. A new approach suitable to the nature of the demand in developing countries is suggested.

The demand for automobiles in highly developed countries such as the United States is primarily a demand for replacements. Although there is some additional demand for second and third cars and the total demand increases with population growth, most families do own automobiles. In forecasting demand the existing stock of automobiles is therefore as important as the income and price factors.

In developing countries car ownership is still increasing, the stock of automobiles is small, and replacement purchases are less important than in developed countries. Since the automobile is a status symbol as well as a means of locomotion, non-economic factors are also important in automobile purchases. The high import component of automobiles limits their availability; it cannot be assumed, as in developed countries, that an ample supply will meet the demand in the long run. The construction of domestic car manufacturing plants, however, usually raises car prices. Supply is therefore a distinct factor in determining purchases in developing countries.

All the factors—non-economic as well as economic and supply as well as demand—can be taken into account by focusing attention on the annual expansion of the automobile market and on the rate at which it becomes saturated at successive levels of growth. The annual demand by new owners can then be derived; it and the replacement estimates are the basis for annual total demand estimates. This method indicates the feasibility of automobile manufacture in a country and the effects of tariff and other tax policies. A new emphasis in the compilation of automobile statistics is necessary.

In both developing and developed countries, random influences disrupt the trends. Because of the importance of automobiles in consumption and production, many of the irregularities in the trends are caused by government policies. It is particularly important that a government understands the trends it seeks to disrupt, and the effects that its decisions will have.

1. AUTOMOBILE DEMAND: A GENERAL VIEW

The techniques for projecting automobile demand in developed countries are based on sophisticated concepts of demand, income and prices, and in addition take into account problems of stocks, depreciation and replacement which have not yet been absorbed in the

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body of conventional economic theory. The data required for forecasts are therefore complex, but the techniques themselves are mathematically simple.

Demand

Conventionally, consumption demand is a function of income and prices, and it is usually divided into a normal part pertaining to necessities and a discretionary part which covers other expenditure. It is therefore the discretionary part that is important in purchases of consumer durables, particularly of automobiles. Since the discretionary part of the consumption function can be postponed, automobile purchases are heavily influenced by business fluctuations.

While in pure theory demand is generally regarded as depending on price alone or on price and national income, in practice other economic and non-economic factors come into play and may be as important as, or even more important than, price and income. The prestige of car ownership is one such factor.

Demand for transportation and car ownership

The demand for new passenger cars is distinct from an individual's demand for transportation or for car usage. The transportation demand can usually be satisfied by using an old car for another year, while the demand for car usage can be met by purchasing a used car. The following factors are therefore important in car purchases:

A purchaser wishes either to obtain possession of a car or to exchange his present car for a new one. There are probably some differences in the manner in which these two groups of consumers behave. While the former predominates in developing countries, the latter is the most important in developed ones. For both groups, however, individual behaviour in car purchases belongs to behavioural categories in which "possession" is one of the explanatory variables;

In developed countries where ownership of private cars is widespread, the rate of increase in income is generally one of the least important variables in the demand function. Cars are purchased even without increases in income because the automobile, like all durable goods, is subject to an acceleration effect caused by the fact that the service desired is a function of income, while the service supplied is a function of the existing stock. In developing countries where the existing stock of automobiles is small, the influence of income changes is likely to be more important;

A car's service yield can be measured by the price a consumer pays for the use of car for one year, that is, the amount by which the car depreciates plus the interest foregone by holding capital in the car:

The rate of depreciation is determined by a number of factors, the most important being the elasticity of the supply of new cars. In periods of limited supply, depreciation falls and can even become negative. In the United Kingdom, 18-month old cars were more expensive than new cars[1] from 1940 to 1952. In the United States, annual car depreciation was about 9 per cent in 1945 and is now about 25 per cent. Low depreciation is typical in developing countries where constraints on supply, due to balance of payments difficulties are common; they are not common in developed countries;

The interest foregone depends largely on other investment opportunities, and on the monetary situation in general.

In developed countries, depreciation and interest are generally not very important, but in developing countries they may be a means of preserving the real value of one's money. The rapid growth of automobile stocks in Brazil, for example, has been stimulated in this way.

Income elasticity of substitutive groups

All classic demand treatises[2] postulate that the income elasticity of the market demand for given goods equals a weighted average of the demand elasticity in different social groups: a change in groups thus leads to changes in weights and in average elasticities. With a few exceptions however, like Engel's Law which it equals in simplicity and appropriateness, this theory has not been applied to studies of automobile demand in developed countries. In any case it does not appear to be a very useful concept in automobile studies in developing countries, where the automobile purchasing groups tend initially to be rather homogeneous.

L. D. Taylor[3] calculated that habit-linked expenditures represent 40 per cent of consumption expenditures in Sweden, while H. S. Houthakker[4] places the level at 60 per cent for the United States. Assuming that these calculations suggest the correct order of magnitude for the stable component of expenditures, the calculation of elasticities for non-habitual expenditures becomes a difficult matter; this has been shown in empirical studies.[5] The difference between the income elasticity for food and that for car purchases is particularly large. In developed countries the former is far below the latter. France is probably typical; the income elasticity was 0.3 for food and 1.47 for car purchases in 1966. In developed countries the income elasticity of a commodity is an increasing function of its price relative to other commodities.[6]

However, this concept has little application in developing countries. First, the average elasticity for food is still very high in these countries; typical examples of

1 O'Herlihy (1965), pp. 2—3.
2 Wold (1952), p. 119, equation 8.
3 Taylor (1964).
4 Houthakker and Taylor (1966).
5 Houthakker and Taylor (1967), p. 227.
6 Houthakker (1957), p. 542.

Petroleum products are compounded with functional additive materials (detergents, dispersants, oxidation and corrosion inhibitors). No refined components shall be used.

The physical requirements are:

Grade 30

Viscosity at 210° F kinematic, centistokes	9.65–12.98
Saybolt universal seconds	58–70
Viscosity at 0° F kinematic, centistokes	Max. 43,570
Saybolt universal seconds	Max. 200,000
Viscosity index	Min.
Pour-point degree F	Max. 0
Stable pour-point degree F	Max.
Flash-point degree F	Min. 390

Viscosity at 0° F is obtained through linear extrapolation of the viscosity values determined at 210° F and 100° F by means of the Kinematic Viscosity Temperature Chart C (or the Saybolt Universal Viscosity Temperature Chart A) described in Method 9121 of Federal Test Method Standard No. 791.

After being cooled below its pour-point, the oil should regain its homogeneity on standing at a temperature not exceeding 10° F above the pour-point.

Most manufacturers of heavy-duty commercial vehicles specify extreme pressure 90W differential grease. This meets military specifications MIL-L-2105B.

Multi-speed transmissions require 90W straight mineral oil in most operations.

income elasticity for food are Brazil 0.795, Ghana 0.840 and India 0.837. Second, the notion that the income elasticity of a commodity is an increasing function of its price relative to other commodities probably only applies to a very small group of goods, such as the more expensive durable consumer goods and housing, which are competitive with automobiles. The better the bargains offered in these competitive fields, the less consumers may be inclined to spend on automobiles, but such considerations may well be swamped by the symbolic value of cars in a developing society.

Income

Personal income is the major variable in aggregate demand function studies. The national accounts of the United States and other developed countries include the following classifications of personal income:

- Y_1 the disposable income;
- Y_2 the net disposable income (Y_1 minus depreciation and subsidies);
- Y_3 the disposable income minus investment financing (business and professional);
- Y_4 the disposable income minus investment financing minus personal consumption.

Some very incomplete adjustments have shown that Y_4 gives the best results in automobile purchase forecasting, but this factor cannot always be isolated in the accounts of developing countries.

Most analyses of income as a factor in demand in developed countries appear to be based on M. Friedman's "expected" income, which is defined as a moving average of disposable income, in which current income accounts for one third of the total weight, and past incomes are progressively declining weights. The aim of this concept is to isolate the share of income pertaining to habits. According to Friedman's income hypotheses, current consumption is determined by the "permanent" component of income, which changes less rapidly than "measured" income. The remaining measured income has no influence on current consumption. But since Friedman does not regard net investment in durables (such as cars) as current consumption, such investment may be related to either or both.

Some authors argue that a continuous habit persistence hypothesis is plausible.[7] Others have suggested that habits formed during the period of the most recent peak in living standards exert a significant influence on current consumption.[8] Under the latter hypothesis, consumers attempt to maintain that peak standard of living in the face of falling incomes but are sluggish in adopting higher standards when their incomes rise above a former peak standard of living.

However useful such notions may be in predicting the demand for automobiles in developed economies, their analytical value is negligible in developing countries with annual *per capita* incomes below $300.

The concept of the threshold

Nonetheless, an understanding of the structure of personal incomes is necessary to calculate the threshold income at which purchase of a car becomes possible. The income relevant to car purchase is household or unit income rather than *per capita* income. The threshold depends not only on the amount of disposable income spent on essentials but also on:

- The relative saturation of demand for other durable goods and housing;
- The introduction of new and cheaper models of automobiles;[9]
- Factors such as higher investment in roads, increased urbanization, industrialization, the development of tourism etc.

J. S. Cramer's pioneering study[10] introduced a median tolerance income M that indicates the level of income (or total expenditure) at which exactly half of all households are motorists. Since 1948, the value of M (expenditure *per annum*) in the United Kingdom has declined from £2,050 to £1,300.

M. G. Vangrevelinghe showed that in Fanrce the median M fell from FF13,000 in 1956 to FF8,500 in 1962 (both calculated *per annum* in 1959 prices). It is expected to decline further to about FF7,000 by 1970. The income of car-owning families is higher than the average family income, but the ratio between the two is decreasing.[11]

The threshold can be shifted by instalment sales plans. In the United Kingdom the lengthening of the contract repayment period from two to three years is estimated to lead to sales increases of 5 to 10 per cent in the long run. In developing countries the effect is even more marked. It is estimated that in Argentina a similar lengthening of the instalment period would increase sales by 38 per cent in the long run. Introduction of instalment plans transforms automobile purchases from a one-payment "lump" expenditure into a divisible expenditure and thus moves the threshold income downwards.

Relationship between age of car and family income

In the United States the ownership of cars is too widespread for the threshold concept to be of value in projecting car demand. The important relationship is between the *per capita* income and the age, operating and replacement costs of a car. This was demonstrated

[7] Brown (1952), pp. 355–371; Klein (1954), p. 291; Klein and Goldberger (1955), p. 8.

[8] Modigliani (1949), pp. 371–441; Duesenberry (1949).

[9] An important factor in Italy; see Savino (1954), p. 546.

[10] Cramer (1959), p 334.

[11] *Etudes et Conjoncture* (1965a), p. 19.

in 1954 by M. S. Farrell,[12] who found the length of ownership of cars to be inversely proportional to personal income. Families owning one-year-old cars had an income of $7,530 while those with seven-year-old cars had an income of $2,290. Families without cars had an income of $1,729.

The relationship of the age of cars to income is becoming increasingly important in other developed countries as car ownership expands. It has application to some developing countries like Argentina or Brazil, where car ownership is already quite widespread. But in most developing countries, it is not yet a major factor in the total car market.

In developing countries the actual expenditure on essentials is usually less than in developed countries, but the threshold for car purchase may be just as high. Because there are so few second-hand cars on the market, they are expensive. The second-hand cars are even more expensive when the supply of new cars is limited.

Social factors may complicate the car ownership pattern by creating more than one income threshold. In South Africa, average Europeans replace their cars after three years, while Africans usually buy second-hand cars and keep them as long as 18 years.[13]

Personal income and business income

There is a distinction between the acquisition of cars for personal use and for business purposes. In developed countries the latter accounts for a small and declining proportion of the total use, and car purchases are accordingly unresponsive to changes in business income. In its long-term forecasts for the United Kingdom, the National Institute of Economic and Social Research has assumed that if business income and personal income both increase by 1 per cent in real terms, car sales will increase by about 2 per cent; a business income increase of 1 per cent will lead to a sales increase of 0.5 per cent, while an equal increase in personal income would lead to an increase of about 1.5 per cent in car sales. In France about 95 per cent of all passenger cars are registered as privately owned, and 74 per cent of these are used for purposes other than business.

In contrast, business use is important in developing countries. Of the 16,280 passenger cars registered in the Republic of Korea in 1965, about 11 per cent were government vehicles; 55.5 per cent were explicitly registered as business cars and only 33.5 per cent for personal use, including professional use by doctors etc. (See table 1.) This pattern of car usage is fairly typical in developing countries. Business activity in the sense of commercial transactions rather than economic growth is therefore an important variable in the demand for cars in developing countries.

[12] Farrell (1954).

[13] *The Economist* (1967), p. 736.

TABLE 1. STOCK OF PASSENGER CARS IN THE REPUBLIC OF KOREA

Year	Passenger cars[a]			
	Government	Private	Business[b]	Total
1952	748	970	731	2,449
1953	1,031	1,581	1,049	3,661
1954	1,214	1,814	1,989	5,017
1955	1,511	2,684	2,361	6,556
1956	1,423	3,984	3,021	8,428
1957	1,501	4,300	3,942	9,743
1958	1,686	4,426	4,654	10,766
1959	2,129	3,899	6,106	12,134
1960	1,950	4,224	6,602	12,776
1961	1,095	1,925	6,789	9,809
1962	1,374	2,571	7,129	11,074
1963	1,491	3,322	7,866	12,679
1964	1,527	4,487	8,572	14,586
1965	1,649	5,580	9,051	16,280

Source: Ministry of Transport, Republic of Korea (1966) *1965 Yearbook*, Seoul.

[a] Figures for the end of the year.
[b] Taxis and minibuses.

Prices

For car-owning families, the relevant elasticity is the change in the quantity of new cars bought relative to a change in the used-car prices. In countries where there are many car owners, this elasticity will probably be below unity because a low trade-in price will not deter many car owners from replacing their cars. However, in developing countries where fewer families own cars, a change in used-car prices will influence families more strongly, and the elasticity will therefore by quite high. On the other hand, if the supply of cars is insufficient due to rationing, the elasticity may be near zero.[14] No matter how high the prices of used cars rise, families will not sell because they cannot buy a replacement.

A rise or fall in car prices should be compared to the price movements of other goods. It has been suggested that the income elasticity of a commodity is an increasing function of its price relative to other commodities.[15] This appears to be valid in Italy and Spain. Prices are also correlated to stocks, that is, the level of ownership of automobiles. In intricate demand functions calculated for the United States the price exponent was found to be as high as —0.74, indicating that an increase of 1 per cent in price would induce consumers to reduce their replacement purchases by 0.74 per cent.[16] This applies only to a minor degree in countries with lower car ownership levels where replacements represent only a small fraction of sales. (See Italy in figure 1.)

[14] Tobin (1952); Tobin and Houthakker (1950/1951).

[15] Bandeen (1957).

[16] Roos and Szelisky (1939), p. 52. This calculation for pre-war United States is confirmed by Chow (1960, p. 149) who found a price elasticity of —0.7 for the early fifties.

Such considerations have little relevance for developing countries. An analysis of marginal price elasticities is a pointless exercise when increased or decreased import duties tend to alter car prices substantially: in this case there will probably be no response to a price decrease or increase within a 0 to 10 per cent range, but beyond this range a sharp response may occur as many customers abruptly enter or leave the market.

Since prices are also correlated to a car's durability and costs of operation, an index of durability could be used theoretically to convert the price into the replacement cost. The durability and costs of operation are indicative of quality and are probably more important than price alone in car purchases.

The price elasticity of automobiles is not as high as might be expected because of their durability and because there are other ways to obtain automobile transportation than to buy new cars: consumers can keep their existing cars with the cost of repair bills; obtain replacements from the used-car stocks of dealers; or use public transport.

Stocks, depreciation and replacement

The simplest regression, where gross investment is taken as a linear function of income and initial inventory, is also the most satisfactory for countries with a high level of car saturation. H. S. Houthakker and J. Haldi calculated this regression for four different levels of income and stocks in the United States. Although there is some overlap, the four "Engel curves" for different levels of initial inventory are on the whole clearly separated, gross investment being highest when initial inventory is smallest. The regression coefficients all have the correct sign and are highly significant.[17]

A correlation between real *per capita* gross domestic product at market prices and the stock of automobiles per 1,000 population is also highly significant for the seventeen countries for which data were obtained (see figure 1). But only three of these countries—Argentina, Mexico and Spain—can be classed as developing countries, and they are relatively advanced. Also, since the straight line of regression crosses the abscissa at a level of about $300 *per capita*, almost all developing countries are eliminated from the picture.

In the market mechanism, the existing stocks supply the trade-in and used-car markets. The prices of used cars trade-in allowances influence a family's decision to replace its car, but they have only a limited effect on the total stock of cars. Only scrapped cars represent real replacements, and the increase in stock in any year is calculated by subtracting the number of scrapped cars from the new registrations.

Once a certain level of ownership is reached, the growth in the stock of cars becomes more and more

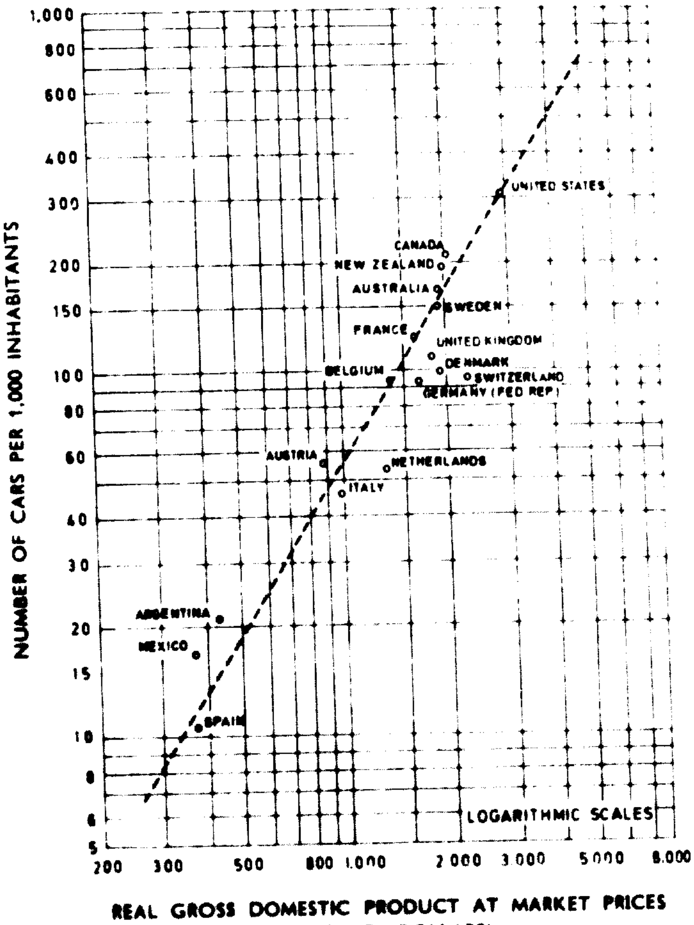

Figure 1. Automobile ownership and level of economic development in 1962. Source: Etudes et Conjoncture *(1965b)*

dampened through the increased number of scrapped cars: this can be demonstrated by calculating the changes in the ratio of scrapped cars to new registrations. Figure 2 shows this ratio for four developed countries. In the United States the ratio of scrapped cars to new registrations has risen from 53 per cent in 1955 to about 70 per cent at present.[18] The ratio in Europe is much lower. Italy is clearly still an "immature" car market despite the advances of the last few years; its very low level of replacement demand is about one tenth of the total in 1965, and replacements have not yet begun to rise. The other countries show signs of rapid increases in the number of scrapped cars. The United Kingdom was at Italy's level about ten years ago, but in 1965 the number of scrapped cars was about 42 per cent of new registrations. In the Federal Republic of Germany the 1965 figure was 35 per cent. In France this ratio is about 31 per cent; it is expected to reach 53 per cent by 1970.[19]

17 Houthakker and Haldi (1960).

18 *The Economist* (1967).

