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WORLD TIRE AND RUBBER DEMAND

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FOREWORD

The study on "Demand and supply of natural rubber" has as its objective: "to assess replanting and new planting policies as well as other aspects of a dynamic production policy for natural rubber and to indicate the policy that optimally meets future demand for natural rubber". It has been undertaken in the hope of reducing the degree of uncertainty facing rubber producers in the world rubber market. The primary audience for whom this study is prepared are the natural rubber producing countries of the Association of Natural Rubber Producing Countries (ANRPC).

The study is carried out at the Economic and Social Institute of the Free University at Amsterdam, commissioned by and in cooperation with the Economic and Social Commission for Asia and the Pacific (ESCAP). Financial assistance was given by the Netherlands Government. In completing this study, help and advice were received from a great number of organizations, private individuals and government officials throughout the world; the study would not have been possible without their direct and generous help.

This paper reports that part of the study, which concerns the analysis of world tire and rubber demand. As such it is a continuation of an earlier paper on "The world vehicle market". The various chapters of that paper will be summarized in this report.

Furthermore papers will be prepared on

- World natural rubber production
 - Natural and synthetic rubber: competition, complementarity and availability.
- Afterwards, the various parts of the study will be integrated, thus trying to assess future developments.

The author is grateful for the many valuable comments received from participants during and after various meetings of the ANRPC and the International Rubber Study Group at which papers on the above subject were presented. Special thanks are due to my colleagues, both at ESCAP and the Free University, in particular Maria J. 't Hooft-Welvaars and Prof.Dr. F.C. Palm, to Dr. P.W. Allen of the Malaysian Rubber Producers' Research Association and to Dr. P.J. Watson of the International Rubber Study Group, who made substantial contributions to the research on which this paper is based.

It goes without saying that the study would not have been possible without the accurate and stimulating work by my subsequent assistants Naree Jongwat-tanatum, Erik Kroon and Maarten van Erven and the patient efforts of everybody making the results of the study visible in this paper.

Chapter 1. INTRODUCTION

1.1 The world rubber economy

The last decade of the century-long history of rubber use has been unusually turbulent for both natural rubber (NR) and synthetic rubber (SR). In the automotive sector, which absorbs a major part of the world rubber supply, demand has been fluctuating as a result of the oil-crisis. Tire technology developments have changed the relative shares of demand for NR and SR. The oil-crisis has also had a different impact on the cost structures of natural and synthetic rubbers.

The growth of the world rubber economy was extremely rapid up to 1973, in large part owing to demand-pull, especially in the automotive sector. A major part of rubber demand arises in the automotive industry, primarily for tires but also to some extent for other automotive parts. The automotive industry in Western Europe and Japan enjoyed high rates of growth during the decade prior to 1973 because of economic growth and rapid penetration of passenger cars. In North America automotive use at a large scale had developed long before, but up to 1973 it continued to show a steady increase.

The oil-crisis of 1973 with its quadrupling of crude oil prices, as well as heavy price increases towards the end of the seventies had a sharp impact on both the demand and the supply sides of the world rubber economy. Increased prices of gasoline and doubts as to future availability of oil affected purchase and use of cars and commercial vehicles, although the short-term effect was far more important than the long-term effect because of overreaction in 1974-1975. This was enhanced by worsening traffic congestion and environmental issues. Automotive use was further influenced by a serious economic recession starting in 1974-1975 and by acceleration of world inflation. The drastic measures taken to combat inflation and their limited success deepened the already existing doubts about the long-term future of world development in general and the rubber industry in particular.

Added to the effects of the automotive sector, changes in the structure of the rubber sector itself were also substantial. Up to the Second World War, NR enjoyed a near-monopoly position; this position started to be challenged by SR in the 1940s as a result of war-time needs. Since the Second World War, NR's share in total world consumption has decreased steadily to about 30 per cent as a consequence of technological evolution of synthetic rubbers, improved

competitiveness due to reductions in relative costs and better marketing methods of SR producers, vertical integration in the SR producing and consuming industries and insufficient availability of NR.

In the second half of the 1960s, the tendency in the tire industry to substitute SR for NR came to an halt owing to the introduction of the radial tire in Western Europe. The radial tire uses more NR than the conventional tire, which had been absorbing only a marginal NR content in the 1960s; however, the radial tire lasts 50 to 100 per cent longer than the conventional tire. In the 1970s the radial tire also penetrated in North America and Japan. The consequent reduction in the number of tires used during the life of a car or commercial vehicle has a major impact on rubber use in the automotive sector. The increase in NR content is extremely beneficial to NR producers at the expense of the SR industry, which has been hard hit by the reduced demand due to the combination of lower SR content per tire plus lower tire output.

The negative influence of the introduction of radial tires on the SR industry became even more pronounced in 1973 because the quadrupling of oil prices created a change of major proportion in the cost structure of SR, which depends heavily upon petrochemical feedstocks. NR was far less affected on the cost side because in its case only fertilizers, yield stimulants and wages are influenced by oil prices and inflation. The competitiveness of NR appears to have strengthened owing to these changes in relative production costs. Production possibilities of NR have improved remarkably as a result of research and development efforts pursued during the past 20 years. High yielding varieties of trees, improved tapping and processing techniques, technically specified rubbers and other marketing aspects can give huge productivity increases over the next decades if applied on a large scale. At the NR price side, the natural rubber price stabilisation agreement aims to achieve stable conditions in international natural rubber trade, by avoiding excessive price fluctuations by means of an international buffer stock of 550 thousand tons.

1.2 The study

This study on "Demand and supply of natural rubber" has as its objective:

- to assess replanting and new planting policies as well as other aspects of a dynamic production policy for natural rubber and to indicate the policy that optimally meets future demand for natural rubber, if possible disaggregated by type -

In order to properly attain the objective of this study the following division can be made:

- a - to analyze and forecast total demand for rubber by (group of) end-use(s);
- b - to analyze current and prospective production (capacity) of rubber by type;
- c - to assess the share of natural rubber by (group of) end-use(s) in relation to
 - (1) technical aspects;
 - (2) economic aspects;
 - (3) availability of hevea and non-hevea types of rubber;
- d - to simulate future developments and to indicate the optimal dynamic production policy for natural rubber.

The various parts will be elaborated below.

a - Total demand for rubber

Demand for rubber can be divided into two broad groups of end-uses: the tire sector and the rest to be called the non-tire sector.

Specific end-uses in the non-tire sector number in the thousands, many of which only consume a few tons a year. It is very hard to obtain adequate statistical information on the major end-uses; especially regarding use of rubber. Besides, there is much fluctuation in production as some end-uses disappear from the rubber scene while others enter. Therefore it has been decided to aggregate these non-tire end-uses.

The tire sector will be given more elaborate treatment. Demand projections can only be arrived at in stages: rubber is an input to tires; tires are attached to passenger cars and commercial vehicles, either for original equipment or for replacement; passenger cars and commercial vehicles, be they new ones or vehicles in use, can be explained from macro-economic and other variables. Changing this explanatory sequence into a causal chain by reversing the order of the above, the main segments of the tire sector forecasting methodology are discussed below.

The ultimate determinants of the over-all development of the vehicle, tire and rubber industries are population size, the level of and growth in income and the availability of energy. United Nations' Medium Variant projections of population

growth will be used, if necessary, with some adjustments. Because future economic growth and availability of oil cannot be predicted at any reasonable level of accuracy, several scenarios of economic development and availability of energy will be introduced in the study. This range of possibilities offers users of our study the opportunity to select the scenario they believe most likely.

The second segment of the model for the tire sector deals with passenger cars and commercial vehicles. For the individual, to operate or not to operate a passenger car is a decision related to a variety of factors like traffic congestion, availability of public transport, distance between home and work, and the like; these factors are all intimately related with and dependent upon income. The number of passenger vehicles in use, then, can be derived from per capita income. The number of commercial vehicles, however, is more closely associated with level of industrialization and is thus better explained in terms of overall GDP.

The third segment of the model for the tire sector concerns changes in the existing stock of vehicles. On the one hand, increase in vehicles in use requires new registration of vehicles; on the other, replacement of discarded vehicles also requires new registration. New registration can therefore be divided into changes in the number of vehicles in use and replacements. Discards can be related to new registration in past periods. Average life of vehicles may be affected by such variables as economic development and availability of energy.

The fourth segment of the tire part relates to the demand for tires. After deriving the number of vehicles newly registered, the number of tires for original equipment can be estimated. An important but often overlooked variable in this regard is the number of tires per vehicle. For passenger cars prospects are for an increased use of "run-flat tires", thereby eliminating the spare tire. For commercial vehicles the number of tires per vehicle has increased in the past due to an increase in the market share of big trucks at the expense of medium-size ones; this trend seems to be flattening out, however, and it can thus be anticipated that the distribution of truck sizes will tend to remain stable in the foreseeable future.

Estimating the number of tires for replacement is a complicated matter. Two factors determine the rate of replacement of used tires: driving distance per vehicle per year and tire distance per set of tires. To generate realistic

projections on this matter it is useful to deal with replacement rates as probability distributions; this method will be employed in the present study. In addition, driving distance per vehicle requires special consideration in view of recent developments such as availability of oil and increasing car density (which will have a negative impact on driving distance despite the fact that it is positively related to income, an ultimate determinant of increased rubber demand). And tire distance, too, is being influenced by a number of changing environmental parameters. Among the important variables are: safety regulations; driving style, with reduced speed limits, which has become particularly relevant after the oil crisis; size and weight of tires; and, most important, market penetration of radial tires, which increase tire distance by about 50-100 per cent. In addition it is important to recognize the changing role of retreads, which may be more and more resorted to in order to save materials, energy and other increasingly costly inputs.

The final segment in the model concerns the demand for rubber itself as an input into the tire sector. This is essentially a direct relationship between the number of tires demanded and the rubber content per tire. Changing tire weights and sizes and ratios of rubber content play the critical role in this relationship.

Separate attention must be paid to those tires which are not attached to passenger cars or commercial vehicles e.g. for airplanes, motor-cycles, bicycles, and off-the-road vehicles.

b - Production of natural rubber

In analyzing and projecting natural rubber production, one should distinguish between production and production capacity.

The latter is related to the number and the type of rubber trees available, whereas production, involving the degree of capacity utilisation, is related to tapping behaviour including stimulation of the trees. Rubber prices and potential income from alternative types of employment appear on the scene. These topics are elaborated upon below.

Production capacity relates to a series of variables, the first of which is the type of clone or seedling, because various trees have different performances. A new high yielding clone produces many times the amount of rubber tapped from a pre-war tree. Not only average yield is important. Because trees can be productive for about 25 to 35 years and because production per tree

is not independent of the age of the tree it is important to base an analysis of production capacity on

- yield curves as a function of the age of the trees, related to the type of clone
- area distribution of trees by type of tree and year of planting.

The above explanation of production capacity clearly points to a vintage model as the appropriate approach for these topics. This facilitates to incorporate policies on replanting and new planting, which will only positively affect rubber production 4-7 years later. A further reduction in the average immaturity period may be achieved through improved technology and by spreading these improvement amongst smallholder through intensive extension work.

One way of extending production is increasing the area covered with rubber trees. Thus new planting gives a rise in production after 4-7 years. Before planting can be started, administrative procedures and physical clearing of the land will require quite some time. The opposite of new-planting is uprooting of rubber trees without replacing them with new rubber trees. The reason may be higher income earnings from alternative allocation of the area, or labour constraints.

Because productive life of a rubber tree is limited to 25-35 years, it is necessary to cut down trees at the appropriate time and to replace these trees with new ones. The result of cutting down trees for replanting purposes is a decrease in production in the immediate future but an increase in the long run because replanting material will give a higher yield. The decrease in production will create a decrease in income for the smallholder whose rubber land is too small to spread replanting over many years. Various replanting schemes and aid programmes for smallholders try to give them income during the years of immaturity, thus allowing smallholders to replant their rubber land.

Application of the above described system of vintage models may encounter serious obstacles for countries other than Malaysia because of severe data limitations. For these countries, Indonesia, Thailand, India, Sri Lanka a.o., restrictions on parameters and simplification of the model may be necessary.

The degree of capacity utilisation, being the ratio of production and production capacity, is for a major part influenced by prices. This shows the way to simultaneously determining the effects of prices and capacity variables on production, thus providing us with a theoretical basis for fixing a series of figures for production capacity. Incorporated into this analysis may be such factors as use of fertilisers and stimulants. Parts of this may be included as embodied or disembodied technical progress in the production function determining production capacity.

c - Market share of natural rubber

In 1972 a study on competition between natural and synthetic rubber, titled: "The techno-economic potential of NR in major end-uses" was undertaken by P.W. Allen, P.O. Thomas en B.C. Sekhar. It was published by the Malaysian Rubber Research and Development Board in 1974. The study started off with the observation that the current share of NR is below the potential share because of supply limitations and was based on the assumption that NR's potential market share is less than 100 % because of technical and economic considerations and due to various other economic/marketing disadvantages of NR.

For the base year (1970) the potential market share or "techno-economic norm" was derived for three regions:

USA	34 per cent
EEC	47 per cent
Japan	46 per cent.

Besides, it was assumed that the norm for the rest of the world, excluding the Centrally Planned Economy Countries, was 50 %. Calculating a weighted average resulted in a norm of 43 % for the world (excl. CPEC).

For the present study, NR's market share should be assessed taking into account the following considerations:

- a. In the past supply limitations of NR have been the major constraint in expansion of NR's market share. Thus, one might calculate NR's market share as NR supply over total rubber demand;
- b. Any techno-economic norm for NR should be interpreted as a techno-economic norm for isoprenic including such rubbers as cis-polyisoprene and guayule;
- c. Such a techno-economic norm can only be reached by NR if it is sufficiently available at competitive and reasonably stable prices with appropriate marketing arrangements and without such heavy barriers as captive markets and political protection for synthetic rubbers;

- d. The techno-economic norm is only relevant at an end-use level. Any aggregation presupposes no changes in the composition of aggregate production of rubber manufactured goods. The shift to radial tyres e.g. increases the norm. Further penetration of retreaded tires decreases the norm because only the tread is replaced, which largely consists of synthetic rubber, especially in the case of passenger car tires.

