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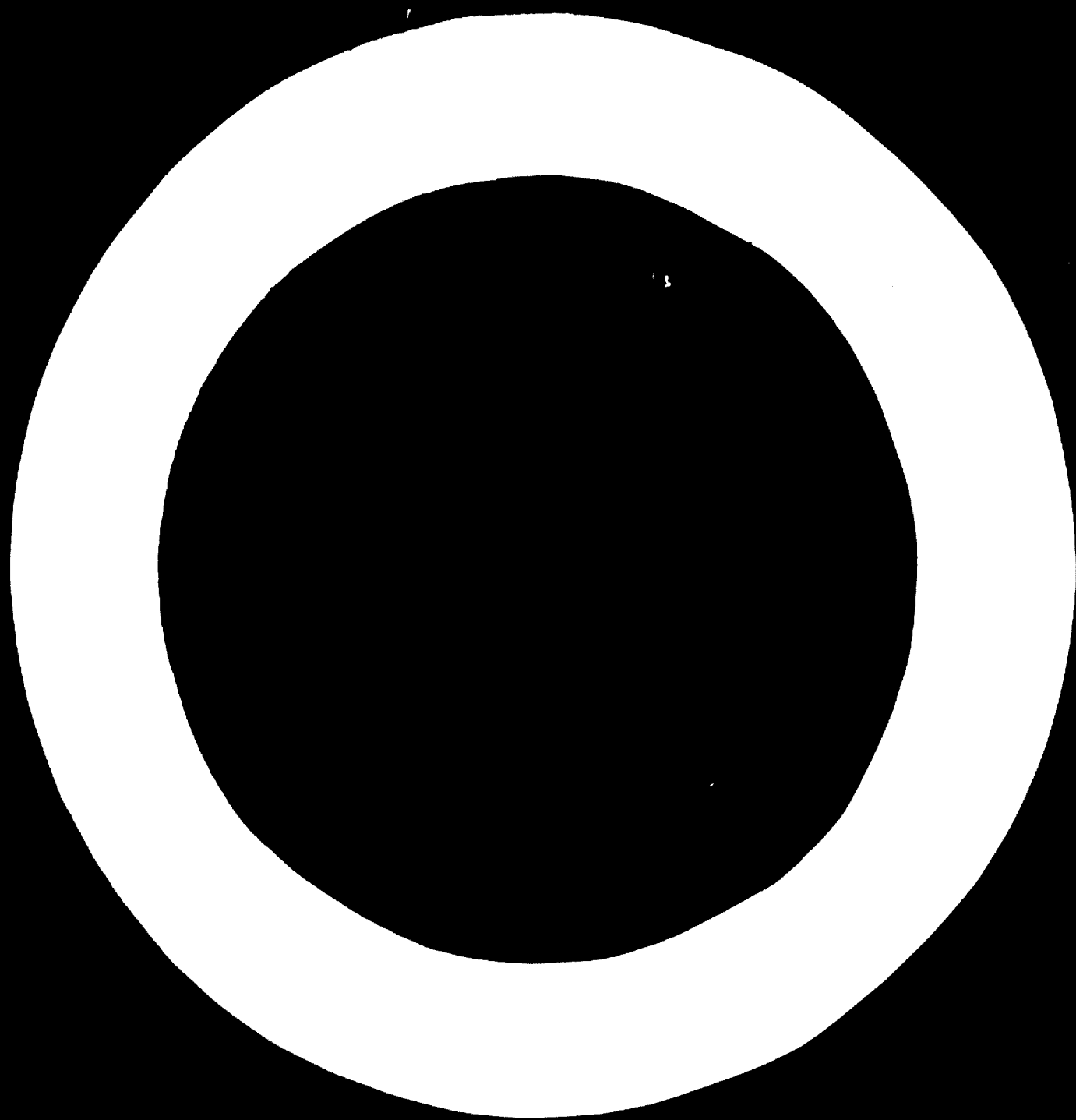
The Seminar on the Establishment and Development
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AUTOMOBILE DEMAND IN DEVELOPING COUNTRIES^{1/}

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AUTOMOBILE DEMAND IN DEVELOPING COUNTRIES

October 31, 1968

This note reviews problems in projecting demand for automobiles in developed countries and gives examples of approaches to demand projection in some developing countries. It then proposes a new method of calculating demand in developing countries based on a growth and saturation model of the car market, and discusses how it could be used to formulate policy with respect to automobile manufacture.

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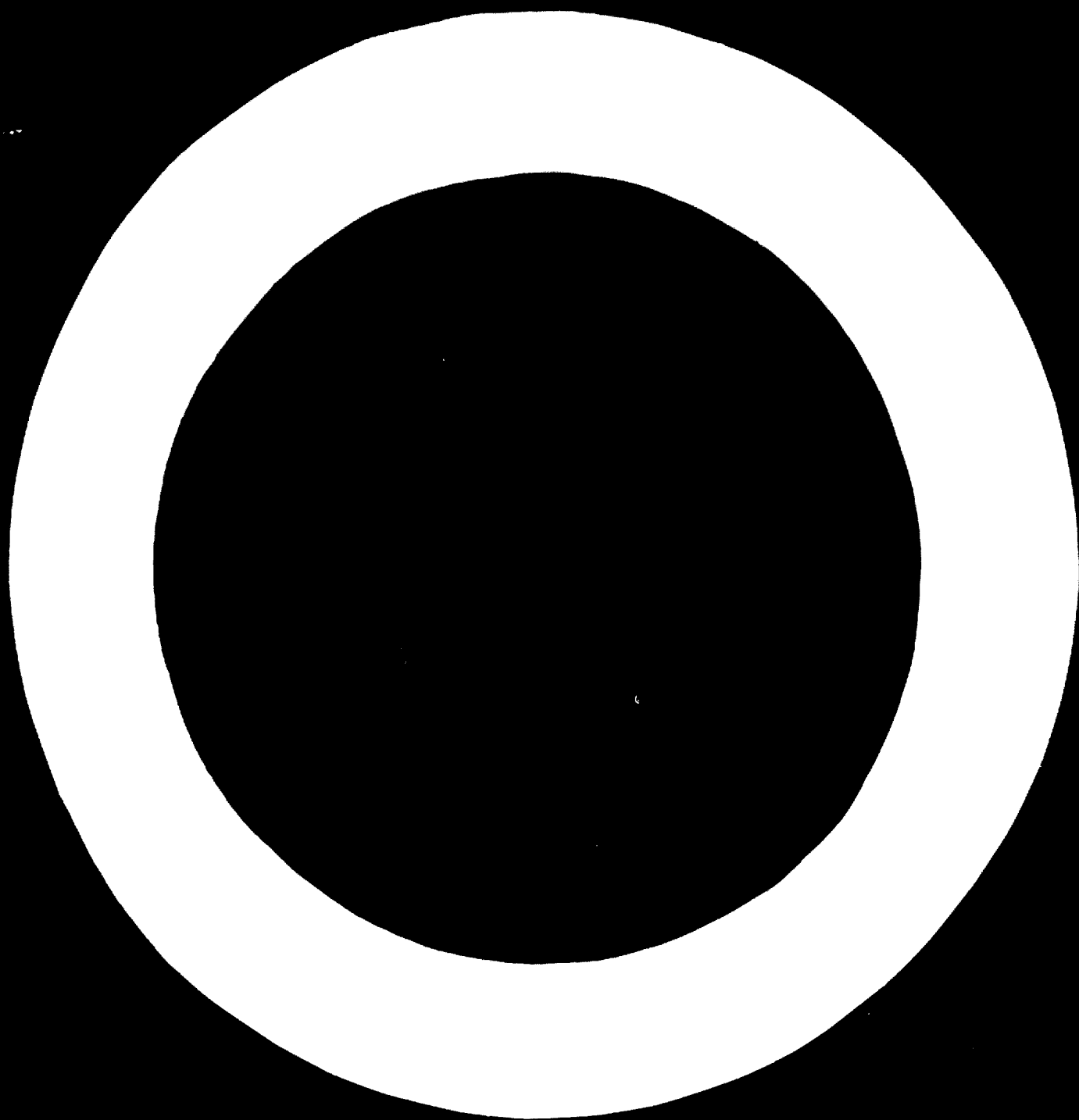
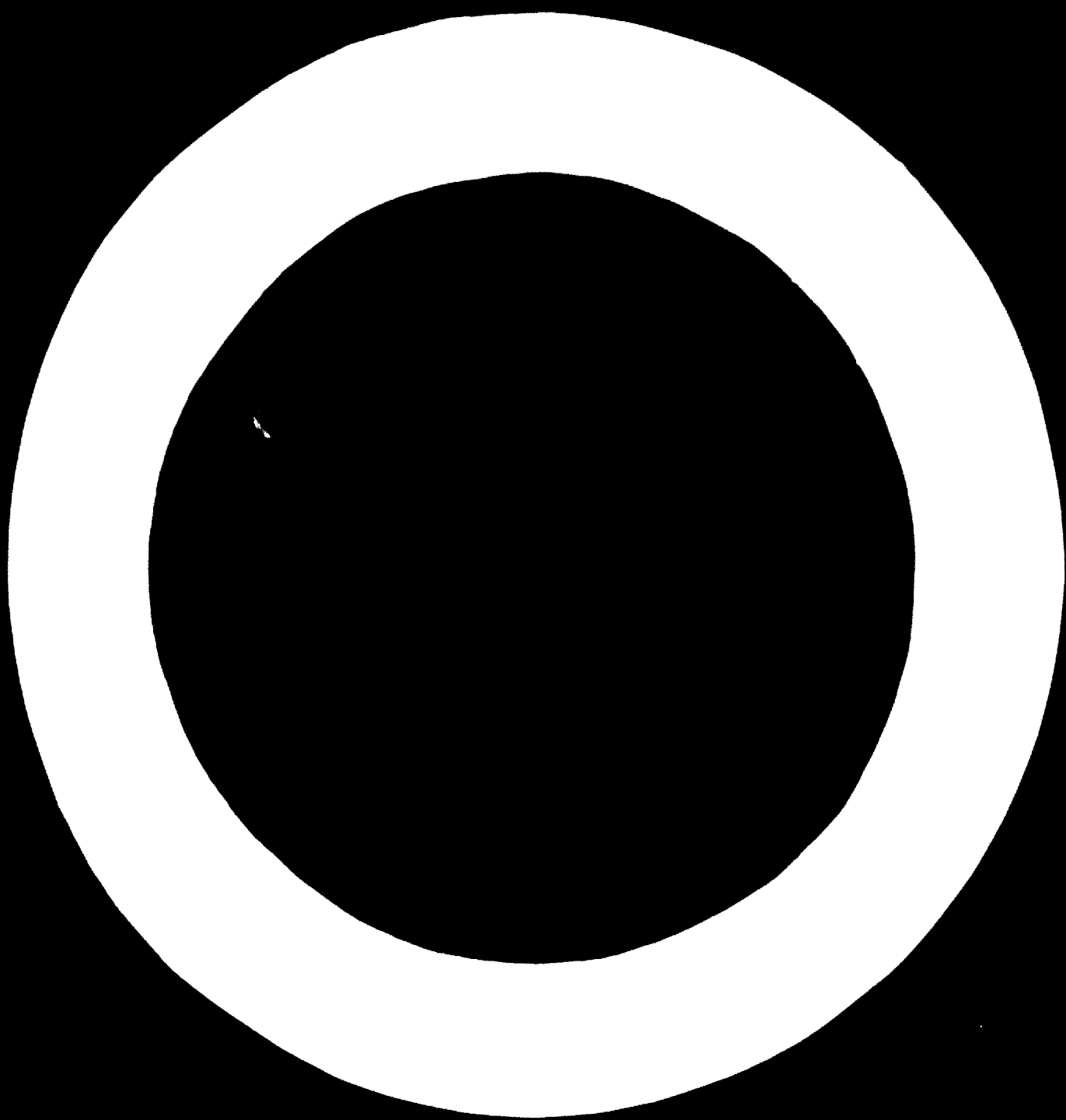