19 Data of the Institute of Statistics and Economic Studies in Paris.

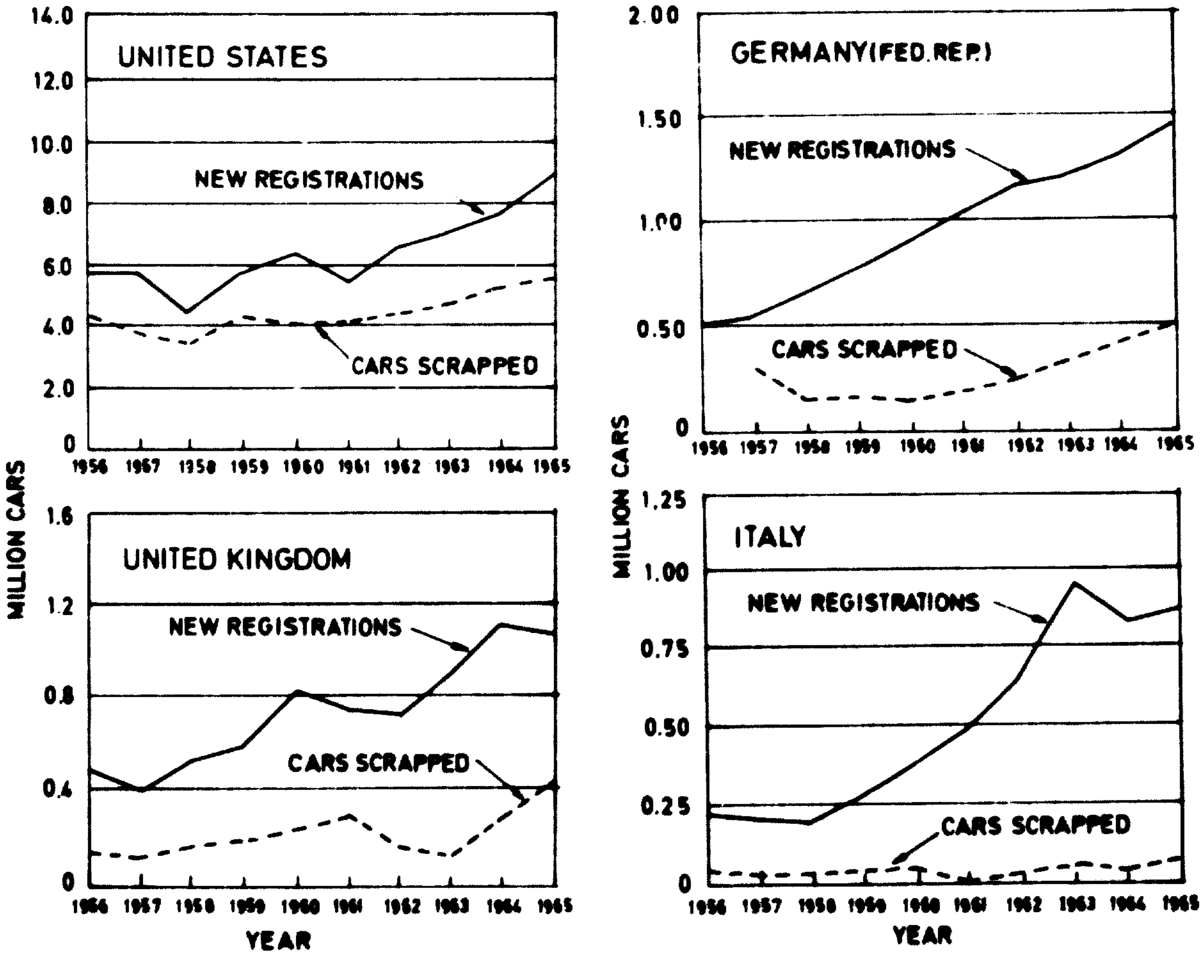

Figure 2. Annual registration of new cars and replacement of used cars in the United States, the Federal Republic of Germany, the United Kingdom and Italy from 1956 to 1965. Source: The Economist *(1967)*

The replacement ratio is also dependent on the average life span of a car. The following data show that the life span is decreasing:

Country	*Year*	*Life span (years)*
United States	1954	14
	1962—1964	10
Federal Republic of Germany	1954—1956	13.6
	1960	12.7
United Kingdom	1965	12
Sweden	1960	11.5

Source: United States, K. Boulding, "An Application of Production Analysis to the Automobile", Kyklos, Vol. 8, No. 2; Sweden, Wallander, "Studien i Bilismens Economi"; Federal Republic of Germany, *Absterbe-Ordnungen für Kraftfahrzeuge*, Essen, 1962.

The decreased life span of passenger cars is caused by:

The additional demands of driving in heavy traffic and parking difficulties;

The shorter technological life span of new models due to built-in obsolescence;

Increased obsolescence due to higher living standards.

The last factor is probably the most important in developed countries. In developing countries, poor roads and improper maintenance decrease the life span to such an extent that there is probably only a small difference in the life span of cars in developed and developing countries.

Forecasting methods

The methods for forecasting automobile demand in developed countries can be divided into three categories: complex projection methods, less complex projection methods and simple projection methods.

Complex projection methods involve calculating the threshold of access to motorization and the number of families with incomes above the threshold. The analysis of income distribution data is required. When these data are known, the underlying mathematics are simple. (See appendix 1.)

Less complex projection methods are based on estimates derived by least-squares regression. Since both the retail price and the number of new cars sold are endogenous variables, an estimate by least squares gives biased results; nevertheless, the bias is likely to be negligible by comparison with errors in the data. The use of elaborate techniques in order to avoid this bias is uneconomical. (See appendix 1.)

Simple projection methods can be used after establishing the co-variance between automobile demand and other leading macro-economic indicators. This co-variance has different values at different levels of economic development even among developed countries.

Figure 3 shows the co-variances (one in absolute and another in marginal terms) of automobile sales with such basic indicators as the index of industrial production in the United States and also a co-variance of new car registration (percentage of car population in the previous census) with consumer spending (percentage increase with constant prices) in the United Kingdom. The curves of automobile demand run almost exactly parallel to those of the above indicators. This simply shows that purchases of cars at a certain level of development are subject to the same type of business fluctuations as other more aggregated phenomena, although there may be a time lag both on the uprise, where car sales increase in anticipation of a favourable business climate and decline prior to a period of business restraint or even a recession. Thus, a 1.5 per cent increase in real consumption is preceded by a 12 per cent increase in new car registration, while a 4 per cent increase in consumption is preceded by a 17 per cent jump in car sales. A decrease in the elasticity coefficient is the result of various dampening factors, such as an increased stock of cars, rising car prices or a limited production.

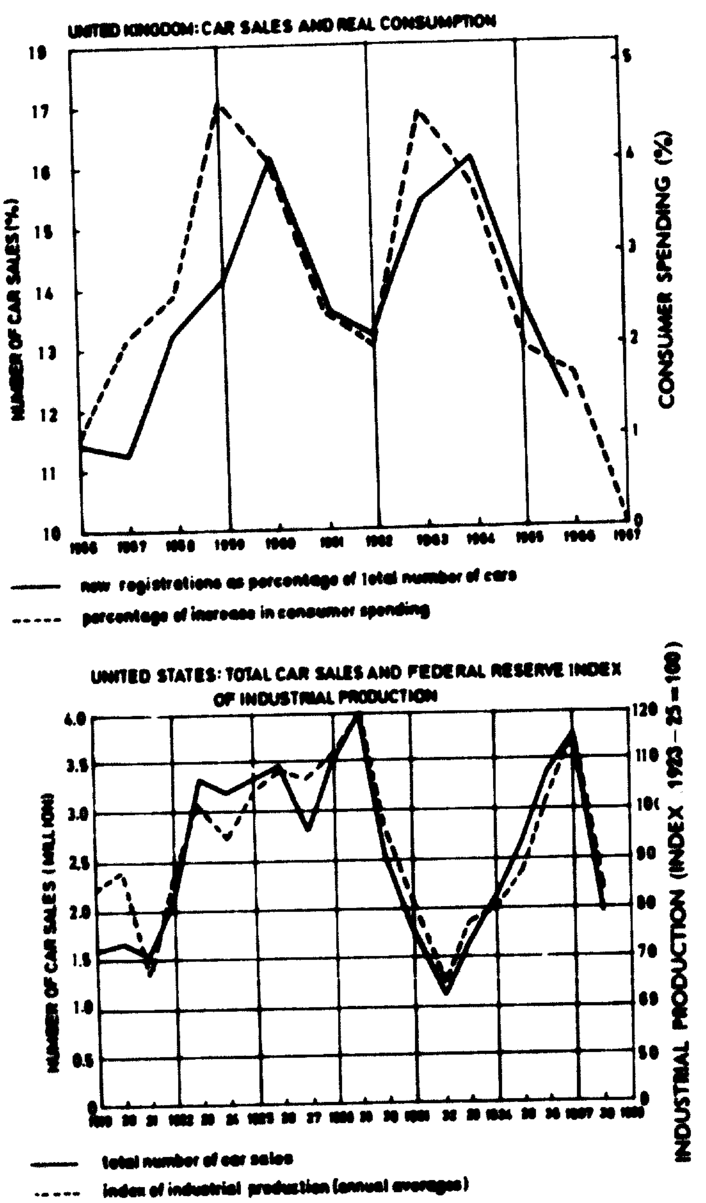

Figure 3. Relationships between car sales and leading indicators in the United States and the United Kingdom. Source: calculated from statistics published in United Nations Statistical Yearbook *and in various issues of the* Quarterly Economic Review, *National Institute, London*

Another simple forecasting method is to calculate the ratio of expenditure on automobiles to increments of income. Table 2 shows this ratio for different percentages of economic growth in three countries: the ratio has a marked upward tendency; in some countries a very high "marginal rate of automobile consumption" —more than 10 per cent—is attained at a comparatively early stage of economic growth.

2. AUTOMOBILE DEMAND IN DEVELOPING COUNTRIES

Structure of income

Brazil is one of the very few countries where the pattern of income distribution has been taken into account in projections of automobile demand. The growth of passenger car sales[20] was forecast by means of the following equation:

$$1 + q = \frac{(1+r)^{\alpha}}{(1+p)^{\alpha-1}},$$

where q is the potential rate of growth of automobile stocks,

r the growth of GNP in constant prices,

p the population growth,

α the Pareto income distribution coefficient, which is the parameter of the income distribution curve calculated as the elasticity of the number (Y) of income-receiving units, persons or families to the lower income limit x, i.e.

$$\frac{d \log Y}{d \log x} = -\alpha.$$

With the gross national product in constant prices growing at 6.1 per cent *per annum*, population at 2.4 per

[20] Derived from an equation for q in Confederação Nacional da Indústria (1960):

$$q = \frac{(1+r)^{\alpha}}{(1+p)^{\alpha-1}} - 1.$$

Table 2. Financing new automobile purchases from income increments
(marginal rate of automobile consumption)

	GNP per 1,000 inhabitants, 1964 prices ($)	New cars per 1,000 inhabitants (%)	Additional income per new car ($)	Additional income spent on each new car (%)
	(1)	(2)	(3)	(4)
Italy				
1955	620,000	3.4		
1960	794,000	7.7		
Increment over 1955	174,000	4.3	40,500	4.2
1963	953,000	18.8		
Increment over 1960	159,000	11.1	14,300	11.9
Spain				
1955	350,000	0.6		
1960	403,000	1.6		
Increment over 1955	53,000	1.0	53,000	3.2
1964	567,000	4.1		
1966	645,000	8.8		
Increment over 1964	78,000	4.7	16,600	10.3
France				
1955	1,306,000	10.1		
1960	1,575,000	14.0		
Increment over 1955	269,000	3.9	69,000	2.5
1963	1,756,000	21.9		
Increment over 1960	181,000	7.9	23,000	7.4

Source: Author's estimates.

Note: The percentages of income increments are channelled into purchases of new cars: calculate in column 1 the increase in GNP/1,000 inhabitants over a longer period of time and compare it to the increase in registration of new cars per 1,000 inhabitants over the same period (column 2). An increment of income per additional new car (column 3) can then be easily established. Finally, given $1,700 as the average price for a European car, the percentage of additional income spent on new cars will be determined (column 4).

cent and an income distribution coefficient[21] of 1.7, the growth of car sales can be calculated:

$$1 + q = \frac{(1.061)^{1.7}}{(1.024)^{0.7}} = 1.087.$$

The annual sales are calculated from the difference between the potential stocks of the preceding and current years. Brazilian forecasters add to the annual sales the number of vehicles needed to replace the existing stock. It has been estimated that the average life of passenger cars is about 20 years. If the ages were equally distributed from one to twenty, annual replacements would have to be 5 per cent of the stock. However, life-span data are lacking in Brazil. The estimate of scrapped cars is 2.2 per cent of the stock and sales were 10.2 per cent. Thus, replacement sales amounted to only one fifth of the total sales; the remainder represents purchases by new buyers who crossed the income threshold.

After the rate of scrapped cars has been established, the average car life and the annual rate of growth of car stocks can be included in one formula; this exercise is too lengthy and complex for this paper.

Argentine data illustrate the influence of income distribution on automobile sales. Data were obtained in an investigation of the distribution of expenditures among urban families according to the annual family income. Early in 1963, 454 family units were selected by standard random-sampling techniques in Argentine cities with populations larger than 10,000; they were interviewed in detail. The results indicate that the upper 28 per cent of family units (annual income early in 1963 of over 275,000 pesos or $2,000) were responsible for more than one half of all expenditures on durable goods in 1962. The upper 46 per cent of all family units (annual income above 200,000 pesos or $1,500) purchased more than three fifths of all durable goods in 1962.

Automobiles account for almost one half of all family expenditures on durable goods. Expenditures for cars are even more heavily concentrated than for furs and jewellery: the top quartile of the sample (income over $2,000) accounts for almost 90 per cent of all automobile purchases. The inclusion of families in the $1,500 to $2,000 income bracket adds a mere 4 per cent to this concentration. Purchases of other durable goods such

21 Parameter α has been estimated for Brazil (Loeb and Kingston, 1958). The "normal level" is generally considered to be 1.5 (Davis, 1941, p. 2).

as refrigerators, washing machines and television sets are much less concentrated: here, the upper-income quartile accounts for no more than one fourth to one third of the total.

A similar relationship was found by L. R. Klein for developed countries with little or no expenditures at low income levels. Expenditures rose somewhat faster than the linear rate with increases in income in the low-income group, but thereafter the relationship becomes essentially linear.

Structure of automobile stocks

Colombian projections of automobile demand are not based upon any mathematical model but are derived from observations of the past.[22] From 1950 to 1955 the rate of growth of automobile sales was as high as 22 per cent *per annum*, but from 1958 to 1962 it had fallen to 8.3 per cent.

The elasticity of new car sales to the growth of gross domestic product *per capita* fell from 4.0 from 1950 to 1962 to 2.4 from 1954 to 1962. If the latter elasticity is applied to an expected GDP growth of 5.6 per cent *per annum* and a population increase of 3.1 per cent *per annum*, new sales should grow at a rate of 9 per cent *per annum* in the next few years. The average income elasticity of car sales in all of Latin America was about 1.7 in the late fifties.[23]

To the predicted figure of new car sales, Colombian forecasters also add a number of cars for replacement of scrapped cars. This estimate is far higher than for Brazil, for while it is based on the same 20-year life of a passenger car, it assumes that as much as 5 per cent of the total existing stock will be replaced annually. This estimate of the rate of replacement is clearly too high, for it implies that over 40 per cent of new car purchases are replacements of scrapped cars. The 1965 figures for Italy and France were 10 per cent and 31 per cent respectively. It would appear that lack of information about the actual composition of the car stocks has led to a considerable error.

Figure 4 compares the age structures of automobile stocks in Colombia and the United States.[24] The distribution curve for the United States is very regular; it increases from 2 per cent of the total for cars manufactured in 1953 to 13 per cent for cars manufactured in 1964. The distribution curve for Colombia is very uneven. Car vintages whose share in the total is disproportionately high correspond to years when import restrictions were relaxed and a backlog of accumulated demand could

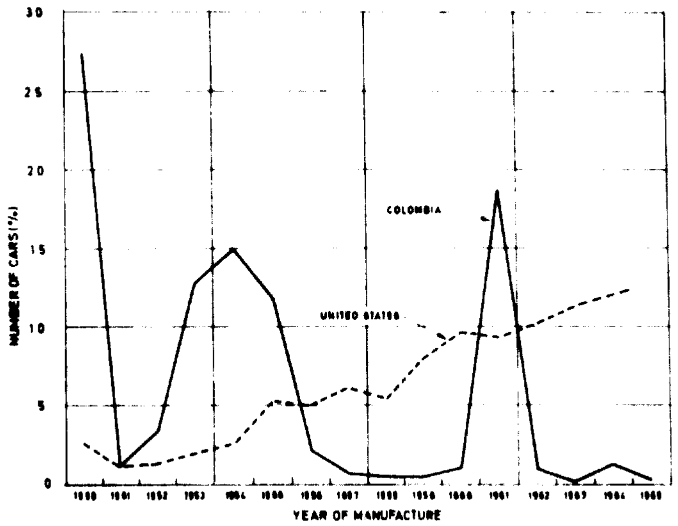

Figure 4. Distribution of the total number of cars in Colombia (mid-1965) and in the United States (end of 1964) according to the year of manufacture. Source: Lewin (1967), p. 742

be satisfied. In 1966 import licenses were issued more freely and more quickly than in 1965, and the total number of cars imported therefore rose from 1,825 during January to September 1965 to 7,401 during January to September 1966.[25]

Figure 4 shows that the 1957 to 1960 vintage automobiles account for only 1 per cent of the total for each of these years. If we assume that the life of a car is 20 years, sales in 1977 and replacements during 1977 to 1980 would be very small. But as almost 20 per cent of all cars (in 1965 the total stock was about 250,000 cars) were of 1961 vintage, in 1981 replacement demand would theoretically jump suddenly to 50,000 new cars and then fall again abruptly in 1982. The real saturation will undoubtedly reflect modifications of these trends, for the life of a car is not uniformly fixed at 20 years. At the same time, this example illustrates the need for a clear-cut government policy on car sales and also for a detailed knowledge of the structure of car stocks.

In the Republic of Korea, too, the car age structure is uneven, and forecasters take into account the volume of business purchases of passenger cars. (See table 3.) They assume that the growth of business car ownership is influenced not as much by income and price movements as by increasing demand for transport services as distinct from ownership. This demand is unlikely to be satisfied without an upward move in incomes, but the link between the two factors is not very clear. The rate of urbanization and other related factors may also be important. The forecast of growth in automobile purchases was therefore derived from a forecast of passenger transport based on highway improvements

22 Banco de la República (1966).

23 Gómez and Ruiz (1958).

24 See also Lewin (1967), p. 742.

25 International Monetary Fund (1967).

and on the relationship between the growth of the gross material product and the increase in transport flows.[26]

TABLE 3. AGE STRUCTURE OF PASSENGER CARS IN THE REPUBLIC OF KOREA

Year of manufacture	Passenger cars		Minibuses	
	Number	%	Number	%
Before 1945	1,545	14.3	58	1.9
Between 1946 and 1950	398	3.7	196	6.5
1951	210	1.9	3	0.1
1952	113	1.0	3	0.1
1953	360	3.3	7	0.2
1954	490	4.5	7	0.2
1955	1,358	12.6	11	0.5
1956	207	1.9	14	0.6
1957	216	2.0	62	2.1
1958	1,530	14.2	103	3.4
1959	352	3.3	16	0.5
1960	223	2.1	7	0.2
1961	209	1.9	12	0.4
1962	1,528	14.1	1,991	66.4
1963	1,745	16.2	207	6.9
1964[a]	327	3.0	300	10.0
Total	10,811	100.0	2,997	100.0

Source: Ministry of Transport, Republic of Korea (1966) *1965 Yearbook*, Seoul.
a First quarter of 1964.

In Morocco, car ownership has shifted from French to Moroccan nationals. Moroccan car statistics give both the age of registered automobiles and the nationality of the owners.

CAR OWNERSHIP IN MOROCCO

	1957	1963	1964
Percentage of cars less than		Per cent	
10 years old...............	—	54.5	57.2
Ownership of cars by nationality:		Vehicles	
Moroccan nationals	43,437	110,441	121,414
French nationals	64,852	53,195	50,410
Spanish nationals	3,431	12,470	12,590
Others	6,691	16,302	13,000
Total French nationals residing in Morocco	450,000		120,000

Source: Marchés Tropicaux et Méditerranéens (1966) February 22, p. 638.

[26] *Korea transportation survey*, Seoul, June 2, 1966, Chapter III, p. 25. It is worth mentioning that although the Transportation Mission, which was financed by IBRD, consisted of more than ten prominent experts from four leading European consulting organizations, no rigorous model was used to project the increase in automobile demand. The Mission's conclusions were that: "The future use of private cars will be stimulated by the improvement of Korean highways and, as soon as import restrictions are removed or lessened the number of cars will increase. Therefore the past trend does not give good indications for future transport. The Mission adopted, arbitrarily, an annual growth rate of 16% for transport by private cars."

From these figures, it would appear that the large increase in the number of car-owning Moroccans was connected to an upward shift in the age structure of the cars, which they had acquired from departing French residents.