Reviewing the above considerations the study will simultaneously assess supply of NR and other rubbers, market share of NR and prices of NR and various synthetic rubbers. Of course, elements of cost prices of NR and SR will be taken into account including oil prices and inflation.

d - Simulation of future development and indication of an optimal dynamic production policy

By now the structure of the study has been described. The last part on simulations in order to obtain an optimal dynamic production policy, follows the same structure:

- a. project future rubber demand by end-use on the basis of expected economic development, oil prices, availability of energy and changes in other variables, included in the model;
- b. project production (capacity) of NR and other rubbers, simultaneously with prices and market shares; all of this can only be done on the basis of a priori given new-planting and replanting policies, which, of course cannot be treated separately from developments in the rest of the economy;
- c. assess market developments derived from b. and c. and indicate the optimal new-planting and replanting policy; afterwards disaggregation of demand and supply by type might be incorporated.

1.3 This paper

As has been stated in the foreword, this paper is a continuation of an earlier paper on the world vehicle market. The various chapters of that paper will be summarized in this report. The bulk of this paper is

chapter 5 - World tire demand

chapter 6 - World rubber demand.

Chapter 2. THE PASSENGER CAR MARKET: PASSENGER CARS IN USE

Saturation levels

Possible saturation levels may play a very important role in long run projections of car ownership. Although historical developments in the sixties and seventies show rather linear functions for the relationships between car ownership and time and income per capita, it is intuitively clear that this cannot continue and that some kind of levelling off must be envisaged due to other influences than those included in the specification.

Determination of saturation levels from time series data is concluded to be extremely dangerous and unrealistic if not bluntly impossible. Therefore a methodology had to be developed in order to arrive at a saturation level for each country. It is clear that the assumption of differences in saturation levels between countries cannot be omitted, because of differences in demographic and geographic characteristics.

Some demographic, geographic and economic factors are used for the explanation of saturation levels in car ownership:

- household size
- population density
- percentage of inhabitable area
- urbanization
- taxes bearing on car ownership and use
- production of passenger cars.

Because only relative saturation levels could be determined, three base levels for saturation in the USA have been used. They are arrived at using population composition (about 68 % are potential car drivers) and current levels of car ownership (about 530 per 1000 persons). Rounded saturation levels, to be used in the analysis can be found in table 2.1.

Table 2.1 Saturation levels for three scenarios, expressed in passenger cars per 1000 persons

	Saturation levels		
	Scenario S1	Scenario S2	Scenario S3
USA	600	650	700
Canada	610	660	710
Japan	320	350	380
Australia	620	680	730
New Zealand	620	680	730
W. Germany	470	510	550
France	480	520	560
United Kingdom	480	520	560
Netherlands	350	370	400
Belgium + Lux.	390	430	460
Denmark	430	470	500
Iceland	580	630	670
Sweden	430	470	500
Switzerland	400	440	470
Ireland	390	420	460
Norway	470	500	540
Finland	320	350	370
Austria	430	470	510
Italy	440	480	510
Spain	400	430	470
Portugal	390	420	450

Car ownership in larger countries with high car density

It may be concluded that for any country in this group the number of cars per 1000 persons (Z_t) is in one way or another related to income per capita (Y_t), autonomous movements, such as diffusion, represented by time (t) and a saturation level S .

$$Z_t = f(Y_t, t, S) \quad (2.1)$$

This function should follow the path of the logistic function, the cumulative normal distribution function or the cumulative lognormal distribution function. As it is very hard to distinguish between these functions, on the basis of available data, the logistic function has been chosen because it is easy to handle.

A possible specification is

$$Z_t = \frac{S}{1 + \alpha_1 e^{-\alpha_2 Y_t - \alpha_3 t}} \quad (2.2)$$

There are at least two objections against (2.2): During most of the sample period income per capita is strongly linearly correlated with time. Therefore multicollinearity creates a lot of estimation problems and a simple logistic function of time might serve as well. However, because of its shape the simple logistic function needs to be abolished in case of car ownership. Secondly, Y_t and t must have their major impact at different points in time. This can only be realized if two separate logistic functions for income and time act as explanatory components

$$Z_t = \frac{S^Y}{1 + \alpha_1 e^{-\alpha_2 Y_t}} + \frac{S^t}{1 + \alpha_1 e^{-\alpha_4 t}} \quad (2.3)$$

under the constraint that $S = S^Y + S^t$. This may be written as $S^Y = \gamma S$ and $S^t = (1-\gamma)S$.

Car ownership in other countries

The countries described in the previous sub-section represented 85 % of world car park in 1977. The remaining 15 % was distributed as follows

Other America	5.5 %
Other Asia, Africa + Oceania	4.0 %
Other Europe	5.5 %.

It is impossible to do a similar elaborated analysis for several reasons:

- quality of the data;
- length of time series;
- less systematic development.

Besides, the contribution of the countries, focussed upon here does not require as detailed an analysis as the countries studied in the previous sub-section.

Many types of equations have been used to analyze developments in the number of cars in use per 1000 persons over time. We shall refrain from giving details on all estimation results and confine ourselves to indicating which specification proved to be useful. The following specifications were applicable in at least one case

$$Z_t = \alpha_1 + \alpha_2 Y_t \quad (2.4a)$$

$$Z_t = \alpha_1 + \alpha_2 t + \alpha_3 Y_t \quad (2.4b)$$

$$\ln Z_t = \alpha_1 + \alpha_2 \ln Y_t \quad (2.4c)$$

$$\ln Z_t = \alpha_1 + \alpha_2 t + \alpha_3 \ln Y_t \quad (2.4d)$$

$$Z_t = \alpha_1 - \alpha_2 e^{-\alpha_3 Y_t} \quad (2.4e)$$

where again Z_t = cars in use per 1000 persons

Y_t = income per capita.

Projections of passenger cars in use

In Appendix A scenarios G1, G2 and G3 for GDP have been detailed and above scenarios for saturation levels S1, S2 and S3 were described. Together with one scenario for population projections, the basis has been laid for projections of passenger cars in use. The energy aspect however - E-scenarios - still has to be fitted in. The three GDP growth scenarios have already taken energy aspects into account, in the sense that E1 does not allow for more growth than G1, or possibly G2, whilst E2 would allow for higher growth rates, i.e. G2 or G3. The energy situation may also affect the saturation level.

The scenarios for GDP growth and saturation level can now be combined via assumptions about the E-scenarios. Although in theory, with G-, E- and S-scenarios $3 \times 2 \times 3 = 18$ combinations all feasible, their interrelationship makes some of these combinations practically impossible, as is shown in table 2.2.

Table 2.2. Relationship between G-, E- and S-scenarios

scenario for		saturation levels			scenario	combination of		
		S1	S2	S3				
growth	G1	E1	-	-	a	G1	E1	S1
in	G2	E1	E2	-	b	G2	E1	S1
GDP	G3	-	E2	E2	c	G2	E2	S2
					d	G3	E2	S2
					e	G3	E2	S3

The first combination: G1, E1 and S1 is called the standard scenario. Projections for passenger cars per 1000 persons for the standard scenario are summarized in table 2.3.

Projections for total cars in use for all 5 scenarios on a world level are shown in table 2.5, while regional projections for the standard scenario are given in table 2.4.

Table 2.3 Projections of passenger cars per 1.000 persons, standard scenario.

	<u>1985</u>	<u>1990</u>	<u>1995</u>	<u>2000</u>
I. North America	537.1	545.4	562.2	572.5
II. Asia, developed	246.1	294.3	315.7	319.5
III. Oceania, developed	446.4	501.8	553.4	584.9
IV. North-West Europe	350.5	370.1	382.1	389.9
V. South-West Europe	181.5	195.0	205.3	211.0
VI. Eastern Europe	37.6	45.4	55.1	65.0
VII. Latin America + Caribbean	49.9	58.6	71.1	85.2
IX. South Asia	2.3	2.8	3.4	4.1
X. South-East + East Asia	12.8	18.1	26.4	38.7
XI. Middle East + North Africa	36.0	39.0	42.9	46.6
XII. Other Africa	13.2	14.7	16.2	17.6

Table 2.4 Projections of passenger cars in use, standard scenario.
(in thousands)

	<u>1985</u>	<u>1990</u>	<u>1995</u>	<u>2000</u>
I. North America	138,388.8	146,376.5	155,649.1	162,784.3
II. Asia, developed	29,708.5	36,252.7	39,537.4	40,645.7
III. Oceania, developed	8,254.5	9,612.3	10,894.9	11,776.0
IV. North-West Europe	82,466.4	87,521.8	90,701.0	92,697.7
V. South-West Europe	35,084.9	39,927.3	44,361.6	47,841.5
VI. Eastern Europe	14,825.8	18,581.9	23,234.2	28,221.6
VII. Latin America + Caribbean	20,778.4	27,951.9	38,380.4	51,786.6
IX. South Asia	2,252.9	3,050.8	4,074.0	5,263.7
X. South-East + East Asia	4,721.3	7,402.7	11,772.5	18,614.7
XI. Middle-East + North Africa	6,121.5	7,539.2	9,316.4	11,251.0
XII. Other Africa	5,668.3	7,341.4	9,439.0	11,961.9
World, excl. Asian Centrally Planned Economies	348,271.1	391,558.3	437,360.5	482,844.7

Table 2.5 Projections of total passenger cars in use, 5 scenarios.
(in thousands)

World, excl. Asian	a	348,271	391,558	437,361	482,845
Centrally Planned	b	357,862	417,578	478,929	548,709
Economies	c	361,244	429,445	499,789	573,863
	d	369,394	450,663	532,829	632,387
	e	372,657	463,348	554,368	658,122

Chapter 3. THE COMMERCIAL VEHICLE MARKET: COMMERCIAL VEHICLES IN USE

The important variables are:

- commercial vehicles in use : X_1
- road transport in ton-kilometer : X_2
- average capacity of vehicles : X_3
- average degree of capacity utilization : X_4
- average distance : X_5

The relation between these given variables is:

$$X_2 = X_1 \cdot X_3 \cdot X_4 \cdot X_5$$

So, ideally X_1 should be explained by

$$X_1 = \frac{X_2}{X_3 \cdot X_4 \cdot X_5}$$

It is argued that the elements of the denominator of this relationship do not seem to fluctuate much over time and their changes might even cancel out, these variables have not been used.

On the other hand, road transport is clearly related to the volume of over-all production, in this case represented by GDP. Taking all these aspects into account it has been decided to relate the number of vehicles in use directly to GDP, possibly via a partial adjustment model.

Using the GDP scenarios from appendix A, projections are derived. Results for the three scenarios are presented in table 3.1.

Table 3.1 Projections of commercial vehicles in use (in thousands), for 3 economic scenarios.

	<u>scenario</u>	<u>1985</u>	<u>1990</u>	<u>1995</u>	<u>2000</u>
I. North America	G1	36,344	40,354	44,716	47,968
	G2	39,261	47,757	57,711	67,390
	G3	41,298	53,233	67,891	83,524
II. Asia, developed	G1	17,866	23,004	29,407	36,430
	G2	18,785	26,155	36,017	47,996
	G3	19,628	28,739	41,517	57,995
III. Oceania, developed	G1	1,770	1,923	2,114	2,309
	G2	1,810	2,082	2,453	2,886
	G3	1,847	2,214	2,735	3,380
IV. North-West Europe	G1	8,871	9,893	11,099	12,264
	G2	9,174	10,861	13,002	15,356
	G3	9,433	11,646	14,568	18,004
V. South-West Europe	G1	4,325	4,855	5,482	6,083
	G2	4,493	5,416	6,595	7,887
	G3	4,645	5,881	7,522	9,443
VI. Eastern Europe	G1	8,389	9,459	10,635	11,851
	G2	8,484	9,777	11,287	12,969
	G3	8,571	10,038	11,830	13,936
VII. Latin America + Caribbean	G1	6,191	7,403	8,975	10,797
	G2	6,372	8,082	10,466	13,469
	G3	6,533	8,644	11,702	15,760
IX. South Asia	G1	1,473	1,872	2,395	3,009
	G2	1,530	2,078	2,846	3,837
	G3	1,583	2,247	3,222	4,551
X. South East + East Asia	G1	2,465	3,393	4,662	6,245
	G2	2,577	3,811	5,617	8,073
	G3	2,679	4,152	6,410	9,647
XI. Middle East + North Africa	G1	2,865	4,068	5,620	7,408
	G2	3,055	4,737	7,059	9,998
	G3	3,219	5,272	8,240	12,214
XII. Other Africa	G1	2,239	2,536	2,870	3,144
	G2	2,386	2,978	3,685	4,399
	G3	2,521	3,342	4,366	5,490
World, excl. Asian Centrally Planned Economies	G1	92,798	108,759	127,975	147,506
	G2	97,925	123,734	156,738	194,260
	G3	101,956	135,408	180,003	233,944

Chapter 4. DISCARDS AND NEW REGISTRATIONS

Discards and new registration of passenger cars and commercial vehicles are essential elements in the process of deriving total demand for rubber. New registrations is supposed to equal discards plus increase in vehicles in use. Having derived vehicles in use in chapters 2 and 3, discards is analyzed in chapter 4.

Discards is related through a probability distribution of vehicle life to new registrations in the past. A complicating factor is that average life should rather not be assumed constant over time. Therefore a method has been developed to estimate average life for each year in the sample period and further to project discards on the basis of projections of average life. Again scenarios have been developed for passenger cars as presented in table 4.1, whereas projected average life of commercial vehicles has been assumed constant at the levels shown in table 4.2. Projections of discards and new registrations of passenger cars and commercial vehicles for the standard scenario only and assuming constant average life are given in tables 4.3 to 4.6. Other scenarios will be included in a later stage.