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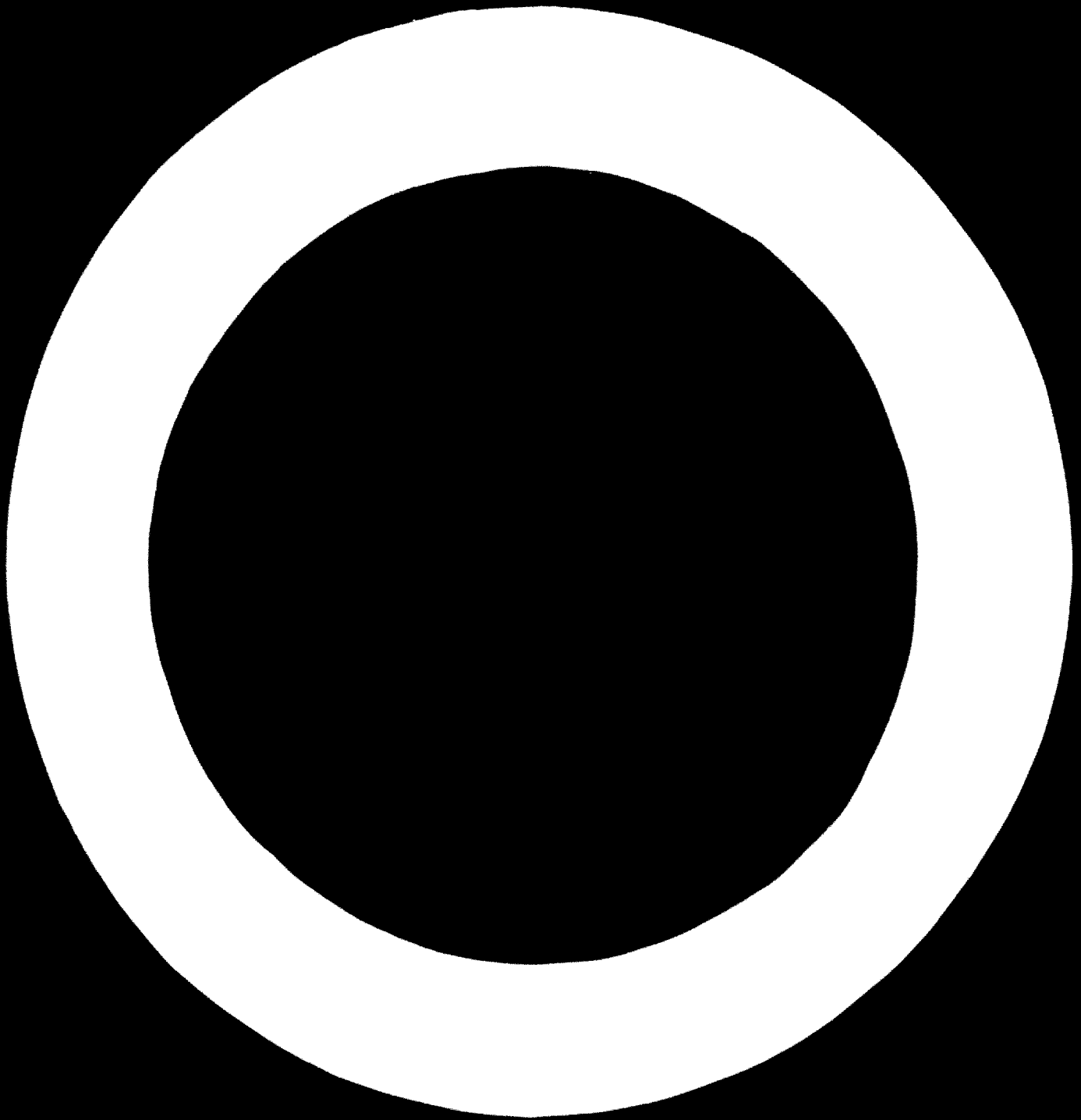
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PROJECTION OF AUTOMOBILE DEMAND IN DEVELOPING COUNTRIES

I. INTRODUCTION

1. This note was undertaken as a desk study to find a useful approach for projecting automobile demand in developing countries. It surveys the demand for automobiles 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.

2. Although only a small proportion of the population in developing countries owns automobiles, purchases of automobiles are an important component of total consumer spending. Since such purchases have a very high import component, they are usually very much the concern of government policies. Automobile industries in most developing countries are still embryonic, but they are given high priority and tariff and other industrial policies are frequently built around them. A knowledge of trends in automobile ownership is also necessary for planning the supply of joint consumption goods such as gasoline, for road use projections, and for other aspects of regional and urban planning.

3. Forecasting the demand for automobiles is important to the formulation of consumption, production and other policies in developing countries, but the methods used for such forecasting in developed countries are inappropriate. A new approach, suitable to the nature of demand for automobiles in developing countries, is suggested by this note.

4. The demand for automobiles in highly developed countries such as the United States is primarily a demand for replacing existing cars. There

is some new demand for second and third cars, and a growth in total demand with population growth, but most families own automobiles, and the principal demand is for replacements. In forecasting demand the existing stock of automobiles therefore becomes as important as income and price factors.

5. 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 symbol of development as well as a means of getting to places, non-economic as well as economic factors are important in automobile purchases. The high import component of automobiles invites constraints on their availability; it cannot be assumed, as in developed countries, that an ample supply will in the long run meet demand. The introduction of domestic motor car manufacturing to meet supply, however, usually raises car prices. Supply is therefore a distinct factor in determining purchases in developing countries.

6. Non-economic as well as economic, and supply as well as demand factors can be taken into account by focusing attention on the year-by-year expansion of the automobile market, and the rate at which it becomes saturated at successive levels of growth. The annual demand by new owners can then be derived, and together with replacement estimates can form the basis for annual total demand estimates. This method also throws light on automobile manufacture feasibility in a country, on the effects of tariff and other tax policies and on other aspects of the demand for automobiles. It requires a new emphasis in motor car statistics collection.

7. In developing countries as well as developed, random influences disrupt the trends. Because of the importance of automobiles in consumption and production, many of the breaks in trends are caused by government policies,

and it is particularly important that policy makers understand the trends they wish to disrupt, and the effects that their disruptions will have.

II. AUTOMOBILE DEMAND: A GENERAL VIEW

8. 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 body of conventional economic theory. The data required for forecasts is therefore complex, but the techniques themselves are mathematically simple.

A. Demand

9. Conventionally consumption demand is a function of income and prices, and it is usually divided into a normal part spent on 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 is postponable, it is heavily influenced by business fluctuations and these are a very important influence on automobile purchases.

10. While in pure theory demand is generally regarded as depending on price alone or on price and national income, in practical life other economic and non-economic factors intrude and may be as important as, or even more important than price and income. The prestige of owning an automobile is one such factor.

Demand for Transportation and Car Ownership

11. The demand for new passenger cars is distinct from the demand for an individual's transport service and from his demand for car usage. The transportation demand can usually be satisfied by running an old car for

another year, while the demand for car usage can be satisfied by purchasing a used car. The following factors are therefore important in car purchases:

(a) The purchasers of a car above all want to possess a car or to change an existing one for a new one. There are probably some differences in the manner in which these two groups of consumers behave. While the former group predominates in developing countries, the latter is the most important in developed ones. For both groups, however, the individual behavior in car purchases belongs to behavioral groups for which "possession" is one of the explanatory variables.

(b) In developed countries where use 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 existing stock. In developing countries where the existing stock of automobiles is low the influence of income changes is likely to be more important.

(c) A car's service yield can be measured by the price consumers are paying for the use of their cars for a year, that is, by the amount by which their cars depreciate plus the interest foregone by holding capital in the form of cars.

(i) The rate of depreciation is the result of a number of factors, among which the elasticity of the supply of new cars is the most important. In periods of supply limitation,

depreciation falls, and can even become negative. In Britain, prices of 18 month old cars between 1940 and 1952 were higher than the prices of new cars.^{1/} In the United States annual depreciation of cars was about 9 per cent in 1945; it is about 25 per cent currently. Low depreciation is typical in developing countries where constraints on supply, due to balance of payments difficulties, are common, but not in developed countries.

(ii) The interest foregone depends largely on money placing 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 way 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

12. All classic demand treatises^{2/} postulate that income elasticity of market demand for given goods equals a weighted average of demand elasticity in different social groups: a change in groups thus leads to changes in weights and changes 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 automobile demand studies in developed countries.

^{1/} See C.S.J. O'Herlihy "Demand for Cars in Great Britain" in Journal of the Royal Statistical Society, Series C, Vol. XIV, 2-3, p. 167, London 1965.

^{2/} H. Wold, Demand Analysis, J. Wiley, New York 1952, p. 119, equation 8.

In any case it is not a concept which would appear to be of very great use in automobile studies in developing countries, where the automobile purchasing groups are initially usually rather homogenous.

13. L.D. Taylor has calculated that habit-linked expenditures represent 40 per cent of consumption expenditures in Sweden,^{1/} and H.S. Houthaker put the level at 60 per cent for the United States.^{2/} 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 difficult, as empirical studies show.^{3/} The difference between income elasticity for food and car purchases is particularly large. In developed countries the former is much below the latter. France, where the income elasticity for food was 0.3 and for car purchases 1.47 in 1966, is probably typical. It is relevant, then, in developed countries, that the income elasticity of a commodity is an increasing function of its price relative to other commodities.^{4/}

14. However the concept has little application in developing countries. First, the average elasticity for food is still very high in developing

^{1/} L.D. Taylor "Personal Consumption Expenditure in Sweden 1931-1958" presented to the meeting of the Econometric Society in Zurich in 1964.

^{2/} H.S. Houthakker and L.D. Taylor, Consumer Demand in the United States 1929-1970, Harvard University Press, 1966.

^{3/} H.S. Houthakker and L.D. Taylor "Formation d'Habitude, et Ajustement de Stock dans L'analyse de la Demande", Economie Appliquée, Vol. XIX, No. 2, page 227, Paris 1967.

^{4/} H.S. Houthakker "An International Comparison of Household Expenditure Patterns, Commemorating the Centenary of Engel's Law", Econometrica, Vol. 24, No. 4, October 1957, p. 542.

countries. Brazil with .795, Ghana .840 and India with .837 are typical. Second, the notion that 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 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 for automobiles, but such considerations may well be swamped by the symbolic value of cars in a developing society.

B. Income

15. Personal income is the major variable in aggregate demand function studies. The United States' and other developed countries' national accounts include the following classifications of personal income:

Y_1 - disposable income

Y_2 - net disposable income (Y_1 minus depreciation and subsidies)

Y_3 - disposable income minus investment financing from private proprietors' income (business, professional, farm)

Y_4 - disposable income minus investment financing by private proprietors minus self-consumption

Some very incomplete adjustments have shown that the last of these (Y_4) permits the best fit in automobile purchase forecasting, but this measure cannot always be isolated in developing countries' accounts.

16. Most analyses of income as a factor in demand in developed countries show a predilection for Milton Friedman's "expected" income, defined as a moving average of disposable income, in which current income receives one-third of the total weight and past incomes receive progressively declining

weights. This concept aims to separate out the share of income connected with 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 remainder of 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.

17. Some authors argue that a continuous habit persistence hypothesis is plausible. ^{1/} Others have suggested that habits formed in the period of most recently experienced peak living standards exercise a significant influence on current consumption. ^{2/} Under the latter hypothesis consumers attempt to maintain the past highest standard of living in the face of falling income and are sluggish in adjusting to higher standards of living when income rises above past peak income.

18. However useful such notions may be in predicting the demand for automobiles in developed economies, their analytical value is negligible in developing countries with income per head below \$300 a year.

The Concept of the Threshold

19. Nonetheless, an understanding of the structure of personal incomes is necessary to calculate the threshold income at which purchase of a car is

^{1/} T.M. Brown in "Habit Persistence and Lags in Consumer Behavior", *Econometrica*, Vol. 20, No. 3, July 1952, pp. 355-371, L. Klein in "Empirical Foundations of Keynesian Economics" in K.K. Kurihara, *Post-Keynesian Economics*, New Brunswick Rutgers University Press, 1954, p. 291, and L.R. Klein and A.S. Goldberger in An Econometric Model of the United States 1929-1952, Amsterdam, North Holland Publishing Company, 1955, p. 8.

^{2/} F. Modigliani in "Fluctuation in the Saving-Income Ratio: A Problem in Economic Forecasting" in Studies in Income and Wealth, Vol. II, New York National Bureau of Economic Research Inc. 1949, pp. 371-441, and J.S. Duesenberry in Income, Savings and the Theory of Consumer Behavior, Cambridge, Harvard University Press, 1949.

possible. The income relevant for car purchase is household or unit income rather than per capita income. The level of the threshold depends not only on how much disposable income is spent on essentials, but also on:

- (a) The relative saturation of demand for other durable goods and housing;
- (b) The introduction of new, cheaper, models of automobiles;^{1/}
- (c) Factors such as higher investment in roads, an increase in urbanization, industrialization, the development of tourism, etc.

20. J.S. Cramer's pioneering study 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.^{2/}

21. M.G. Vangrevelinghe showed that in France the median (M) moved from 13,000 francs in 1956 to 8,500 in 1962 (both calculated per annum in 1959 prices) and expects it to decline to about 7,000 francs by 1970. The income of car equipped families is higher than the average family income but the ratio between the two is decreasing.^{3/}

22. The threshold can be moved by installment sales plans. In the United Kingdom the lengthening of the contract repayment period from two

^{1/} An important factor in Italy. See L. Savino "Un Modello per Previsioni di Circolazione Automotociclistica in Italia" in L'industria, Rivista di Economia Politica, No. 4, 1954, p. 546.

^{2/} J.S. Cramer "Private Motoring and the Demand for Petrol" in Journal of the Royal Statistical Society, Series A. Vol. 122, part 3, 1959, p. 334.

^{3/} "Projection de la Demande de Transport en 1970", in Etudes et Conjoncture, No. 6, 1965, p. 19.

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 installment period would increase sales by 38 per cent in the long run. Introduction of installment plans transforms automobile purchases from a one-payment "lumpy" expenditure into a divisible expenditure, and moves the threshold income down.

Relationship Between Age of Car and Family Income

23. 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 age, operating and replacement cost of an existing car, and per capital income. This was demonstrated in 1954 by M.S. Farrell, who found the length of ownership of cars inversely proportional to personal incomes. Families which owned cars a year old had an income of \$7,530 while families which had cars 7 years old had an income of \$2,290. Families without cars had an income of \$1,729^{1/}.

24. The relationship of the age of cars to income is becoming increasingly important in other developed countries as car ownership widens. It has some application to some developing countries like Argentina or Brazil, which already have considerable car ownership, but in most developing countries it is not yet a very important factor in the total car market.

25. In developing countries the absolute value of spending on essentials is usually lower than in developed countries, but the threshold for buying cars may be just as high. Because there is little stock second-hand cars

^{1/} M.J. Farrell, "The Demand for Motor Cars in the United States", Journal of the Royal Statistical Society, Series A, Vol. 117, 1954.

are expensive. If the supply of new cars is constrained they are even more expensive.

26. Social factors may complicate the car ownership pattern, by creating more than one threshold of income. In South Africa, white South Africans replace their cars with new cars after three years on the average, while black Africans, who buy mainly used cars, keep them up to 18 years.^{1/}

Personal Income and Business Income

27. There is a distinction between the acquisition of cars for personal use and business. In developed countries the use of cars for business is a small and declining proportion of total use, and car purchases are accordingly unresponsive to changes in business income. In its long term forecasts for the United Kingdoms 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; an equal increase in personal income would lead to about 1.5 per cent increase 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.