The relatively small new additions to the total stock in recent years (5 per cent *per annum*) support this view. It seems likely that these additions consisted mostly of replacements by French residents and also by a small number of Moroccans in high-income groups. The French nationals there in 1964 on the whole received higher average incomes than those who were living in Morocco in 1957; this undoubtedly accounts for a rise in ownership among French nationals from one in seven persons in 1957 to one in 2.4 in 1964. While the more affluent French nationals probably replaced cars more rapidly than they did in 1957, the average Moroccan purchased a car from a French national but never can buy a replacement for it. In any case, forecasts of automobile purchases in Morocco must take into consideration the age structure of the automobile stock and the income sources and future intentions of the French community.

Restricted automobile supply

In developing countries it cannot be assumed that the supply of automobiles will meet demand at market prices. Governments may limit car imports to conserve foreign exchange, restrict local production in favour of other goods and ration the available cars to prevent profiteering by importers and local manufacturers.

Tunisia illustrates this point. As in Morocco, the demand for new automobiles diminished with the departure of French nationals; imports fell from 4,157 automobiles in 1955 to 2,903 in 1960. But in 1963 car imports were restricted to 1,700 units a year as part of a strict austerity policy (actual imports were 1,710 in 1963 and 1,774 in 1964). Post-independence registrations in Tunisia cannot thus be regarded as an indication of demand.

Countries which levy high import or sales taxes in order to restrict demand all face the same problem: if these taxes were reduced, demand will presumably rise rapidly as the income threshold at which purchasers enter the market is lowered. In the absence of price elasticity studies, this threshold is difficult to forecast. Attempts to evaluate price elasticity from hypothetical price changes are notoriously difficult exercises.

3. FORECASTING AUTOMOBILE DEMAND IN DEVELOPING COUNTRIES

The forecasting techniques applied in highly developed countries are not suitable for developing countries not so much because of the lack of pertinent statistics but rather because the structure of automobile demand is so different. The structure of the market suggests a forecasting approach based on a concept of growing markets, which, in turn, indicates the necessary statistics. Once the principal market trends are established, the effects of changes in government policies can be considered.

A model of automobile markets in developing countries

In all developing countries car owners and purchasers are rich people by local standards, and a car is a luxury purchase. This is particularly true of initial car purchases in a developing country by the very affluent, by large business enterprises and by government authorities, so that prices tend to be almost irrelevant. Large luxury cars are purchased, and the saturation of these groups of consumers is very high.

As cars become more familiar and the road network improves, new and larger purchasing groups enter the market. Their exact nature and size depend on a country's particular characteristics, but they have some general features in common. There are additional purchases by government authorities and business enterprises, but most of the purchasers are owners of businesses (either for personal or business use), high-ranking government officials, business executives and professional men. As car ownership progresses downward from the very high to the moderately-high income group, the price becomes a more important factor. Both price elasticity and income elasticity rise. Smaller cars whose upkeep will entail less expense are bought. Changes in car prices and income levels produce a greater effect. As the income threshold below which a car cannot be bought is approached, and the amount of discretionary income available to the consumer diminishes, the proportion of car owners in each income group also falls.[27] But the numbers in each successive lower-income group are increasing, and car saturation therefore usually continues to grow at an increasing rate until shortly before the income threshold is reached; then it begins to decline sharply. (See table 4.)

TABLE 4. UNITED KINGDOM CAR OWNERSHIP BY INCOME UNITS IN 1953

Gross income of income unit (£)	*Car-owning income units (%)*
0—99	1.4
100—199	0.3
200—299	3.3
300—399	5.1
400—499	7.4
500—599	10.2
600—699	16.8
700—799	28.9
800—999	30.2
1,000—1,499	51.5
1,500—1,999	60.3
2,000 and over	75.4

Source: Klein (1955), p. 410.

As the threshold is reached the market ceases to expand to new, lower-income groups. Unless there is a substantial change in the ratio of car prices to incomes, further sales to new customers will depend on:

- Increased ownership saturation within existing groups of consumers;
- Additions to the higher-income groups as a result of population growth;
- Improving levels of income with the result that new groups cross the threshold;
- Sales of second and third cars to income units already owning one car.

The basic determinant of the income threshold for car ownership is the relationship of car prices (including black market prices in conditions of restricted supply) to income, but social habits are also important. The degree to which cars are regarded as symbols of social and economic status influences the extent to which consumers will purchase them rather than save the money and prefer them instead of other goods and services. In general, patterns of car ownership tend to include owners of medium-sized businesses and professional workers but not clerks, blue-collar workers and farmers. The car market in developing countries is thus clearly not a mass market; a country with signs of a mass consumption pattern of cars is becoming a developed country.

Supply factors influence the rate of market penetration in developing countries. When the supply of cars is limited, countries sometimes ration the supply of cars, but more often they adopt indirect methods such as sales taxes, import controls and tariffs, and local production schedules: all these tend to raise the income threshold for car purchase.[28]

Gasoline, service and sales facilities, and roads are also of importance in this connexion. In developing countries cars are concentrated in cities partly because this is where the high-income groups live, but also partly because cities have roads (ill-kept and congested though they may be). Service facilities expand wherever cars are concentrated and so does sales pressure; this is particularly true of instalment plans which help to lower the income threshold. Service facilities also develop after the first impact of car ownership, since the tendency is for the rate of car purchases to accelerate.

The attention of international car manufacturers is attracted as car ownership grows. Those already marketing cars in the country increase their efforts, and others become interested in the new market so that sales facilities multiply. The stimulus of expanding sales leads to the formulation of government policies on local assembly and manufacture, particularly if there are pressing problems of balance of payments, while the

[27] This concept is illustrated by Klein (1955), p. 410, in a table reproduced here as table 4.

[28] Baranson (1969) demonstrates how local production raises car prices.

large international companies exert even greater efforts to come in "on the ground floor".

The lack of alternative transport and other services tends to increase the pressure to purchase cars, and in particular accounts for the high volume of business purchases of cars in developing countries. To a certain extent these purchases represent "fringe benefits" to business and government executives. This is probably more important than in developed countries, but in developing countries businesses frequently have a greater need for cars and other transport and communications facilities than in developed countries. In countries where telephones are a rarity, cars are frequently sent with simple business messages ordinarily transmitted by telephone in developed countries, although this is at high cost to the enterprise and adds to the already serious traffic congestion.

The business reasons for car ownership tend to be most pressing in periods of rapid economic growth, particularly booms in industrialization; such periods also coincide with a rapidly increasing personal demand for cars. However, as the supply of telephones increases, the rate of growth in the demand for business cars tends to decline. The lack of public transport in some cases extends car ownership to clerical and blue-collar workers who purchase cars on the instalment plan in order to travel to work and cover the cost by carrying fellow employees.

Both demand and supply factors therefore tend to impose a three-stage pattern in the growth of car saturation in a developing country. The first stage is a period of slow growth as cars are introduced in the country through purchases by the wealthy: sales and service facilities are expanded; roads are built. The second stage is a period of rapid growth when car ownership is a reality to a very high proportion of income earners from the wealthy down to the income threshold for car ownership: cars become readily available; business demand for cars is high; the road network is expanded. In the third stage there is a much reduced rate of growth after the principal market has been established and saturated; sales depend on additions to the upper-income groups and on car replacements (figure 5).

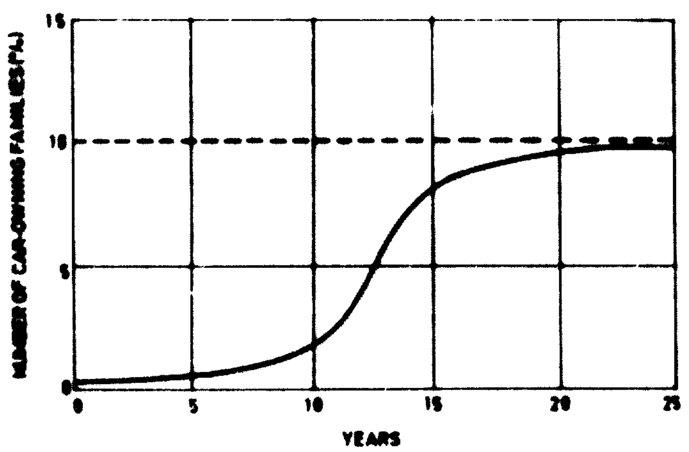

Figure 5. A model curve of the saturation of the market for automobiles in a developing country

The model curve in figure 5 focuses attention on the saturation of the car market and on new car sales in the early stages of car market growth when replacements are negligible. As the market progresses towards saturation, replacements become an important factor and have to be taken into account. Ultimately, as a country's economy develops and car ownership becomes widespread, replacements swamp purchases by new consumers. Therefore forecasting methods must be based on replacement models.

Calculating the demand for automobiles in developing countries

A three-stage growth pattern with a slow build-up, a steeply accelerating middle slope and a decelerating approach to an upper asymptote is a familiar economic phenomenon that is usually described in mathematical terms as an S-shaped growth function. H. T. Davis[29] fitted a logistic function to the growth of automobile production in the United States between 1913 and 1927 and extrapolated the curve to 1939 to indicate the extent of overproduction in 1929 and underproduction from 1930 to 1936. The expected production rate was again attained in 1937.

The logistic curve is obtained from the function:[30]

$$y = \frac{k}{1 + e^{a+bx}} \text{ where } b < 0.$$

At first sight, fitting and S-shaped curve to past new-car sales in a developing country and extrapolating future sales would appear to be the most logical forecasting method, but there are difficulties in its application. The model suggesting this approach is best applicable in the early stages of a car market, for at this point there are not enough data from which to extrapolate future trends with confidence. By the time data are available, replacement sales are swamping new sales and other forecasting methods are more appropriate. The fact that new-car sales data are not usually available for developing countries is an added, though minor, complication. In most cases they can be calculated from import and local production figures.

A more complex forecasting alternative is to convert the model of market expansion into an S-shaped curve by estimating the constants. The model of car saturation lends itself best to this approach because reasonable saturation prospects are not too difficult to estimate. Sales to new consumers can be calculated once the saturation path is plotted, and additional sales due to

[29] Davis (1941), pp. 210—211. Davis followed Kuznets (1930), who showed the appropriateness of the logistic function to the growth of product demand by fitting it to some 50 series.

[30] James and James (1968), p. 223.

PROBLEMS RELATED TO THE PRODUCTION AND SUPPLY OF AUTOMOTIVE COMPONENTS

*Emil F. Gibian**

INTRODUCTION

No automotive manufacturer produces every part of a vehicle in his own plant; many components come from external sources. While the content of purchased parts in a finished vehicle will vary from manufacturer to manufacturer, from vehicle type to vehicle type and from country to country, it is estimated that most mass-produced passenger cars contain, on the average, 30 to 50 per cent purchased components. In trucks, and particularly in heavy trucks, this ratio may be as high as 70 per cent.

The manufacturers of these components are an essential and important branch of the automotive industry. They have distinct problems, particularly in developing countries where the maintenance of an existing fleet of motor vehicles and the introduction of local automotive production require careful planning and the solution of technical, financial, political and human-relations problems. This paper attempts to deal with these problems and to suggest how to satisfy the demand for automotive components by producing an adequate supply of parts. This approach is based on experience in developing countries and on an analysis of the reasons for the successes, as well as for the failures, that have occurred.

1. CLASSIFICATION OF AUTOMOTIVE COMPONENTS IN WORLD TRADE

Parts are classified according to their function in specific sections of the vehicle. The usual categories are:

Engine parts—pistons, piston pins, piston rings, valves, valve guides, valve lifters, valve springs, fuel pumps, oil pumps, water pumps, carburettors, air and oil filters, bearings, radiators, thermostats, and electrical components such as starters, generators or alternators, sparking plugs, distributors and condensers;

Power-train components—transmissions, clutches, drive shafts, differentials, universal joints, rear axles, wheels and tires;

Steering components—steering wheels and columns, steering gears, tie rods and ball joints;

Suspension and braking system components—king bolts, ball-joint suspensions, leaf springs, coil springs, shock absorbers, brakes, brake cylinders, fittings and hoses;

Instruments and lighting accessories—dashboard instruments, headlights, tail-lights, electric batteries, wiring, windshield wipers and rear-view mirrors;

Chassis parts—petrol tanks, exhaust pipes, silencers and bumpers;

Accessories—heaters, air-conditioning systems, fans, radios, cigarette lighters and ash trays;

Body trim and hardware—hinges, handles, locks and window mechanisms;

Miscellaneous tools—jacks, grease guns, tire wrenches, screwdrivers and other hand tools.

This normal classification does not take into consideration the problems encountered in world trade, particularly those affecting developing countries and their demand for automotive components. Developing countries tend initially to classify automotive components according to the frequency with which they must be replaced. Since there are no local manufacturers, such countries must satisfy this demand by importing parts either from the service departments of the vehicle manufacturers or from specialized parts manufacturers. If the parts manufacturer is also a supplier to the vehicle manufacturer, identical parts may be available from either.

The special requirements of a region will be dictated by road conditions, climate and, perhaps most importantly, by the human element; that is, both the ability of the driver of the vehicle and the competence of the man who services it. A developing country concerned with the problem of maintaining its vehicle fleet should establish its own priorities for an adequate supply of replacement parts according to the frequency with which they are needed.

As the number of vehicles in a country increases, a point may be reached at which it becomes feasible to develop a national industry to produce replacement parts. While such a development is discussed in detail later in this paper, it should be noted here that a develop-

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multiple ownership and replacement can be estimated separately and added. Experience with consumer durable saturation suggests that the best fit is likely to be obtained with the Gompertz curve which has the following function:

$$\log y = \log k + (\log a)\, b^x,$$

or

$$y = ka^{b^x},$$

where $0 < a < 1$,

$0 < b < 1$.

At $x = 0$, $y = ka$, and as x approaches infinity, y approaches k. The increments in y as x increases are such that the differences in the increments of $\log y$ are proportional to the corresponding differences in $\log y$.[31] This curve generally provides a better fit for car saturation than the logistic curve because the inflexion point appears earlier and is also somewhat sharper.

A Gompertz curve can be calculated from reasonable assumptions about the values of the upper asymptote and inflexion point, the time taken to reach them and the initial saturation. The initial saturation can be estimated quite arbitrarily since it has relatively little influence on the shape of the curve. Taking the number of families in a country as an approximation of the income units, it can be assumed that at the beginning of the growth of the car market, saturation will be 0.1 per cent of all families. The inflexion point and the time taken to reach it are the critical values; they can be estimated by observing the development patterns of car sales and stocks. In Argentina and Thailand, the inflexion point was reached about 1956 (figure 6). The asymptote can be estimated from the income threshold for car purchases in a country at current prices, the likely saturation of the market which has evolved from this threshold and the time needed to reach this level of saturation. The number of families above the threshold and their ultimate "car saturation" as a proportion of the total number of families will not vary greatly among developing countries at similar stages of development, but the number of years to reach the saturation point will vary. A rapidly developing country will require much less time to reach this point than a struggling one. Once the pattern of saturation is calculated, annual demand can be derived, and the growth of car stocks cumulated; replacement demand must of course be added.

Separate saturation models can be constructed for second-car ownership and for business ownership, and annual sales can then be derived for this component of demand and added to personal demand. This may be worth-while in countries where business demand for cars is an important component of total demand, but otherwise simpler projections based on past sales will suffice. The demand for second cars is generally too small to warrant much attention.

[31] *Ibid.*, p. 163.

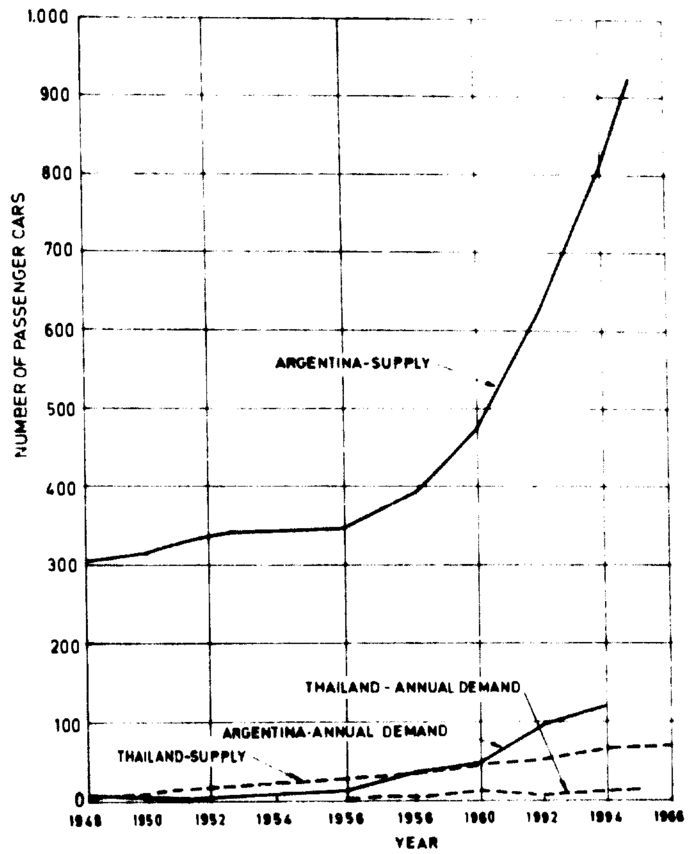

Figure 6. Supply and annual demand for passenger cars in Argentina and Thailand from 1948 to 1966. Source: calculated from data in United Nations Statistical Yearbook *and data in national annual trade statistics*

Major shifts in incomes, car prices or social habits will, of course, affect saturation by shifting its path to a new curve; these shifts must consequently be incorporated in current forecasts. The saturation pattern will also be influenced by short-term fluctuations in business conditions, changes in the money market and other factors which may accelerate or postpone the decision to purchase a car. Because of the prestige attached to the possession of a car and also its intrinsic value, such fluctuations are, however, unlikely to affect the long-term saturation pattern to any major extent.

The degree to which the techniques outlined can be used in formal econometric models will largely depend on the statistical information available. The income threshold for car purchases is always difficult to estimate. The data on income distribution in developing countries are too incomplete to calculate the number of income units above the threshold. In the early stages annual stock increments can be regarded as new-car sales if stock figures are available, for the number of scrapped cars will be negligible. The number of new-car sales can usually be calculated by adding imports and local production; it can serve as a check on stock figures and also as a basis for scrapped car estimates (see table 5 for data on selected countries for which annual figures were calculated if not available).

The saturation approach to forecasting strengthens the argument for more precise car statistics similar to those published for developed countries. The tendency to publish statistics only of stocks rather than annual sales as well as stocks has been encouraged by the United Nations Statistical Yearbook which gives only the former.[32] One hesitates to add to the burdens of statisticians in developing countries by suggesting the publication of new series, but annual car sales figures are essential to accurately forecast the demand for cars, because they provide the basis for reasonably sound scrapped car estimates. They are, moreover, easy to collect: consult the car registration files and separate the new registrations from the re-registrations. There is a case for classifying the registrations according to the type or size of car. The market for cars can be regarded as the sum of the markets for all the various types of cars; this can also be usefully incorporated in forecasts. In developed countries car manufacturers find the monthly publication of new car registrations according to the type of car a very useful aid in production planning. The United Nations Statistical Yearbook might therefore publish new registrations as well as stocks and thus encourage countries to provide more precise annual, new-registration data.

Some countries in the initial stages of car saturation have neither the statistics nor the need for elaborate econometric forecasts. The concept of changing slopes of growth and of the saturation asymptote associated with an income threshold can nevertheless help them to formulate car policies.

TABLE 5. ANNUAL DEMAND FOR CARS IN SELECTED COUNTRIES
(1,000 cars)

Country	*1948*	*1950*	*1952*	*1954*	*1956*	*1958*	*1960*	*1962*	*1964*	*1966*	*1967*
Argentina	7.4	1.9	2.3	4.6	11.2	35.7	48.2	96.0	119.5		
Production and assembly	—	—	—	1.5	2.3	20.7	45.1	93.9	119.0		
Imports	7.4	1.9	2.3	3.1	8.9	15.0	3.1	2.1	0.5		
Colombia	6.2	6.4	5.0	16.7	2.0	0.6	6.8	6.2	4.0		
Assembly	—	—	—	—	—	—	—	2.0	0.9		
Imports	6.2	6.4	5.0	16.7	2.0	0.6	6.8	4.2	3.1		
Morocco											
New registrations									8.2	6.7	10.2
Thailand											
New registrations					1.4	2.6	12.1	6.2	11.0		

Source: For Argentina and Colombia, production and assembly figures come from United Nations *Statistical Yearbook*, and imports from country annual trade statistics. For Morocco, registrations beginning in 1964 are published in the *Bulletin Mensuel de Statistique*, *Service Central des Statistiques*. Thailand publishes new registrations after 1964 in the *Quarterly Bulletin of Statistics* issued by the National Statistical Office.