Table 4.1 Scenarios for projected average life for passenger cars

		<u>1980</u>	<u>1985</u>	<u>1990</u>	<u>1995</u>	<u>2000</u>
1. United States	D1	12.0	12.0	12.0	12.0	12.0
	D2	12.0	12.1	12.2	12.3	12.4
	D3	12.0	11.8	11.6	11.4	11.2
2. Canada	D1	11.7	11.7	11.7	11.7	11.7
	D2	11.7	11.8	11.9	12.0	12.1
	D3	11.7	11.5	11.3	11.1	10.9
3. Japan	D1	8.8	8.8	8.8	8.8	8.8
	D2	8.8	9.0	9.2	9.4	9.6
	D3	8.8	8.7	8.6	8.5	8.4
4-5. Australia + New Zealand	D1	13.6	13.6	13.6	13.6	13.6
	D2	13.6	13.6	13.6	13.6	13.6
	D3	13.6	13.4	13.2	13.0	12.8
6. Germany, F.R.	D1	9.6	9.6	9.6	9.6	9.6
	D2	9.6	9.8	10.0	10.2	10.4
	D3	9.6	9.4	9.2	9.0	8.8
7. France	D1	10.2	10.2	10.2	10.2	10.2
	D2	10.2	10.4	10.6	10.8	11.0
	D3	10.2	10.0	9.8	9.6	9.4
8. United Kingdom	D1	10.1	10.1	10.1	10.1	10.1
	D2	10.1	10.3	10.5	10.7	10.9
	D3	10.1	9.9	9.7	9.5	9.3
9-14. N.W. Europe	D1	8.9	8.9	8.9	8.9	8.9
	D2	8.9	9.1	9.3	9.5	9.7
	D3	8.9	8.8	8.7	8.6	8.5
15-18. N.W. Europe	D1	11.1	11.1	11.1	11.1	11.1
	D2	11.1	11.3	11.5	11.7	11.9
	D3	11.1	10.9	10.7	10.5	10.3
19. Italy	D1	13.0	13.0	13.0	13.0	13.0
	D2	13.0	13.1	13.2	13.3	13.4
	D3	13.0	12.8	12.6	12.4	12.2
20-25. S. Europe	D1	13.6	13.6	13.6	13.6	13.6
	D2	13.6	13.6	13.6	13.6	13.6
	D3	13.6	13.4	13.2	13.0	12.8
26-32. E. Europe	D1	13.6	13.6	13.6	13.6	13.6
	D2	13.6	13.6	13.6	13.6	13.6
	D3	13.6	13.4	13.2	13.0	12.8
33-36. Latin America	D1	14.0	14.0	14.0	14.0	14.0
	D2	14.0	14.0	14.0	14.0	14.0
	D3	14.0	13.8	13.6	13.4	13.2

Table 4.1 (continued)

		<u>1980</u>	<u>1985</u>	<u>1990</u>	<u>1995</u>	<u>2000</u>
39-43. S. Asia	D1	15.0	15.0	15.0	15.0	15.0
	D2	15.0	15.0	15.0	15.0	15.0
	D3	15.0	14.8	14.6	14.4	14.2
44-52. E. + S.E. Asia	D1	14.0	14.0	14.0	14.0	14.0
	D2	14.0	14.0	14.0	14.0	14.0
	D3	14.0	13.8	13.6	13.4	13.2
53-54. Middle East + N. Africa (oil)	D1	12.0	12.0	12.0	12.0	12.0
	D2	12.0	12.2	12.4	12.6	12.8
	D3	12.0	11.8	11.6	11.4	11.2
55-58. Other M.E. + Africa	D1	14.0	14.0	14.0	14.0	14.0
	D2	14.0	14.0	14.0	14.0	14.0
	D3	14.0	13.8	13.6	13.4	13.2

Table 4.2 Projected average life of commercial vehicles

	<u>Years</u>
1. United States	12.4
2. Canada	9.9
3. Japan	12.3
4-5. Australia + New Zealand	12.8
6. Germany, F.R.	10.6
7. France	7.0
8. United Kingdom	7.3
9-14. N.W. Europe I	9.8
15-18. N.W. Europe II ^{*)}	10.5
19. Italy	12.3
20-58. Other regions ^{*)}	12.5

^{*)} assumed.

Table 4.3 Projections of discards of passenger cars (in thousands)

		<u>1985</u>	<u>1990</u>	<u>1995</u>	<u>2000</u>
I.	North America	10781.1	11519.8	11939.6	12668.1
II.	Asia, developed	2667.6	3655.0	4297.4	4692.9
III.	Oceania, developed	529.6	577.1	692.7	799.8
IV.	North-West Europe	6828.8	7685.7	7969.4	8376.8
V.	South-West Europe	2136.2	2414.6	2777.0	3132.1
VI.	Eastern Europe	1032.1	1250.8	1368.5	1805.5
VII.	Latin America + Caribbean	976.3	1320.6	1591.4	2260.3
IX.	South Asia	108.5	131.9	185.4	244.5
X.	South-East + East Asia	167.1	265.7	407.6	651.4
XI.	Middle-East + North Africa	278.6	326.1	341.2	462.7
XII.	Other Africa	334.6	433.6	591.4	772.1

Table 4.4 Projections of new registrations of passenger cars (in thousands)

	<u>1985</u>	<u>1990</u>	<u>1995</u>	<u>2000</u>
I. North America	11444.5	13532.0	13735.6	13922.4
II. Asia, developed	3984.6	4799.4	4694.5	4855.2
III. Oceania, developed	771.0	855.7	929.3	943.7
IV. North-West Europe	8035.2	8533.9	8520.4	8714.9
V. South-West Europe	3004.0	3382.2	3613.0	3791.9
VI. Eastern Europe	1606.8	2066.3	2379.2	2880.6
VII. Latin America + Caribbean	1969.9	2961.5	3997.1	5337.6
IX. South Asia	235.8	307.8	410.9	504.5
X. South-East + East Asia	548.5	912.3	1465.5	2302.7
XI. Middle-East + North Africa	390.8	499.4	560.8	689.0
XII. Other Africa	717.4	931.2	1216.0	1512.3

Table 4.5 Projections of discards of commercial vehicles (in thousands)

	<u>1985</u>	<u>1990</u>	<u>1995</u>	<u>2000</u>
I. North America	2747.1	3057.8	2921.8	3487.0
II. Asia, developed	1031.8	1305.6	1682.2	2137.6
III. Oceania, developed	115.8	133.8	136.4	151.2
IV. North-West Europe	904.0	1004.2	1121.5	1258.4
V. South-West Europe	271.3	325.7	343.0	400.0
VI. Eastern Europe	713.0	782.6	841.4	956.0
VII. Latin America + Caribbean	373.6	441.0	511.8	641.0
IX. South Asia	49.2	88.1	105.5	146.3
X. South-East + East Asia	133.1	194.2	235.2	343.5
XI. Middle-East + North Africa	83.5	105.6	100.7	131.6
XII. Other Africa	175.8	249.3	338.1	458.8

Table 4.6 Projections of new registrations of commercial vehicles (in thousands)

	<u>1985</u>	<u>1990</u>	<u>1995</u>	<u>2000</u>
I. North America	3056.0	3888.0	3822.8	4147.3
II. Asia, developed	1834.5	2425.6	3077.9	3654.3
III. Oceania, developed	141.3	167.5	177.6	190.9
IV. North-West Europe	1050.5	1224.7	1376.9	1498.0
V. South-West Europe	360.5	440.0	476.0	522.5
VI. Eastern Europe	906.2	1004.4	1086.4	1208.6
VII. Latin America + Caribbean	562.8	711.9	857.2	1031.8
IX. South Asia	111.1	176.8	221.4	281.6
X. South-East + East Asia	275.1	403.7	521.5	698.0
XI. Middle-East + North Africa	114.2	148.4	152.1	183.7
XII. Other Africa	371.1	529.6	699.0	855.3

Chapter 5. DEMAND FOR TIRES FOR PASSENGER CARS AND COMMERCIAL VEHICLES

5.1 Introduction

In chapters 2, 3 and 4 projections were derived of the number of vehicles in use, new registrations and discards of vehicles both for passenger cars and commercial vehicles. This detailed analysis of the basic indicators of the size and the growth of the vehicle park was necessary in order to determine the demand for tires in the country where the tire is used and not where it is produced for obvious reasons. As has been pointed out previously, new registrations of vehicles can be used as the variable determining the demand for tires for original equipment. The demand for tires for tire replacement purposes, however, is determined by vehicles in use minus that year's discards.

After some background information about properties of and types of tires (section 5.2), the method of deriving demand for tires will be presented: original equipment (OE) tires in section 5.3 and replacement (RP) tires in section 5.4. The relationships referred to in this chapter are illustrated in figure 5.1.

5.2 Types and properties of tires

5.2.1 Conventional versus radial tires

The past two decades have shown dramatic changes on the tire scene. In the early sixties virtually the only types of tire were the cross-ply tires. At that time the radial tire started conquering the market in Europe. First there was the textile radial tire; more recently the steel radial has become increasingly important. In the USA meanwhile the bias belted tire had become popular, both with glass and steel belts. In Japan, the move to radial obtained momentum in the seventies as well. Some historic data are shown in table 5.1.

Advantages of using radial tires

Which are the advantages of the radial tire compared to the conventional cross-ply or bias-ply tire? The most important aspect is tire distance defined as the number of kilometers over which the (set of) tires can last from the start until replacement. Radial tire distance will reach some 50 % - 100 % more than conventional tires, while bias belted tires are somewhere in between.

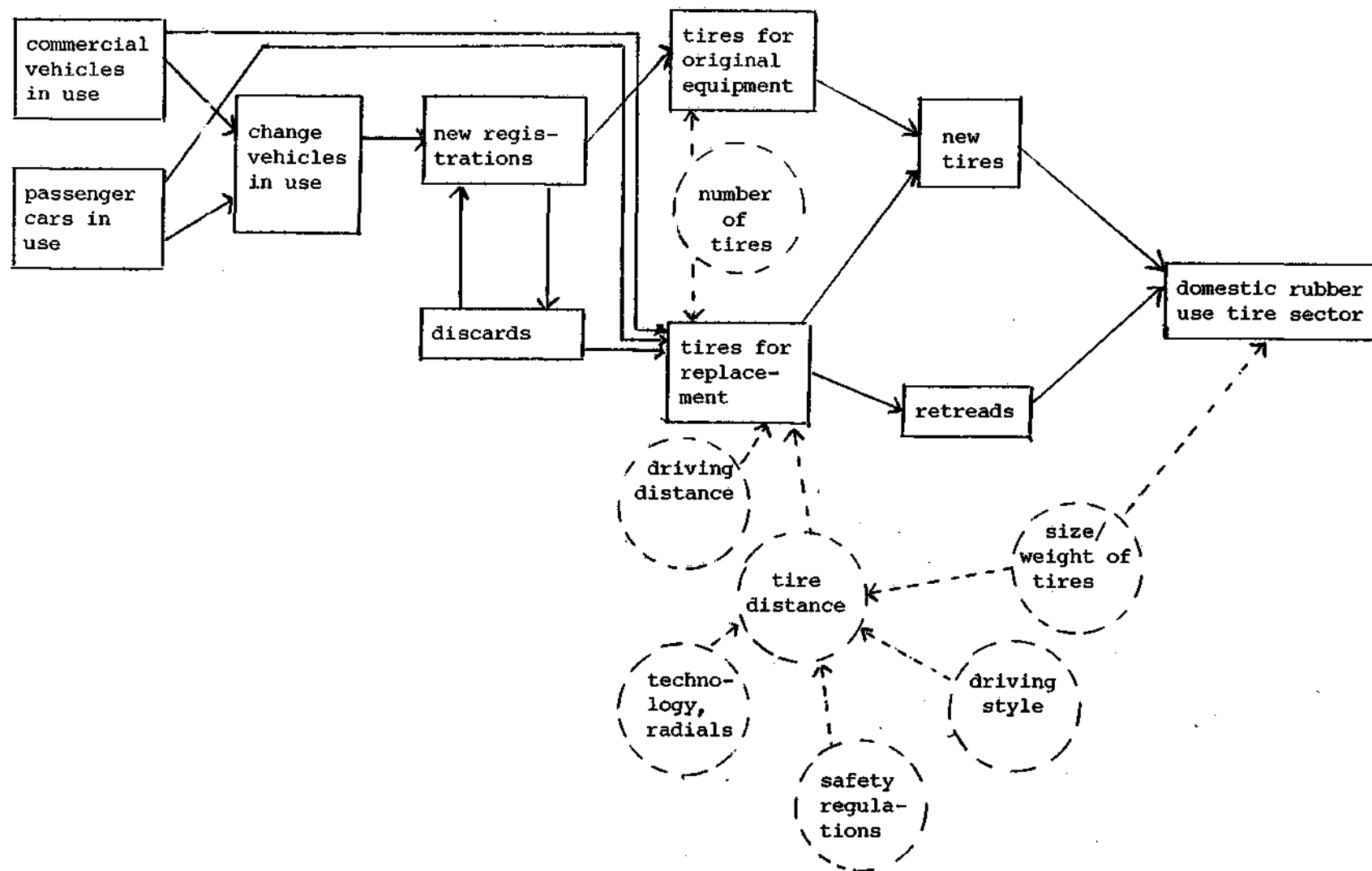


Figure 5.1 Relationships concerning rubber use in the tire sector.

Table 5.1 Percentage share of radial tires in tire market

<u>Countries</u>			<u>1965</u>	<u>1970</u>	<u>1975</u>
U.S.A. ^{a)}	pass.cars	O.E.	0	1.2	64.5
		R.P.	0.3	3.5	30.4
	com. veh.	O.E.	0	10.0	35.0
Japan ^{b)}	pass.cars	Total	0	11.8	45.1
W. Germany ^{c)}	pass.cars	R.P.	0	45.0	82.0
	light c.v.	R.P.	0	32.0	79.0
	heavy c.v.	R.P.	0	36.0	72.0
France ^{d)}	pass.cars	Total	70.0	80.0	100.0
	com. veh.	Total	70.0	90.0	100.0
U.K. ^{e)}	pass.cars	O.E.	0	34.2	90.5
		R.P.	0	36.9	64.0
	com. veh.	Total	10.0	35.0	70.0
Benelux ^{d)}	pass.cars	Total	40.0	50.0	80.0
	com. veh.	Total	30.0	45.0	80.0
Italy ^{d)}	pass.cars	Total	35.0	50.0	90.0
	com. veh.	Total	25.0	50.0	85.0
Spain ^{d)}	pass.cars	Total	30.0	60.0	90.0
	com. veh.	Total	30.0	55.0	80.0

Notes: a) USA-industry: auto tire sales.
b) Japan Automobile Tire Manufacturer Association
c) Rubber Trends, March 1976.
d) Euro-economics.
e) Rubber Statistical Bulletin

O.E. = original equipment
R.P. = replacement

The availability of bias belted tires in the USA and their higher tire distance was one of the reasons behind postponement of penetration of the radial tire.

Further advantages of radial tires are in the area of cooler running, better tread wear and better road holding under most conditions. One of the most important factors is better rolling resistance, thus reducing energy consumption for driving. For further information see Vila (1972), Botasso (1980), Buckler et al. (1980), Kaneko (1980), Kovac and Ambelang (1980) and Alexander (1981).

One of the consequences of the increase in tire distance is reduction in material consumption over the same kilometrage. Many studies (e.g. by Botasso (1980) show a considerable reduction in elastomer consumption per kilometer for radials compared to conventional tires.