28. In contrast, business use is important in developing countries. Out of 16,280 passenger cars registered in Korea in 1965, about 11 per cent

^{1/} "The Motor Car Millennium", The Economist, February 25, 1967, p. 736.

were used for government purposes, and another 55.5 per cent were explicitly registered as being used for business. This leaves only 33.5 per cent of all cars for personal use including professional uses by doctors, etc. (See Table 1) This car use pattern is fairly typical of 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.

C. Prices

29. For families which already have a car, the relevant elasticity is the change in quantity of new cars bought relative to a change in the price being offered for used cars. In countries where car ownership is high, this elasticity will probably be below unity because a low trade-in price will not deter many car-owners from replacing their car. However, in developing countries where fewer families own cars, a change in used car prices will influence families more strongly, and elasticity will therefore be quite high. On the other hand if the supply of cars is insufficient due to rationing, elasticity may be near zero: ^{1/} no matter how high prices go for used cars, families will not sell because they cannot buy a replacement.

30. A rise or fall in car prices should be compared to price movements of other goods. It has sometimes been suggested that the income elasticity of a commodity is an increasing function of its price relative to other commodities. ^{2/} This seems to be borne out by Italian and Spanish experience.

^{1/} J. Tobin, "A Survey of the Theory of Rationing", Econometrica, 1952, and the same author and M.S. Houthakker, "The Effects of Rationing on Demand Elasticities", Review of Economic Studies, 1951.

^{2/} R. Bandeen, "Automobile Consumption, 1940-1950", Econometrica, Vol. 25, No. 2, April 1957.

Prices are also auto-correlated with 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 cut their replacement purchases by 0.74 per cent. This applies to a much lesser degree to countries with lower car ownership levels where replacement represent only a small fraction of sales (See Italy in Graph 1).

31. Such considerations have little relevance for developing countries. The analysis of marginal price elasticities loses its point when upward or downward changes in customs tariffs tend to alter car prices substantially. There will then probably be no response to a price decrease or increase within an 0-10 per cent range, but beyond this range a violent response may be felt as large groups of customers abruptly enter or leave the market.

32. Since prices are also correlated to a car's durability and operation cost, theoretically at least, an index of durability could be used to convert price into replacement cost. Taken together, durability and operation costs, which measure automobile quality, are probably more important than price alone in car purchases.

33. The durable character of automobiles, and the fact that in the short run consumers have other ways of obtaining their automobile transportation than by buying new cars, explains why the price elasticity for automobiles is not as high as might be expected. Consumers can run their existing cars longer at the cost of somewhat higher repair bills; they can obtain cars from the used car stock of dealers, or they can use public transport instead of buying a new car.

1/ C. Roos and V. Szelisky, The Dynamics of Automobile Demand, General Motors, New York, 1939, p. 52. This calculation, made for pre-war U.S.A., checks with G.C. Chow, who found a price elasticity of -0.7 for the early fifties in the U.S. See his "Statistical Demand Functions for Automobiles and their use for Forecasting" in The Demand for Durable Goods, edited by Arnold Harberger, University of Chicago Press, 1960, p. 119.

D. Stocks, Depreciation & Replacement

34. The simplest regression, which assumes that gross investment is a linear function of income and initial inventory, is also the most satisfactory for countries with a high car saturation. H.S. Houthakker and J. Haldi calculated this regression for four various initial stocks and levels of income in the United States. Although there is some crossing over, the four "Engel curves" for different levels of initial inventory are on the whole clearly separated, gross investment being highest when initial inventory is least. The regression coefficients all have the correct sign and are highly significant.^{1/}

35. 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 17 countries for which data could be obtained (See Graph 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.

36. In the market mechanism, existing stock supplies the trade-in and used car markets. The prices of used cars and trade-in allowances affect an individual family's decision to replace, but they have only a limited effect on the total stock of cars. Only scrappage represents real replacement, and in any year the number of cars scrapped must be subtracted from new registrations to record the increase in stock.

^{1/} "Household Investment in Automobiles: An Intertemporal Cross-section Analysis", Proceedings of the Conference on Consumption and Saving, Vol. I, p. 175, University of Pennsylvania, 1960.

37. Once a certain level of ownership is reached, the growth in the stock of cars becomes more and more dampened through the increasing scrappage of cars, so that the rate of growth of stock shows a tendency to decline. This can be shown by calculating change in the ratio of cars scrapped to newly introduced cars. Graph 2 shows this ratio for four developed countries. In the United States the ratio of cars scrapped to new registrations has risen from 53 per cent in 1955 to about 70 per cent at present.^{1/} Europe lags a long way behind this. Italy, clearly still a thoroughly "immature" car market despite the advances of the last few years, has a very low level of replacement demand, 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 scrappage. Britain was at Italy's level about ten years ago, but in 1965 scrappage was about 42 per cent of new registrations. In Germany the 1965 figure was 35 per cent. In France this ratio is about 31 per cent, and it is expected to reach 53 per cent by 1970.^{2/}

38. The replacement ratio is also dependent on the average life-span of a car which, as the data obtained from the following countries shows, is decreasing:

Life-span of Passenger Cars

<u>Country</u>	<u>Year</u>	<u>Life-span</u>
United States	1954	14 years
	1962-64	10 years
Sweden	1960	11.5 years
Germany	1954-56	13.6 years
	1960	12.7 years
Great Britain	1965	12 years

Source: United States, K. Boulding, "An Application of Production Analysis to the Automobile", *Kyklos*, Vol. 8, No. 2; Sweden, Wallander, "Studien i Bilismens Ekonomi"; Germany, Abstarbe Ordnungen fuer Kraftfahrzeuge, Essen, 1962.

^{1/} The Economist, February 25, 1967, "The Motor Car Millennium".

^{2/} Data of the Institute of Statistics and Economic Studies in Paris.

The falling life-span of passenger cars is largely due to:

- (a) Greater strain in using cars in heavy traffic and more parking difficulties;
- (b) A shorter technological life-span of new models due to built-in obsolescence;
- (c) Increasing obsolescence due to higher living standards.

The last is probably the most important factor in developed countries. In developing countries, bad roads and poor maintenance probably shorten car life fast enough to leave only a small difference in the life-span of cars between developed and developing countries.

E. Forecasting Methods

39. There are three levels of forecasting automobile demand in developed countries: (a) complex projection methods, (b) less-complex projection methods, (c) simple projection methods.

40. Complex projection methods take income distribution into consideration. They involve calculating the threshold of access to motorization, and the number of families receiving an income which exceeds the threshold. This requires income distribution information and analysis. Once this information is obtained the underlying mathematics are simple. (See Annex I)

41. Less complex methods of projecting automobile demand involve estimates derived by least squares regression. It may be argued that since both the retail price of new cars and the number sold are endogenous variables, the estimate by least squares leads to biased results. This is so, but the bias is likely to be negligible in comparison with errors in the data, and the use of an elaborate technique in an attempt to avoid this bias is uneconomical. (See Annex I)

42. Simple methods of projection of the automobile demand can be used after establishing covariance between automobile demand and other leading macro-economic indicators. Such covariance yields different results at different levels of economic development even among developed countries.

43. Graph 3 shows covariance of automobile sales with such basic indicators as the index of industrial production and consumer spending. The curve of automobile demand runs almost exactly parallel to the curves of these indicators. This shows that at certain levels of development, car purchases fluctuate in the same way as other, more aggregated business phenomena. It is interesting to note that car purchases may increase in anticipation of a favorable business climate and decline before a general downswing in business activity.

44. Another simple forecasting method measures changing shares of expenditures on automobiles in relation to increments of income. Table 2 measures this share for different percentages of economic growth in three countries. The results show that this share has a very marked upward tendency, and in some countries a very high share -- more than 10 per cent -- of "marginal automobile consumption rate" is attained in earlier stages of growth relative to other countries.

III. AUTOMOBILE DEMAND IN DEVELOPING COUNTRIES

45. The following problems of automobile demand projection in developing countries have been chosen to illustrate the effects of income structure, stocks, and supply constraints on automobile demand.

A. Structure of Income

46. Brazil is one of the very few countries where the pattern of income distribution has been taken into consideration in projecting automobile demand. The following equation was used to forecast the growth of sales of passenger cars.^{1/}

$$1 + q = \frac{(1 + r)^{\alpha}}{(1 + p)^{\alpha - 1}}$$

where: q - potential rate of growth of the stock of automobiles in the country

r - growth of the GNP in constant prices

p - population growth

α - Pareto's income distribution coefficient, that is, the parameter of the income distribution curve, calculated as elasticity of the number of income-receiving units, persons or families (Y) to the lower income limit (x), i.e.,

$$\frac{d \log Y}{d \log x} = -\alpha$$

47. With gross national product in constant prices growing at 6.1 per cent per annum, population growing at 2.4 per cent per annum, and an income

^{1/} Derived from an equation for q from Análise e Perspectivas da Indústria Automobilística, Confederação Nacional da Indústria, Departamento Econômico. Rio de Janeiro, January 1960:

$$q = \frac{(1 + r)^{\alpha}}{(1 + p)^{\alpha - 1}} - 1$$

distribution coefficient of 1.7,^{1/} the growth of car sales can be calculated as:

$$1 + q = \frac{(1.061)^{1.7}}{(1.024)^{0.7}}$$
$$= 1.087$$

48. To annual sales, calculated from a difference between potential automobile stocks of the preceding and the current year, Brazilian forecasters add a certain number of vehicles necessary to replace the existing stock. It has been estimated that the average life of passenger cars until their retirement is about 20 years. If the structure of car ages were equally distributed, from 1 to 20, annual replacements would have to be equal to 5 per cent of the stock. As there was insufficient information about the life of cars in Brazil, scrappage was estimated directly, and it was put at 2.2 per cent of the automobile stock. Sales were 10.2 per cent. Thus replacement sales amounted to only one-fifth of total sales, the remainder representing purchases by new buyers who crossed the income threshold.

49. Once the scrappage rate is established, average car life and the annual rate of growth of car stocks can be included in one formula, but this exercise is too long and complex for this paper.

50. Argentine data illustrates the influence of income distribution on automobile sales. Data was obtained from an investigation of the distribution of expenditures among urban families according to the size

^{1/} Parameter α has been estimated, for Brazil, from "O Imposto Complementar Sobre a Renda e a Inflação" G. F. Loeb and J. Kingston in Revista Brasileira de Economia, September 1958. The "normal level is generally considered to be 1.5, according to H. T. Davis in The Theory of Econometrics, Bloomington, 1947, p. 2.

of family income. Early in 1963, 454 family units were selected according to standard random sampling techniques from all family units in Argentine cities of over 10,000 and interviewed in detail. Table 2 illustrates the not surprising point that the upper 28 per cent of family income units (those with annual income in early 1963 of over 275,000 pesos or US\$2,000) were responsible for over half of all expenditures in durable goods in 1962. The top 46 per cent of all family units (these with annual incomes above 200,000 pesos or US\$1,500) purchased over three-fifths of all durable goods in 1962.

51. Automobiles account for almost a half of all expenditures on durables by families. Expenditure on cars is even more heavily concentrated than on furs and jewelry: the top quartile of the sample (income over \$2,000) account for almost 90 per cent of all automobile purchases. Including the families in the \$1,500-\$2,000 income bracket adds a mere 4 per cent to this concentration. Purchases of other durable goods such as refrigerators, washing machines and television sets are much less concentrated. For these goods purchases by the upper-income quartile of the sample is one-fourth to one-third of the total.

52. A similar relation was found for developed countries by L. R. Klein with nil or small expenditures at low income levels. Expenditures rose somewhat faster than at a linear rate with increases in income in the low income group, but thereafter the relationship becomes essentially linear.

B. Structure of Automobile Stock

53. Colombian projections of automobile demand are not based upon any mathematical model, but derive from observation of the past.^{1/} In

^{1/} Compilacion de Documentos Sôbre Ensamble de Automotores en Colombia, Banco de la Republica, Departamento de Investigaciones Economicas, Bogotá, 1966.

1950-55 the rate of growth of automobile sales was as high as 22 per cent per annum, but by 1958-62 it had fallen to 8.3 per cent per annum.

54. The elasticity of new car sales to the growth of gross domestic product per capita has fallen from 4.0 for 1950-62 to 2.4 for 1954-62. If the latter elasticity is applied to expected gross domestic product growth of 5.6 per cent per annum and 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 the whole of Latin America was about 1.7 in the late fifties.^{1/}

55. 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 accepts the same 20-year life of a passenger car, it assumes that as much as 5 per cent of the total existing stock is to be replaced annually. This rate of replacement appears to be too high, for it implies that over 40 per cent of new car purchases are to replace scrappage. The proportion was 10 per cent in Italy and 31 per cent in France in 1965. It seems that lack of information about the real composition of the stock of motor cars has led to a considerable error.

56. Graph 4 compares the age structures of stocks of automobiles in Colombia and the United States.^{2/} While the distribution curve for the United States is very regular, rising from 2 per cent of the total for cars manufactured in 1953 to 13 per cent of the total for cars of 1964

^{1/} Oscar Gómez and Jorge Ruiz, La Fabricación de Automotores en Colombia, Bogotá 1958.