Implications for policy

The general pattern of the market for cars is relevant to the formulation of certain government policies in developing countries. Initially, annual sales are usually more important, but the growth in the stock of cars is also a significant factor in economic policies and plans.

As car saturation begins to grow, governments generally become aware that car sales can be revenue earners either through import duties or sales taxes. Once the demand of wealthy private persons, government officials and business executives is satisfied, duties and taxes will retard the rate of saturation and raise the income threshold which constitutes the basis of the market and thus reduce the extent of the market. If governments wish to reduce spending on luxuries as well as to raise revenue, this policy should be adopted.

Countries with balance-of-payment difficulties frequently try to restrict car imports. The market saturation pattern suggests that in the early stages high duties or taxes are not likely to be a very effective means of restricting demand, but that they nevertheless become increasingly effective as successively lower income groups become consumers.

Import restrictions will reduce demand to the required level if they are strictly enforced. But unless they are accompanied by stringent rationing, a black market in cars will develop under the pressure of unsatisfied demand. Such black market prices are likely to fall with the increase in saturation and the new demand of lower-income groups. Very high tariffs or sales taxes will have the same effect as restrictions in reducing the number of imported cars and will probably channel them to the same consumers who would otherwise purchase cars in the black market. Therefore, high tariffs and sales taxes are preferable because they do not encourage disregard for laws.

[32] Stock figures are given in the United Nations *Statistical Yearbooks*, Transport, "Motor Vehicles in Use", by country, year and passenger as compared with commercial vehicles. Production figures, including the number of firms and domestic content, are given in Baranson (1969), table 12, p. 79, "Manufacturing and assembly operation in developing countries by regions, 1965".

The economies of scale in the automobile industry are so great that car assembly and manufacture can begin spontaneously only in very large, relatively prosperous developing countries or in those which serve as distribution centres for a region. For most developing countries the establishment of an automobile industry involves a deliberate government choice which must be supported by appropriate policies.

There are various options available in the establishment of an automobile industry; the size of the domestic market is one of the most important factors to be taken into account. Despite the complexity of the problem, some general rules can be stated:

The domestic market for automobiles in a developing country will tend to stabilize as saturation approaches the asymptote; this is the annual level of demand at which local production plans can aim. A danger in planning local production arises out of the tendency to regard the upswing—particularly in its last, most steeply accelerating phase just before it begins to decline—as a linear demand trend, and then extrapolate future demand and production from it;

The estimate of annual domestic demand as the saturation level is approached should indicate whether a country should encourage the establishment of an automobile industry unless there are exceptionally good prospects for exports. If the annual demand appears to be large enough, then the country still must decide whether it should merely encourage the assembly of knocked-down cars or ultimately aim at the manufacture of car parts. If the latter alternative is chosen, then the percentage of car components which can be manufactured economically for a given market must be determined;

The scale of the market and the type of manufacturing activity chosen will determine the number of economic manufacturing units. Since economies of scale grow with the backward integration of automobile production from assembly to manufacture, and since car manufacturers tend to integrate their production backwards for fear that the component suppliers will build up a monopoly, a country which only envisages assembly can safely encourage wider entry into the industry as compared with one whose ultimate objective is the entire car manufacturing process. Experience in developing countries suggests that it is difficult to restrict entry into manufacturing after several assemblers have been permitted to enter a country.

The establishment of a local car manufacturing industry raises the cost of cars. While it is now well established that inexperience and other factors contribute to high costs, the principal cause is the lack of economies of scale.[33] This ist not simply due to limited markets but also to market fragmentation by a relatively large number of production units. In an industry highly subject to increasing returns to scale, classical arguments for competition do not hold. The choice in any case is not between monopoly/duopoly and competition, but between monopoly/duopoly and oligopoly, and the latter, which is characteristic of car production in developing countries, is probably an independent and additional cause of high prices. A monopoly with a technically efficient production structure can ultimately be exposed to competition from imports; if, however, there are several production units, this will not be possible.

The importance of high car prices in developing countries is directly related to the problem of economies of scale in production. By raising the income threshold for car purchase, increased prices reduce the total size of the market, lower the saturation level and shorten the time to reach saturation. This reduces the scale of production in the period during which the industry is being established and also lowers the ultimate production level.

Sales taxes have a similar effect. Governments which are trying to encourage the growth of an economic local car manufacturing industry should not a the same time regard cars as a luxury item which must be taxed at high rates. They are more likely to increase their revenues by taxing the industry itself, particularly if they do not dissipate such revenues in unnecessary concessions to manufacturers.

The scale of the market should be used as a yardstick to evaluate the need for incentives for car manufacturers. A forecast of a promising market is an incentive in itself and may obviate the need for direct incentives such as taxation concessions. On the other hand, manufacturers can receive extremely high incentives, either directly through taxation concessions or indirectly through high tariffs and favourable exchange rates, or even all three; yet none will be effective in establishing an economic automobile manufacturing industry if the prospective market is small.

Protective measures are likely to be necessary in developing countries, even in promising markets, to overcome the inevitable problems of the infant industry, but the pattern of saturation suggests that subsidies, provided that they are viable in other respects, may be better than tariffs. Subsidies are also easier to abolish after the market levels off towards saturation.

The short-term effects of fiscal and other government policies which temporarily change the relation between price and income will depend on the degree of market saturation. In the early stages when price and income elasticity is low, these effects are not likely to be very marked; as the final saturation level is approached,

33 Baranson (1969) demonstrates this and also shows that the additional production cost rises with the percentage of total production in the developing country: in this connexion, it should be remembered that economies of scale are an important factor in the manufacture of complex components.

however, demand will be extremely sensitive to such measures. However, to the extent that such changes are transitory, they will merely result in a temporary dampening or acceleration of the saturation pattern. After a period of business restraint, a government should expect a sudden rise in car sales, which reflects a pent-up, unsatisfied saturation demand.

The main purpose of automobile forecasting in developing countries is to provide annual car demand estimates; this is true even for such broad planning problems as the annual increments required for road expenditure or the extent to which an increasing demand for gasoline will exert pressure on the balance of payments and justify the construction of oil refineries and the establishment of a petrochemical industry. This can be calculated from annual demand forecasts with due allowance for scrapped cars. The availability of roads and supplies such as gasoline, moreover, will influence the annual demand for cars and the ultimate saturation level. High gasoline prices, for example, have a similar effect on the car market as high car prices; they influence the use of cars as well as their purchase. Long-term government policies on road construction and gasoline procurement will affect the future demand for cars; the government policies will in their turn be influenced by car purchasers who soon become formidable political lobbyists. Seemingly simple decisions about car prices and income relationships will thus eventually affect much wider areas of the economy than is apparent at first sight.

APPENDIX 1

METHODOLOGY

Complex projection methods involve calculation of the income threshold of access to motorization and the number of families with incomes above the threshold. This method is more adapted to developing countries, where income distribution is largely skewed, than to developed countries, where it is more normal. Studies of family budgets and analyses of income distribution are being carried out in some developing countries. Data on incomes can usually be obtained from domestic revenue authorities, while family budgets are frequently an object of research by

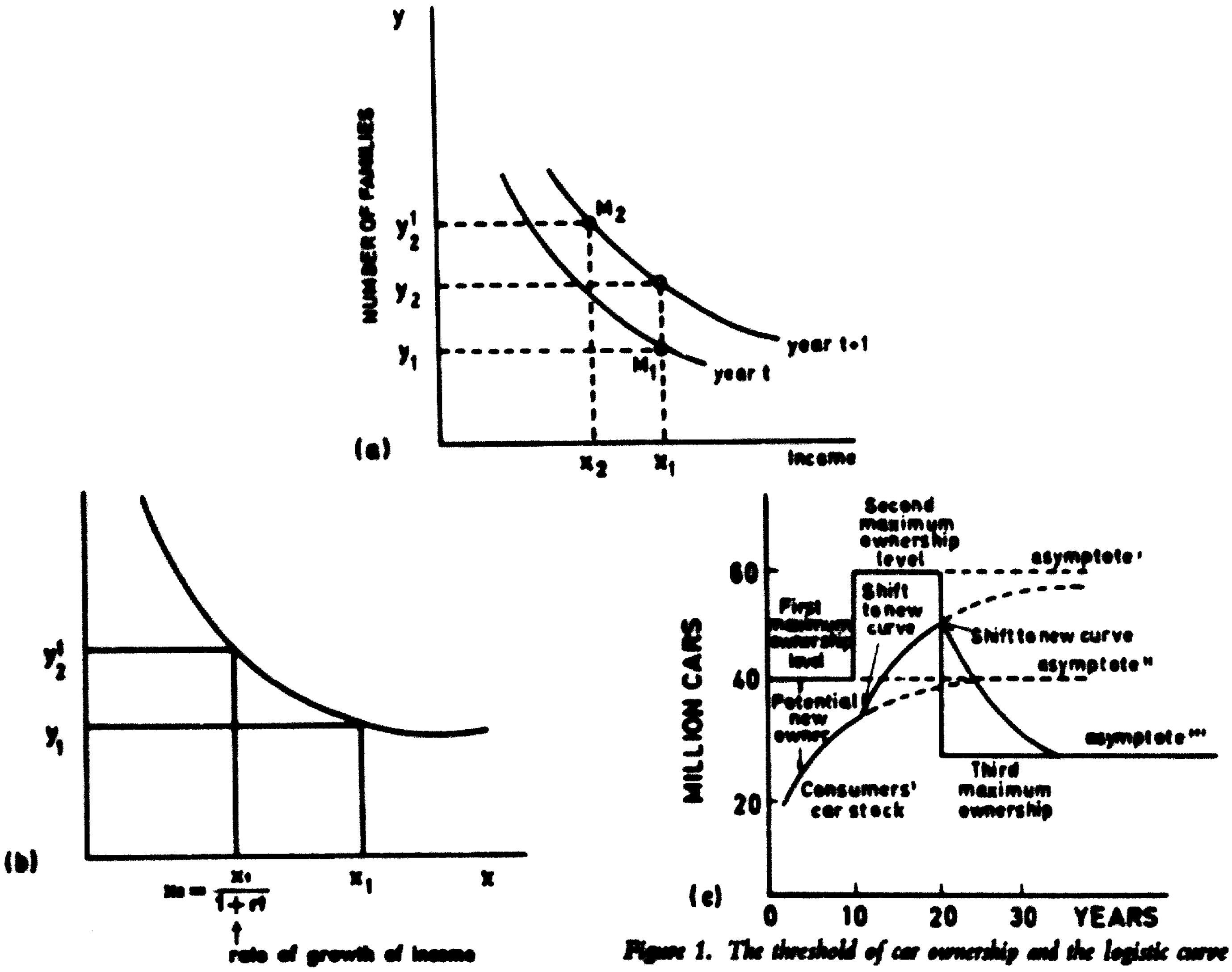

Figure 1. The threshold of car ownership and the logistic curve

development centres of national universities. Once this information is obtained, the underlying mathematics is simple.

Let x be the income threshold. (See figure 1a.) Given the normal Pareto curve of income distribution, each point $M_1(x_1, y_1)$ represents the number of families y receiving an income exceeding x at a given time t. An increase in incomes will shift the curve to the right. At the same time, the threshold is decreasing with the passage of time. Therefore the new point will be $M_2(x_2, y_2^1)$. We should therefore distinguish three separate phenomena:

Connexion between x and y through a Pareto Law: $y = (A/X^a)$, where A and a are constants;

Upward shift of this curve with growing incomes. During a short period of time, there is no deformation of the curve as it shifts, i.e. the distribution of income does not change. Instead of shifting the curve toward growing incomes, we can simply divide the threshold x by $(1 + r)^t$, or, in first approximation, $(1 + rt)$ if r is low, where r is the rate of annual increase in the average income. (See figure 1b);

Downward shift of the threshold with the passage of time. This is due to various factors apart from the income effect such as diffusion of car use, imitation effect, relative fall in prices of cars as compared with other goods etc. The mathematical formula is:

$$y = \frac{A}{\left(\frac{x}{1 + rt}\right)^a},$$

where y is the number of families receiving an income greater than x;

x the threshold below which car purchase is impossible. This threshold is, in principle, moving downwards with the passage of time;

r the yearly growth of income;

t the time.

Therefore, x becomes a logistic factor, decreasing in relation to time, and its asymptote (x''') is defined by a certain income below which purchase of a car is out of the question. (See figure 1c.)

The following generalized formula is for less complex projection methods based on estimates derived by least-squares regression:

$$R = a_1 \Delta Y + a_2 \Delta \frac{P}{M} + a_3 \Delta S + a_4 \Delta X \cdot a_0,$$

where R is the retail sales of new cars;

Y the real disposable income;

P the real retail price of new cars;

M the average credit terms (number of months in the average automobile instalment contract);

S the stock of used cars in circulation;

X the first difference of a dummy shift variable to account for the special conditions of the automobile market in years of severe import controls.

APPENDIX 2

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Annex

DATA ON THE IMPORT AND ASSEMBLY OF MOTOR VEHICLES IN SEVEN DEVELOPING COUNTRIES

Definitions of terms used in the Annex

Passenger cars

Small cars (less than 1,100 cm³)
Medium-size cars (1,100 to 1,800 cm³)
Large cars (more than 1,800 cm³)

Buses

Minibuses (less than 10 seats)
Small buses (10 to 30 seats)
Large buses (more than 30 seats)

Trucks

Pick-up trucks (less than 1 ton payload)
Light trucks (1 to 5 tons)
Heavy trucks (more than 5 tons)

Tractors

Light tractors (up to 170 hp)
Heavy tractors (more than 170 hp)

Trailers

Light trailers (up to 9 tons)
Heavy trailers (more than 9 tons)

Import and assembly of motor vehicles in Colombia

A. *Imports*

	1960	1961	1962	1963	1964	1965	1966	1967	1968 (Jan. – June)
Cars	2,603	3,842	2,191	598	1,361	1,832	8,628	6,881	2,020
Jeeps	1,831	3,901	3,396	1,211	1,990	2,104	3,529	3,806	1,899
Bus chassis	—	—	—	—	—	—	696	1,489	1,032
Truck chassis	6,662	1,264	1,112	1,865	2,039	4,745	601	612	1,025
Pick-up trucks	2,059	495	157	591	149	1,289	3,257	2,068	242
Heavy trucks	3	41	6	350	153	—	—	—	—
Light trucks	24	62	33	21	34	24	—	—	—
Tank trucks	2	—	8	3	1	5	760	87	62
Tractor trucks	—	—	—	—	—	99	84	305	26
Special-purpose vehicles	113	114	189	51	222	59	1,163	838	196

B. *Age of the motor vehicles*

Year	Number of vehicles	Minimum age (years)	Percentage
1967	259,608	1	100.00
1966	251,107	2	96.73
1965	232,885	3	89.71
1964	231,227	4	89.07
1963	213,325	5	82.17
1960	188,376	8	72.56
1956	161,509	12	62.21
1952	67,358	16	25.95

There is only a small amount of foreign exchange for the import of motor vehicles (both CBU and CKD) because of Colombia's unfavourable balance of payments. Customs duties further increase the price of the few imported vehicles.

The percentage of vehicles withdrawn from service is very small (approximately 1 per cent); the remaining vehicles are very old and expensive to maintain.

C. *Local assembly of vehicles*

	1961	1962	1963	1964	1965	1966	1967	1968
Cars	821	2,646	1,237	1,209	510	765	1,486	—
Buses	—	—	—	—	10	238	376	—
Trucks	—	—	120	756	120	601	545	—

D. *Assembly plants*

1. Chrysler plant "Colmotores"

	Vehicles assembled[a]		
	1966	1967	1968 (estimated)
Dodge cars	100	730	1,200
Simca cars	—	—	800
Dodge buses	198	256	900
Dodge chassis up to 3 tons	217	327	1,000
Dodge heavy trucks	166	158	1,100
Total	681	1,471	5,000

[a] SKD assembly.

2. "Leonidas Lara e Hijos"

	Vehicles assembled[a]								
	1961 (Sept.–Dec.)	1962	1963	1964	1965	1966	1967	Total	1968 (estimated)
Willys (jeeps)	821	1,422	—	204	102	305	612	3,466	1,500
Willys light trucks	—	612	528	523	252	258	—	2,173	1,000
Willys pick-up trucks	—	612	711	482	156	102	—	2,063	—
International trucks and tippers up to 7 tons	—	—	—	—	—	—	—	—	700
International 10-ton trucks	—	—	120	756	120	218	60	1,274	500
International bus chassis	—	—	—	—	10	40	120	170	300
Peugeot cars	—	—	—	—	—	—	144	144	—
Total	821	2,646	1,359	1,965	640	923	936	9,290	5,000

[a] SKD assembly.

E. *Ancillary Industries*

1. Present production

Part or component	Manufacturer
Stove enamels Cellulose lacquers	Pinturas Colombianas "PINTUCO" Apartado aéreo 1194 Medellin
Mudguards (fibre glass)	Fivres Limitada
Various springs	Industrias Metálicas Iderna S.A. Urbanización San Cancio Manizales Industrias Sayva Limitada
Gear-box pins Cross-bars	Industria Nacional de Repuestos "INCABE" Car. 5 No. 46—98 Cali
Brake linings	Repuestos Colombianos "RECO" Carrera 61 No. 14—88 Medellin Rusco de Colombia S.A. Via 40 No. 62—226 Barranquilla
Front bell housing bushes for Dodge trucks	Metalúrgica Exacta Limitada "METALEXACTA" Carrera 34 A No. 6—96 Bogotá
Brake shoes	Colombiana de Frenos Carrera 14 No. 16—21 Oficina 201 Bogotá
Asbestos sheet, including shaped asbestos sheet	Repuestos de Colombia "RECO"
Batteries	Esbic Corporation S.A. Calle 3a No. 438—39 Barranquilla Industria Colombiana de Llantas S.A. Calle 9a No. 65—40 Bogotá
Dynamo field coils Ignition coils Sparking plugs	Industrias Eléctricas Prestolite de Colombia S.A. Calle 30 No. 3—469 Barranquilla
Condensers Platinum points	Industria Nacional de Repuestos y Accesorios INRA Carrera 35 No. 17—12 Bogotá

Suspension components	Industria Nacional de Repuestos "INCABE"
Rear spring clamp	Metalúrgicas Exacta Limitada
Torsion bars Leaf springs	INCABE
Brackets	Empresa Siderúrgica S.A.
End-plates and shells	Fundiciones Técnicas S.A. FUTEC Calle 17 No. 44—39 Medellín

2. FUTURE PRODUCTION

Part or component	Manufacturer
Bus seats	Fivres Limitada
Jeep cabs (fibre glass)	Figlas Limitada Calle 32 No. 41—139 Itagui
Door locks	Carraduras de Colombia S.A. "CERRACOL" Calle 12 No. 32A—39 Bogotá
Curved wind-shields (Triplex safety glass)	Efraím Rodriguez H-& Cia. Carrera 3a No. 7—30 Fontibon
Glass components	CRISCOL LIMITADA
Gear change connecting rods Gear-box forks Clutch forks	Forjas de Colombia Apartado aéreo 700 Bucaramanga
Clutch pedals	METALEXACTA
Steering drop arms Links	Forjas de Colombia
Links	INCABE
Tubework for power steering systems	Tubos Bundy de Colombia S.A. Calle 10 No. 40—78 Bogotá
Steering gear forgings	Empresa Siderúrgica S.A. Edificio Banco Popular Parque de Barrió Medellín
Steering end joints (unmachined)	Forjas de Colombia
Steering worms Steering rods	Centrales de Servicio Corona S.A. Autopista Sur
Valve gear rocker arms	Forjas de Colombia
Water pumps	Colombiana de Sportes COSDESO Medellín
Connecting rods (unmachined)	Forjas de Colombia
Cushion and seat frames	Industrias Metálicas de Palmira S.A. "IMP" Carrera 32 Calles 16 y 17 Palmira
Cylinder blocks and engine castings	Fundiciones y Repuestos FURESA Avenida Simón Bolívar Apartado Aéreo 636 Itagui
Camshafts (unmachined)	Forjas de Colombia
Inlet manifolds	Industrias Metalúrgicas Apolo S.A. Autopista Sur No. 35-87 Medellín
Pistons Crankshaft pulleys Water pump pulleys	Centrales de Servicio Corona S.A.
Brake drum hubs	Registradoras America "REAMERICA" Carrera 38 No. 10—24 Bogotá
Brake cylinders	Industrias Apolo S.A.
Air brake cams	Forjas de Colombia
Brake pump levers	METALEXACTA
Dynamo pulleys	Centrales de Servicio Corona S.A.
Shock absorbers	INCABE
Spring brackets	Empresa Siderúrgica S.A.
Truck brackets	Industria Metal-Mecánica Ingersol Apolo S.A. Calle 4a Sur No. 46-25 Medellín
Universal joint spider blanks (unmachined)	Forjas de Colombia
Axles	FURESA
Front axles up to 1.60 m long (unmachined) Rear axles up to 5 in. flange diameter	Forjas de Colombia
Propeller shaft universal joints	INCABE
Driving axle yokes (unmachined)	Forjas de Colombia
Shock absorbers Torsion bars	Industria Nacional de Repuestos INCABE
Gear blanks (unmachined)	Forjas de Colombia

F. *The Colombian Government's policy for development of the automotive industry*

Locally assembled cars are very expensive because of the low production, the high customs duties on CKD parts and the inefficiency of the assembly firms. The price of the Dodge Coronet is approximately 160,000 pesos. The same car if imported has a customs duty of 350 per cent, sales tax and freight charges; it would cost 240,000 pesos. The loss of revenue for locally assembled vehicles is considerable, while the advantage to the consumer is only small. If the average annual income in Colombia is 25,000 pesos, the purchase of this car would require at least 20 years' work.