Elastomer weight of tires

It is very hard to arrive at an estimate of such an indicator as the average passenger car tire weight. The most important factor is the size of the car. This, in turn, is influenced by a shift in some countries to smaller cars for the purpose of fuel conservation. The composition of the car park may therefore change considerably over time. Besides, there is no fixed proportionality between the weight of the tire and its elastomer weight. In a paper by the Secretariat of the International Rubber Study Group (1980), the elastomer weight was fixed at 5 kg per tire for reasons of simplifying calculations. For many European countries elastomer weights per tire may be some 20 % lower and for the USA they may be about 10 % higher. Besides, the elastomer weight in a radial tire for the same car may be some 10 % - 20 % more than that of a cross-ply tire. For commercial vehicles, data on elastomer weights per tire are even more difficult to arrive at. The major reason is the huge spread in commercial vehicle size and thus in tire size. Average may be around 20 kg per tire. More attention to the subject of the elastomer weight per tire will be paid in Chapter 6.

Elastomer composition

A further impact of the switch from conventional to radial tires is the composition of the rubber content: the content of natural rubber (NR) and polyisoprene rubber (IR) increases dramatically at the cost of styrene butadiene rubber (SBR). This applies both to passenger car and to truck tires. NR is used in the sidewalls of the tires and is required for technical

purposes particularly in the area of obtaining complete adhesion at the interface of the steelcord and the rubber parts, in view of the big stress concentration that can develop there (cf. Buckler et al. (1980), Botasso (1980), Kaneko (1980)).

One of the targets which may receive further priority in the years ahead is lowering rolling resistance with the effect of reducing fuel consumption. In this respect NR has an advantage thus creating opportunities for NR to take an even larger share of the rubber content of passenger car tires (cf. Botasso (1980)).

5.2.2 Tire distance and replacement

How long does a car tire last? It is impossible to answer this question because tire distance depends on a huge variety of factors such as

- the type of tire: cross-ply, bias-belted, textile radial, steel radial
- tubeless radial tires which last longer than tubed radial tires
- the size of the tire c.q. the size of the car on the commercial vehicle
- front wheel drive which reduces tire distance with some 20 %
- heavy loads reduce tire life
- road quality
- traffic conditions
- speed limits
- driving style
- safety regulations.

It will be clear that only an estimate of average life can be derived which will change over time, and which ought to be disaggregated between conventional and radial tires. Some estimates have been made in a recent article by Allen (1980). He arrives at estimates of radial-ply tire distance of 46,000 km for the United Kingdom, 50,000 km for West Germany and 56,000 km for the USA. This is roughly twice the tire distance of conventional tires. A shift from textile radials to steelcord reinforced radials may provide another increase in tire distance of about 6,000 km. In section 5.4 our own analysis will be presented.

A worn-out tire may be scrapped. However, disposition of used tires creates increasingly serious environmental problems. Some alternative uses of scrapped tires, either whole or shredded are possible (cf. OECD (1980)) e.g. landfill, floating breakwater and artificial reefs, erosion control and marginal land

improvement, rubber crumb for construction purposes. Reclaimed rubber from scrapped tires virtually cannot be used for new tire production, owing to technological considerations.

If the worn-out tire is not damaged the tread may be replaced (retreaded, remoulded, recovered). Thus, a reduction in usage of commodities and energy is attained. Retreading the same carcass can only be done a few times. A prerequisite is that the old tread has not fully disappeared. There may be technical difficulties in retreading tires, especially lower quality tires. Although technical improvements have been considerable over the past decades, there is still concern by users about safety of tires after retreading. Another impediment to further penetration of retreaded tires is the prices of certain qualities of new tires, compared to retreaded tires, particularly in case of imports of very cheap tires in some countries. A retreaded tire will have about the same tire distance as a new tire (75 % - 100 %).

In case of truck tires with a thick tread, it may be possible to apply the technique of regrooving: an extra 2-3 mm is cut out after part of the tread has disappeared. This may extend tire distance by another 50 % - 100 %.

5.3 Tires for original equipment

Passenger cars

First, passenger car tires will be discussed. Nobody will question the statement that over 99.9 per cent of passenger cars nowadays are driving around on four wheels, and it does not seem likely that this will change in the near future. What is of major importance is the presence of the spare tire, which means that virtually all new cars are equipped with five tires. However, newly developed tires (so-called safety tires or run-flat tires) scheduled to be introduced in the near future may have an impact on this variable because of their ability to cover a considerable distance after puncture. Owing to the chemical composition of these tires, little or no manoeuvrability is lost after puncture and this enormously reduces the danger of accident after puncture. The share of this new system of tires will increase over time depending on the country. This phenomenon will reduce the average number of tires per new passenger car. It is assumed that this trend will develop along the lines shown in table 5.2 and this development has been included in our projections.

Table 5.2 Average number of tires per new passenger car

	<u>1980</u>	<u>1985</u>	<u>1990</u>	<u>1995</u>	<u>2000</u>
1 United States	5	5	4.9	4.8	4.8
2 Canada	5	5	4.9	4.9	4.8
3 Japan	5	5	4.9	4.8	4.7
4-5 Australia and New Zealand	5	5	5	5	4.9
6 Germany, Fed.Rep. of	5	5	4.9	4.8	4.7
7 France	5	5	4.9	4.8	4.7
8 United Kingdom	5	5	4.9	4.8	4.7
9-14 North-West Europe I	5	5	4.9	4.8	4.7
15-18 North-West Europe II	5	5	4.9	4.8	4.7
19 Italy	5	5	5	4.9	4.8
20-25 Southern Europe	5	5	5	5	4.9
26-32 Eastern Europe	5	5	5	5	5
33-58 Rest of the world	5	5	5	5	5

An alternative possibility, and perhaps prior to the elimination of the spare tire, may be the introduction of the light replacement tire, the "space saver" tire, which provides a "get you home" service. These developments have not been explicitly included in this analysis.

Projections of new registrations have been derived in chapter 4:five scenario combinations of economic growth and saturation in car park for passenger cars. They have been the basis for the need for original equipment tires disaggregated into conventional tires and radial tires because, as mentioned before, radial tires are heavier and use more than conventional tires and because the share of NR in the elastomer content of radials is far higher. Projections of the share of radials, based on the data in table 5.1, are presented in table 5.3. Multiplying projections of tires for original equipment with the shares of conventional tires and radials gives the component projections for conventional tires and radial tires, presented in table 5.4.

Commercial vehicles

For commercial vehicles it is extremely difficult to obtain adequate statistical information on the number of tires per vehicle. The main determinant is the average size. Table 5.5 shows that for some European countries the share of bigger commercial vehicles in use has been increasing except for Italy. The dominant role of big commercial vehicles is intensified by the fact that the life of small commercial vehicles is shorter than the life of big commercial vehicles. As to United States factory sales, shares

Table 5.3 Projections of percentage share of radial tires

		1980	1985	1990	1995	2000
1	United States					
	Pass. car: o.e.	80	90	95	100	100
	: Rep.	55	80	95	100	100
	Com. veh.: Total	60	80	95	100	100
2	Canada					
	Pass. car: o.e.	80	90	95	100	100
	: Rep.	60	80	95	100	100
	Com. veh.: Total	60	80	95	100	100
3	Japan					
	Pass. car: Total	65	85	95	100	100
	Com. veh.: Total	55	75	90	95	100
4-5	Australia and New Zealand					
	Pass. car: Total	60	80	95	100	100
	Com. veh.: Total	50	70	90	95	100
6	Germany, F.R.					
	Pass. car: Total	90	95	100	100	100
	Com. veh.: Total	85	95	100	100	100
7	France					
	Pass. car: Total	100	100	100	100	100
	Com. veh.: Total	100	100	100	100	100
8	United Kingdom					
	Pass. car: o.e.	100	100	100	100	100
	: Rep.	85	95	100	100	100
	Com. veh.: Total	85	95	100	100	100
9-14	North-West Europe I					
	Pass. car: Total	90	95	100	100	100
	Com. veh.: Total	90	95	100	100	100
15-18	North-West Europe II					
	Pass. car: Total	90	95	100	100	100
	Com. veh.: Total	90	95	100	100	100
19	Italy					
	Pass. car: Total	95	100	100	100	100
	Com. veh.: Total	90	95	100	100	100
20-25	Southern Europe					
	Pass. car: Total	85	95	100	100	100
	Com. veh.: Total	70	85	95	100	100
26-32	Eastern Europe					
	Pass. car: Total	40	60	80	90	95
	Com. veh.: Total	30	50	70	85	95
33-36	Latin America					
	Pass. car: Total	40	60	80	90	95
	Com. veh.: Total	30	50	70	85	95
39-43	S. Asia					
	Pass. car: Total	20	40	60	70	80
	Com. veh.: Total	20	40	60	70	80
44-52	E. + S.E. Asia					
	Pass. car: Total	50	70	90	95	100
	Com. veh.: Total	40	60	80	90	95
53-54	M.E. + N.Africa					
	Pass. car: Total	50	70	90	95	100
	Com. veh.: Total	40	60	80	90	95
55-58	Other M.E. + Africa					
	Pass. car: Total	20	40	60	70	80
	Com. veh.: Total	20	40	60	70	80

Table 5.4 Projections of demand for original equipment tires
(in thousands) for passenger cars

	code	scenario	1985	1990	1995	2000
I. North America						
C	a		5722.	3315.	0.	0.
	b		6304.	3509.	0.	0.
	c		6406.	3770.	0.	0.
	d		6083.	3823.	0.	0.
	e		7015.	4121.	0.	0.
R	a		51500.	62991.	66060.	66828.
	b		56738.	66668.	68197.	69946.
	c		57658.	71633.	73172.	74942.
	d		61951.	72644.	72774.	75793.
	e		63131.	78301.	78363.	81210.
T	a		57222.	66307.	66060.	66828.
	b		63042.	70177.	68197.	69946.
	c		64064.	75403.	73172.	74942.
	d		68834.	76467.	72774.	75793.
	e		70146.	82422.	78363.	81210.
II. Asia, developed						
C	a		2988.	1176.	0.	0.
	b		3225.	1174.	0.	0.
	c		3197.	1320.	0.	0.
	d		1434.	1303.	0.	0.
	e		3568.	1438.	0.	0.
R	a		16935.	22341.	22534.	22819.
	b		18277.	22308.	22710.	22719.
	c		18117.	25075.	24609.	25076.
	d		19460.	24753.	24873.	24915.
	e		20218.	27323.	26806.	27117.
T	a		19923.	23517.	22534.	22819.
	b		21503.	23482.	22710.	22718.
	c		21314.	26394.	24609.	25076.
	d		22895.	26056.	24873.	24915.
	e		23786.	28762.	26806.	27117.
III. Oceania, developed						
C	a		771.	214.	0.	0.
	b		843.	239.	0.	0.
	c		849.	257.	0.	0.
	d		920.	274.	0.	0.
	e		934.	296.	0.	0.
R	a		3084.	4065.	4647.	4624.
	b		3370.	4540.	4721.	4764.
	c		3305.	4884.	5240.	5157.
	d		3679.	5211.	5088.	5210.
	e		3736.	5616.	5544.	5546.
T	a		3855.	4279.	4647.	4624.
	b		4213.	4778.	4721.	4764.
	c		4243.	5141.	5240.	5157.
	d		4599.	5485.	5088.	5210.
	e		4670.	5912.	5544.	5546.

Table 5.4. (cont. 1)

	code	scenario	1985	1990	1995	2000
IV. North-West Europe	C	a	1209.	0.	0.	0.
		b	1256.	0.	0.	0.
		c	1358.	0.	0.	0.
		d	1414.	0.	0.	0.
		e	1527.	0.	0.	0.
	R	a	38967.	41816.	40898.	40960.
		b	40364.	42810.	42516.	42533.
		c	42278.	44780.	44943.	45274.
		d	43794.	45391.	46450.	46528.
		e	45998.	47421.	49070.	49431.
	T	a	40176.	41816.	40898.	40960.
		b	41621.	42810.	42516.	42533.
		c	43636.	44780.	44943.	45274.
		d	45208.	45391.	46450.	46528.
		e	47525.	47421.	49070.	49431.
V. South-West Europe	C	a	293.	0.	0.	0.
		b	322.	0.	0.	0.
		c	321.	0.	0.	0.
		d	351.	0.	0.	0.
		e	351.	0.	0.	0.
	R	a	14727.	16911.	17859.	18372.
		b	16134.	18650.	19735.	21572.
		c	16475.	19771.	20541.	22256.
		d	17947.	20943.	22362.	25937.
		e	18263.	21986.	22978.	26578.
	T	a	15020.	16911.	17859.	18372.
		b	16456.	18650.	19735.	21572.
		c	16796.	19771.	20541.	22256.
		d	18299.	20943.	22362.	25937.
		e	18614.	21986.	22978.	26578.
VI. Eastern Europe	C	a	3214.	2066.	1190.	706.
		b	3614.	2521.	1580.	1005.
		c	3614.	2521.	1580.	1005.
		d	4029.	2887.	1917.	1275.
		e	4029.	2887.	1917.	1275.
	R	a	4820.	8265.	10706.	13409.
		b	5421.	10085.	14218.	19091.
		c	5421.	10085.	14218.	19091.
		d	6044.	11549.	17256.	24230.
		e	6044.	11549.	17256.	24230.
	T	a	8034.	10332.	11896.	14115.
		b	9034.	12606.	15798.	20096.
		c	9034.	12606.	15798.	20096.
		d	10074.	14437.	19174.	25505.
		e	10074.	14437.	19174.	25505.

Table 5.4. (cont. 2).

		<u>code</u>	<u>scenario</u>	<u>1985</u>	<u>1990</u>	<u>1995</u>	<u>2000</u>
VII. Latin America + Caribbean	C	a		3938.	2962.	1999.	1334.
		b		4760.	4094.	3163.	2423.
		c		4760.	4094.	3163.	2423.
		d		5658.	5144.	4385.	3700.
		e		5658.	5144.	4385.	3700.
	R	a		5907.	11846.	17987.	25354.
		b		7139.	16375.	28463.	46040.
		c		7139.	16375.	28463.	46040.
		d		8487.	20575.	39463.	70303.
		e		8487.	20575.	39463.	70303.
	T	a		9845.	14808.	19986.	26688.
		b		11899.	20469.	31625.	48463.
		c		11899.	20469.	31625.	48463.
		d		14145.	25719.	43848.	74003.
		e		14145.	25719.	43848.	74003.
IX. South Asia	C	a		707.	616.	616.	504.
		b		783.	739.	779.	685.
		c		783.	739.	779.	685.
		d		861.	837.	919.	848.
		e		861.	837.	919.	848.
	R	a		472.	923.	1438.	2018.
		b		522.	1108.	1818.	2738.
		c		522.	1108.	1818.	2738.
		d		574.	1256.	2144.	3391.
		e		574.	1256.	2144.	3391.
	T	a		1179.	1539.	2055.	2523.
		b		1305.	1847.	2597.	3423.
		c		1305.	1847.	2597.	3423.
		d		1435.	2094.	3064.	4239.
		e		1435.	2094.	3064.	4239.
X. South-East + East Asia	C	a		823.	456.	366.	0.
		b		896.	535.	458.	0.
		c		896.	535.	458.	0.
		d		970.	599.	538.	0.
		e		970.	599.	538.	0.
	R	a		1920.	4105.	6961.	11514.
		b		2090.	4814.	8702.	15430.
		c		2090.	4814.	8702.	15430.
		d		2263.	5391.	10215.	19040.
		e		2263.	5391.	10215.	19040.
	T	a		2743.	4562.	7327.	11514.
		b		2986.	5349.	9159.	15430.
		c		2986.	5349.	9159.	15430.
		d		3234.	5991.	10753.	19040.
		e		3234.	5991.	10753.	19040.