^{2/} See also "El Ciclo de las Importaciones y la Política Fiscal en Colombia", by Jonathan Lewin in Revista del Banco de la República, Bogotá, Colombia, June 1967, p. 742.

vintage, for Columbia this curve is very unevenly piked. Car vintages whose share in the total is disproportionately high correspond to years when import restrictions were relaxed and a backlog of accumulated demand for automobiles could become 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 in January-September 1965 to 7,401 in January-September 1966.^{1/}

57. Graph 4 shows that the share of automobiles of 1957, 1958, 1959 and 1960 vintages is only 1 per cent of the total for each of these years. If a simple 20-year longevity for cars were accepted, sales of cars in 1977 and replacements during these four years would be very small. But as almost 20 per cent of all cars (in 1965 the total stock was about 250,000 cars) was of 1961 vintage, in 1981 replacement demand would theoretically jump suddenly up to 50,000 new cars, and then fall again abruptly in the following year. The real saturation will undoubtedly show 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 importance of government policy on car sales, and the need for a somewhat detailed knowledge of the structure of car stocks.

58. Korea also has an uneven age structure of automobile stocks, and Korean forecast methods consider the importance of business purchases of passenger cars. (See Table 3.) Korean forecasters assumed that the growth of business car ownership is not influenced 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

^{1/} Background Materials for 1966 Article XIV Consultations with Columbia, Part II, IMF, March 15, 1967, p. 118.

incomes, but the link between the two is far from clear, and the rate of urbanization and similar factors may be important. The forecast for the growth in automobile purchases was therefore derived from a forecast of passenger transport based on highway improvements and the relation between growth of gross material product and increase in transport flows.^{1/}

59. In Morocco, car ownership has moved from French to Moroccan nationals. Moroccan car statistics give both the ages of automobiles registered and the nationality of owners.

Car Ownership in Morocco

	<u>1957</u>	<u>1961</u>	<u>1962</u>	<u>1963</u>	<u>1964</u>
<u>Percentage of cars less than 10 years old</u>		72.5	67.0	54.5	57.2
<u>Ownership of cars by nationality:</u>					
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
<u>Total French nationals residing in Morocco</u>		450,000			120,000

Source: "Marches Tropicaux et Meditteraneens," February 22, 1966, p.638.

From these figures it seems that the large increase of car owners among Moroccan nationals was carried out at the expense of the age structure of

^{1/} Korea Transportation Survey, Seoul, June 2, 1966, Chapter III, p.25. It is worth mentioning that although the Transportation Mission, which was financed by the IBRD, consisted of more than 10 top experts from four leading European consulting organizations, no rigorous model was used for projecting increase of 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." (Chapter III, p.25)

cars in circulation, and that these cars were acquired from departing French residents.

60. The fact that new additions to the total stock have been relatively small in recent years (5 per cent per annum) supports this view. It seems likely that these additions consisted mostly of replacements of cars by French residents and also by a fraction of Moroccans receiving high incomes. The French population remaining in 1964 on the whole receives higher average incomes than the 1957 French population of Morocco, and this undoubtedly accounts for a rise in ownership among French nationals from one for every seven persons in 1957 to one for every 2.4 persons in 1964. While the richer French nationals are probably replacing cars more rapidly than they did in 1957, for many Moroccans the car they purchase from French nationals may be the only one they ever own, and these cars may not be replaced when they wear out. In any case forecasts for automobile purchases in Morocco must take into consideration the age structure of the automobile stock, and sources of income and future intentions of the French community.

C. Constrained Automobile Supply

61. In developing countries it can not be assumed that the supply of automobiles will meet the demand at market prices. Governments may limit the supply of imported cars to conserve foreign exchange and restrict local production in favor of other goods, introducing various methods of rationing available automobiles to prevent unduly high profits by importers or local manufacturers.

62. Tunisia illustrates this point. Like Morocco, demand for new automobiles was reduced with the departure of French nationals, so that 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 can not hence be regarded as an indication of demand.

63. Countries using high import or sales taxes to restrict demand present a similar problem. Should such taxes be reduced, demand will presumably rise rapidly as the threshold of income at which purchasers come into the market is lowered, but in the absence of price elasticity studies, the level of such income is difficult to forecast, and attempts to evaluate price elasticity from hypothetical price changes are notoriously difficult to make.

IV. FORECASTING AUTOMOBILE DEMAND
IN DEVELOPING COUNTRIES

64. It is not so much because appropriate statistics are not available, but because automobile demand is so different that forecasting techniques suitable for automobile projections in highly developed countries are not applicable to developing countries. The structure of the market suggests a forecasting approach using a concept of growing markets, and this in turn delineates the statistics required. Once the principal market trends are established, the effects of changes in government policies can be considered.

A. A Model of Automobile Markets in Developing Countries

65. 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. These are generally made 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 saturation of these groups of consumers is very high.

66. As cars become more familiar and road networks improve within and outside the principal cities, new, 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 consumers are business owners acting either in their personal or business capacity, high ranking government officials and business executives, and professional men. As car ownership progresses downward from the very high to the still relatively high income groups prices become more important. Price elasticity rises and so does income elasticity. Smaller cars which are cheaper to run are bought, and

there is greater reaction to changes in car prices and in income levels. As the threshold below which income is too low to allow a car to be bought is approached, and the amount of discretionary income available to the consumers diminishes, the proportion of car owners in each income group also falls.^{1/} 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 threshold income for car purchases is reached, when it begins to decline sharply.

67. As the threshold is reached the market ceases to expand to new, lower income level groups. Unless there is a substantial change in the ratio of car prices to incomes, further sales to new consumers must depend on:

- (a) increased ownership saturation within existing consuming groups;
- (b) additions to these groups from new people joining the higher income group as a result of population growth;
- (c) improving levels of incomes which push new consumers over the threshold, and
- (d) sales of second and third cars to income units already owning one car.

68. The basic factor which determines threshold of income 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 ownership is held to be a measure of social and economic status influences the extent to which consumers will purchase cars at the expense of other goods and services, invest in cars rather than save, and so on. In general, car ownership tends to reach down to incomes earned by medium-sized business owners and professional workers, and to stop

^{1/} This concept is illustrated by L.R. Klein, "Major Consumer Expenditures and ownership of Durable Goods, Bulletin of the Oxford Institute of Statistics, Vol. 17, 1955, P. 410, in a table reproduced as Table L.

short of clerical workers, blue collar workers and farmers. The car market in developing countries is thus clearly not a mass market; a country which shows signs of having mass consumption in motor cars is becoming a developed country.

69. Supply factors influence the rate of market penetration in developing countries. In the limiting case countries ration the supply of cars, but more usually they influence it in more complex ways by sales taxes, import controls and tariffs, and local production policies which all tend to raise the income threshold required to enter the car market.^{1/}

70. The supply of joint products such as gasoline, service and sales, and roads is also influential. In developing countries cars are concentrated in cities partly because this is where the high income earning groups are, but partly also because cities have roads, ill-kept and congested though they may be. Service facilities grow where cars are concentrated, and so does sales pressure itself. This is particularly true of time payment arrangements which are necessary to press down the income threshold. Such facilities also grow over time. They tend to develop after the first impact of motor car ownership is established, and to the tendency for the rate of car purchases to accelerate.

71. The attention of the international car manufacturers is attracted as motor car ownership grows. Those already making sales in the country accelerate their efforts, and others become interested in the new market so that sales facilities multiply. The stimulus of expanding sales leads to government policies of local assembly and manufacture, particularly if balance of payments problems seem pressing, and the large international companies accentuate their efforts to come in "on the ground floor".

^{1/} J. Baranson, in Automotive Industries in Developing Countries, Bank Report No. EC-162, demonstrates how local production raises car prices.

72. The lack of alternative transport and other services tends to increase the pressure to purchase motor cars, and in particular accounts for the importance of business purchases of cars in developing countries. To some degree such purchases represent "fringe benefits" to business and government executives, and this is probably more important than in developed countries, but in developing countries businesses frequently have a greater need for car ownership than in developed countries, for transport and also for other communication needs. In countries where telephones are not readily available, cars are frequently sent with simple business messages ordinarily handled by telephone in developed countries, although this is at high cost to the enterprise and at great social cost in congested roads.

73. The business reasons for car ownership tend to be most pressing in periods of rapid business growth, and particularly in bursts of industrialization. Such periods of course also coincide with rapidly increasing personal demand for cars. In time, as bottlenecks such as the supply of telephones are eased the demand for car services is reduced, and the rate of growth in the demand for cars for business purposes also tends to decline. The absence of public transport in some cases pushes car ownership down among clerical and blue collar workers who purchase cars on time payment to travel to work, covering the cost by carrying fellow employees to work.

74. Both demand and supply factors therefore tend to impose a three-stage pattern in the growth of car saturation in a developing country: firstly a period of slow growth as cars become introduced through purchases of the wealthy and as sales and service facilities expand and roads are built; secondly, a period of rapid growth when car ownership penetrates to a very

high proportion of income earners from the wealthy down to the threshold level of income for car ownership; cars become readily available; business demand for cars is high, and the road network is expanding; thirdly, a much reduced rate of growth after the principal market has been established and saturated, when sales depend on the expansion of upper income groups and car replacements (Graph 5).

75. This model 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 and its saturation grows, replacements become important 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, and forecasting methods derived from replacement models apply.

B. Calculating the Demand for Automobiles
in Developing Countries

76. 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, usually translated into mathematical terms as an S-shaped growth function. H.T. Davis fitted a logistic function to the growth of automobile production in the United States between 1913 and 1927, extrapolating the curve to 1939 to indicate the extent of overproduction in 1929 and underproduction from 1930 to 1936. Expected production was again attained in 1937.^{1/}

^{1/} H.T. Davis, The Theory of Econometrics, Bloomington, Ind; 1941, pp 210-1. Davis followed S.S. Kuznets, who showed the appropriateness of the logistic function to the growth of product demand by fitting it to some 50 series in Secular Movements in Production and Prices, Boston, 1930

77. The logistic curve is given by the function:

$$y = \frac{k}{1 + e^{a + bx}} \quad \text{where } b < 0. \frac{1}{}$$

78. At first sight, fitting an S-shaped curve to past new car sales in a developing country and extrapolating future sales seems the most logical forecasting method, but there are difficulties in its application. The model which suggests this approach applies best in the early stages of development of a car market, and at this point there is insufficient data from which to extrapolate with confidence for future trends. By the time the data is available replacement sales are swamping new sales and other forecasting methods are more appropriate. The fact that new car sale 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.

79. A more complex forecasting alternative is to translate the model of car market expansion into an S-shaped curve by estimating the constants. The model of car saturation lends itself best to this approach because reasonable estimates of saturation prospects are not too difficult to make. Sales to new consumers can be calculated once the saturation path is plotted, and additional sales due to 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 function:

1/ James and James, Mathematics Dictionary, Third Edition, Princeton, N.J., 1968, p. 223.

$$\log y = \log k + (\log a) b^x$$

$$\text{or } y = ka^{bx}$$

where $0 < a < 1$ and

$$0 < b < 1$$

At $x = 0$, $y = ka$, and as x approaches infinity, y approaches k . The increments in y as x increases are such that the difference of increments of $\log y$ are proportional to the corresponding differences in $\log y$.^{1/} This curve generally gives a better fit for car saturation than the logistic because the inflexion point comes somewhat earlier, and is somewhat sharper.

80. A Gompertz curve can be calculated from reasonable assumptions about the value of the upper asymptote and the time taken to reach it, the value and time taken to reach the inflexion point, and initial saturation. 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 income units, it can be assumed that at the beginning of the growth of the motor car market saturation will be, say, 0.1 per cent of all families. The inflexion point, and the time it takes to reach it is the critical value; it can be estimated by observing the behavior of car sales and stocks. In Argentina and Thailand, for example, this seems to have occurred in about 1956. (Graph 6) The asymptote can be estimated by considering the threshold of income for car purchases in a country at given current car prices, the likely saturation of the market whose magnitude is established by such a threshold, and the time it will take for this level of saturation to be reached. The number of families above the threshold and their ultimate "car saturation" as a proportion of total families will not vary

^{1/} Ibid., James and James, op. cit., p. 163

greatly among developing countries in similar stages of development, but the time taken to reach saturation will. A strongly developing country will have a much shorter period of growth to saturation than a struggling one. Once the pattern of saturation is calculated, annual demand can be derived, and the growth of car stocks cumulated. The replacement demand has to be added as it becomes appropriate.

81. 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 doing 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.

82. Major shifts in incomes, in car prices, or in social habits will, of course, affect saturation, shifting its path to a new curve, and they will have to be incorporated in running forecasts accordingly. The saturation pattern will also be influenced by short term fluctuations in business conditions, changes in monetary conditions and similar factors which may accelerate or postpone decisions to purchase motor cars. Because of the values associated with the possession of a car as well as its intrinsic utility such fluctuations are, however, unlikely to affect the long run saturation pattern greatly.

83. The degree to which the techniques outlined can be used in formal econometric models will largely depend on the statistical information available. The estimation of the threshold income for car purchases always presents difficulties, and in developing countries poor income distribution figures will make the calculation of the number of income units above this level

difficult. Initially annual stock increments can be regarded as new car sales if stock figures are available since scrappage will be negligible. New car sales series can usually be calculated by adding imports and local production and these can serve as a check on stock figures and serve as a basis of scrappage estimates. (See Table 5 for data on selected countries for which annual figures were either available or were calculated.)

84. The saturation approach to forecasting strengthens the argument for better motor car statistics on lines of those published for developed countries. The tendency to publish statistics of stocks only rather than annual sales as well as stocks has been encouraged by the United Nations Statistical Yearbook which only uses the former.^{1/} 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 forecasting the demand for cars because they enable reasonable assumptions to be made about scrappage. They are, moreover, easy to collect because they are already available in car registration files and merely require a clerical separation between new car registrations and re-registrations. There is an argument for publishing registrations by makes or sizes of cars. The market for cars can be regarded as the sum of markets for different types of cars and this too can be usefully incorporated into forecasts. In developed countries car manufacturers find the publication of monthly car registrations of new cars by type of car extremely useful in production planning. The United Nations Statistical Yearbook might therefore usefully publish new registrations as well as stocks annually, hence encouraging countries to improve their annual new registration figures.