The main reason for this unfortunate situation is the very erratic system of import licences. The number of licences granted has been very small in comparison with the needs; therefore it has not been possible to rationalize production, to completely use the installed capacity or to reduce the prices.

In response to this situation, the Government outlined its policy for future development of the automotive industry. Resolutions 1142 and 1143 were issued in 1967 by the Ministry of Development in pursuance of this new policy. The main criteria are now discussed.

Type of vehicle

After a consideration of the size of the market and the buying power of the Colombian consumer, it was decided that two basic types of vehicles should be produced: a medium-sized car with 1,800 cm^3 maximum cylinder capacity and a heavy vehicle for transport of goods and passengers.

Competition

In order to avoid the proliferation of different makes and to co-ordinate and rationalize Colombian production of parts and components, it was undesirable to establish more than one firm for the production of each type of vehicle. The Government would supply at least 50 per cent of the capital in the firm. The size of the plant would secure economies of scale and thus greater efficiency. In developing countries the lack of production savings in small-scale plants and the requirements of a high content of locally manufactured parts are the main causes of high costs.

Expansion of the market

The size of the market is probably the most important factor for a true rationalization of production. In this connexion, it is necessary to bear in mind (as a precondition for the establishment of new automotive plants) the possibility of future complementation or compensation agreements with other Latin American countries in the same industry or sector. Since the Bogotá Declaration, the Andean subregional market has assumed great importance; the marketing possibilities in the automotive manufacturing sector within this group of countries must be studied.

Determination of the level of integration

In view of the serious obstacles raised by the definition of the level of integration on the basis of volume or value, this level was defined to include the net effect on the balance of payments:

$$\text{level of integration} = 1 - \frac{M - E}{S},$$

where M is the total foreign exchange required by the company and its specialized suppliers, E the f.o.b. value of the exports of components, parts and finished vehicles and S the c.i.f. value of the imports considered to have been replaced. The production plans and exports are subject to the approval of the Ministry of Development. Thus a meaningful index of the level of integration achieved by any manufacturing or assembly company can be calculated. The establishment of incentives for the economic integration of several countries is also facilitated.

Moreover, this system shows the fallacy of the general belief that import substitution implies a kind of autarky, regardless of the cost to the country's resources. To implement these new criteria, Colombian firms would specialize in the efficient manufacture of parts or units for export. This would reduce costs and increase the volume of production.

Another advantage of this formula is that the total foreign exchange includes imports of the suppliers also. This avoids one of the present errors which classifies every part purchased in the country as a local manufacture regardless of its imported component.

Article 206 of Decree No. 444 (exchange regulations) provides for the possibility of accepting parts imported from Latin American countries as locally produced parts when there are adequate compensatory arrangements: imports should be compensated for by exports of equal value so that there are no adverse effects on the balance of payments. The above formula is based on the adequate compensation of trade.

The experience of developing countries indicates that, for a given volume of production, costs increase in direct proportion to the content of nationally manufactured parts (expressed as a percentage of the total value of the finished vehicle). Compensatory trade agreements decrease production costs and allow a considerable savings of foreign exchange.

Customs duties

The present customs situation is not consistent. The duty on parts for CKD vehicles is 115 per cent, while the duty on the same parts imported as spares is only 5 per cent.

The customs duties on CKD parts must be consistent with the duties levied on imported spares, on the raw materials used in manufacture and on capital goods for actual or potential national manufacture. This is possible, inasmuch as imported CKD parts are favoured in the customs regulations.

Customs duties are important factors in securing efficient import substitution. When there are customs duties of 250 per cent or more on CBU vehicles and average duties of only about 10 per cent on parts, the assembly of vehicles is encouraged and not the local manufacture of parts. The Customs Reform Committee is studying the customs structure as it applies to motor vehicles and will transmit its report to the Automotive Commission.

ing country may well start classifying automotive components according to the feasibility of producing them locally.

At the top of the list of parts to be made locally will be those made from readily available materials by simple manufacturing processes not requiring elaborate equipment or tooling; some examples are silencers, filters and ignition cables. The next category may include relatively simple machined components such as water pumps, brake drums, bushings and various springs. More technical and financial help may be required for the third category of parts, which calls for higher skills, more sophisticated materials and more elaborate equipment, including forging and foundry installations to produce valves and valve train components, pistons and piston rings, steering components, complete brakes, sparking plugs, distributors, carburettors, starting motors and generators. This classification furnishes a key not only to the progress by which a developing country satisfies the demand for automotive components but also to the stages through which a developing country advances to provide a reasonable supply of automotive equipment components.

2. Factors controlling the demand for automotive components

First, let us consider a developing country with no automotive industry, where all motor vehicles must be imported. Since there will be no domestic sources, all components needed for replacement or repair would also have to be imported.

The motor vehicle fleet of a developing country usually has a higher proportion of trucks and buses than a developed country. Figures from twelve countries selected at random illustrate this condition in the table below, which shows the total car, truck and bus registrations in 1966 and their individual percentages of the total.

It will be noted that developed countries (with the exception of Japan) have a high proportion of passenger cars, whereas trucks and buses together comprise only 9 to 18 per cent of the total registration. Japan, which has developed its automotive industry only recently, is an exception and probably will remain so because of its geographical make-up and its extremely dense population. Developing countries, particularly those which have no railroad networks, have greater needs for trucks and buses. The developing countries in the table below serve as examples, since trucks and buses together represent 43.5 to 56.5 per cent of all registered vehicles. Thus the nature of the vehicle fleet must be recognized as an important factor in assessing the demand for automotive components. Developing countries need components for the maintenance of their truck and bus fleets in a greater proportion than do the more developed countries, where the relative number of passenger automobiles is higher.

As mentioned previously, the condition of the roads and the climate of the country will also influence the demand for components. For instance, poor roads and dust will increase the demand for shock absorbers, tie-rod ends, springs, brake linings, pistons and piston rings, filters and wheel bearings, to cite just a few chassis and engine parts. Hot and humid climates will increase the replacement demand for ignition wiring and miscellaneous rubber parts. A very cold climate may cause a significant increase in the wear and replacement rates of batteries and starters.

As was also noted, possibly the most important factor affecting the demand for replacement parts is the technical competence of the people who drive and

Vehicle registrations in selected countries in 1966

Country	*Number of cars, trucks and buses*	*Percentage of total*		
		Cars	*Trucks*	*Buses*
Developed				
France	10,772,500	82.0	17.5	0.5
Germany (Federal Republic)	10,763,700	91.0	8.7	0.3
Italy	6,155,500	89.0	10.5	0.5
Japan	6,823,700	32.0	66.5	1.5
United Kingdom	10,882,700	84.0	15.0	1.0
United States	90,486,000	83.5	16.2	0.3
Intermediate				
Australia	3,788,000	76.5	23.0	0.5
Brazil	1,902,100	55.5	40.0	4.5
Developing				
Chile	193,000	48.0	45.5	6.5
Greece	172,900	56.5	37.5	6.0
India	715,500	51.7	37.1	11.2
Turkey	197,000	43.5	44.5	12.0

Source: World Automotive Market Survey, 1966, McGraw-Hill, New York.

Foreign exchange

Assembly industries recognized by the Ministry of Development should be given priority in securing import licences. This priority should be given to the foreign exchange required by the principal suppliers of the assembly plants.

Consortia

An effective way to rationalize production would be for the Government to consider a group of firms satisfying certain requirements regarding the level of integration and minimum production plans as a single enterprise. Moreover, these firms could become vertically integrated with their national suppliers, and thus facilitate the extension of technical assistance and possibly finance for developing the production plans of their suppliers.

Ancillary industries

The parts and components industry is of crucial importance in the development of the motor industry. In the most highly developed countries, 60 per cent of the needs of motor manufacturers are supplied by ancillary industries, whereas in Mexico and Brazil this percentage is about 40 per cent. In developing countries, the manufacturer has a great responsibility to help a developing ancillary industry. Vertical integration is therefore a major necessity in a country like Colombia. The survey of the parts and components industry carried out by the Department for Planning gives preliminary evidence that Colombia has a promising ancillary industry which could achieve greater efficiency if it had a larger market and more Government protection, especially by customs regulations. Moreover, the acquisition of know-how is one of the important advantages that could be derived from the development of the automotive industry; additional knowledge can be obtained as the ancillary industry develops.

Application of government policy

In order to implement the above considerations, the Colombian rights for the assembly of motor vehicles and the production of parts and assemblies were thrown open to tender in 1967 by resolutions 1142, 1143 and 1307 in which the new Government policy was taken into account.

The result was the recommendation of negotiations with Régie Nationale des Usines Renault, France, for the annual assembly of 15,000 vehicles and with Diesel Nacional S.A., Mexico, for the annual production of 2,500 trucks and buses.

IMPORT AND ASSEMBLY OF MOTOR VEHICLES IN IRAN

A. *Imports*

	1963	1964	1965	1966	1967	1968
Cars	9,895	14,717	14,081	15,655	11,744	6,900
Buses	645	656	727	1,460	920	617
Trucks	791	2,244	2,239	2,431	3,332	3,550
Trailers	1,955	2,903	682	1,237	1,985	1,700

B. *Motor vehicles in Iran, February 1967*

Passenger cars	
Small cars	51,649
Medium-size cars	80,994
Large cars	34,500
Buses	
Small buses	9,833
Large buses	10,906
Trucks	
Pick-up trucks	4,500
Light trucks	11,578
Heavy trucks	18,000
Tractors	
Light tractors	21,000
Heavy tractors	...
Trailers	
Light trailers	12,000
Heavy trailers	5,000

C. *Locally assembled vehicles*

	1960	1961	1962	1963	1964	1965	1966	1967	1968
Cars	2,500	2,085	2,586	2,604	2,797	3,693	3,072	3,183	11,583
Buses	40	74	272	120	1,179	2,308	2,402	3,001	3,960
Trucks	146	110	319	412	1,083	1,671	1,719	2,123	5,950
Trailers	240	328	668	720	2,959	2,075	2,800	3,250	4,200

D. *Assembly plants*[1]

1. IRAN NATIONAL CO.

Number of employees	3,070
Area of building	250,000
Capital expenditure	54
National holding	100
Total present production capacity	
Cars	20,000
Buses, minibuses, pick-up trucks	2,100

	Rate of pre-assembly (%)	*1963*	*1964*	*1965*	*1966*	*1967*	*1968*
Hillman Hunter (Peykan)	65	—	—	—	—	6,860	16,500
Mercedes buses	75	120	600	1,000	1,200	1,782	2,700
Mercedes minibus, pick-up trucks	75	—	100	610	710	870	2,480

2. IRAN JEEP RAMBLER CO.

Number of employees	1,516
Area of building	500,000
Capital expenditure	20
National holding	100
Total present production capacity	
Jeeps	3,000
Ramblers	5,000

	Rate of pre-assembly (%)	*1962*	*1963*	*1964*	*1965*	*1966*	*1967*	*1968*
Jeeps	60	886	818	1,296	1,200	1,337	1,176	1,500
Jeep station cars	65	1,060	870	1,361	920	725	1,022	1,110
Rambler American Aria-Shahin	75	—	—	—	—	—	504	4,000

3. KHAVAR JOINT STOCK CO.

Number of employees	450
Area of building	123,000
Capital expenditure	18
National holding	100
Total present production capacity	
Mercedes trucks	1,500

	1960	*1961*	*1962*	*1963*	*1964*	*1965*	*1966*	*1967*	*1968*
Mercedes trucks (3, 5, 10, 18 tons)	186	184	150	138	472	767	767	952	1,750

The rate of pre-assembly is 75 per cent.

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[1] In the description of the assembly plants, the number of employees includes the production workers and other staff; the building area is in m²; the capital expenditure of the assembly plant is in millions of dollars; the national holding is a percentage of the capital stock; the total present production capacity is in units/year (licence capacity).

4. LEYLAND MOTORS IRAN CO.

Number of employees	625
Area of building	120,000
Capital expenditure	8
National holding	100
Total present production capacity	
Trucks	1,250
Pirouz utility cars	1,200

	Rate of pre-assembly (%)	*1962*	*1963*	*1964*	*1965*	*1966*	*1967*	*1968*
Leyland trucks (6, 8, 10 tons)	75	124	224	479	688	492	620	800
Pirouz cars	80	—	—	—	—	—	—	500

5. ZAMYAD JOINT STOCK CO. (VOLVO)

Number of employees	100
Area of building	160,000
Capital expenditure	1.6
National holding	75
Total present production capacity	
Volvo trucks	400
Tractors	250

	Rate of pre-assembly	*1964*	*1965*	*1966*	*1967*	*1968*
Volvo trucks (5, 8, 10 tons)	75	112	185	224	300	400
Volvo tractors	30	250	250	250	250	250

6. FIAT JOINT STOCK CO. (SAICA)

Number of employees	30
Area of building	10,000
Capital expenditure	1.6
National holding	—
Total present production capacity	
Fiat 1100	600

	1960	*1961*	*1962*	*1963*	*1964*	*1965*	*1966*	*1967*	*1968*
Fiat 1100	450	500	550	640	762	608	553	600	600

The rate of pre-assembly is 35 per cent.

7. Mobatab Joint Stock Co. (Land Rover)

Number of employees	100
Area of building	100,000
Capital expenditure	1.1
National holding	100
Total present production capacity	
Land Rovers	3,000

	1963	1964	1965	1966	1967	1968
Land Rovers (7 and 12 seats)	347	428	299	520	1,240	1,450

The rate of pre-assembly is 55 per cent.

8. Kaveh Joint Stock Co. (Mack)

Number of employees	350
Area of building	10,000
Capital expenditure	1.6
National holding	80
Total present production capacity	
Trucks[a]	400

	1966	1967	1968
Mack trucks	200	256	350

The rate of pre-assembly is 80 per cent.

[a] The plant produces boilers as well.

9. Pars Lux Joint Stock Industrial Manufacturing Co.

Number of employees	287
Area of building	20,000
Capital expenditure	0.95
National holding	100
Total present production capacity	
Deutz buses and minibuses	1,900
Pick-up trucks	3,000

	1967	1968
Deutz buses	168	500
Pick-up trucks		

The rate of pre-assembly is 65 per cent.

10. Consortium of Bus Manufacturers

Number of employees	120
Area of building	10,000
Capital expenditure	0.8
National holding	100
Total present production capacity	
Buses and minibuses	210

	1967	1968
Buses	140	1,800

The rate of pre-assembly is 75 per cent.

11. Joint Stock, Iranian Citroën Co. (Saipak)

Number of employees	250
Area of building	246,000
Capital expenditure	13.5
National holding	75
Total present production capacity	
Cars and trucks	3,000

	1968
Citroën cars and trucks	1,700

The rate of pre-assembly is 65 per cent.

12. Iran Peyma Joint Stock Co.

Number of employees	125
Area of building	10,000
Capital expenditure	0.5
National holding	100
Total present production capacity	
Mercedes buses[a]	40

	1967	1968
Mercedes buses	21	25

The rate of pre-assembly is 45 per cent.

[a] Iran National Co. has a contract with this plant for 40 Mercedes chassis annually.

E. *Ancillary industries*

Part or component	*Manufacturer*	*Capacity*	*Total investment in thousands of dollars*
Iran General	Tires	480,000	6,387
Iran Goodrich	Tires	340,000	10,000
Niru	Batteries	500,000	3,907
Iran Muffler	Mufflers	75 tons	450
Rena	Radiators	30,000	134
Iran Leaf Spring	Leaf springs	2,400 tons	867
Zar	Leaf springs	4,000 tons	800
Abgineh	Auto glass	25,000 tons	6,700
Iran Filter Part Joint Stock	Oil filters	110,000	15
M. M. Industrial	Air and oil filters	16,000	20

Many other small companies manufacture spare parts; their capacities vary according to market demand. They produce the following items: air and oil filters, silencers, weather stripping, rubber mountings, textiles, foam rubber and paints.

F. *Ex-works and list price of the five most popular models*

Make and model	*Ex-works price without taxes or delivery cost*		*List price of the delivered vehicle*	
	In local currency (rial)	*Equivalent in dollars*	*In local currency (rial)*	*Equivalent in dollars*
Hillman Hunter (Peykan) 1969	178,900	2,385	210,000	2,800
Aria (Rambler) 1969	275,715	3,676	324,215	4,322
Shahin (Rambler) 1969	237,620	3,168	284,500	3,793
Jeep 1969	238,913	3,185	175,858	3,678
Citroën	129,000	1,720	150,500	2,008
Fiat 1100	193,357	2,575	228,024	3,040

G. *General information on the motor-vehicle market*

Most of the 317,000 automobiles in Iran have been imported. However, more than 40 per cent of the spare parts of passenger cars, 75 per cent of the spare parts of trucks and 80 per cent of the total number of trucks and buses were manufactured in Iran; chassis, bodies, tires, batteries and radiators are also made in Iran.

On the recommendation of the Ministry of Economy, the Board of Ministers prohibited the issuance of new import permits from 1965 to 1970.

The import restrictions stimulated the development of the Iranian factories; qualified technicians, improved working conditions and low costs were encouraging signs for investments. Some factories have had considerable success in the manufacture of large moulds in addition to automobile parts.

Automobile engines are not manufactured in Iran; however stationary diesel engines from 9 to 230 hp and automotive engines from 80 to 210 hp are included in the 1970—1971 production schedules.

IMPORT AND ASSEMBLY OF MOTOR VEHICLES IN NIGERIA

A. *Imports*

	1960	*1961*	*1962*	*1963*	*1964*	*1965*	*1966*	*1967*	*1968 (Jan.–Oct.)*
Cars	14,573	14,373	11,799	11,457	14,752	17,736	17,092	13,422	3,847
Buses	459	758	526	385	546	639	505	380	40
Trucks	5,935	5,292	2,459	4,048	7,021	5,873	5,007	5,875	6,059
Trailers (tonnage in cwt)	23,153	24,339	17,088	16,941	54,372	42,774	28,235	51,096	45,320

B. *Motor vehicles in Nigeria, 1966*

Cars		60,000
Buses, Trucks, Trailers		25,000
	Total	85,000

C. *Locally assembled vehicles*

	1966	1967	1968 (Jan.–Sept.)
Buses	3,712	4,642	3,002

D. *Assembly plants*[2]

1. SCOA MOTORS, APAPA

Number of employees	212
Area of building	75,348
Capital expenditure	5.3
Total present production capacity	
Peugeot small trucks	1,000
Austin small buses	500
Trucks (1.5 to 9 tons)	1,250

	1960	1961	1962	1963	1964	1965	1966	1967	1968
Peugeot small trucks	—	—	—	—	11	230	351	365	139
Austin small buses	—	160	216	191	120	213	270	424	218
Other trucks	680	1,258	1,076	745	882	757	490	648	696

Parts made within the plant: none.

2. FEDERATED MOTORS INDUSTRIES (THE UAC OF NIGERIA LTD.)

Number of employees	400
Area of building	110,000
Capital expenditure	1.6
Total present production capacity	
Buses and trucks	1,800

	1960	1961	1962	1963	1964	1965	1966	1967	1968
Bedford small buses	—	14	—	—	96	144	60	—	—
Bedford trucks (0.5 to 3 tons)	12	64	—	16	72	25	—	24	36
Bedford trucks (1.25 to 5 tons)	1,260	1,641	950	906	996	956	616	962	1,141
Bedford trucks (6 to 8 tons)	—	—	12	12	42	276	36	—	—

Parts made within the plant: truck and bus bodies from imported sheet metal.