Table 5.4 (cont. 3)

	code	scenario	1985	1990	1995	2000
XI. Middle East + North Africa	C	a	586.	250.	140.	0.
		b	682.	326.	209.	0.
		c	682.	326.	209.	0.
		d	757.	389.	271.	0.
		e	757.	389.	271.	0.
	R	a	1368.	2247.	2664.	3376.
		b	1591.	2932.	3967.	5495.
		c	1591.	2932.	3967.	5495.
		d	1766.	3499.	5142.	7591.
		e	1766.	3499.	5142.	7591.
	T	a	1954.	2497.	2804.	3376.
		b	2273.	3258.	4176.	5495.
		c	2273.	3258.	4176.	5495.
		d	2524.	3888.	5413.	7591.
		e	2524.	3888.	5413.	7591.
XII. Other Africa	C	a	2152.	1862.	1824.	1512.
		b	2254.	2014.	2003.	1698.
		c	2254.	2014.	2003.	1698.
		d	2350.	2131.	2158.	1865.
		e	2359.	2131.	2158.	1865.
	R	a	1435.	2794.	4256.	6049.
		b	1502.	3022.	4675.	6792.
		c	1502.	3022.	4675.	6792.
		d	1573.	3197.	5035.	7462.
		e	1573.	3197.	5035.	7462.
	T	a	3587.	4656.	6080.	7561.
		b	3756.	5036.	6678.	8489.
		c	3756.	5036.	6678.	8489.
		d	3932.	5328.	7193.	9327.
		e	3932.	5328.	7193.	9327.
World total (excl. Asian C CPE countries)	C	a	22404.	12917.	6135.	4057.
		b	24938.	15151.	8191.	5810.
		c	25119.	15576.	8191.	5810.
		d	27636.	17388.	10188.	7689.
		e	28029.	17842.	10188.	7689.
	R	a	141135.	178305.	196010.	215323.
		b	153148.	193312.	219720.	257118.
		c	156188.	204477.	230346.	268292.
		d	167539.	214408.	250804.	310399.
		e	172054.	226115.	262017.	321899.
	T	a	163538.	191222.	202145.	219380.
		b	178086.	208462.	227911.	262929.
		c	181307.	220053.	238537.	274102.
		d	195176.	231796.	260991.	318088.
		e	200083.	243957.	272204.	329587.

Notes: C = conventional tires
R = radial tires
T = total tires

Table 5.5 Percentage distribution of commercial vehicles in use; load capacity

Year	West Germany				France				Austria			
	less than 1,000 kg	less than 1,500 kg	less than 3,000 kg	less than 5,000 kg	less than 1,000 kg	less than 1,500 kg	less than 3,000 kg	less than 5,000 kg	less than 1,000 kg	less than 1,500 kg	less than 3,000 kg	less than 5,000 kg
1955	40.4	-	67.1	89.3	43.5	-	79.8	88.6	34.6	-	65.5	94.8
1960	38.1	-	68.2	86.7	47.4	-	82.6	88.6	36.4	-	60.8	87.6
1965	32.8	-	66.0	79.9	50.2	-	83.1	87.9	33.6	-	58.5	77.7
1970	-	43.1	65.9	79.6	-	68.6	-	74.0	-	48.7	61.1	74.6
1975	-	43.9	64.7	79.5	-	73.6	-	77.7	-	52.2	62.7	72.8

Year	Denmark				Italy			
	less than 1,000 kg	less than 1,500 kg	less than 3,000 kg	less than 5,000 kg	less than 1,000 kg	less than 1,500 kg	less than 3,000 kg	less than 5,000 kg
1955	56.2	-	74.0	91.7	54.1	-	81.5	91.9
1960	69.7	-	81.2	90.1	59.4	-	80.6	89.2
1965	69.3	-	83.9	88.7	39.2	-	78.8	87.7
1970	-	76.0	83.2	87.0	-	-	-	-
1975	-	70.8	82.6	86.4	-	-	-	-

Source: United Nations Annual Bulletin of Transport Statistics for Europe 1975-1953

of different size of vehicles did not change much over time. Ideally, commercial vehicles should be divided into groups according to size, especially since very small commercial vehicles normally use passenger car tires.

This has been attempted but the results are not very sound, the main bottle-neck being availability of data. Only the aggregate result is therefore presented. In consultation with experts and on the basis of several publications reasonable information has been obtained for some years and for some countries on the number of tires per commercial vehicle. It has been assumed (for want of different evidence) that commercial vehicle size, and therefore the number of tires per commercial vehicle, will not change on average over the foreseeable future. Thus, projections to the year 2000 on the number of tires per commercial vehicle have been derived (see table 5.6). By simply multiplying these data by the number of commercial vehicles newly registered as derived in chapter 4 for three economic scenarios, it is possible to make projections of the number of tires for original equipment (see table 5.7), divided into conventional and radial tires on the basis of table 5.3.

Table 5.6 Estimated number of tires per commercial vehicle.

<u>Countries</u>	<u>Year 1975 - 2000</u>
1 U.S.A.	8.0
2 Canada	8.0
3 Japan	6.0
4-5 Australia and New Zealand	8.0
6 West Germany	9.0
7 France	8.5
8 United Kingdom	8.0
9-14 North-West Europe I	8.5
15-18 North-West Europe II	8.0
19 Italy	8.0
20-25 Southern Europe	7.5
26-32 Eastern Europe	8.0
33-58 Rest of the world	6.0

Table 5.7 Projections of demand for original equipment tires
(in thousands) for commercial vehicles

		<u>code</u>	<u>scenario</u>	<u>1985</u>	<u>1990</u>	<u>1995</u>	<u>2000</u>
I. North America	C	G1		4890.	1555.	0.	0.
		G2		5746.	1995.	0.	0.
		G3		6628.	2335.	0.	0.
	R	G1		19558.	29549.	30582.	33178.
		G2		22982.	37911.	44102.	51287.
		G3		26514.	44363.	55236.	67370.
	T	G1		24448.	31104.	30582.	33178.
		G2		28728.	39906.	44102.	51287.
		G3		33142.	46698.	55236.	67370.
II. Asia, developed	C	G1		2752.	1455.	923.	0.
		G2		3108.	1794.	1219.	0.
		G3		3477.	2067.	1475.	0.
	R	G1		8255.	13098.	17544.	21926.
		G2		9325.	16145.	23169.	31331.
		G3		10431.	18599.	28018.	39820.
	T	G1		11007.	14554.	18467.	21926.
		G2		12433.	17939.	24389.	31331.
		G3		13909.	20665.	29493.	39820.
III. Oceania, developed	C	G1		339.	134.	71.	0.
		G2		371.	158.	90.	0.
		G3		402.	178.	107.	0.
	R	G1		791.	1206.	1350.	1527.
		G2		866.	1424.	1717.	2109.
		G3		939.	1598.	2029.	2630.
	T	G1		1130.	1340.	1421.	1527.
		G2		1237.	1582.	1807.	2109.
		G3		1341.	1776.	2136.	2630.
IV. North-West Europe	C	G1		280.	0.	0.	0.
		G2		301.	0.	0.	0.
		G3		322.	0.	0.	0.
	R	G1		8553.	10306.	11591.	12618.
		G2		9194.	11956.	14389.	16800.
		G3		9844.	13274.	16754.	20501.
	T	G1		8833.	10306.	11591.	12618.
		G2		9495.	11956.	14389.	16800.
		G3		10166.	13274.	16754.	20501.

Table 5.7 (cont. 1)

		<u>code</u>	<u>scenario</u>	<u>1985</u>	<u>1990</u>	<u>1995</u>	<u>2000</u>
V. South-West Europe	C	G1	311.	106.	0.	0.	
		G2	352.	130.	0.	0.	
		G3	393.	149.	0.	0.	
	R	G1	2459.	3272.	3662.	4021.	
		G2	2768.	3990.	4849.	5755.	
		G3	3078.	4568.	5871.	7318.	
	T	G1	2769.	3378.	3662.	4021.	
		G2	3119.	4120.	4849.	5755.	
		G3	3472.	4717.	5871.	7318.	
	VI. Eastern Europe	C	G1	2945.	1959.	1059.	393.
			G2	3023.	2066.	1152.	441.
			G3	3104.	2152.	1233.	485.
R		G1	2945.	4570.	6002.	7463.	
		G2	3023.	4820.	6531.	8385.	
		G3	3104.	5022.	6987.	9217.	
T		G1	5890.	6529.	7062.	7856.	
		G2	6046.	6886.	7683.	8826.	
		G3	6208.	7174.	8221.	9703.	
VII. Latin America + Caribbean	C	G1	1688.	1281.	771.	310.	
		G2	1851.	1513.	975.	420.	
		G3	2012.	1697.	1149.	519.	
	R	G1	1688.	2990.	4372.	5881.	
		G2	1851.	3529.	5526.	7981.	
		G3	2012.	3961.	6510.	9854.	
	T	G1	3377.	4271.	5143.	6191.	
		G2	3702.	5042.	6501.	8401.	
		G3	4025.	5658.	7658.	10372.	
IX. South Asia	C	G1	400.	424.	399.	338.	
		G2	454.	515.	525.	470.	
		G3	510.	588.	634.	605.	
	R	G1	267.	636.	930.	1352.	
		G2	303.	773.	1225.	1915.	
		G3	340.	882.	1479.	2422.	
	T	G1	667.	1061.	1328.	1690.	
		G2	757.	1288.	1750.	2394.	
		G3	851.	1470.	2113.	3027.	

Table 5.7 (cont. 2)

		<u>code</u>	<u>scenario</u>	<u>1985</u>	<u>1990</u>	<u>1995</u>	<u>2000</u>
X. South-East + East Asia	C	G1	660.	484.	313.	209.	
		G2	732.	580.	405.	290.	
		G3	806.	656.	485.	363.	
	R	G1	990.	1938.	2816.	3979.	
		G2	1098.	2318.	3649.	5515.	
		G3	1209.	2625.	4363.	6890.	
	T	G1	1651.	2422.	3129.	4188.	
		G2	1830.	2898.	4054.	5806.	
		G3	2015.	3281.	4847.	7252.	
XI. Middle East + North Africa	C	G1	274.	178.	91.	55.	
		G2	303.	210.	118.	75.	
		G3	324.	234.	140.	93.	
	R	G1	411.	712.	821.	1047.	
		G2	454.	839.	1062.	1434.	
		G3	487.	937.	1260.	1772.	
	T	G1	685.	890.	913.	1102.	
		G2	757.	1048.	1180.	1510.	
		G3	811.	1171.	1400.	1865.	
XII. Other Africa	C	G1	1336.	1271.	1258.	1026.	
		G2	1598.	1678.	1771.	1566.	
		G3	1869.	1994.	2213.	2048.	
	R	G1	891.	1907.	2936.	4105.	
		G2	1065.	2517.	4132.	6264.	
		G3	1246.	2991.	5163.	8192.	
	T	G1	2227.	3178.	4194.	5132.	
		G2	2663.	4196.	5902.	7830.	
		G3	3115.	4985.	7375.	10240.	
World total (excl. Asian CPE countries)	C	G1	15875.	8849.	4886.	2331.	
		G2	17839.	10638.	6257.	3272.	
		G3	19850.	12050.	7435.	4113.	
	R	G1	46809.	70185.	82606.	97098.	
		G2	52929.	86223.	110350.	138777.	
		G3	59205.	98819.	133671.	175987.	
	T	G1	62684.	79033.	87492.	99429.	
		G2	70767.	96862.	116606.	142049.	
		G3	79055.	110870.	141105.	180100.	

Notes: C = conventional tires
R = radial tires
T = total tires

5.4 Tires for replacement

5.4.1 Background information

Demand for replacement tires is determined by tire life which can be derived from tire distance divided by driving distance per year. One complicating factor, however, is the variation in driving distance as well as in tire distance within a country or a region. This is why in the analysis probability distributions have been applied in order to derive average tire distance from replacement tire demand on the one hand and vehicle park and driving distance on the other hand. Afterwards, for projection purposes, demand for replacement tires can be derived from projections about vehicle park, tire distance and driving distance. The analysis is presented below for the case of passenger cars. The model for commercial vehicles runs completely parallel to the model for passenger cars.

Driving distance

For some countries or regions, only scattered information on driving distance could be obtained. For many countries, however, the data base was more adequate. Analysing driving distance for passenger cars for some countries, it becomes clear that while there is some variation over time for all countries there is far greater variation among countries. This may be due partly to the method of data collecting. Some general conclusions for some developed countries can be drawn from regression analyses. It was found, first, that income has a very small positive influence on driving distance for most of the countries investigated. Second, the number of cars in use per 1,000 persons has a negative influence; this can be explained by the growing incidence of second and third cars in a family, by worsening traffic congestion and by the increasing number of cars used solely for holiday purposes. Third, gasoline prices, of course, show a negative coefficient; it can be assumed, however, that the estimated coefficient was too high because driving distance during 1974 was mainly influenced by temporarily extreme oil shortages, as well as the temporarily extreme reaction thereto, whereas gasoline price showed very little increased, if any.

Using the above factors projections have been made (see table 5.8). These show that for the United States and Canada the slightly declining trend will continue, becoming more pronounced in the middle of the 1980s. Japan has already experienced a steep decrease in driving distance; this is levelling off and we assume that the minimum will be reached at 8,000 km per year. Car density will become an extremely important factor for Western Europe and to a lesser extent for Oceania if it is regarded as proportional to country size and population density. Projections for Eastern Europe, being constant over time, may be as good as any other. Although traffic congestion is becoming more and more important in developing countries' major cities, it is not expected to become a more important factor than income increase for the next 10 years for Latin America and for the next 15 years for the other developing countries.

Table 5.8 Projected average driving distance per year (in 1000 km) per passenger car in use.