^{1/} Stock figures are given in the United Nations Statistical Yearbooks, Transport, "Motor Vehicles in Use", by country, year and passenger vs. commercial vehicles. Production figures, including the number of firms and domestic content, are given in J. Baranson, op. cit., Table 12, p. 79, "Manufacturing and Assembly Operation in Developing Countries by Regions, 1965".

85. 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 saturation asymptote associated with an income threshold can nevertheless usefully inform their thinking about automobile policies.

C. Implications for Policy

86. The general shape of the market for cars is relevant to a number of government policies in developing countries. Annual sales are usually more important in the first instance, but the growth in the stock of cars is also a factor in economic policy and planning.

87. As car saturation begins to grow, governments generally become aware that car sales can be revenue earners either through revenue import duties or sales taxes. Once the very wealthy, official and business demand which is inelastic in price is satisfied, duties and taxes will retard the rate of saturation and raise the income threshold which determines the market, thus reducing the total extent of the market. If governments wish to reduce spending on luxuries as well as to raise revenue such policies will therefore achieve their objective.

88. Countries with balance of payments difficulties frequently wish to restrict the imports of cars. The pattern of market saturation suggests that in the early stages high duties or taxes are not likely to be very successful in restricting demand, but that they will become increasingly so as successively lower income groups become consumers.

89. Import restrictions will reduce demand to the required level to the extent to which they are policed. But unless they are accompanied by stringent rationing, and probably even with rationing, a black market in cars will develop under the pressure of unsatisfied demand. Such black market prices are likely to drop in time as saturation is increased and as the new demand for cars comes from lower income groups. Very high tariffs or sales taxes,

which will have the same effect as restrictions in reducing the number of cars imported, and which will probably channel them to the same consumers as an imperfectly operated restriction scheme which allows black marketeering, are therefore probably preferable because they do not encourage disregard for law and order.

90. The economies of scale in car manufacture are so great that car assembly and manufacturing begins spontaneously only in very large, relatively prosperous developing countries or those which are entrepôt distributing centers for a region. For most developing countries the establishment of an automobile industry involves a deliberate government choice which has to be backed up by appropriate policies.

91. The choices in establishing an automobile industry are extremely complex, and the size of the domestic market is not the only factor in the choice to be made. It should, however, be one of the important ones, and in spite of the complexity of the problem, some general rules apply.

- (a) In a medium range period of time the domestic market for automobiles in a developing country will tend to stabilize as saturation approaches the asymptote, and this is the annual level of demand at which local production plans can aim. A danger in planning for local production arises out of the tendency to regard the upward swing, particularly in its last, most steeply accelerating phase just before it begins to decline, as a linear demand trend, and extrapolate from this for future demand and production forecasts.
- (b) The estimated 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 a country

still has to decide whether it should merely aim to encourage the assembly of knocked-down cars, or whether ultimately it should aim at the manufacture of car parts. If the latter alternative is chosen, then the percentage of the value of car components which can be manufactured economically with a given market has to be decided.

- (c) 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 manufacturing, and since car manufacturers tend to integrate their production backwards out of fear of car component suppliers' monopoly, a country which only envisages assembling activities can safely encourage wider entry into the industry than one which ultimately wishes to see a full range of car manufacturing. Experience in car industries in developing countries suggests that it is difficult to restrict entry into manufacturing once several assemblers have been permitted to enter a country.

92. Establishing local car manufacturing raises the cost of cars. While it is now well established that lack of experience and other factors are important in causing high costs, the principal cause is the absence of economies of scale.^{1/} This is not simply the result of limited markets, but also of 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 or duopoly and competition, but between monopoly or duopoly and

^{1/} Baranson, op. cit., demonstrates this, and also shows that the extra cost of production rises with the percentage of total production undertaken in the developing country. This is related to the importance of economies of scale in complex component manufacture.

and oligopoly, and the latter, characteristic of car production in developing countries, is probably an independent and further cause of high prices. A monopoly car industry with a technically efficient production structure can ultimately be exposed to competition from imports; with several production units this will not be possible.

93. The importance of high prices of cars in developing countries is directly related to the problem of economies of scale in production. By raising the threshold of income required to buy a car, increased prices reduce the total size of the market, lower the saturation level, and shorten the time it takes to reach saturation. This reduces the scale of production in the period the industry is being established, and cuts down the ultimate production level.

94. Sales taxes have a similar effect, and governments which are trying to encourage the growth of an economic local car manufacturing industry should not at the same time regard cars as a luxury item which should be taxed at high rates. They are likely to make greater revenue gains by taxing the industry itself, particularly if they do not dissipate such revenues in unnecessary concessions to manufacturers.

95. The scale of the market should be used to evaluate the need for incentives for car manufacturers. A good 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 will require extremely high incentives, either directly through taxation concessions or indirectly through high tariffs and favorable exchange rate manipulation, and probably all three, and yet none will be effective in establishing an economic automobile manufacturing industry if the prospective market is small.

96. Protective measures are likely to be necessary in developing countries, even in promising markets, to overcome inevitable infant industry problems, but the pattern of saturation suggests that subsidies, if they are

viable in other respects, may be better than tariffs. They could also be easier to remove once the market levels off towards saturation.

97. The short run effects of government monetary, fiscal and other policies which alter prices and income relationships temporarily will depend on the stage of market saturation. In the early stages when price and income elasticity is low, they are not likely to be effective; as the final saturation level is approached, demand will be extremely sensitive to such measures. However, to the extent that such changes are temporary, they will merely result in a temporary dampening or accelerating of the saturation pattern. After a period of business constraint, a government should expect a jump in car sales, which reflects a pent-up, unsatisfied saturation demand.

98. The main use of automobile forecasting in developing countries is for annual car demand estimates, and this is true even for such broad planning problems as the annual increments required for road expenditure, or the extent to which increasing demand for gasoline will exert a pressure on the balance of payments and justify the construction of oil refineries and a petrochemical industry. It can be calculated from annual demand forecasts with due allowance for scrappage. The supply of roads and goods such as gasoline, moreover, will influence the annual demand for cars and the ultimate saturation level. High gasoline prices, for example, have a similar impact on the car market as high car prices, and they influence the use of cars as well as their purchase. Long-run government policies influencing roads building and the supply of gasoline will affect the demand for cars, and policy will in turn be influenced by car purchasers who soon become formidable political lobbyists. Apparently simple decisions about car prices and income relationships thus reach into much wider areas of the economy than is apparent at first sight.

ANNEX I

Methodology

1. Many methods can be used to calculate the automobile demand in a developing country. For the sake of simplicity one may distinguish three levels: complex projection methods, less complex projection methods, and simple projection methods.
2. Complex projection methods involve calculation of the income threshold of access to motorization and the number of families with income 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 of a normal type. The analyst will need family budget studies and income distribution analyses, slowly becoming available in developing countries. The latter can often be obtained from Income Tax authorities, while the former is frequently an object of investigation by development centers of national universities. Once this information is obtained, the underlying mathematics is simple.
3. Let \underline{x} be the income threshold. (See Graph 7(a)) Using normal Pareto curve of income distribution each point (x_1, y_1) represents the number of families y receiving an income exceeding \underline{x} , at a given time \underline{t} . An increase in incomes will shift the curve to the right. At the same time, the threshold is lowering with time. We, therefore, should distinguish between three separate phenomena:
 - a. Connection between \underline{x} and \underline{y} by a Pareto Law: $y = \frac{A}{X^a}$
where \underline{A} and \underline{a} are constants;
 - b. 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 \underline{x} by $(1 + r)^t$, or, in first approximation $(1 + r.t)$ if r is low, where r is the rate of annual increase of the average income. (See Graph 7(b))

- c. Downward shift of the threshold of access to motorization over time, due to various factors, apart from the income effect, such as diffusion of car use, imitation effect, relative decrease of car prices compared to other goods, etc. The mathematical formula to show this is:

$$y = \frac{A}{\left(\frac{x}{1 + rt}\right)^a}$$

where:

y = number of families, receiving an income than \underline{x}

x = threshold, below which access to a car purchase become

impossible. This threshold is, in principle, lowering with time.

r = yearly growth of incomes

t = time

Therefore, \underline{x} becomes a logistic curve, decreasing in function of time, and its asymptote is defined by an income k , which can be calculated from family budgets and below which a purchase of a car becomes inconceivable. (See Graph 7(c))

4. Less complex methods of projecting automobile demand involve estimates derived by least squares regression. A generalized formula may take a following form:

$$R = a_1 \Delta Y + a_2 \Delta \frac{P}{M} + a_3 \Delta S + a_4 \Delta X + a_0$$

where:

R = retail sales of new cars

Y = real disposable income

P = real retail price of new cars

M = average credit terms (number of months the average automobile installment contract runs)

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

It may be argued that since, in this model, both the retail price of new passenger cars and the number sold are endogenous variables, the estimate by least squares leads to biased results. This is so, but in view of the very rough data which will be employed, any such bias is surely negligible in comparison with errors in the data, and the use of an elaborate technique in an attempt to avoid this bias is uneconomical if not presumptuous.

5. Simple methods of projection of the automobile demand can be used after having established the covariation between automobile demand and other leading macro-economic indicators. Such covariation yields different results at different levels of economic development.

We calculated such relations for various groups of countries. Graph 3 shows covariations (one in absolute, and another in marginal terms) of the automobile sales with such basic indicators, as the index of industrial production (in the United States) and a covariation of new car registration (as % of car population at previous census) with consumer spending (as % increase, in constant prices) in Great Britain. The curves of automobile

demand run almost exactly parallel to the curves of the above indicators. This shows simply that purchases of cars at a certain level of development are subjected to the same kind of business fluctuations as other, more aggregated phenomena, although there may be some time lag both on the uprise, where car sales increase in anticipation of favorable business climate and on the downslide, where they precede a downturn of more general tendencies. Thus, increase in real consumption by 1.5 percent is preceded by increase in new car registrations of 12 percent, and increase of consumption by 4 percent is preceded by 17 percent jump in car sales. Decrease in the elasticity coefficient was a result of various dampening factors, such as an increased stock of cars, rising car prices and limited supply from new production.

ANNEX II

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Table 1
Stock of Passenger Cars in Korea

Year	Passenger Cars ^{/1}			Total
	Gov't	Private	Business ^{/2}	
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	1,950	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

^{/1} Figures for the end of every year.

^{/2} Taxis and microbus

Source: 1965 Yearbook, Ministry of Transport, Seoul, 1966.

Table 2

FINANCING OF NEW AUTOMOBILE PURCHASES FROM
INCOME INCREMENTS
(Marginal Rate of Automobile Consumption)

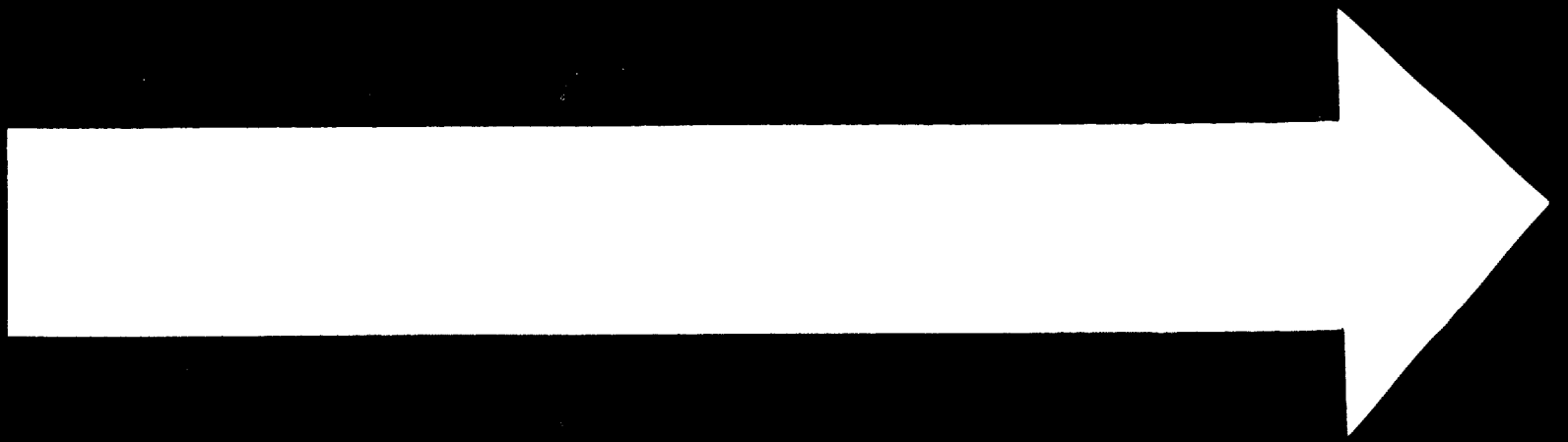
	GNP/1,000 inh. (US\$, 1964 prices)	New cars/ 1,000 inh.	Additional income per new car in US\$	Percent of addi- tional income spent on each new car
	(1)	(2)	(3)	(4)
<u>Italy</u>				
1955	620,000	3.4		
1960	794,000	7.7		
(Increment over 1955)	174,000	4.3	40,500	4.2%
1963	953,000	18.8		
(Increment over 1960)	159,000	11.1	14,300	11.9%
<u>Spain</u>				
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%
<u>France</u>				
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%

Cont'd

Note:

The Objective of this table is to determine what part of the increase in incomes is channelled into purchases of new cars. This could be done by calculating in column 1, increase of GNP/thousand inhabitants over a longer period of time and comparing it to increase in registration of new cars per 1,000 inhabitants over the same period of time (column 2). An increment of income per one additional new car (column 3) can then be easily established. Finally, assuming an average price for a European car at \$1,700, the percentage of additional income spent on new cars can be found (column 4).