3. A. G. LEVENTIS & CO. (MOTORS), APAPA

Number of employees	250
Area of building	67,280
Capital expenditure	0.5
Total present production capacity	
Mercedes heavy trucks (5 to 20 tons)	2,050
Blumhardt trailers	600

	1960	1961	1962	1963	1964	1965	1966	1967	1968
Mercedes heavy trucks	475	765	618	575	1,208	1,130	800	940	754
Blumhardt trailers	—	—	—	—	182	139	168	260	156

Parts made within the plant: none.

[2] In the description of the assembly plants, the number of employees includes the production workers and other staff; the building area is in ft^2; the capital expenditure of the assembly plant is in millions of dollars; the national holding is a percentage of the capital stock; the total present production capacity is in units/year. None of the four assembly plants has any national holdings in the capital stock. The entire production is CKD assembly.

4. CFAO MOTORS, IKEJA

Number of employees	90
Area of building	40,800
Capital expenditure	0.4
Total present production capacity	
Morris trucks (2 to 7 tons)	1,500
Morris pick-up trucks	1,000

	1966	*1967*	*1968*
Morris small trucks	304	435	269
Morris pick-up trucks	370	426	497

Parts made within the plant: none.

E. *Ancilliary industries*

Part or component	*Manufacturer*
Tires and tubes[a]	Dunlop Nigeria Ltd. Ikeja Michelin (Nigeria) Ltd. Port Harcourt
Batteries[b]	Associated Battery Manufacturers (Nigeria) Ltd.
Paint	ICI (Paints) Ltd. Apapa
Foam rubber	Vitafoam (Nigeria) Ltd. Apapa Nigerian Foam Rubber Co. Ibadan
Leaf springs[c]	UAC of Nigeria Ltd.

[a] The estimated capacities for 1966 are Dunlop 220,000 cross-ply tires and Michelin 223,000 radial tires. Production has been halted at the Michelin factory.
[b] The 1967–1968 production was 30,000 units.
[c] The daily production was 150 leaf springs. However, the plant has ceased production; it could not compete with cheap imported springs.

F. *List prices of five most popular models*

Make and model	*Local currency (Nigerian pounds)*	*Equivalent in dollars*
Peugeot small bus/truck	1,015	2,840
Austin 3-ton chassis/scuttle	1,350	3,780
Bedford truck (1.5 ton)	1,495	4,190
Mercedes truck (6 ton)	3,125	8,750

G. *General information on the motor-vehicle market*

The total number of private cars in Nigeria in the early 1950s was only about 10,000 but is has now increased to 60,000. In the same period the annual demand for new cars has increased from 4,000 cars to about 18,000 in 1965. Of the total number of private cars in Nigeria, about 30 per cent are newly registered and about 20 per cent are scrapped.

The number of commercial vehicles increased from 8,000 in 1951 to 23,000 in 1961 at a growth rate of 12 per cent. This number appears to have increased only slightly in recent years. However, the carrying capacity of commercial vehicles has increased since scrapped trucks are replaced by larger vehicles.

Imported cars are CBU, while most commercial vehicles and buses are assembled locally from CKD components. However, the Nigerian market is now large enough to warrant the assembly of cars and commercial vehicles. The Government has granted duty concessions to automobile manufacturers.

IMPORT AND ASSEMBLY OF MOTOR VEHICLES IN SINGAPORE

A. *Imports*

	1960	*1961*	*1962*	*1963*	*1964*	*1965*	*1966*	*1967*	*1968*
Cars	10,600	12,800	13,200	15,800	13,800	15,100	12,900	8,400	6,800
Buses	350	300	340	360	240	180	80	85	65
Trucks	1,040	1,320	1,000	2,000	2,770	3,070	2,570	1,530	1,180

B. *Motor vehicles in Singapore, January 1969*

Passenger cars	126,515
Buses	1,907
Trucks	27,652
Trailers	158
Total	156,232

C. *Locally assembled vehicles*

	1960	*1961*	*1962*	*1963*	*1964*	*1965*	*1966*	*1967*	*1968*
Cars	895	1,272	1,114	1,868	1,973	2,244	2,837	2,116	4,357
Buses and trucks	425	471	609	746	835	863	585	542	996
Total	1,320	1,743	1,723	2,614	2,808	3,107	3,422	2,658	5,353

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service the vehicles. When a country begins to motorize its economy, several years will be needed to train people in the use and maintenance of automotive equipment. Inevitably, during this period, inexperience and prejudice will exact a heavy toll on many parts and components that would otherwise last much longer with proper care. Many inexperienced or careless drivers will wear out clutches, transmissions, brakes and engine valves at an alarming rate. Poorly equipped service shops and poorly trained mechanics will accelerate the need for replacement of ignition components, valve lifters, gaskets, tires etc.

Two examples from personal experience in a developing country will illustrate the importance of the human factor. Both of them show what can happen when there is a lack of understanding of an engine cooling system and how inexperience or ignorance shorten the normal life of the components.

In the first of these cases, our party was riding in a newly imported American car in a tropical country. Part of the route led over a spectacular mountain road involving a steady and steep climb of 3,000 feet in less than ten miles. We stopped at the last petrol station at the foot of the mountain, and the driver had the radiator checked and filled; he also personally made sure that the radiator cap be left loose because, he explained, the water would get hot and one must let the steam escape. My pleas to put the cap on tightly were of no avail and we started. "Nobody in this country", I was told, "would be foolish enough to drive up this mountain with a tightly screwed-on radiator cap." There are several lay-by areas on this road, and all of them were packed with steaming cars, their bonnets up, while their drivers waited for the boiling to subside before they refilled the radiators. As we drove on, the temperature indicator approached the red warning zone, but the driver drove until, just at the summit, the overheated engine stalled. Apparently almost all the coolant had boiled away, and we had to haul bucket after bucket of water from a well some distance away. This time I disregarded the driver's protest, put the radiator cap on tightly and explained carefully that keeping the cooling system under pressure raised the boiling point of the coolant and prevented its evaporation and loss. I have learned later that my advice was followed, and the mountain stretch has since been negotiated by this driver frequently without any radiator trouble. The local engineer of a truck manufacturer confirmed that the practice of loosening the radiator cap before a long climb was prevalent in the region and was the cause of premature damage to vital engine parts.

The second example from the same country concerns a local prejudice which had an adverse effect on the life of truck-engine components. The truck drivers there assumed that the thermostat regulating the coolant temperature was not only unnecessary in the warm climate of this country but on the contrary, harmful. Most drivers removed the thermostats from their engine-cooling systems. This resulted not only in a long engine warming-up period but, too often, the engine never reached a proper operating temperature. The obvious effect was unusually rapid wear of engine components. It took intensive research by the truck manufacturer's engineers to discover why their engines lasted barely half as long as they should. A massive educational campaign finally corrected this condition.

These two examples show how the human element may significantly affect the useful life of automotive components and, consequently, their demand. Producers of automotive vehicles should recognize the initial lack of technical knowledge in developing countries and help to prevent situations such as those described by writing special instruction manuals tailored to the particular needs of various countries or regions.

3. Supply of automotive components

With the import of the first motor vehicles in a developing country, the automobile manufacturer assumes the responsibility to import and supply the parts and components needed for maintenance. When several makes and models of vehicles are imported, a second source of replacement parts is likely to develop, namely, the parts distributor. He is usually an aggressive local businessman who sees the opportunity to establish himself in a growing and promising field geared to the economic growth of his country. He secures franchises from well-known manufacturers abroad; from them he receives not only brand-name merchandise but also technical help and training and, very often, some needed capital. The obvious advantage of this franchised distributor is that he can furnish genuine brand-name replacement parts to repair and maintenance shops. The repair shops thus have a source from which to obtain quickly all the components needed for their work.

An ultimate stage of supply is finally reached when the developing country has acquired a substantial motor vehicle fleet with a corps of trained mechanics and has the resources to start domestic production of some of the components. The problems associated with the domestic manufacture of automotive parts are described in some detail in the next section.

4. Domestic manufacture

A developing country strives for industrialization, and one of the first steps towards it is often taken by establishing plants for making simple automotive components. It is important to understand that this production is not undertaken to furnish parts at prices lower than those of imported ones. Such domestically manufactured parts and components may be two to eight times as expensive as the imported articles and possibly also of poorer quality. This apparent waste is often criticized by local consumers as well as by exporters in developed countries. It should be remembered, however, that those parts are produced primarily to provide employment and to teach industrial processes to local workers, and also to avoid import of these components, thereby saving foreign exchange. Industrialization is undertaken, regardless of cost, to raise the standard of living in the country.

Technical, as well as financial, assistance is often needed to begin the manufacture of automotive components. In addition, the Government must adopt policies and regulations that will render such assistance feasible. The United Nations has assisted a number of developing countries in this respect by providing experienced technical personnel to study their needs and capabilities and to give guidance in starting factories. These engineers and technicians develop over-all plans for a modest industrialization, select the products, organize small factories, specify the equipment and provide the initial training of the management personnel and the labour force. With such help a good start can be made toward domestic production of automotive components.

Domestic production of automotive components will increase when certain conditions evolve which justify the manufacture of parts in greater variety and complexity, particularly those for which the supply of raw materials is readily available. Some of these conditions are considered below.

First, there must be a market large enough for a foreign parts manufacturer to consider it worth-while to license a local manufacturer, to give him technical assistance, to enter into a partnership with a local establishment or even to establish a wholly owned subsidiary. As a rule, the market is large enough for the production of the more sophisticated automotive components when the number of registered vehicles in the area to be served, which could be one or several countries, has reached about 400,000.

A second condition to be met is the availability of factory sites with access to basic utilities (electricity, gas, water and telephone service) and reasonable means of transport. A third condition is the existence of adequate banking facilities to handle commercial and foreign-exchange transactions, extend credits to buyers etc. A fourth condition is the assurance to the investor that the Government of the developing country will maintain a fiscal policy that will provide a reliable base for planning the operation.

Particular reference is made to the needs of the foreign participant, be he licenser, partner or sole owner, that the laws and regulations provide him with licence and patent protection, that the employment of his technicians and engineers is feasible, and that the tax laws and other regulations are clear and uniformly applied. To attract foreign manufacturers and investors, inducements may be offered. These may consist of tax relief for the first few years, the easing of customs duties on imported equipment which is not available in the country, or regulations permitting remittance abroad of funds earned by technical assistance services and of a share of the profits. A further inducement to attract foreign participation may be favourable regulations for the reinvestment of profits, thereby ensuring internal growth and benefits to the economy of the country.

A country enters the third and final phase of automotive-component production when it begins its own motor-vehicle production, progressing from assembly to integrated domestic national manufacture. Starting with the assembly of vehicles mostly from imported parts, the industry begins to replace imported parts by locally produced articles and gradually approaches the ideal of 100 per cent national content.

Pressure is usually applied to set up manufacturing plants for every component needed as governmental authorities prescribe a schedule for increasing local production; the manufacturers strive to comply. It is usual for the manufacturer to urge the parent component suppliers either to licence a domestic concern and give it technical and financial assistance or to establish a partly or wholly owned subsidiary for the local production of the needed components. This presupposes the existence or creation of auxiliary industries on which the component manufacturer must depend, such as machine shops, tool shops, sources of tool steels, cutting tools, grinding wheels, lubricants, coolants and heat-treatment and welding supplies.

5. Manufacturing methods

The manufacturing methods used in a developed country cannot and should not be copied by the component manufacturer in the developing country. Many factors will influence the selection of the most advantageous manufacturing method and equipment taking into account economic, technical, financial and manpower considerations. The manufacturer in the developed country often has the advantage of a large volume that justifies the use of automated equipment. The relatively high cost of labour and low cost of materials promote labour-saving installations requiring a high investment in tools and equipment.

The automotive component manufacturer in a developing country usually deals with small volumes of great variety which require numerous set-ups and tool changes. Installation of complex high-production equipment is not feasible in this situation. The direct labour saving would be insignificant when weighed against the increased cost of intricate machines and the amortization of the expensive equipment; the labour force may not be sufficiently skilled to operate and service such a production line. The unavailability of some materials obtainable only in the developed country may require changes in the methods.

The foreign company sponsoring the establishment of the manufacturing plant in the developing country may have perfectly good used machine tools that are not needed at home and are well suited to the production methods planned for the developing country. Such equipment may be provided at a considerable saving. The following examples will illustrate the influence of these various factors on the modification of methods for manufacturing automotive steering-linkage parts. The high-production methods practised in a plant in the United States are compared with the small-volume methods of a developing country that was developing its own automotive vehicle assembly and production and wanted to replace some previously imported components with domestic ones. These instances show how production methods were adapted to the capability of a developing component industry.

Manufacture of ball studs

The first example deals with a familiar part, ball-headed stud or a ball stud, which provides the flexible joints for the steering linkage. This heat-treated, precision product is made to close tolerances and to exacting finish specifications. The high-production method employed by the American plant starts with heading on a progressive cold header, the stock being fed to it as wire from a coil through a wire-draw straightener. The stud is cold formed, completely finished, except for the cotter hole and the thread, at an hourly rate of approximately 2,300 pieces. Next the cotter hole is drilled and countersunk on a special machine, the studs being fed automatically into the drilling machine from a hopper through a feeding device, the hourly production rate being again about 2,300 pieces. Finally, the thread is rolled on a high-production roll threader, again automatically fed and having an hourly output of approximately 6,600 pieces. Heat treatment completes the production process.

This manufacturing method was obviously not feasible for the developing country, where the production volume was small, with lot sizes seldom exceeding 5,000 pieces. It was also not feasible to use the cold-heading method because cold-heading steel was not available. Furthermore, the investment in a progressive cold header (approximately $250,000) and its intricate tooling could not be considered in view of the low volume and absence of adequate facilities for producing the header tools. Similar considerations applied to the special machine for drilling and countersinking the cotter hole. A simpler manufacturing process was devised for small-lot production; it was adapted not only to the available raw material (hot-rolled steel bars) but also to standard machine tools and to medium-skilled labour. After the blanks are cut, they are heated in a small furnace, and the head is hot-forged on a conventional punch press. The forged stud blanks are then finish-turned on contour-turning lathes equipped with duplicating attachments: one lathe finishes the head and another finishes the shank at an hourly rate of 50 pieces for each operation. The drilling and countersinking of the cotter hole is done on conventional drill presses, and the thread is formed on a regular thread roller.

Even this sketchy description and comparison of the two methods discloses several reasons why the over-all manufacturing cost of the simpler method is unavoidably higher, primarily because the increased labour input by far exceeds the savings made possible by lower wage rates. The reject rate also is important; it is very low in the automated method and relatively high in the simpler method with its dependence on human skills.

Manufacture of centrelinks

A second example compares methods of forging a centrelink. This forging with its bends and the close tolerance in the angular and dimensional relations of its two forged ends is produced in the American plant on a 3-inch upsetter. Each end is finish-forged in one heat provided by an automatic induction-heating installation that requires no attendant; only one operator is needed to produce these accurate forgings at an hourly rate of about 120 pieces. To duplicate this set-up would be entirely uneconomic at the start of manufacture in a developing country, not only because expensive equipment would operate for only a few hours monthly, which would involve several costly set-up changes, but also because power shortages would preclude the use of electric induction heating. However, in the developing country, a rather primitive but temporarily adequate arrangement was devised. An oil-fired pigeonhole furnace was used for heating, and a conventional punch press performed the various gathering and forming operations; each required an uncomplicated die set-up. At the time of writing the increases in local automotive production, in the acquired skill of the workers and in the electrical power supply have created conditions under which the installation of an upsetter and an induction heating device have become feasible. An added inducement for this investment is the expected and desirable improvement in the quality of centrelink forgings and the reduction of the high rate of rejects.

Manufacture of vertical sockets

A third example compares methods for the production of vertical sockets of two similar types — the short-stem socket and the long-stem socket — on identical or similar equipment. Comparison of production methods clearly indicates the influence of high volume and the necessity of labour savings in a high-wage country such as the

United States and the influence of the opposite conditions in a new plant starting in a developing country. In the American plant the socket is forged on a 2.5-inch upsetter equipped with a magazine feed of blanks to an induction-heating device. The forging is produced to close tolerances, permitting accurate location on the subsequent machining operation, and only a small amount of excess stock need be allowed for machining. The hourly output of one operator is approximately 150 pieces.

Compare this method with the steps employed in the forging plant of the developing country. There the blanks are heated in an oil-fired furnace, where the proper temperature is checked frequently by means of a pyrometer. The end is then blocked on an air hammer, reheated, and the final forming is done on a home-made drop hammer operated by three men. Altogether it takes six men and approximately 10 per cent more steel to produce about 60 pieces per hour than for a single American operator to produce 150 pieces per hour. However, the forging equipment was already in operation in the developing country, whereas an installation of the American type would have cost nearly $150,000. No doubt these facilities will be eventually installed, but the initial primitive set-up satisfied an immediate need.

The machining of the socket head also leads to an interesting comparison of methods. The American plant has a battery of special seven-station index machines, each of which completes the entire head at an hourly rate of over 500 pieces. The costly tools and set-up gauges are economic for the large volume and the frequent long runs. A complete set-up requiring about six hours is seldom needed; most change-overs are accomplished by a partial set-up in two hours, which limits the size of the economic lot to a minimum of 5,000 pieces. No such conditions exist in the developing country, where the various machining operations are not combined but are performed in separate steps on conventional drill presses at an hourly rate of 20 pieces.

A hollow-milling operation on the back of the socket is performed in the American plant by a ten-spindle rotomatic where the table and the tool head rotate together. This arrangement requires ten sets of identical tools and a very precise set-up; the high hourly output of 700 pieces in a concentrated space is suitable only for very long runs. In the plant of the developing country, where the lots are small, the same operation is performed on single-spindle screw machines at an hourly rate of approximately 60 to 70 pieces.

Assembly of the ball stud to the socket

A fourth example is the assembly of the ball stud to the socket, which includes the insertion of lubricant, a spherical bearing, a spring, a cover plate and other parts, depending on the particular design. A special index-type assembly machine for short- or long-stem sockets in the American plant operates in conjunction with a hydraulic press. The various parts and the lubricant are fed to their respective stations automatically. The finished assembly, lubricated and sealed, leaves the machine at an hourly rate of 300 socket assemblies. Compare this operation with the method in the plant of the developing country, where all the parts are assembled by hand and the only machine operation is the final closing of the assembly on a home-made spinning machine built from an old drill press and actuated by an hydraulic cylinder at an hourly rate of 100 pieces.

Manufacture of piston-ring castings

A final example is a foundry for the production of piston-ring castings to supply a piston-ring machining line. Quality castings are not available in the country, and their import is prohibited. It became necessary to install a complete minimum-size iron foundry, which nevertheless has excess capacity and fills the current requirements by operating only two days a week. It is obvious that a foundry cannot be operated economically on such an abbreviated schedule. The pouring operation was not mechanized because this added investment would have only increased the financial losses. On the other hand, the sand-handling and moulding facilities are of the latest design to ensure good castings. There is the expectation, if not the assurance, that the eventual growth of the markets for original equipment and replacements will generate enough volume for the utilization of the foundry capacity to become economic.

6. Long-range planning: the case of Brazil

As pointed out earlier, to assemble or build automobiles in a developing country, it is first necessary to create an automotive-component industry. Plans for the introduction of automotive production into a developing country frequently originate in the Government and are accompanied by laws concerning the types, quantities, time schedule, financing, taxation policies, percentage of national content, investment sources, technical assistance from abroad, location of plants, procurement of raw materials, and sources and training of labour. To have a change of success, such an integrated plan is best worked out in co-operation with the present and prospective automotive producers, domestic and foreign, and must be flexible enough to adapt to unforeseen or changing conditions.

Possibly the best way to describe the aspects of such planning, although it will vary from country to country according to the conditions encountered, is to select a successful case which is well documented. The principles embodied there may serve as a guide for similar projects in other countries.

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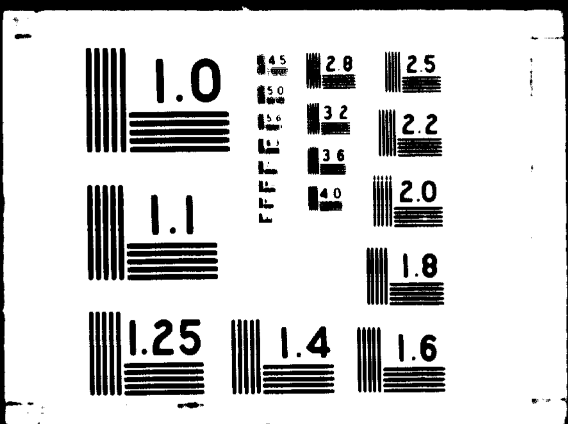


D. *Assembly plants*[3]

1. Ford Motor Co. (Private) Ltd.

Number of employees	193
Area of building	153,000
Capital expenditure	1.8
Present production capacity	
Cars and trucks	2,200

	1960	*1961*	*1962*	*1963*	*1964*	*1965*	*1966*	*1967*	*1968*
Prefect/Anglia/Escort	480	686	395	444	400	480	579	300	641
Zephyr/Corsair	90	124	31	307	173	442	367	31	—
Consul/Cortina	215	313	483	1,101	1,400	1,298	1,437	1,033	1,003
Falcon and Taunus	110	149	205	16	—	—	—	—	123
Commercial vehicles	425	471	609	746	835	863	585	512	226

2. Cycle and Carriage Co. (Industries) Ltd.

Number of employees	211
Area of building	110,000
Capital expenditure	1.1
Present production capacity[a]	
Cars and trucks	2,100

	1965	*1966*	*1967*	*1968*
Mercedes Benz	24	454	752	790
Volkswagen 1300	—	—	—	690
Commercial vehicles	—	—	30	260

[a] Local production began November 1965.