	<u>1980</u>	<u>1985</u>	<u>1990</u>	<u>1995</u>	<u>2000</u>
United States	15.0	14.5	14.0	13.0	12.0
Canada	15.0	14.5	14.0	13.0	12.0
Japan	8.5	8.1	8.0	8.0	8.0
Oceania	16.0	15.0	14.0	13.0	12.0
Western Europe	12.0	10.0	9.0	8.0	8.0
Eastern Europe	16.0	16.0	16.0	16.0	16.0
Latin America	20.0	20.0	19.0	18.0	17.0
Rest of the world	20.0	20.0	20.0	19.0	18.0

For commercial vehicles we expect increasing influence from other modes of transport such as container transport by train, particularly for developed countries. Driving distance is therefore projected to decrease slightly by 100 km per year in developed countries (table 5.9).

Table 5.9 Projected average driving distance per year (in 1000 km) per commercial vehicle in use.

	<u>1980</u>	<u>1985</u>	<u>1990</u>	<u>1995</u>	<u>2000</u>
United States	18.0	17.5	17.0	16.5	16.0
Canada	18.0	17.5	17.0	16.5	16.0
Japan	15.0	14.5	14.0	13.5	13.0
Oceania	18.5	18.0	17.5	17.0	16.5
Western Europe	18.0	17.5	17.0	16.5	16.0
Eastern Europe	19.0	18.5	18.0	17.5	17.0
Latin America	20.0	20.0	20.0	20.0	20.0
Rest of the world	20.0	20.0	20.0	20.0	20.0

Tire distance

One of the major problems in this analysis is the determination of tire distance, the average number of kilometers, achieved with one set of tires of type j ($j = 1$ for conventional tires and $j = 2$ for radial tires) as well as changes over time in tire distance for each type.

Some factors affecting tire distance change over time and differ among countries. Two types of factors are relevant. The first is the security aspect, be it legal or personal. In the United Kingdom, for instance, tire distance has decreased considerably as a result of increased safety consciousness; in particular, a 1968 law on the quality of tires created a boom in the demand for replacement tires. Safety consciousness and security regulations also provide a major explanation of the difference in tire distance among countries. Tire distance in many developing countries, by comparison, can on these terms be expected to be relatively high.

The second influence on tire distance consists of factors like the positive relationship of tire weight and size to tire distance. This is the main cause, for instance, of the difference in tire distance between the United States and Japan. We have already mentioned driving style and road conditions: how powerful are the engine and the brakes; is the road a congested city street, a super highway or a dirt road; is driving over 100 km per hour allowed and so forth?

An extremely important problem in estimating tire distance is the availability of accurate properly disaggregated data. We shall just mention a few aspects of the tire data, which are a cause of inaccuracy:

- An important category of vehicles is the car derived van, which is of the passenger car station-wagon type constructed for transportation of goods. They use normal or slightly reinforced passenger car tires, which can not be found separately in data sources.
- Some other light vans (pick-up trucks etc.) may use reinforced passenger car tires as well.
- Tires for replacement can be either new tires or retreaded tires. Vast improvements in technology in recent years have succeeded in raising tire distance for a retreaded tire to about the same level as for a new tire. For this reason no reduction was made in tire distance for retreaded tires compared to new tires. The share of retreading in total tire replacement for passenger cars has decreased in the 1970s mainly due to the already longer life of radial tires, technical difficulties in adequately retreading a radial tire and insufficient supply of tires to be retreaded. Since the tire industry now seems to have overcome these problems and because of related material savings and lower prices, an increased retread share is expected in the future (see table 5.10). Data about retreads, understandably, are not very good.
- For commercial vehicles retreading has remained very important due to the relatively high share of tire costs in total costs of running a commercial vehicle. After consultation of expert opinion from industry sources, the share of retreaded tires in total replacement has been assumed to develop in the future as presented in table 5.11.
- An other important factor affecting tire distance for heavy commercial vehicles is the possibility of regrooving: as the tread cannot be too thick for stability reasons and the belt consists of a rather thick layer of rubber, some 2-3 millimetres can be cut out after the depth of the tread has reduced. This will again add to tire distance.
- Imports of tires by domestic tire manufacturers may not have been properly distinguished from domestic production. Black imports may also affect accuracy.

It is essential, in conclusion, to be careful with estimation results, and to incorporate results from other studies or expert opinions.

5.4.2 The model

Estimating tire distance has been done on a world scale, where difference between countries or regions based on the above considerations have been incorporated wherever possible. In view of the importance of development in recent years for future tire use, emphasis has been placed on obtaining accurate estimates for the second half of the 1970s.

Starting point is a division of the total number of passenger cars in use in each region (Z_t) into groups of passenger cars with the same type of tires (j), which tires have lasted for the same number of years (i). The number of cars in each group is indicated with $Z_{i,t}^j$. Tires have been divided into 2 groups: conventional ($j = 1$) and radial ($j = 2$). The number of years a (set of) tires has lasted, i , runs from 1 to a maximum of say 8.

The share of cars in $Z_{i,t}^j$ replacing their tires is represented by $p_{i,t}^j$. This share depends on

- the accumulated driving distance on the current set of tires ($DD_{i,t}$)
- the tires distance for this set of tires (TD_j^j).

Of course, each car in $Z_{i,t}^j$ has a different number of kilometers driven thus far on the current set of tires. Besides, each set of tires of type j has a different life. Consequently $p_{i,t}^j$ should depend on a probability distribution of $DD_{i,t}$ and a probability distribution of TD_t^j . It has not been possible to empirically distinguish between the two. A good approximation has been found to be a relationship between $p_{i,t}^j$ and $(DD_{i,t} - TD_t^j)$ specified as a logistic function, with S_t^j as a parameter, related to the standard deviation.

$$p_{i,t}^j = \frac{1}{1 + e^{-(DD_{i,t} - TD_t^j)/S_t^j}} \quad (5.1)$$

graphically shown in figure 5.2.

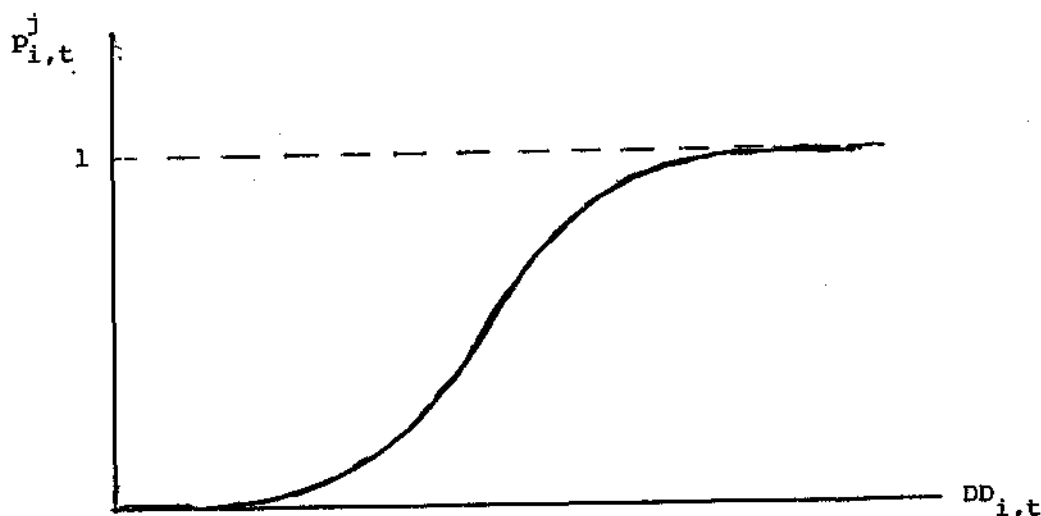


Figure 5.2 Probabilities of tire replacement

Calculating the number of tires required for replacement is a straightforward job. The number of cars replacing their tires ($ZR_{i,t}^j$) is

$$ZR_{i,t}^j = p_{i,t}^j \cdot z_{i,t}^j \quad (5.2)$$

while the number of tires for replacement TR_t is related to the number of cars replacing their tires (ZR_t)

$$ZR_t = \sum_i \sum_j ZR_{i,t}^j \quad (5.3)$$

and

$$TR_t = NT_t \times ZR_t \quad (5.4)$$

with NT_t is the number of tires attached to the passenger car (excluding the spare tire).

In the above analysis a number of problems come to the fore. First the determination of next years distribution of cars over the various groups. For cars which do not replace their tires, the only problem is how to include, or rather exclude discarded cars (H_{t+1}). They are supposed to be proportionately distributed over the various groups with tires of more than one year old in year $t+1$. Using (5.2) one may derive

$$z_{i+1,t+1}^j = z_{i,t}^j - ZR_{i,t}^j - \frac{z_{i,t}^j - ZR_{i,t}^j}{\sum_{j=1}^2 \sum_{i=1}^7 (z_{i,t}^j - ZR_{i,t}^j)} \cdot H_{t+1} \quad (5.5)$$

because i was supposed less or equal 8.

The group of cars with $i=1$ consists of cars having their tires replaced in the previous year (ZR_t) and new registrations (G_{t+1}) having original equipment tires. For both groups it is necessary to know the share of conventional tires and radial tires (cf. tables 5.1 and 5.3), which will be indicated as follows:

q_t^{oe} = share of radial tires in original equipment

q_t^{rp} = share of radial tires in replacement.

The above results in the following definitions

$$z_{1,t+1}^1 = (1 - q_{t+1}^{oe}) G_{t+1} + (1 - q_{t+1}^{rp}) ZR_t \quad (5.6)$$

$$z_{1,t+1}^2 = q_{t+1}^{oe} G_{t+1} + q_{t+1}^{rp} ZR_t \quad (5.7)$$

which completes the distribution over the various groups in year $t+1$.

An important problem which has thusfar not yet been discussed, is the distribution in the starting year t_0 : z_{i,t_0}^j . It is clear that z_{i,t_0}^j is related to G_{t_0-k} for $k = 0, 1, 2, \dots$ through $p_{i,t}^j$ with $t < t_0$. Assuming values for $DD_{i,t}$ and TD_t^j for $j = 1, 2$ and $t < t_0$ one may derive this starting distribution $z_{i,t}^j$. Accumulated driving distance $DD_{i,t}$ is defined as

$$DD_{i,t} = \sum_{k=0}^{i-1} \bar{D}_{t-k}$$

with $\bar{D}_t$ = average driving distance per country or region.

5.4.3 Estimation results and projections

Using the above model and data on production of new and retreaded tires estimates of tire distance have been derived. They have been represented by the 1980 figures in tables 5.12 and 5.13.

The second step, of course, is to make projections of tire distance for the future. It has been assumed that there will be an increase in tire distance mainly for radial tires due to technological improvements; effects of possible changes in other factors influencing tire distance have been neglected because they are hard to predict. Projections for 1980-2000 are presented for passenger car tires and commercial vehicle tires in tables 5.12 and 5.13 respectively.

The third step has been to use these projections to determine tire demand projections. Using the probability distribution for tire distance, including projected average tire distance and combining this through the model with projections of driving distance per year (tables 5.8 and 5.9), projections of the demand for tires for replacement for passenger cars and commercial vehicles have been made both for new and retreaded tires by using tables 5.10 and 5.11. Some of the results appear in tables 5.14 to 5.23.

Table 5.10 Projected percentage share of retreaded tires for replacement for passenger car tires, conventional and radial

<u>Country/region</u>		<u>1980</u>	<u>1985</u>	<u>1990</u>	<u>1995</u>	<u>2000</u>
North America	C	20	25	30	30	30
	R	10	15	20	25	30
Japan	C	15	20	25	30	30
	R	10	15	20	25	30
Oceania	C	10	15	20	25	25
	R	5	10	15	15	20
Western Europe	C	20	25	30	30	30
	R	10	15	20	25	30
Eastern Europe	C	10	15	15	20	25
	R	5	5	10	15	20
Latin America	C	5	10	10	15	20
	R	2	5	5	10	15
Rest of the world	C	5	5	10	10	15
	R	2	2	5	5	10

Notes: C = conventional tires
R = radial tires

Table 5.11 Projected percentage share of retreaded tires for replacement for commercial vehicle tires, conventional and radial.

Country/region		Year	1980	1985	1990	1995	2000
North America	C		40	45	45	50	50
	R		30	35	40	45	50
Japan	C		45	45	50	50	50
	R		30	35	40	45	50
Oceania	C		40	45	45	45	50
	R		25	30	35	40	45
Western Europe	C		50	50	50	50	50
	R		40	45	50	50	50
Eastern Europe	C		40	45	45	45	50
	R		25	30	35	40	45
Latin America	C		20	25	25	30	30
	R		5	10	15	20	20
Rest of the world	C		10	15	20	20	25
	R		0	5	10	15	15

Note: C = conventional tires.

R = radial tires.

Table 5.12 Projected tire distance of conventional and radial passenger car tires (thousands of kilometres)

			<u>1980</u>	<u>1985</u>	<u>1990</u>	<u>1995</u>	<u>2000</u>
1.	United States	C	33.3	34.2	35.1	36.0	37.0
		R	51.7	52.7	53.6	54.5	55.4
2.	Canada	C	33.3	34.2	35.1	36.0	37.0
		R	51.7	52.7	53.6	54.5	55.4
3.	Japan	C	24.5	25.9	27.3	28.6	30.0
		R	43.9	46.2	48.5	50.8	53.1
4-5.	Oceania	C	30.5	31.4	32.3	33.3	34.2
		R	50.4	51.7	53.1	54.5	55.9
6.	Germany, Federal	C	29.1	30.5	31.9	33.3	34.7
	Republic of	R	48.5	50.8	53.1	55.4	57.8
7.	France	C	19.9	21.3	22.6	24.0	25.4
		R	46.7	49.0	51.3	53.6	55.9
8.	United Kingdom	C	27.3	28.6	30.0	31.4	32.8
		R	46.7	49.0	51.3	53.6	55.9
9-14.	North-West Europe I	C	26.3	27.7	29.1	30.5	31.9
		R	43.9	46.2	48.5	50.8	53.1
15-18.	North-West Europe II	C	26.3	27.7	29.1	30.5	31.9
		R	43.9	46.2	48.5	50.8	53.1
19.	Italy	C	26.3	27.7	29.1	30.5	31.9
		R	42.5	44.4	46.2	48.0	49.9
20-25.	Southern Europe	C	26.3	27.7	29.1	30.5	31.9
		R	40.7	42.5	44.4	46.2	48.0
26-32.	Eastern Europe	C	26.3	27.7	29.1	30.5	31.9
		R	38.8	40.7	42.5	44.4	46.2
33-58.	Rest of the world	C	26.3	27.7	29.1	30.5	31.9
		R	36.5	37.9	39.3	40.7	42.0

Notes: C = Conventional tires
R = Radial tires

Table 5.13 Projected tire distance of conventional and radial commercial vehicle tires (thousands of kilometres).