Source: - Author's estimates

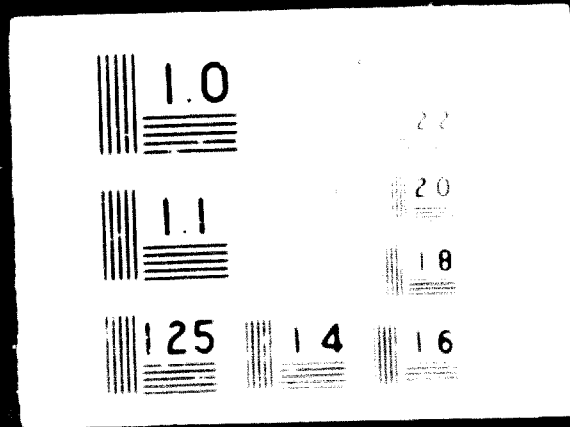


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Table 1

THE STRUCTURE OF PASSENGER CARS IN 1954

Year of Manufacture	Passenger Cars		Merchandise	
	1954	1950	1954	1950
Before 1951	1,54	16 10	10	1 10
1951-1952	8	17	10	4 1
1953	2,000	1,000	1,000	1,000
1954	1,000	1,000	1,000	1,000
1955	1,000	1,000	1,000	1,000
1956	1,000	1,000	1,000	1,000
1957	1,000	1,000	1,000	1,000

▲ This column is for 1954

Source: U.S. Census Bureau, Bureau of Economic Analysis, 1954

Table 4

Great Britain: Motor Car Ownership by Income Unit in 1951

<u>Gross Income of</u> <u>HOUSEHOLD</u> <u>(£)</u>	<u>Percentage of Income units</u> <u>OWNING MOTOR CARS</u>
0-100	1.4
100-150	0.3
150-200	1.1
200-250	5.1
250-300	7.4
300-350	12.1
350-400	15.0
400-450	12.0
450-500	12.1
500-600	12.1
600-700	12.1
700-800	12.1
800-900	12.1
900 and over	12.1

NOTE: 1. The figures are based on the 1951 Census of Great Britain and are based on the number of motor cars owned by the head of the household. The figures are based on the 1951 Census of Great Britain and are based on the number of motor cars owned by the head of the household. The figures are based on the 1951 Census of Great Britain and are based on the number of motor cars owned by the head of the household.

Table 5

Annual Imports for Cars in Selected Countries

(in thousand cars)

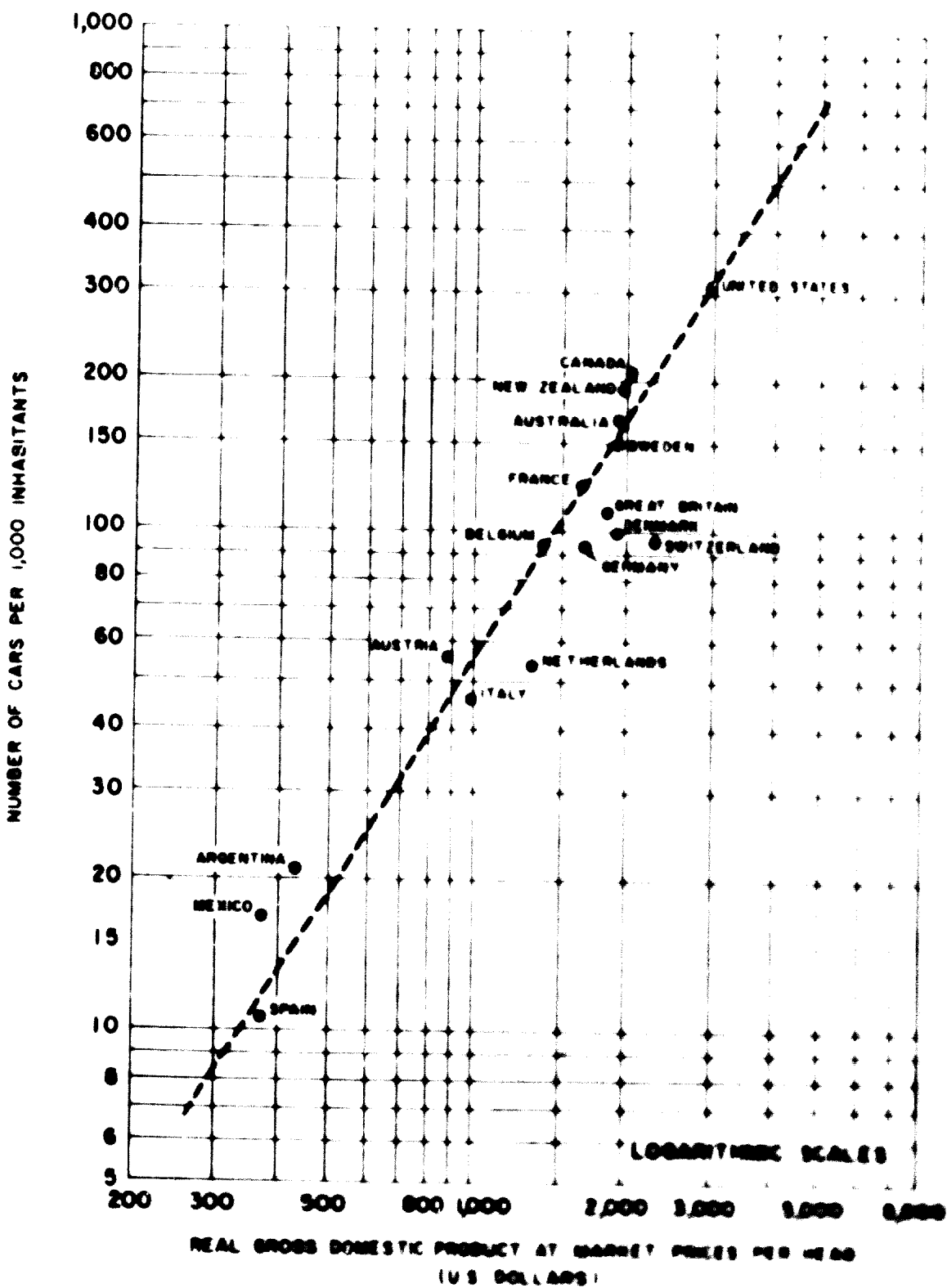
	1948	1950	1952	1954	1956	1958	1960	1962	1964	1966	1967
<u>Argentina</u>	7.4	7.2	7.1	7.6	11.2	15.7	48.2	96.0	119.5		
<u>Colombia</u>	7.4	1.9	2.3	3.1	6.9	15.0	15.1	93.9	119.6		
<u>Thailand</u>	6.2	6.4	5.0	16.7	2.0	0.6	6.8	6.2	4.0		
<u>Japan</u>	6.2	6.4	5.0	16.7	2.0	0.6	6.8	4.2	3.1		
<u>France</u>									8.2	6.7	10.2
<u>Italy</u>					1.4	2.6	12.1	6.2	11.0		

Source: For Argentina and Colombia, production and assembly figures came from the 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, National Statistical Office.

Graph Sources

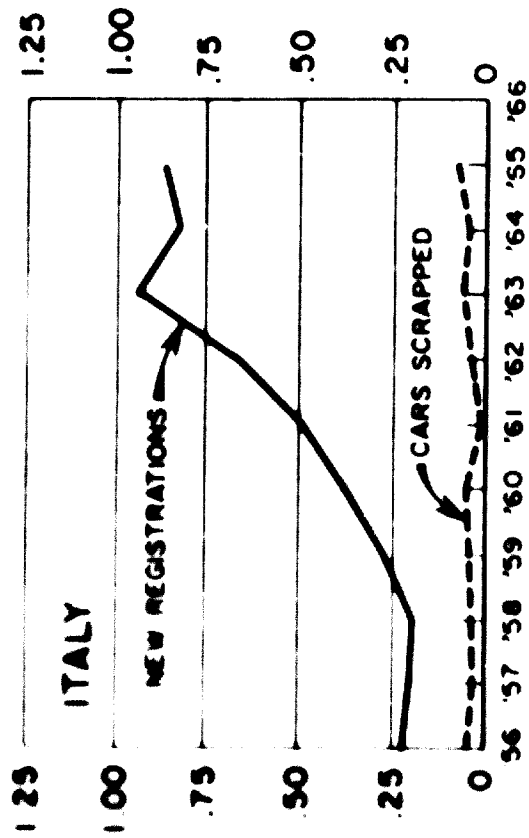
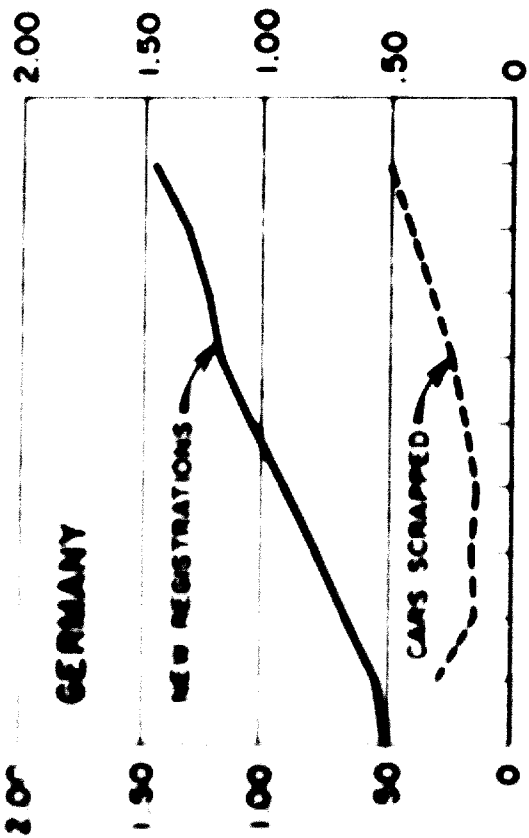
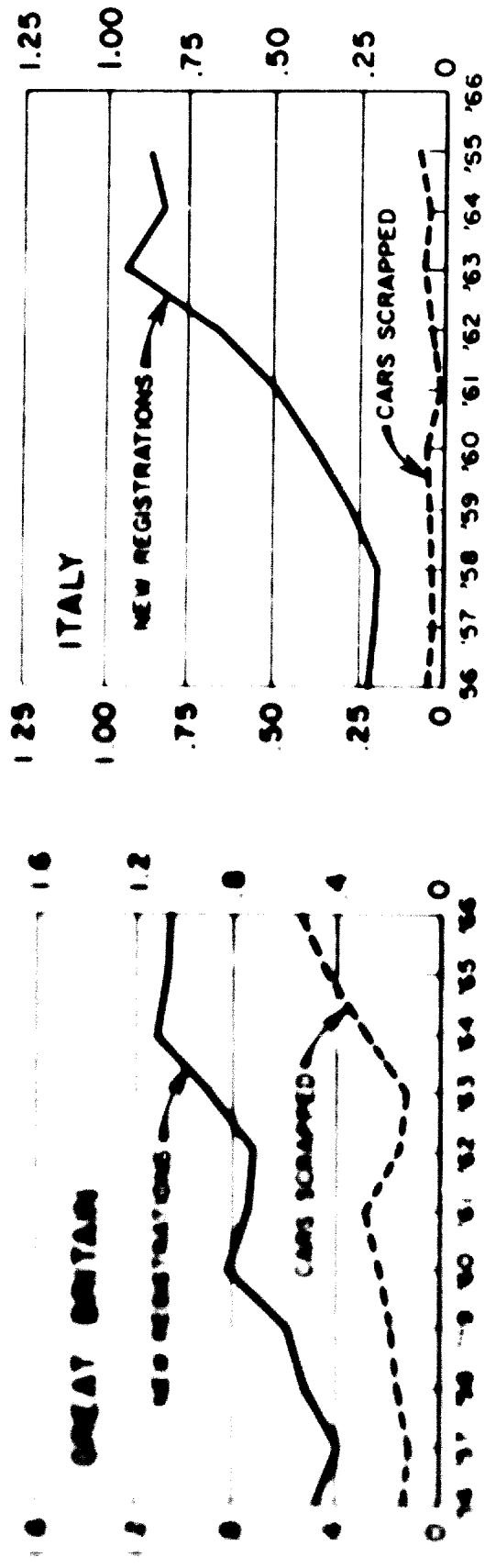
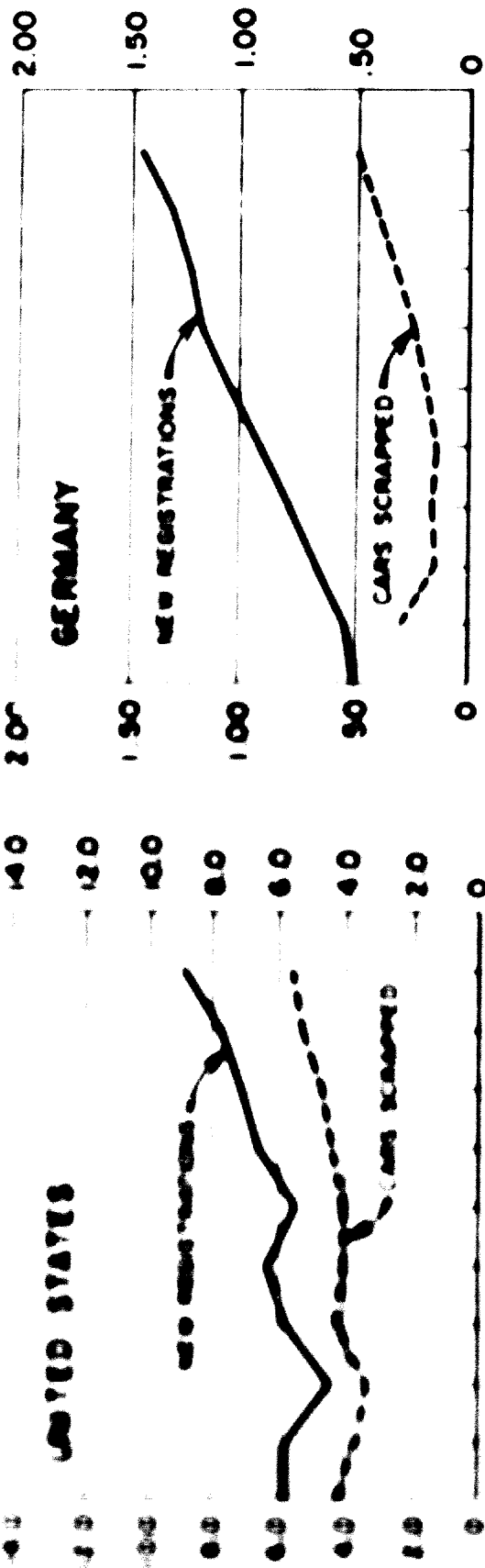
- Graph 1. Etudes et Conjoncture, No. 6, Paris 1965 (in French).
- Graph 2. The Economist, London, Feb. 25, 1967.
- Graph 3. Calculated from statistics published in the U.N. Statistical Yearbook and in various issues of the Quarterly Economic Review, published by the National Institute, London.
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- Graph 5. Mathematical illustration.
- Graph 6. Calculated from data in United Nations Statistical Yearbooks and in country annual trade statistics.
- Graph 7. Theoretical diagrams.