3. Associated Motor Industries Ltd.

Number of employees	322
Area of building	140,000
Capital expenditure	1.9
Present production capacity[a]	
Cars, trucks and buses	2,500

	1968
Austin/Morris 1100, Mini etc.	380
Vauxhall	350
Renault R 10	160
Chevrolet Impala	20
Commercial vehicles	510

[a] Local production began September 1968.

4. Singapore Nissan Motors (Private) Ltd.

Number of employees	44
Area of building	33,000
Capital expenditure	0.3
Present production capacity[a]	
Datsum pick-up trucks	700

	1968
Datsum pick-up trucks	200

[a] Local production began October 1968.

E. *Ancillary industries*

Part or component	*Manufacturer*
Tires and tubes	Bridgestone Singapore Co. (Pte.) Ltd.
Batteries	Singapore Batteries Manufacturers Ltd.
	Chloride Electrical Storage Co. (F.E.) Ltd.
Seat cushions	Dunlop Industries Ltd.
Paints, primers etc.	I.C.I. Singapore (Pte.) Ltd.
	P.A.R. Malayan Paintworks Ltd.
Thinners, oil and grease	Shell, Esso, Mobil Oil, B.P. and Caltex

[3] In the description of the assembly plants, the number of employees includes the production workers and other staff; the building area is in ft²; the capital expenditure of the assembly plant is in millions of dollars (fixed asset); the total present production capacity in units/year based on a single shift is approximately 30 per cent below maximum capacity. No parts were made within the plants.

B. *Motor vehicles in Turkey*

	As of 1966
Cars	
Small cars	50,000
Medium-size cars	31,000
Large cars	10,500
Buses	
Minibuses	10,500
Small buses	5,000
Large buses	7,500
Trucks	
Pick-up trucks	16,000
Light trucks	22,000
Heavy trucks	42,000

C. *Local assembly of vehicles*

	1960	1961	1962	1963	1964	1965	1966	1967	1968
Cars including jeeps	—	—	—	—	1,500	500	858	2,950	4,843
Buses	—	—	—	—	400	1,600	850	1,507	1,517
Trucks	2,168	1,818	1,354	1,324	4,656	3,000	10,020	12,482	14,050[a]

[a] Total assembly of the firms in Turkey.

D. *Assembly plants*[5]

1. Türk Willys Overland Fab. A.S.

Number of employees	...
Area of building	...
Capital expenditure	1.5
National holding	75
Total production capacity	
Jeeps and pick-up trucks	9,000

	1964	1965	1966	1967	1968
Jeeps and pick-up trucks	2,702	786	1,486	1,454	1,511

2. Chrysler Sanayii A.S.

Number of employees	...
Area of building	...
Capital expenditure	2.2
National holding	40
Total production capacity	
Trucks	10,000

	1964	1965	1966	1967	1968
Trucks	230	819	3,010	2,487	240

3. MAN

Number of employees	173
Area of building	...
Capital expenditure	0.6
National holding	66.7
Total production capacity	
Trucks	1,200
Buses	400

	1967	1968
Trucks	146	750
Buses	66	100

[5] In the description of the assembly plants, the number of employees includes the production workers and other staff; the building area is in m²; the capital expenditure of the assembly plant is in millions of dollars; the national holding is a percentage of the capital stock; the total present production capacity is in units/year.

4. GENOTO

Number of employees	418
Area of building	. . .
Capital expenditure	2.7
National holding	100
Total production capacity	
Trucks	8 per day

	1965	1966	1967	1968
Trucks	156	840	1,307	1,500
Minibuses	—	16	—	—

5. OTOSAN

Number of employees	1,227
Area of building	. . .
Capital expenditure	3.7
National holding	100
Total production capacity	
Trucks	3,000
Cars	6,000
Buses and minibuses	1,800

	1964	1965	1966	1967	1968
Cars	—	—	18	1,760	3,543
Trucks	1,005	521	1,289	1,591	1,964
Buses and minibuses	400	1,245	64	867	1,031

6. BMC

Number of employees	. . .
Area of building	40,000
Capital expenditure	2
National holding	74
Total production capacity	
Trucks	3,500
Tractors	3,500

	1967	1968
Trucks	1,778	300
Tractors	395	300
Minibuses	204	—

7. Çelik Montaj

Number of employees	250
Area of building	. . .
Capital expenditure	0.6
National holding	100
Total production capacity	
Motor cycles	6,400
Trucks	2,200

	1965	1966	1967	1968
CZ 125	864	2,943	2,663	2,700
Jawa 250	520	2,482	3,650	3,700
Skoda 1202	—	932	1,834	2,200

8. Türk Otomotiv Endüstrisi

Number of employees	750
Area of building	. . .
Capital expenditure	5.5
National holding	85
Total production capacity	
Trucks	5,400
Tractors	4,500
Trailers	900
Chassis	21,000

	1964	1965	1966	1967	1968
Trucks	2,295	1,132	2,072	1,519	2,100
Tractors	—	—	—	—	495
Chassis	. . .	. . .	. . .	4,144	16,772

E. *Ancillary industries*

The following parts are manufactured in Turkey: tires, hoses, rubber belts, batteries, starters, friction bearings, oil seals, oil and fuel filters, radiators, petrol tanks, silencers, heaters, glass, upholstery, speedometers, cables and electrical equipment, water pumps, wheels and caps.

The iron foundries in Istanbul and Ankara are well suited to supply the parts required by assembly plants. However, pilot foundry and forging projects manufacture important components of transmission units, engines, pistons and sleeves.

An important project is under construction to manufacture 20,000 transmission and rear axles of trucks and buses annually.

The Perkins Diesel Engine Project will have an annual capacity of 50,000 engines.

F. *Ex-works and list prices of the five most popular models*

Make and model	*Ex-works price without taxes or delivery cost*		*List price of the delivered vehicle*	
	In local currency (Turkish lira)	*Equivalent in dollars*	*In local currency (Turkish lira)*	*Equivalent in dollars*
TOE IH Loadstar 1800 trucks	82,000	9,000	124,000	13,600
BMC TM 140 trucks	64,000	7,000	93,000	10,200
Genato KGLC 60 trucks	70,000	7,700	103,000	11,400
Otosan "Anadol" cars	18,000	2,000	26,500	2,900
Otosan Ford Bluebird buses (estimated)	250,000	27,500	310,000	34,000

G. *General information on the motor-vehicle market*

The import of vehicles is limited by the small amount of foreign exchange and by high customs duties. In a similar way, assembly is limited both by import quotas and by plant capacities.

The demand in Turkey can be studied in two ways. One is a simulation and correlation study between Spanish and Turkish markets taking into consideration a ten-to-twelve-year difference, and using *per capita* income and total cash expenditure for cars. The other more realistic study uses family income levels and an average of car prices. According to these studies, the car demand for 1972 varies from 29,000 to 33,000 cars (32,000 and 28,000 Turkish lira retail prices).

These retail prices ($3,300 and $3,100) are higher than average world-wide prices. If the average retail price were $2,400, the demand would probably increase to 45,000 or 50,000 for 1972. The minimum supply in 1968 was estimated to be 17,000 or 18,000 cars. Fiat has offered a project that has an annual capacity of 20,000 cars in two shifts. However, Fiat will not be able to meet the total demand in Turkey; therefore another plant should be established in the very near future. The demand for trucks and buses are better satisfied by the assembly plants and by imports. Transportation needs are however changing; the demand for small trucks will increase but trailers will be important for long-distance transportation.

IMPORT AND ASSEMBLY OF MOTOR VEHICLES IN YUGOSLAVIA

A. *Imports*

	1960	*1961*	*1962*	*1963*	*1964*	*1965*	*1966*	*1967*	*1968*
Cars	6,950	9,110	2,895	1,057	4,859	13,049	20,212	51,770	50,000
Buses	196	208	125	5	50	50	89	258	200
Trucks	669	688	119	527	1,565	1,648	1,015	8,405	8,000

B. *Motor vehicles in Yugoslavia*

1. CARS, JUNE 1968

Make		*Percentage*		*Number of vehicles*
ZCZ—Fiat		51.8		196,800
600—750	37.0		140,600	
1300—1500	9.7		36,800	
Other models	5.1		19,400	
Citroën (Tomos)		1.4		5,300
NSU (Pretis)		2.7		10,300
Peugeot		2.8		10,600
Simca		1.0		3,800
Renault		3.7		14,000
Opel		8.0		30,400
Volkswagen		7.0		26,600
Ford D		4.8		18,200
Mercedes		0.7		2,700
Škoda		8.2		31,200
Moskvic		2.1		8,000
Wartburg		0.7		2,700
Others		5.1		19,400
Total		100.0		374,000

2. Commercial vehicles from 1960 to 1970 (payload in kg)

Year	*Trucks* Less than 1,000	1,001 to 5,000	More than 5,000	Total (trucks)	*Special vehicles*
1960	2,170	25,463	5,894	33,527	3,984
1961	2,344	23,312	6,356	32,012	4,065
1962	3,000	26,476	8,227	37,703	4,412
1963	3,576	29,333	9,564	42,573	5,057
1964	4 305	32,960	11,639	48,904	6,021
1965	5,564	38,308	14,703	58,575	6,663
1966	6,941	44,593	18,581	70,115	7,379
1967	8,890	52,745	23,852	85,487	8,108
1968	10,355	66,686	17,516	94,557	8,561

C. *Local assembly of vehicles*

	1960	*1961*	*1962*	*1963*	*1964*	*1965*	*1966*	*1967*	*1968*
Cars	10,461	14,999	13,125	20,923	27,854	35,880	33,698	42,338	56,000
Buses	896	829	2,144	1,823	2,362	2,287	2,257	1,939	2,000
Trucks	4,564	5,426	6,454	7,975	9,081	9,572	10,459	11,364	12,000

D. *Assembly plants*[6]

1. Zavodi Crvena Zastava, Kragujevac

Number of employees	10,200
Area of building	100,000
Capital expenditure	48
National holding	90
Present total production capacity	
Zastava 750	36,000
Zastava 1300	11,000
Zastava AR 51/55	1,500
Zastava 615/620	2,000
Zastava 1300 TF	1,500
Assembly of vehicles from components	7,000

	Rate of pre-assembly (%)	*1960*	*1961*	*1962*	*1963*	*1964*	*1965*	*1966*	*1967*	*1968*
Zastava 750	40	7,354	9,895	8,368	14,319	21,356	27,684	25,641	29,225	33,822
Zastava 1300	33	—	113	1,469	3,423	4,554	5,495	5,729	6,466	10,103
AR 51/55	30	837	987	609	1,089	934	1,311	838	1,182	523
Zastava 615/620	37	940	1,303	1,341	1,644	1,893	2,734	2,164	1,812	1,246
Zastava 1300 TF	23	375	486	616	740	937	927	931	1,233	1,198
Fiat Zastava 850	MKD	—	—	—	—	—	—	—	2,472	2,887
Fiat Zastava 1100 R	MKD	—	—	—	—	—	—	—	2,819	1,221
Fiat Zastava 124	MKD	—	—	—	—	—	—	—	—	1,561
Fiat Zastava 125	MKD	—	—	—	—	—	—	—	—	1,028

Parts made within the plant: the complete body and chassis of cars and the chassis of trucks. The truck bodies with the exception of Zastava AR 51/55 that are produced here, are supplied by special body plants.

[6] In the description of the assembly plants, the number of employees includes the production workers and other staff; the building area is in m^2; the capital expenditure of the assembly plant is in millions of dollars; the national holding is a percentage of the capital stock; the total present production capacity is in units/year.

2. PRETIS SARAJEVO

Number of employees	650
Area of building	9,000
Capital expenditure	1.8
National holding	100
Present total production capacity	
Cars	10,000

	Rate of pre-assembly (%)	*1965*	*1966*	*1967*	*1968*
1000	35	520	1,800	1,600	1,200
1100	25	—	700	2,400	1,500
1200	20	—	—	—	3,300

Parts made within the plant: parts and assemblies of the front and rear suspensions with transmission and some body parts.

3. TOVARNA MOTORNIH VOZIL, KOPER

Number of employees	204
Area of building	3,800
Capital expenditure	0.46
Present total production capacity	
Cars and trucks	4,000

	Rate of pre-assembly (%)	*1960—1963*	*1964*	*1965*	*1966*	*1967*	*1968*
AZL	10	761	180	210	329	676	523
AZU	10	301	85	71	30	116	94
AM	10	69	225	314	435	614	256
AMF	10	—	—	15	—	30	502
AY	SKD	—	—	—	—	—	295

Parts made in the plant and with the local ancillary industry: welded assemblies, electric installations, leaf springs, head lights and locks.

4. ZDRUŽENO PREDUZEĆE FAP-FAMOS, BEOGRAD

Number of employees	8,615
Area of building	124,000
Capital expenditure	...
National holding	100
Total present production capacity	
Trucks	3,000
Buses	1,000

	1960	*1961*	*1962*	*1963*	*1964*	*1965*	*1966*	*1967*	*1968*
Trucks	1,010	1,539	1,663	1,866	2,082	1,361	2,467	2,044	2,719
Buses	440	461	455	834	1,151	644	1,295	754	973

The rate of pre-assembly is 40 per cent.
Parts made within the plant: engines, chassis, rear and front axle units, cabs, cases and wheels.

5. TOVARNA AVTOMOBILOV IN MOTORJEV (TAM), MARIBOR

Number of employees	5,479
Area of building	102,000
Capital expenditure	...
National holding	100
Total present production capacity	
Trucks	6,500

	1960	1961	1962	1963	1964	1965	1966	1967	1968
Truck-Pi	971	225	—	—	—	—	—	—	—
Bus PB	149	20	—	—	—	—	—	—	—
TAM 4500	1,440	2,243	2,272	2,448	2,381	2,381	545	—	—
A 3000	203	213	297	323	284	286	241	168	132
A 3500	11	90	34	63	116	204	308	378	516
TAM 2000	3	48	410	674	772	861	655	938	1,271
TAM 5500	—	—	—	—	6	1	26	102	243
TAM 5000	—	—	—	—	—	128	2,306	3,066	3,290
TAM 6500	—	—	—	—	69	82	4	112	61

The rate of pre-assembly is 50 per cent.
Parts made within the plant: complete engine, complete gear-box, differential assembly, front suspension, steering, cab and other parts.

E. *Ancillary industries*

Part or component	*Manufacturer*
Car engines	Dvadeset Prvi Maj Rakovica Belgrade
Aluminium pistons for auto and diesel engines, piston rings, cylinders, car universal joints, steel and iron castings	27 Mart Ind.zona b.b. Novi Sad
Various steering mechanism tie rods	FAD Gornji Milanovac
Equipment	FADIP Bečej
Diesel engine injection pumps and injectors, carburettors, distributors, fuel and water pumps	Industrija Precizne Mehanike V. Ilića 141 Belgrade
Bus bodies	11 Oktomvri ul. 516 br. 10 Skopje
Complete pistons, light alloy castings and forgings	Petar Drapšin Mladenovac
Instruments, equipment, lamps, filters	Poslovno Tehnička Saradnja Čis Kotnikova 6 Ljubljana
Engine and other equipment	21 Oktobar Kragujevac
Dynamos, starters and other electric equipment	Iskra Kranj Linhartova 35 Ljubljana
Electric equipment, instruments, contact breakers, radios and radar to check speed of motor vehicles	Rudi Čajavec Braće Pavlica 25 Banja Luka
Lamps	Saturnus Moste ob železnici 16 Ljubljana
Fuel injection pumps for diesel engines, parts and tools	Rikard Benčić Borisa Kidriča 28 Rijeka
Complete instrument panels, instruments and fuel pumps	Teleoptika Cara Dušana 139 Zemun
Equipment	Tovarna Avtooprene (TAP) Rajšpova ulica Ptuj
Diesel engines and aggregates	Torpedo Rijeka
Forgings of front and rear axles and semi-axles, crank-shafts, connecting rods and other forged parts	Bratstvo Novi Travnik
Wheels and pressings	EMO Celje
Hydraulic, telescopic, and other shock absorbers	Fabrika Amortizera Priština
Leaf springs	Fabrika Vagona Kraljevo
Air, oil and fuel filters and their elements	FRAD Petra Zeca 34 Aleksinac
Trailer and bus bodies	GOŠA Industrijska 1 Smederevska Palanka
Safety glass	Industrija Stakla Prvomajska 10 Pančevo
Batteries	MUNJA Vrbanićeva ul. 50 Zagreb
Seals, gaskets and filters	Tesnilka Medvode
Tires, covers and tubes, tubeless tires and rubber parts	TIGAR 22 divizije br. 10 Pirot
Hand tools, lifting devices and other equipment	ZASTAVA Knić kod Kragujevaca
Forgings, castings, gears, steel, leaf springs	Železarna Ravne Ravne na Koroškem
Spring steels and profiles, steel castings	Železarna Štore Štore pri Celju

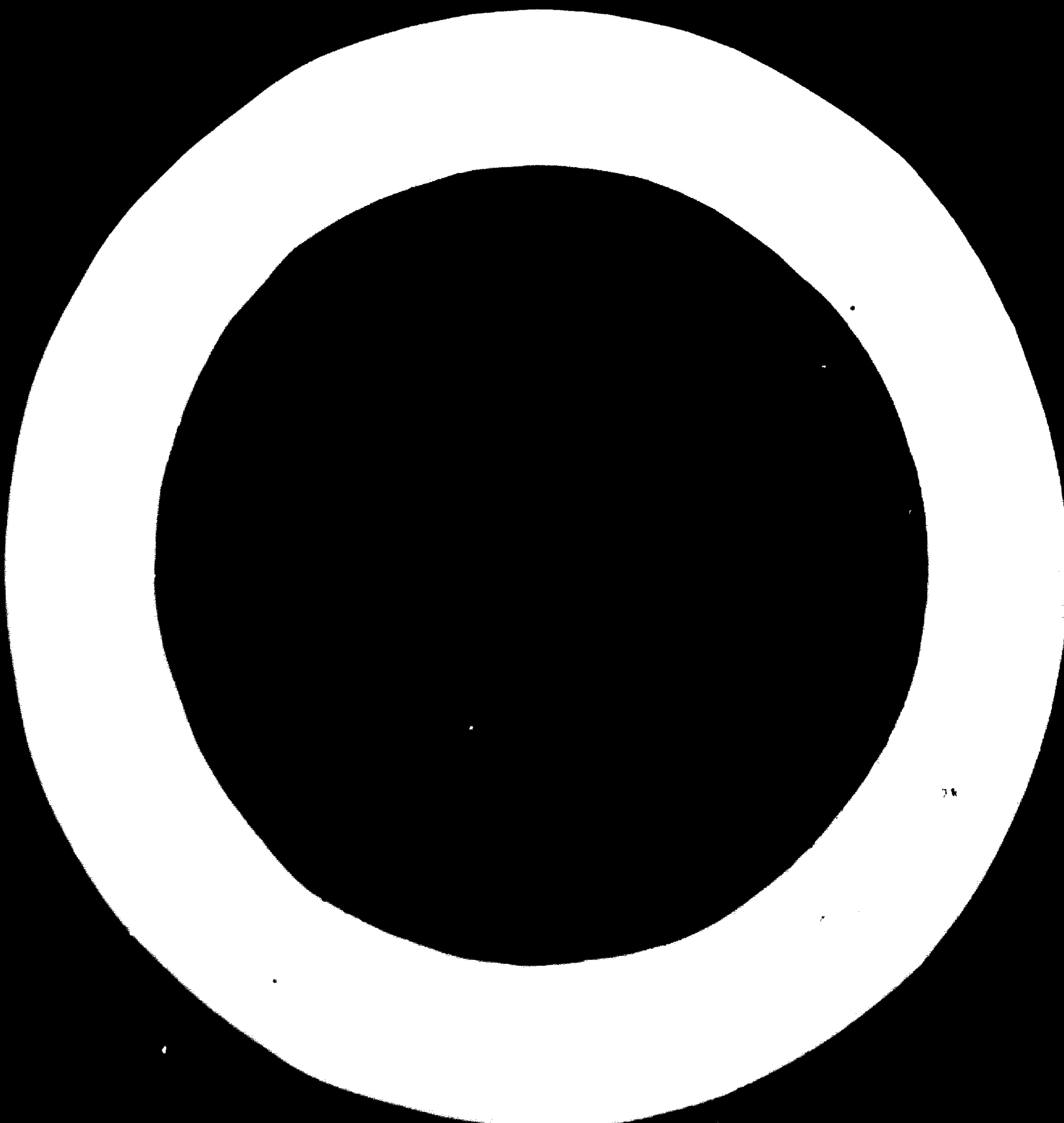
F. *Ex-works and list prices of the five most popular models*

Type and model	*Ex-works price without taxes or delivery costs*		*List price of the delivered vehicle*	
	In local currency (dinars)	*Equivalent in dollars*	*In local currency (dinars)*	*Equivalent in dollars*
Zastava 750	13,400	1,072	15,691	1,255
Zastava 1300	22,950	1,836	26,852.50	2,148
AMF Tomos	20,383	1,630	24,663	1,973
FAP 13 B, 8 t	97,000	7,752	102,000	8,160
TAM 5000	—	—	66,800	5,344
Pretis 1200	21,081	1,664	24,950	1,997

G. *General information on the motor-vehicle market*

In Yugoslavia there are 17.65 cars per 1,000 inhabitants. The car density is highest in the Republic of Slovenia (50.63 cars per 1,000 inhabitants) and the least in the Republic of Bosna and Hercegovina (7.40 cars per 1,000 inhabitants).