			<u>1980</u>	<u>1985</u>	<u>1990</u>	<u>1995</u>	<u>2000</u>
1.	United States	C	45.2	47.4	49.5	51.7	53.8
		R	72.3	75.8	79.2	82.7	86.1
2.	Canada	C	45.2	47.4	49.5	51.7	53.8
		R	72.3	75.8	79.2	82.7	86.1
3.	Japan	C	31.9	33.6	35.3	37.0	38.7
		R	54.2	56.8	59.4	62.0	64.6
4-5.	Oceania	C	40.9	43.1	45.2	47.4	49.5
		R	72.3	75.8	79.2	82.7	86.1
6.	Germany, Federal	C	45.2	47.4	49.5	51.7	53.8
	Republic of	R	81.4	85.2	89.1	93.0	96.9
7.	France	C	40.9	43.1	45.2	47.4	49.5
		R	77.1	80.9	84.8	88.7	92.6
8.	United Kingdom	C	40.9	43.1	45.2	47.4	49.5
		R	72.3	75.8	79.2	82.7	86.1
9-14.	North-West Europe I	C	40.9	43.1	45.2	47.4	49.5
		R	77.1	80.9	84.8	88.7	92.6
15-18.	North-West Europe II	C	36.2	37.9	39.6	41.3	43.1
		R	68.0	71.5	74.9	78.4	81.8
19.	Italy	C	36.2	37.9	39.6	41.3	43.1
		R	68.0	71.5	74.9	78.4	81.8
20-25.	Southern Europe	C	31.9	33.6	35.3	37.0	38.7
		R	54.2	56.8	59.4	62.0	64.6
26-32.	Eastern Europe	C	36.2	37.9	39.6	41.3	43.1
		R	68.0	71.5	74.9	78.4	81.8
33-58.	Rest of the world	C	36.2	37.9	39.6	41.3	43.1
		R	59.0	62.0	65.0	68.0	71.0

Notes: C = Conventional tires
R = Radial tires

Table 5.14 Projections of demand for passenger cars tires (in thousands) for the standard scenario G1

Notes: NC = new conventional tires

NR = new radial tires

RT = retreaded tires

TT = total tires

		Code	1985	1990	1995	2000
I.	North America	NC	27347.	8000.	0.	0.
		NR	149468.	164641.	162106.	153369.
		RT	23752.	26633.	31156.	36184.
		TT	200568.	199274.	193262.	189553.
II.	Asia, developed	NC	3515.	1176.	0.	0.
		NR	26937.	32893.	32459.	30896.
		RT	4955.	6197.	7187.	7162.
		TT	35407.	40266.	39646.	38058.
III.	Oceania, developed	NC	2219.	561.	0.	0.
		NR	9216.	11074.	11543.	11468.
		RT	937.	1324.	1724.	1711.
		TT	12372.	12959.	13268.	13179.
IV.	North-West Europe	NC	2857.	0.	0.	0.
		NR	84487.	79933.	72284.	64836.
		RT	8582.	9529.	10462.	10232.
		TT	95926.	89462.	82746.	75068.
V.	South-West Europe	NC	725.	0.	0.	0.
		NR	37252.	37459.	36492.	35873.
		RT	4119.	5137.	6211.	7500.
		TT	42096.	42596.	42703.	43373.
VI.	Eastern Europe	NC	10574.	5860.	3294.	1883.
		NR	16510.	24386.	30913.	37263.
		RT	2598.	3793.	5753.	6356.
		TT	29682.	34039.	39960.	45501.
VII.	Latin America + Caribbean	NC	17803.	10868.	6652.	3953.
		NR	27860.	45227.	62335.	78219.
		RT	2696.	2635.	5749.	9984.
		TT	48359.	58730.	74736.	92156.
IX.	South Asia	NC	2941.	2408.	2254.	1713.
		NR	2008.	3761.	5345.	7137.
		RT	149.	348.	522.	782.
		TT	5098.	6517.	8121.	9632.
X.	South-East + East Asia	NC	3072.	1475.	1081.	0.
		NR	7334.	13786.	20840.	32251.
		RT	229.	623.	1286.	2304.
		TT	10635.	15884.	23207.	34555.
XI.	Middle East + North Africa	NC	2469.	916.	507.	0.
		NR	5900.	8579.	9798.	11391.
		RT	192.	407.	661.	891.
		TT	8561.	9903.	10966.	12281.
XII.	Other Africa	NC	10685.	8248.	7356.	5443.
		NR	7303.	12904.	17452.	22696.
		RT	569.	1242.	1762.	2543.
		TT	18556.	22393.	26570.	30682.
	World total (excl. Asian CPE countries)	NC	84208.	39512.	21146.	12992.
		NR	374275.	434644.	461566.	485397.
		RT	48777.	57868.	72473.	85650.
		TT	507259.	532024.	555185.	584039.

Table 5.15 Projections of demand for commercial vehicles
tires (in thousands) for the standard
scenario G1

Notes: NC = new conventional tires
NR = new radial tires
RT = retreaded tires
TT = total tires

	Code	1985	1990	1995	2000
I. North America	NC	10240.	2829.	0.	0.
	NR	44850.	55948.	57001.	57383.
	RT	17996.	18641.	21615.	24204.
	TT	73087.	77418.	78616.	81587.
II. Asia, developed	NC	4887.	1987.	923.	0.
	NR	18348.	25214.	31001.	35897.
	RT	7181.	8609.	11010.	13971.
	TT	30416.	35809.	42934.	49868.
III. Oceania, developed	NC	806.	274.	140.	0.
	NR	2177.	2695.	2777.	2930.
	RT	975.	916.	1008.	1148.
	TT	3958.	3885.	3926.	4078.
IV. North-West Europe	NC	479.	0.	0.	0.
	NR	14916.	16175.	17113.	18271.
	RT	4441.	4802.	5523.	5652.
	TT	19837.	20977.	22636.	23923.
V. South-West Europe	NC	738.	227.	0.	0.
	NR	6063.	6789.	7094.	7615.
	RT	2831.	2998.	3432.	3594.
	TT	9632.	10013.	10526.	11209.
VI. Eastern Europe	NC	6373.	3879.	2003.	666.
	NR	7308.	9866.	11834.	13183.
	RT	4674.	4423.	4660.	4953.
	TT	18354.	18169.	18497.	18802.
VII. Latin America + Caribbean	NC	6318.	4077.	2161.	802.
	NR	7552.	10818.	13933.	16577.
	RT	1852.	1802.	2283.	2885.
	TT	15722.	16696.	18377.	20264.
IX. South Asia	NC	1556.	1230.	1103.	849.
	NR	1128.	1996.	2678.	3668.
	RT	249.	352.	485.	579.
	TT	2933.	3578.	4266.	5095.
X. South-East + East Asia	NC	2019.	1226.	753.	472.
	NR	3269.	5273.	7029.	9632.
	RT	360.	556.	853.	1085.
	TT	5648.	7055.	8635.	11189.
XI. Middle East + North Africa	NC	931.	487.	252.	138.
	NR	1513.	2102.	2362.	2829.
	RT	174.	232.	312.	342.
	TT	2619.	2820.	2927.	3309.
XII. Other Africa	NC	4608.	3642.	3355.	2549.
	NR	3329.	5907.	8134.	11007.
	RT	706.	1037.	1442.	1725.
	TT	8642.	10586.	12931.	15281.
World total (excl. Asian CPE countries)	NC	38955.	19857.	10691.	5476.
	NR	110452.	142783.	160956.	178991.
	RT	41440.	44368.	52623.	60140.
	TT	190847.	207007.	224270.	244606.

Table 5.16 Percentage share of replacement tires (incl. retreads)
in total tires (passenger cars)

	<u>1985</u>	<u>1990</u>	<u>1995</u>	<u>2000</u>
I. North America	71.5	66.7	65.8	64.7
II. Asia, developed	43.7	41.6	43.2	40.0
III. Oceania, developed	68.8	67.0	65.0	64.9
IV. North-West Europe	58.1	53.3	50.6	45.9
V. South-West Europe	64.3	60.3	58.2	57.6
VI. Eastern Europe	72.9	69.6	70.2	69.0
VII. Latin America + Caribbean	79.6	74.8	73.3	71.0
IX. South Asia	76.9	76.4	74.7	73.8
X. South-East + East Asia	74.2	71.3	68.4	66.7
XI. Middle East + North Africa	77.2	74.8	74.4	72.5
XII. Other Africa	80.7	79.2	77.1	75.4
World total (excl. Asian CPE countries)	67.8	64.1	63.6	62.4

Table 5.17 Percentage share of replacement tires (incl. retreads)
in total tires (commercial vehicles)

	<u>1985</u>	<u>1990</u>	<u>1995</u>	<u>2000</u>
I. North America	66.5	59.8	61.1	59.3
II. Asia, developed	63.8	59.4	57.0	56.0
III. Oceania, developed	71.4	65.5	63.8	62.6
IV. North-West Europe	55.5	50.9	48.8	47.3
V. South-West Europe	71.2	66.3	65.2	64.1
VI. Eastern Europe	67.9	64.1	61.8	58.2
VII. Latin America + Caribbean	78.5	74.4	72.0	69.4
IX. South Asia	77.3	70.4	68.9	66.8
X. South-East + East Asia	70.8	65.7	63.8	62.6
XI. Middle East + North Africa	73.8	68.4	68.8	66.7
XII. Other Africa	74.2	70.0	67.6	66.4
World total (excl. Asian CPE countries)	67.2	61.8	61.0	59.4

Table 5.18 Projections of demand for replacement tires (in thousands)
for passenger cars

	<u>code</u>	<u>scenario</u>	<u>1985</u>	<u>1990</u>	<u>1995</u>	<u>2000</u>
World total (excl. Asian CPE countries)	C	a	73668.	31567.	17450.	10889.
		b	75316.	34520.	20595.	13636.
		c	75862.	34721.	20595.	13636.
		d	77224.	37227.	23376.	16257.
		e	77409.	37367.	23376.	16257.
	R	a	270053.	309235.	335590.	353770.
		b	273727.	329359.	373339.	413598.
		c	275939.	334796.	385523.	427871.
		d	278762.	351954.	416312.	480932.
		e	279912.	357255.	428829.	495453.
	T	a	343721.	340802.	353040.	364659.
		b	349044.	363879.	393934.	427234.
		c	351801.	369517.	406119.	441508.
		d	355986.	389181.	439687.	497189.
		e	357321.	394622.	452205.	511710.

Notes: C = conventional tires
R = radial tires
T = total tires

Table 5.19 Projections of demand for retreaded tires (in thousands)
for passenger cars

	<u>code</u>	<u>scenario</u>	<u>1985</u>	<u>1990</u>	<u>1995</u>	<u>2000</u>
World total (excl. Asian CPE countries)	C	a	11864.	4973.	2440.	1954.
		b	12073.	5385.	2922.	2490.
		c	12208.	5444.	2922.	2490.
		d	12368.	5790.	3348.	3003.
		e	12414.	5830.	3348.	3003.
	R	a	36913.	52896.	70034.	83696.
		b	37284.	55677.	75922.	93881.
		c	37547.	56712.	79159.	98270.
		d	37810.	59089.	83675.	106759.
		e	37990.	60235.	87022.	111219.
	T	a	48777.	57868.	72473.	85650.
		b	49357.	61062.	78843.	96371.
		c	49755.	62157.	82080.	100760.
		d	50179.	64878.	87022.	109762.
		e	50404.	66065.	90369.	114222.

Notes: C = conventional tires

R = radial tires

T = total tires

Table 5.20 Projections of demand for new tires (in thousands)
for passenger cars

	<u>code</u>	<u>scenario</u>	<u>1985</u>	<u>1990</u>	<u>1995</u>	<u>2000</u>
World total (excl. Asian CPE countries)		a	84208.	39512.	21146.	12992.
		b	88181.	44286.	25865.	16957.
		c	88773.	44852.	25865.	16957.
		d	92492.	48825.	30216.	20943.
		e	93024.	49379.	30216.	20943.
	R	a	374275.	434644.	461566.	485397.
		b	389592.	466994.	517138.	576835.
		c	394579.	482561.	536711.	597893.
		d	408491.	507273.	583441.	684572.
		e	413976.	523136.	603824.	706133.
	T	a	458482.	474156.	482712.	498389.
		b	477773.	511280.	543002.	593792.
		c	483352.	527413.	562576.	614850.
		d	500983.	556098.	613656.	705515.
		e	506999.	572514.	634040.	727076.

Notes: C = conventional tires
R = radial tires
T = total tires

Table 5.21 Projections of demand for replacement tires (in thousands)
for commercial vehicles

	<u>code</u>	<u>scenario</u>	<u>1985</u>	<u>1990</u>	<u>1995</u>	<u>2000</u>
World total (excl. Asian CPE countries)	C	G1	35697.	16376.	8080.	4422.
		G2	36869.	17866.	9358.	5591.
		G3	37562.	19047.	10395.	6576.
	R	G1	92466.	111598.	128699.	140754.
		G2	96055.	124116.	153691.	180358.
		G3	97909.	133693.	173427.	213039.
	T	G1	128163.	127974.	136778.	145177.
		G2	132924.	141982.	163049.	185949.
		G3	135471.	152740.	183822.	219615.

Notes: C = conventional tires
R = radial tires
T = total tires

Table 5.22 Projections of demand for retreaded tires (in thousands)
for commercial vehicles

	<u>code</u>	<u>scenario</u>	<u>1985</u>	<u>1990</u>	<u>1995</u>	<u>2000</u>
World total (excl. Asian CPE countries)	C	G1	12618.	5368.	2275.	1278.
		G2	13045.	5835.	2579.	1587.
		G3	13276.	6201.	2826.	1848.
	R	G1	28822.	38999.	50348.	58862.
		G2	29994.	43516.	60390.	75868.
		G3	30575.	46948.	68294.	89854.
	T	G1	41440.	44368.	52623.	60140.
		G2	43039.	49350.	62969.	77455.
		G3	43850.	53149.	71121.	91703.