AUTOMOBILE OWNERSHIP AND LEVEL OF ECONOMIC DEVELOPMENT, 1962



REGISTRATION OF NEW CARS AND REPLACEMENT OF OLD CARS

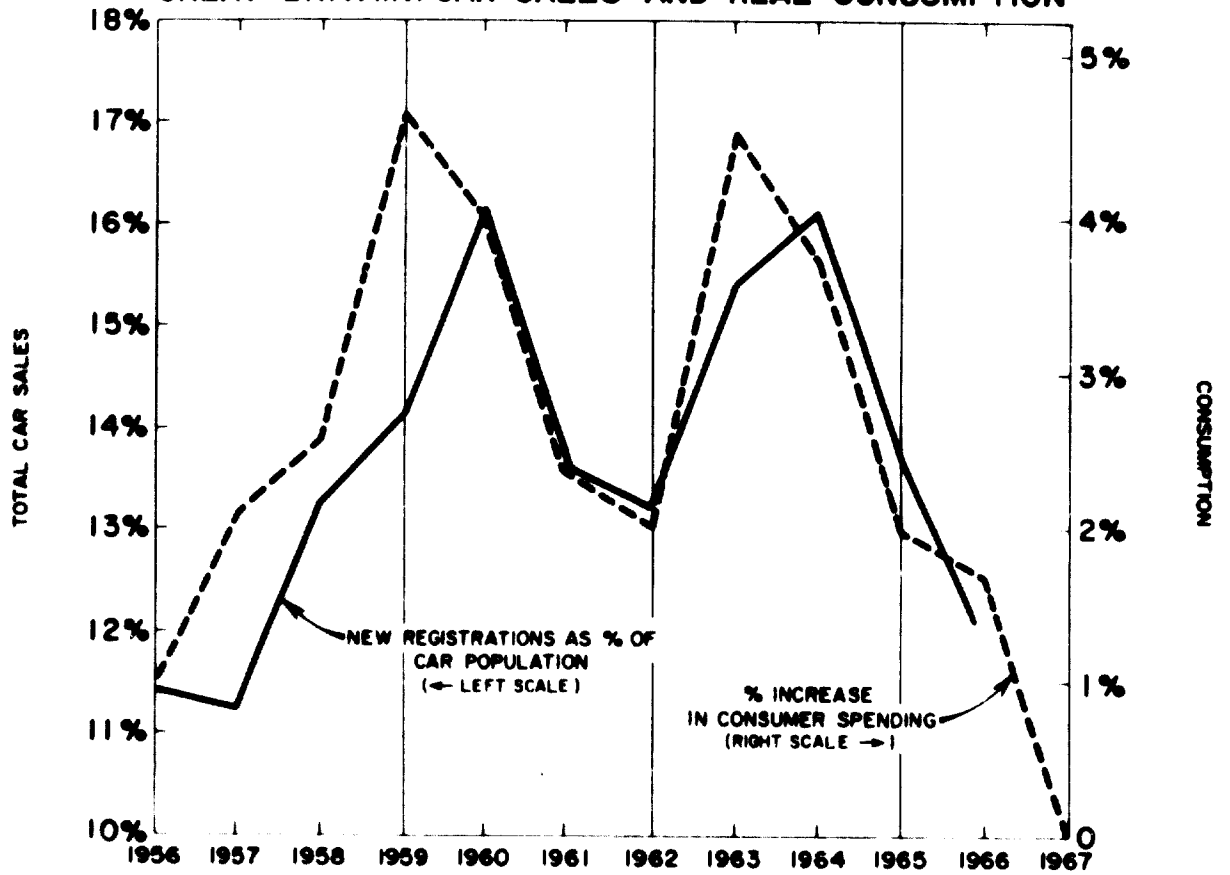
(MILLIONS OF CARS)



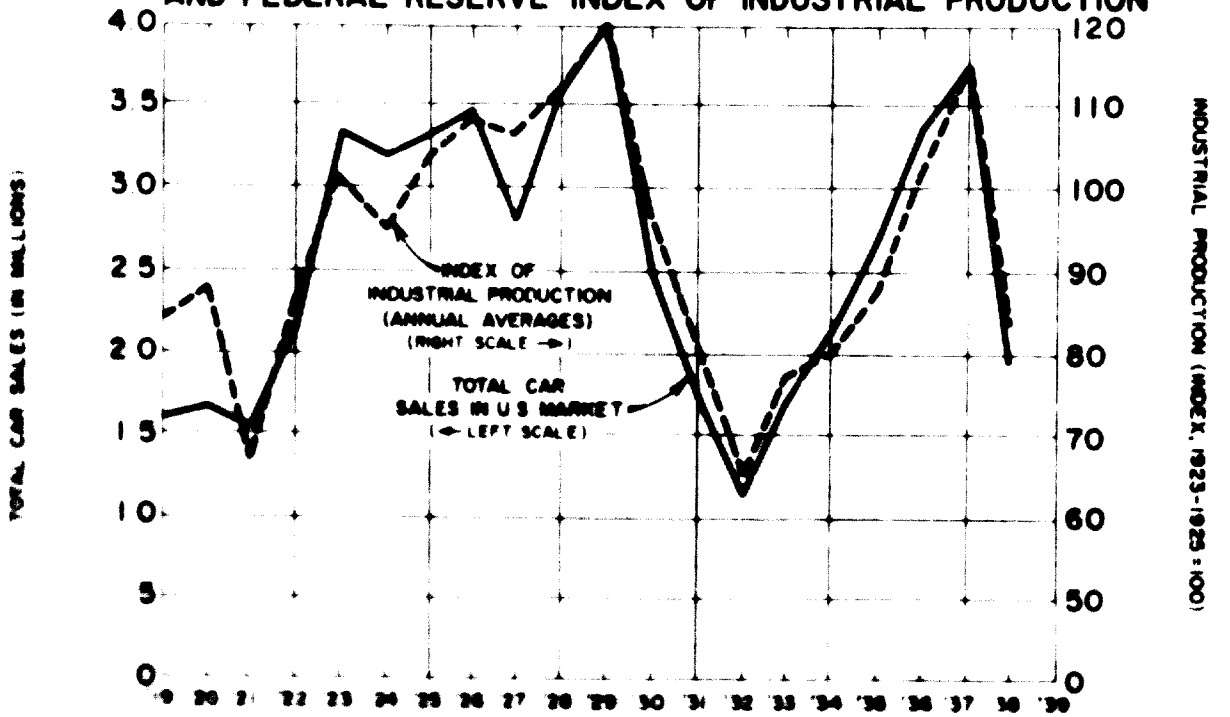
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CO-VARIANCE OF CAR SALES AND LEADING INDICATORS