The recent rate of increase is 29 per cent. Only 8.9 per cent of the cars was in the public sector at the end of 1967; the percentage was 57.2 per cent in 1968. There is a constant increase in the demand for trucks, especially with 3 to 5 tons payload. In order to compete with imports, manufacture of commercial vehicles shows tendencies of a large-scale integration.



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F. *Ex-works and list prices of the five most popular models*

Make and model	*Ex-works prices excluding taxes*		*List price of the delivered vehicle including taxes*	
	In local currency (Singapore dollars)	*Equivalent in dollars*	*In local currency (Singapore dollars)*	*Equivalent in dollars*
Volkswagen 1300	4,423	1,475	6,850	2,280
Ford Cortina deluxe	5,978	1,990	7,875	2,620
Ford Escort deluxe	5,180	1,725	6,825	2,280
Vauxhall Viva	4,882	1,630	7,020	2,340
Mercedes 200	9,770	3,255	13,800	4,600

G. *General information on the motor-vehicle market*

The annual demand is about 10,000 units—8,000 cars and 2,000 commercial vehicles. The annual rate of increase is about 10 per cent.

Prior to 1966 almost 70 per cent of the vehicles were imported CBU, duty-free and without restrictions. There was however a registration tax of 15 to 25 per cent on the c.i.f. value of the unit depending on the country of origin of the vehicles.

The local assembly programmes were completed by 1968; then a duty of 30 per cent of the open market value was levied on CBU vehicles in addition to higher registration taxes.

IMPORT AND ASSEMBLY OF MOTOR VEHICLES IN SPAIN

A. *Imports*

	1960 (estimate)	*1961 (estimate)*	*1962*	*1963*	*1964*	*1965*	*1966*	*1967*	*1968*
Cars	5,000	8,000	12,208	10,974	13,074	13,282	14,776	14,182	14,000
Buses	230	250	287	288	188	183	212	213	200
Trucks	3,200	3,200	3,223	2,896	3,150	4,251	5,274	6,231	6,500

B. *Estimate of motor vehicles in Spain, 31 December 1968*

Passenger cars	
Small cars	1,098,969
Medium-size cars	549,446
Large cars	33,237
Buses	
Minibuses[a]	—
Small buses	11,276
Large buses	16,690
Trucks	
Pick-up trucks	289,561
Light trucks	186,657
Heavy trucks	132,852
Tractors	
Light tractors	205,000
Heavy tractors	—
Trailers[b]	
Light trailers	11,112
Heavy trailers	3,563

[a] Cars with up to nine seats are considered to be passenger vehicles under Spanish legislation.

[b] Excluding agricultural trailers.

C. *Local assembly of vehicles*

	1960	*1961*	*1962*	*1963*	*1964*	*1965*	*1966*	*1967*	*1968*
Cars	39,483	50,019	63,409	75,414	112,452	144,585	248,450	274,392	310,530
Buses	769	1,150	1,691	2,135	2,410	2,580	3,060	2,915	2,810
Trucks	14,300	28,287	38,970	47,220	60,306	79,990	88,668	86,370	77,062
Trailers[a]	500	712	935	681	623	827	1,120	1,018	1,100

[a] Excluding agricultural trailers.

D. *Assembly plants*[4]

1. Aeronautica Industrial S.A. (AISA)

Number of employees	200
Area of building	40,000
Capital expenditure	3.6
National holding	100
Present total production capacity	
Commercial vehicles	6,500

	1961	*1962*	*1963*	*1964*	*1965*	*1966*	*1967*	*1968*
Avia	402	885	1,387	2,210	3,210	4,066	4,089	4,283

Seven different models are manufactured. Pre-assembly system: domestic manufacture with practically 100 per cent integration (only about 2 per cent CKD).

Parts and assemblies made within the plant: all basic units except the engine and auxiliary equipment such as electrical fittings, wheels, brakes etc.

2. Automóviles de Turismo Hispano-Inglesa S.A. (AUTHISA)

Number of employees	927
Area of building	55,000
Capital expenditure	12.1
National holding	100
Present total production capacity	
Passenger vehicles	43,000

	1966	*1967*	*1968*
Morris and MG	27	14,607	19,483

Six different models are manufactured. Pre-assembly system: domestic manufacture with practically 100 per cent integration (only about 12 per cent CKD).

Parts and assemblies made within the plant: all basic units (engine, gear-box, axles, body etc.) except auxiliary equipment such as electrical fittings, wheels, brakes etc.

[4] In the description of the assembly plants, the number of employees includes the production workers and other staff; the building area is in m^2; the capital expenditure of the assembly plant is in millions of dollars; the national holding is a percentage of the capital stock; the total present production capacity is in units/year.

3. Barreiros Diesel S.A.

Number of employees	8,844
Area of building	357,591
Capital expenditure	85.7
National holding	23
Present total production capacity	
Passenger vehicles (in two shifts)	65,000
Commercial vehicles[a]	9,200

	1960	*1961*	*1962*	*1963*	*1964*	*1965*	*1966*	*1967*	*1968*
Barreiros cars	—	—	—	—	—	—	48,758	27,528	30,284
Barreiros commercial vehicles	1,120	2,846	4,496	4,907	6,482	10,210	10,991	10,228	7,407

[a] Agricultural tractors are also manufactured at an annual output of 6,600 units.

Some 32 different models are manufactured. Pre-assembly system: domestic manufacture with practically 100 per cent integration (approximately 12 per cent CKD).

Parts and assemblies made within the plant: all basic units (engines, gear-box, axles, steering, body etc.) except auxiliary equipment such as electrical fittings wheels, brakes etc.

4. Citroën Hispania S.A.

Number of employees	3,350
Area of building	118,600
Capital expenditure	26.8
National holding	55
Present total production capacity	
Cars and commercial vehicles (in two shifts)	60,000

	1960	*1961*	*1962*	*1963*	*1964*	*1965*	*1966*	*1967*	*1968*
Cars	15	1,385	3,684	4,190	8,021	17,514	23,768	15,325	23,[illegible]
Commercial vehicles	3,448	4,900	8,486	15,237	17,928	22,209	19,244	21,414	16,279

Seven different models are manufactured. Pre-assembly system: domestic manufacture with practically 100 per cent integration (only about 2 per cent CKD).

Parts and assemblies made within the plant: all basic units (engine, axles, body, suspension) except the gear-box and auxiliary equipment such as electrical fittings, wheels, brakes etc.

5. Empresa Nacional de Autocamiones S.A. (ENASA)

Number of employees	9,020
Area of building	192,900
Capital expenditure	71.4
National holding	74.86
Present total production capacity	
Pegaso	12,000

	1960	*1961*	*1962*	*1963*	*1964*	*1965*	*1966*	*1967*	*1968*
Pegaso	2,156	3,572	5,802	5,703	5,610	7,286	10,260	9,687	9,459

About 50 different models are manufactured. Pre-assembly system: domestic manufacture with practically 100 per cent integration.
Parts and assemblies made within the plant: all basic units (engine, gear-box, axles, differentials, injection system etc.) except auxiliary equipment such as electrical fittings, wheels, brakes etc.
It also has smelting facilities with the capacity of smelting all the castable parts used in its manufactures and to supply these parts to other automotive factories.

6. Empresa Nacional de Motores de Aviación S.A. (ENMASA)

Number of employees	2,000
Area of building	37,167
Capital expenditure	3.4
National holding	68.1
Present total production capacity	
Commercial vehicles	4,800

	1963	*1964*	*1965*	*1966*	*1967*	*1968*
Mercedes	404	1,096	1,449	2,053	1,661	1,411

Pre-assembly system: domestic manufacture with greater than 90 per cent integration. The remaining 10 per cent includes some mechanical and body parts in CKD assembly.
Parts and assemblies made within the plant: all basic units (engine, gear-box, axles etc.) except auxiliary equipment such as electrical fittings, wheels, brakes etc.

7. Fabricación de Automóviles Diesel S.A. (FADISA)

Number of employees	322
Area of building	24,000
Capital expenditure	2.1
National holding	100
Present total production capacity	
Commercial vehicles	3,800

	1960	*1961*	*1962*	*1963*	*1964*	*1965*	*1966*	*1967*	*1968*
Fadisa	668	548	879	1,996	1,960	1,040	1,224	1,141	3,224

Six different models are manufactured. Pre-assembly system: domestic manufacture with practically 100 per cent integration (approximately 5 per cent CKD).
Parts and assemblies made within the plant: all basic equipment (engine, axles, miscellaneous parts etc.) except auxiliary equipment such as electrical fittings, wheels, brakes etc.

8. FABRICACIÓN DE AUTOMÓVILES RENAULT DE ESPAÑA S.A. (FASA-RENAULT)

Number of employees	5,230
Area of building	81,300
Capital expenditure	43
National holding	50
Present total production capacity	
Cars and commercial vehicles	80,000

	1960	1961	1962	1963	1964	1965	1966	1967	1968
Cars	8,407	14,978	22,083	25,690	29,945	39,169	52,672	58,604	58,964
Commercial vehicles	—	—	—	56	3,122	8,232	12,090	13,735	11,887

Seven different models are manufactured. Pre-assembly system: domestic manufacture with approximately 92 per cent integration and the remaining 8 per cent includes a few mechanical and body parts in CKD assembly.

Parts and assemblies made within the plant: all the basic units (engine, gear-box, axles, body components etc.) except auxiliary equipment such as electrical fittings, wheels, brakes etc.

9. INDUSTRIAS DEL MOTOR S.A. (IMOSA)

Number of employees	1,956
Area of building	78,000
Capital expenditure	16.4
National holding	50
Present total production capacity	
Commercial vehicles	12,000

	1960	1961	1962	1963	1964	1965	1966	1967	1968
DKW	3,726	5,807	5,170	4,878	9,866	10,418	11,719	9,497	8,008

Ten different models are manufactured. Pre-assembly system: domestic manufacture with practically 100 per cent integration.

Parts and assemblies made within the plant: all the basic units (axles, body, miscellaneous parts etc.) except engine, gear-box and auxiliary equipment such as electrical fittings, wheels, brakes etc.

10. METALÚRGICA DE SANTA ANA S.A. (MSA)

Number of employees	3,000
Area of building	62,500
Capital expenditure	15
National holding	75
Present total production capacity	
Land Rovers (in two shifts)	8,000

	1960	1961	1962	1963	1964	1965	1966	1967	1968
Land Rovers	2,056	2,050	3,071	3,000	3,590	4,139	4,683	5,120	5,720

Nine different models are manufactured. Pre-assembly system: domestic manufacture with practically 100 per cent integration (approximately 4 per cent CKD).

Parts and assemblies made within the plant: all the basic units (engine, gear-box, axles etc.) except auxiliary equipment such as electrical fittings, wheels, brakes etc.

11. MOTOR IBÉRICA S.A.

Number of employees	1,677
Area of building	52,000
Capital expenditure	9.5
National holding	67.8
Present total production capacity	
Commercial vehicles[a]	12,000

	1960	1961	1962	1963	1964	1965	1966	1967	1968
EBRO commercial vehicles	776	3,742	5,283	5,483	4,409	6,834	5,726	4,880	5,339

[a] There is also a production capacity of 9,000 agricultural tractors.

Some 24 different models are manufactured. Pre-assembly system: domestic manufacture with practically 100 per cent integration (approximately 2 per cent CKD).

Parts and assemblies made within the plant: all the basic units (engine, gear-box, axles, body etc.) except auxiliary equipment such as electrical fittings, wheels, brakes etc.

12. SOCIEDAD ANÓNIMA VEHÍCULOS AUTOMÓVILES (SAVA)

Number of employees	1,285
Area of building	60,000
Capital expenditure	8.2
National holding	88.66
Present total production capacity	
Commercial vehicles[a]	8,000
Engines	3,000

	1960	1961	1962	1963	1964	1965	1966	1967	1968
SAVA	598	2,067	2,445	2,802	3,395	4,037	6,097	4,116	3,529

[a] There is also a production capacity of 10,000 agricultural tractors.

Fifteen different models are manufactured. Pre-assembly system: domestic manufacture with practically 100 per cent integration.

Parts and assemblies made within the plant: all the basic units (engine, axles, miscellaneous parts etc.) except gear-box and auxiliary equipment such as electrical fittings, wheels, brakes etc.

13. SOCIEDAD ESPAÑOLA DE VEHÍCULOS DE TURISMO S.A. (SEAT)

Number of employees	17,178
Area of building	392,200
Capital expenditure	159
National holding	64
Present total production capacity	
Cars and commercial vehicles	310,000

	1960	1961	1962	1963	1964	1965	1966	1967	1968
Cars	30,944	33,625	36,759	43,843	72,779	87,691	122,801	158,295	177,854
Commercial vehicles	172	2,613	3,026	1,999	1,510	1,554	1,480	2,364	2,128

Sixteen different models are manufactured. Pre-assembly system: domestic manufacture with practically 100 per cent integration (approximately 3 per cent CKD).

Parts and assemblies made within the plant: all the basic units (engine, gear-box, axles, steering assembly, body etc.) except auxiliary equipment such as electrical fittings, wheels, brakes etc.

14. VEHÍCULOS INDUSTRIALES Y AGRÍCOLAS S.A. (VIASA)

Number of employees	172
Area of building	60,000
Capital expenditure	2.2
National holding	100
Present total production capacity	
Commercial vehicles	6,000

	1960	1961	1962	1963	1964	1965	1966	1967	1968
Jeeps	308	418	341	325	582	560	900	903	1,032

Six different models are manufactured. Pre-assembly system: domestic manufacture with practically 100 per cent integration, except one special model in which about 6 per cent of the assembly is CKD assembly.

Parts and assemblies within the plant: all the basic units (engine, axles etc.) except gear-box and auxiliary equipment such as electrical fittings, wheels, brakes etc.

E. *Ancillary industries*

The ancillary industries can be classified in the following three groups:

- Industries producing equipment and components for the first stage of assembly;
- Industries producing accessories and spare parts;
- Industries producing special tools, equipment and appliances for maintenance and repair.

The order of the groups indicates to some extent the degree of development of the industries; the first group reflects the demand for new vehicles, and the other two groups are dependent on the resulting increase in repair and maintenance.

The entire sector includes about 450 companies. However, a group of 230 associated companies sell 50 per cent of the vehicles and are responsible for 80 per cent of the total demand for preliminary assembly, spare parts, and maintenance and repair equipment.

These associated companies began production at different times; 24 per cent were established before 1940, 64 per cent between 1940 and 1963 and 12 per cent after 1963. Their productive labour force of 60,000 is 1.5 per cent of the total industrial manpower; 80 per cent of the workers are less than 40 years old. The plants are in the industrial areas of Barcelona, Madrid, Vizcaya, Guipuzcoa, Zaragoza and Pamplona. Elsewhere there are a few companies, even some of importance, but they do not constitute an industrial nucleus.

At ex-works prices, the output of the associated factories is worth 32 billion pesetas ($457 million). About 75 per cent of the companies are regular suppliers to plants manufacturing vehicles and about 41 per cent manufacture under foreign licenses.

Import of 30 per cent of the raw materials is necessary; 60 per cent of the companies import products or use imports. The percentage of integration in line with the Government's policy varies from 80 to 96 per cent with a tendency towards the higher percentage.

Exports have been limited, although they have increased considerably during 1968 in an effort to supplement the limited domestic market with foreign markets. There are some exports from 51 per cent of the associated companies. These exports will increase because the production was estimated at only 70 per cent of full capacity. Imports exceeded exports by 5 billion pesetas ($71.3 million) in 1968.

Local manufacture of the following components supplies 90 per cent of the automotive industry:

Batteries	FEMSA and S.E. del Acumulador
Sparking plugs	Firestone Hispania, S.A., and Robert Bosch Española
Electrical equipment	FEMSA
Radiators	FRAPE and Radiadores Puma-Chausson, S.A.
Driving chains	JORESA and Cadenas Iris
Tires	Michelin, Pirelli, Firestone Hispania and Neumáticos General

Bearings	DESLITE and Cojinetes de Fricción
Clutches	Fraymon, S.A.E.
Brakes	BENDIBERICA
Steering wheels	IMENESA
Power plants	FISA and TARABUSI

Too many companies manufacture electrical and injection equipment, filters, carburettors, shock absorbers, suspension springs and seats; the supply exceeds the demand.

The manufacture of tools, equipment and appliances for maintenance and repair is still at an early stage of development. The expansion of these activities depends on the rate of increase of car owners. In one particular group of these companies the sales per worker are around 700,000 to 800,000 pesetas ($10,000 to $11,400); in another smaller group a similar rate of sales dropped to such an extent the production must be changed or else ceased.

However, the situation may be improved by associations, increased technical competence, better marketing methods, the diversification of risks (with production going partly to other sectors and the direct marketing of spare parts) and, finally, exports.

F. *Ex-works and list prices of the five most popular models*

Make and model	*Ex-works prices excluding taxes and delivery charges*		*List price of the delivered vehicle*	
	Local currency (pesetas)	*Equivalent in dollars*	*Local currency (pesetas)*	*Equivalent in dollars*
SEAT 600 D	63,000	900	76,790	1,097
Simca 1000	95,000	1,357.1	121,235	1,731.9
Renault R-8	102,900	1,470	130,905	1,870
Citroën Berlina Azl	68,950	985	84,630	1,209
SEAT 1500	136,000	1,943	169,660	2,423.7

G. *General information on the motor-vehicle market*

The Spanish market for motor vehicles has expanded rapidly since the initiation of the stabilization process in 1958. In that year, the motor-vehicle industry began a period of accelerated development culminating in 1966 when the highest levels of production were reached (except for passenger cars). As the production increased, prices could be reduced and made more competitive, thus facilitating sales.

In 1966 and 1967, the market slackened as a result of an economic crisis, which came to a head in November 1967 with the devaluation of the currency. This crisis affected all Spanish industry. Since that date, there has been a new period of stabilization in the vehicle market. The market for cars and trucks has entered a new phase of expansion; increased production and sales are predicted.

There is a tendency to use heavy commercial vehicles owing to the increase (from 10 to 13 tons) in the maximum axle capacity. The very popular Seat 600 and other utility models continue to dominate the market, although there has also been an increased demand for cars of larger cylinder capacity.

A number of Spanish firms—Pegaso, Barreiros and Santana—export a considerable number of commercial vehicles to several countries. The design of a wholly Spanish car is presently being studied.

Import and assembly of motor vehicles in Turkey

A. *Imports*

	1960	*1961*	*1962*	*1963*	*1964*	*1965*	*1966*	*1967*	*1968*
Cars	2,172[a]	411	221	1,344	3,040	574	1,406	1,822	5,980
	—	—	—	—	—	13,000[b]	15,000	21,050	14,600
Buses	524	1,210	1,099	747	326	616	338	47	89
Trucks	11,417	8,876	13,463	10,119	4,465	2,214	2,030	1,065	191

[a] State Institute of Statistics.

[b] Data calculated from the General Directory of Security records taking into consideration replacements for scrapped cars.