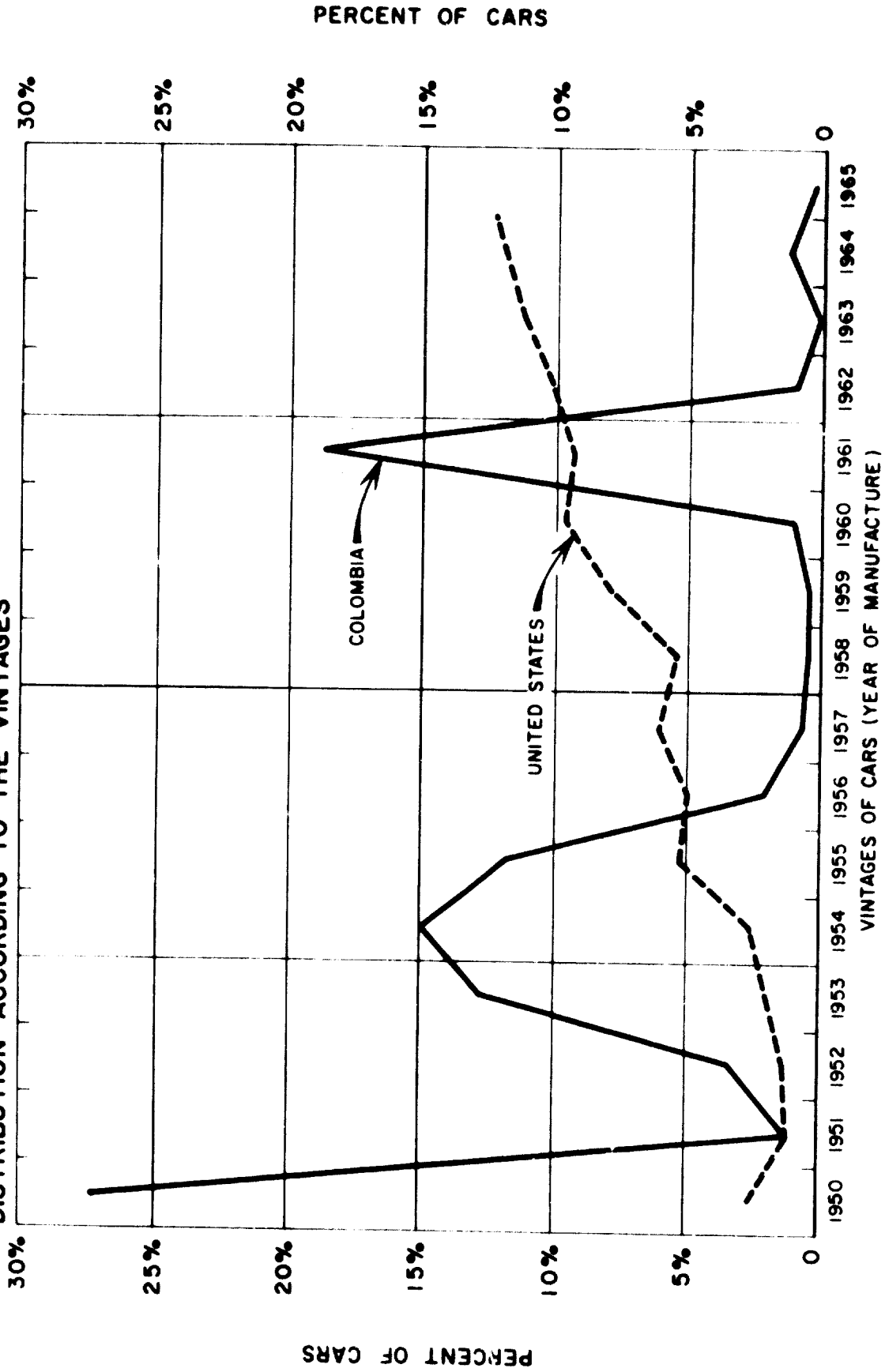
GREAT BRITAIN: CAR SALES AND REAL CONSUMPTION



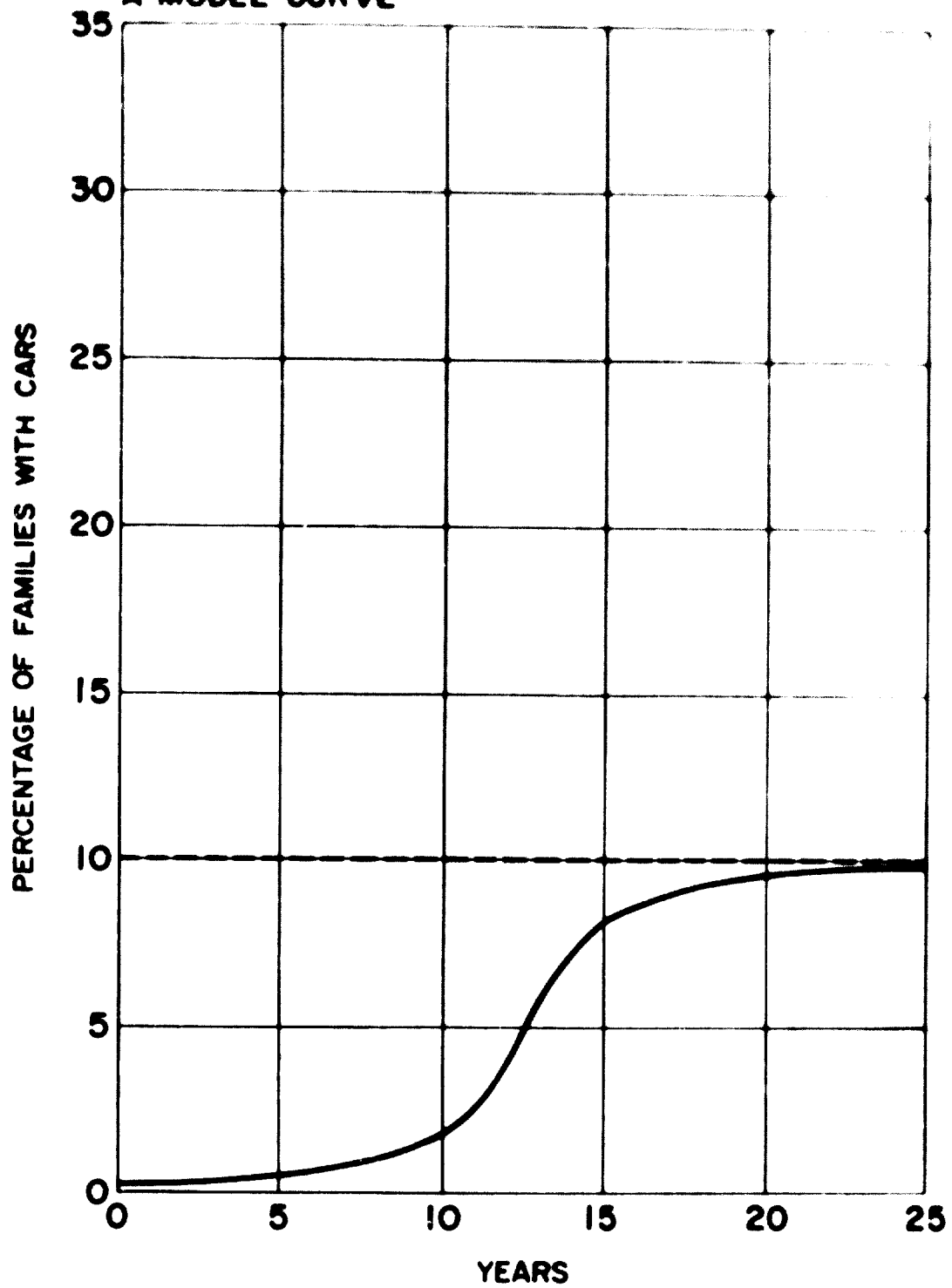
UNITED STATES: TOTAL CAR SALES IN DOMESTIC MARKET AND FEDERAL RESERVE INDEX OF INDUSTRIAL PRODUCTION



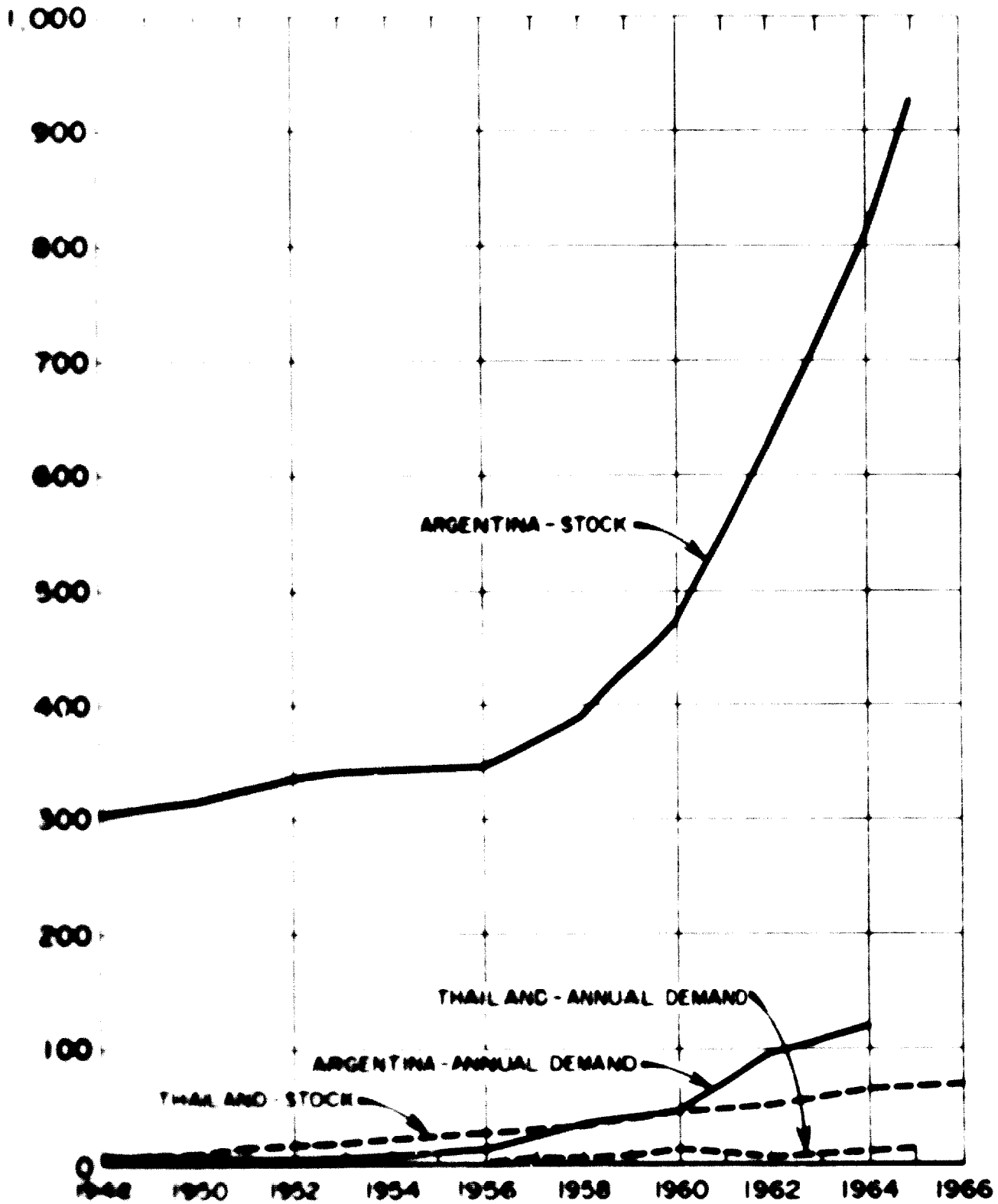
STOCK OF CARS CIRCULATING IN COLOMBIA (MID-1965) AND IN THE UNITED STATES (END OF 1964) DISTRIBUTION ACCORDING TO THE VINTAGES



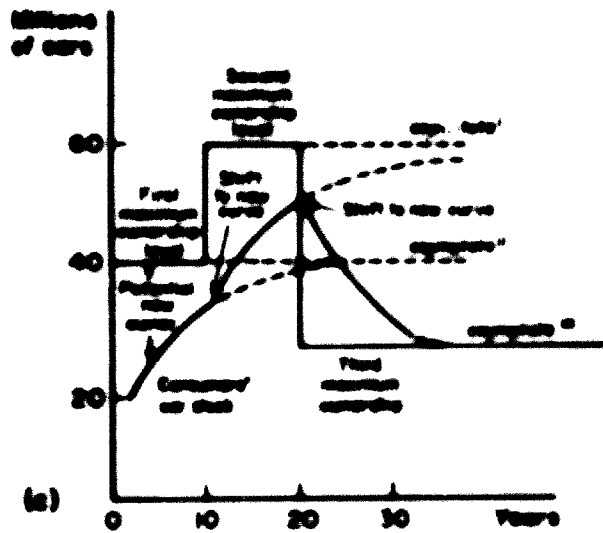
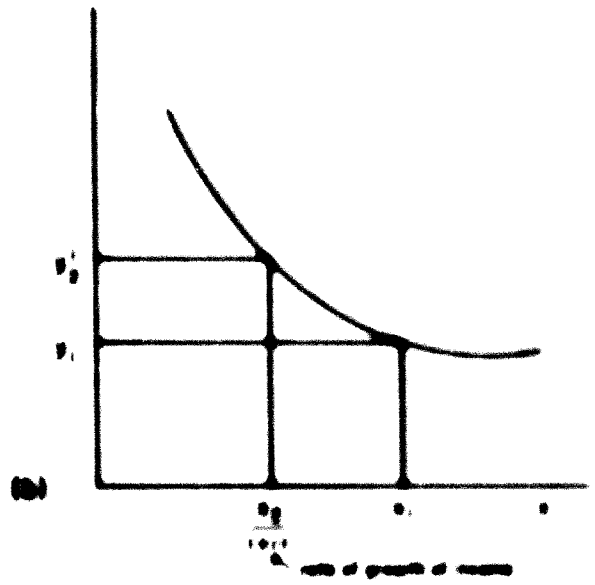
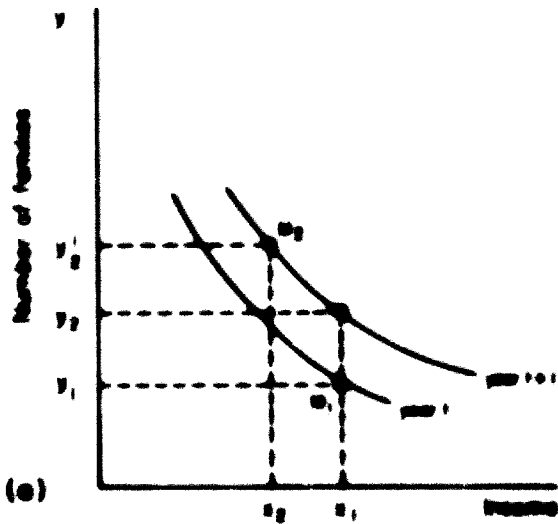
**SATURATION OF THE MARKET
FOR AUTOMOBILES IN A DEVELOPING
COUNTRY
A MODEL CURVE**

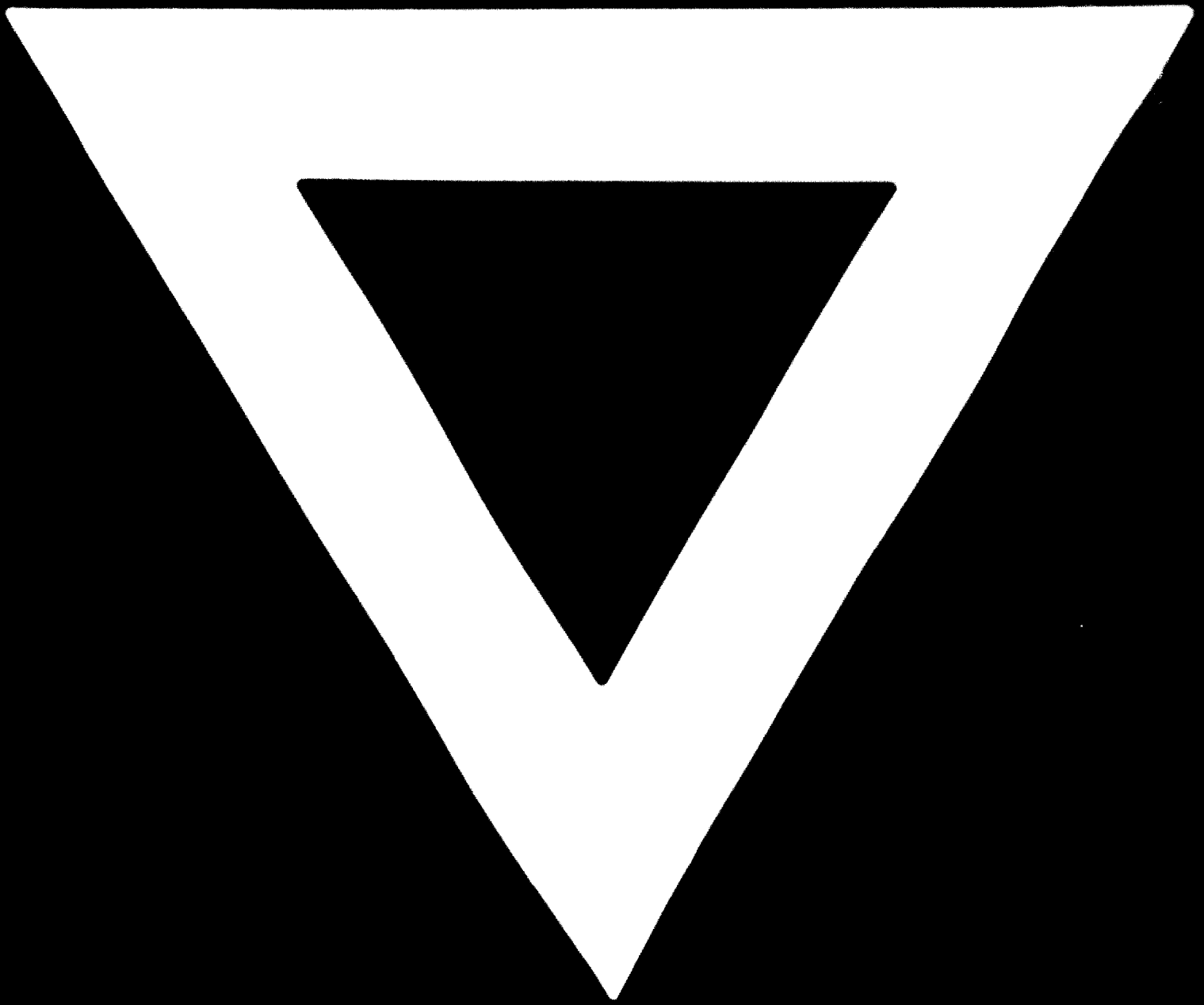


STOCK AND ANNUAL DEMAND FOR PASSENGER CARS IN ARGENTINA AND THAILAND, 1948-1966



THE CAR OWNERSHIP THRESHOLD AND THE LOGISTIC CURVE





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