Notes: C = conventional tires
R = radial tires
T = total tires

Table 5.23 Projections of demand for new tires (in thousands)
for commercial vehicles

		<u>code</u>	<u>scenario</u>	<u>1985</u>	<u>1900</u>	<u>1995</u>	<u>2000</u>
World total (excl. Asian CPE countries)	C	G1		38955.	19857.	10691.	5476.
		G2		41663.	22670.	13036.	7276.
		G3		44136.	24897.	15003.	8841.
	R	G1		110452.	142783.	160956.	178991.
		G2		118989.	166824.	203650.	243267.
		G3		126539.	185564.	238803.	299172.
	T	G1		149408.	162640.	171648.	184467.
		G2		160652.	189494.	216685.	250543.
		G3		170675.	210461.	253806.	308012.

Notes: C = conventional tires
R = radial tires
T = total tires

6. WORLD RUBBER DEMAND6.1 Introduction

World rubber consumption has increased dramatically in the past two decades, although world economic recession in the late seventies certainly has severely depressed the rubber market. A broad picture of development in rubber consumption can be seen in the data in table 6.1. While for the world as a whole rubber consumption has more than tripled between 1960-1980, some countries have only shown moderate increase: USA, West-Germany, France and the United Kingdom. Extremely high growth rates over the past two decades have been achieved by e.g. Brazil, Japan, some developing countries and Eastern Europe.

Table 6.1 Total rubber consumption, 1950-1980 (in tons)

	<u>1955</u>	<u>1960</u>	<u>1965</u>	<u>1970</u>	<u>1975</u>	<u>1980</u>
USA	1,554,174	1,583,299	2,087,794	2,516,918	2,629,685	2,565,000
Canada	85,880	92,495	141,165	186,082	251,557	280,000
Brazil	40,304	61,161	64,413	122,093	235,050	324,884
Germany, F.R.	175,791	254,100	366,384	558,812	556,991	600,997
France	156,255	221,625	276,963	419,150	433,873	509,619
UK	273,913	300,500	369,400	461,800	436,800	379,000
Italy	70,003	133,000	200,000	310,000	338,000	420,000
Japan	n.a.	230,000	377,000	779,000	870,000	1,312,000
Sub-total	n.a.	2,876,180	3,883,119	5,353,855	5,751,956	6,391,500
Rest of the world excl. E. Europe and China	n.a.	517,070	851,631	1,496,145	1,888,544	2,633,500
Total excl. Eastern Europe and China	n.a.	3,393,250	4,734,750	6,850,000	7,640,500	9,025,000
E. Europe and China	n.a.	469,250	620,250	1,785,000	2,755,000	3,400,000
Grand Total World	2,945,000	3,862,500	5,355,000	8,635,000	10,395,000	12,425,000

Source: Rubber Statistical Bulletin

Data on rubber consumption split up between the tire sector and the non-tire sector are available for a number of countries (see tables 6.2 and 6.3). These 8 countries accounted for a large although declining share of world rubber consumption: 74.4 % in 1960, 62.0 % in 1970 and 51.6 % in 1980. From tables 6.2 and 6.1 the percentage share of the tire sector in total rubber consumption can be derived. For the 8 countries together this share is remarkably stable over time (cf. table 6.4),

Table 6.2 Rubber consumption in the tire sector (in tons)

	1955	1960	1965	1970	1975	1980
USA	975,213	1,010,786	1,327,309	1,602,912	1,643,808	1,520,960 ^p
Canada	56,717	64,213	100,349	144,953	171,916	198,000
Brazil	n.a.	47,497	45,637	79,603	147,215	203,405
Germany F.R.	n.a.	139,550	207,400	284,000	262,420	275,070
France	92,179	126,052	160,369	262,427	283,677	354,497
United Kingdom	147,726	158,200	193,200	233,400	213,900	182,900
Italy	n.a.	71,000	111,000	159,000	161,900	176,000
Japan	n.a.	99,070	182,750	399,000	540,100	833,500
Total	n.a.	1,716,368	2,328,014	3,165,295	3,424,936	3,744,332

Source: Rubber Statistical Bulletin

p = provisional

Table 6.3 Rubber consumption in the non-tire sector (in tons)

	1955	1960	1965	1970	1975	1980
USA	578,961	572,513	760,485	914,006	987,877	1,044,040
Canada	29,163	28,282	40,816	41,129	92,108	92,500
Brazil	n.a.	13,664	18,776	42,490	87,835	121,479
Germany F.R.	n.a.	114,550	158,984	274,812	294,571	325,927
France	64,076	95,573	116,594	156,723	150,196	155,122
United Kingdom	126,187	142,300	176,200	228,400	222,900	196,100
Italy	n.a.	62,000	89,000	151,000	176,100	244,000
Japan	n.a.	130,930	194,250	380,000	329,900	478,500
Total	n.a.	1,159,812	1,555,105	2,188,560	2,341,487	2,657,668

Source: Rubber Statistical Bulletin.

Table 6.4 Percentage share of tire sector in total rubber consumption

	1955	1960	1965	1970	1975	1980
USA	63	64	64	64	62	59
Canada	66	69	71	78	65	68
Brazil	n.a.	78	71	65	63	63
Germany F.R.	n.a.	55	57	51	47	46
France	59	57	58	63	65	70
United Kingdom	54	53	52	51	49	48
Italy	n.a.	53	56	51	48	42
Japan	n.a.	43	49	51	62	64
Sub-total	n.a.	60	60	59	59	58

Note: Derived from previous tables.

6.2 Non-tire rubber demand

6.2.1 General information

As was stated in chapter 1, specific non-tire end-uses for rubber number in the thousands. To mention a few: rubber thread, rubberised cloth, footwear, window strips, engine mouldings, conveyor belts, hoses, rubber sheets, roofing sheets, rubber gloves, carpet backing, elastic rubber bands, fishing ropes and soft-balls. It goes without saying that availability of data, manpower and time are barriers to doing any kind of detailed analysis.

Even if these constraints were not relevant, the next barrier would be the availability of information about the rubber content of the various products. It is quite impossible to determine the rubber content of such a thing as the average conveyor belt. First, even conveyor belts can be found in many different types and, second, the mix of materials prevent the researcher from singling out the rubber contents.

A way out is to focus on the countries where the rubber products are produced, because it is there where disappearance of rubber might be traced. Reducing the number of end-uses by concentrating on broad categories, an analysis of the composition of rubber consumption can be given such as for the case of Japan in table 6.5.

Table 6.5 Composition of rubber consumption by broad non-tire end-uses in Japan, percentages

	<u>1961</u>	<u>1964</u>	<u>1967</u>	<u>1970</u>	<u>1973</u>
Rubber footwear	34	34	26	18	11
Belting	10	10	11	11	7
Hose	5	4	4	4	4
Rubberised cloth	6	5	4	3	3
Industrial and latex products	16	10	35	31	33
Wire and cable	5	6	4	3	4
Miscellaneous	24	31	16	30	38

Source: Rubber Statistical Bulletin.

A few conclusions can be drawn from this table.

The relative contribution of footwear to total rubber consumption has declined dramatically. The major reason for this is increased competition from such low-wage countries as Korea and Taiwan. Next, there is a tendency for developed countries to produce goods which require a high level of technology: industrial products and miscellaneous. Finally, many products, which were end-uses of rubber in the past, are now made of plastics. Concluding: products disappear from the rubber scene and new ones emerge. This strongly complicates the analysis, because, even if one might be able to forecast disappearance of an end-use, it is quite impossible to accurately predict which new end-uses may come to the fore and how much impact they will have.

Data on rubber consumption by non-tire end-uses as a whole are available for seven (groups of) countries: United States and Canada, Japan, West-Germany, France, the United Kingdom, Italy and Brazil. Graphs per country are shown in figure 6.1.

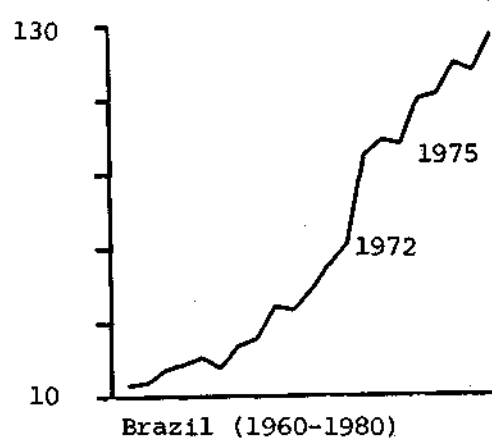
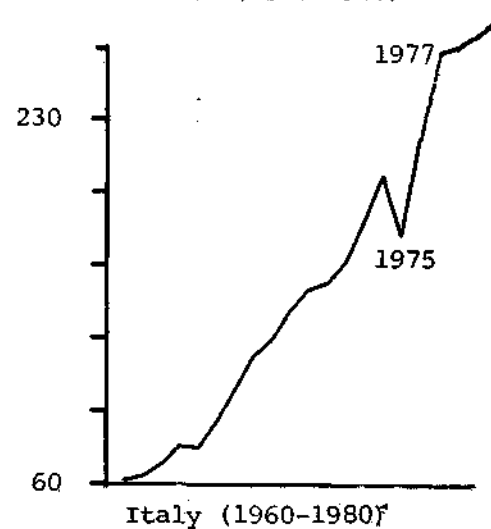
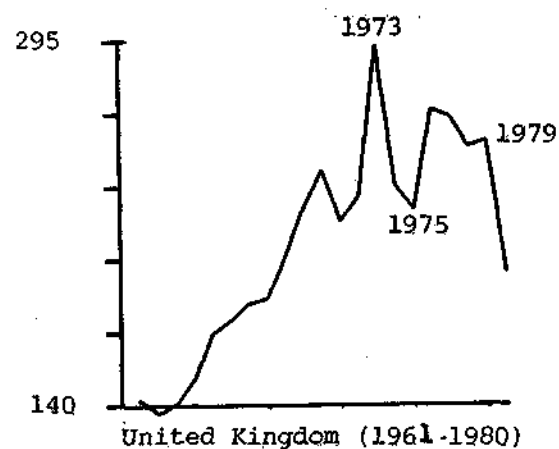
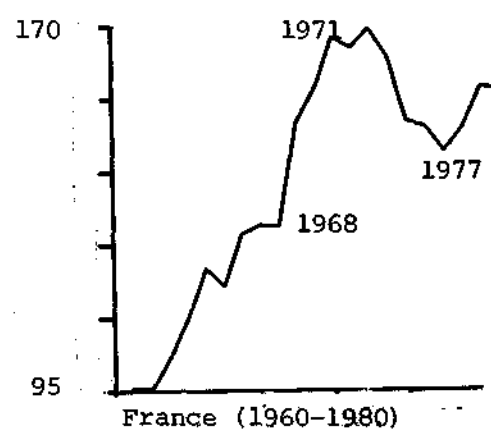
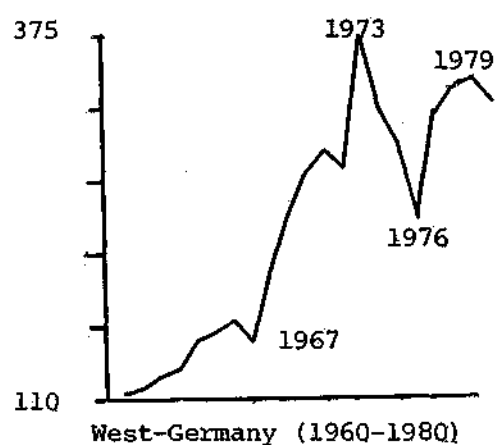
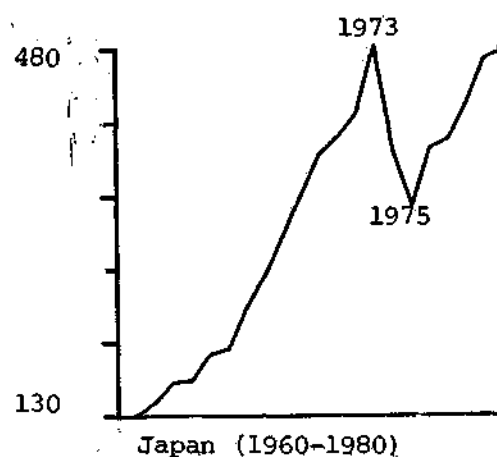
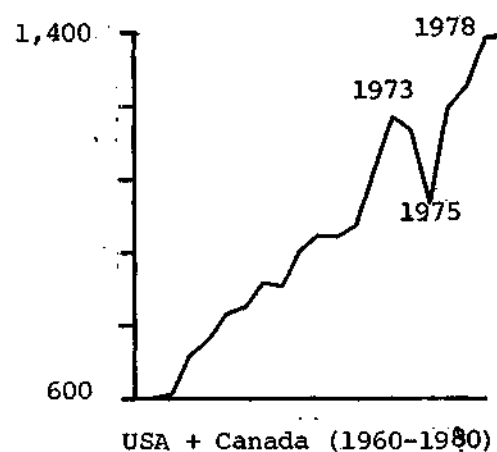


Figure 6.1 Non-tire rubber consumption (1000 m.t.)

6.2.2 Analysis and projections

As it is only possible within the scope of this study, to analyze non-tire consumption at an aggregate level, one must find explanatory variables determining developments in non-tire rubber consumption. A plausible variable may be an index of industrial production. On the other hand, using GDP should be advantageous because all projections thusfar have been based on GDP-scenarios. From the regression analyses, it became clear that an index of (manufactured) industrial production did not provide better results than GDP.

As a considerable part of non-tire end-uses has the automotive industry as its destination, it has been tried to also include vehicle production as an explanatory variable. Results were by no means satisfactory.

Europe: four countries

As mentioned above, data on non-tire rubber consumption are available for only four European countries: West-Germany, France, United Kingdom and Italy. The analysis will be presented for each of the four countries and for the four together.

West-Germany

Since the figure for 1973 can be considered as an outlier, a dummy has been included for 1973. Relating non-tire rubber consumption (C_t^N) in the simplest way to GDP (Y_t) gives the following regression equation

$$C_t^N = -124.99 + 0.95940 Y_t + 81.058 D_{73} \quad (6.1)$$

(20.677) (0.05457) t (20.692)

$$R^2 = 0.952, DW = 1.47$$

The quality of the analysis is reasonable. The DW-statistic is rather low.

France

Figure 6.1 shows a rather extraordinary development in French non-tire rubber consumption: since 1971 a decline can be observed. This is represented in the poor quality of the simple regression equation:

$$C_t^N = 66.104 + 0.25810 Y_t \quad (6.2)$$

(11.385) (0.03936) t

$$R^2 = 0.694, DW = 0.28$$

Clearly, other countries have taken over part of the French production of non-tire rubber goods.

United Kingdom

From figure 6.1 it can be concluded that the U.K. situation is not very bright at all in particular in 1980. The year 1973 is rather exceptional. Including dummies for these years gives the following regression equation:

$$C_t^N = -104.60 + 1.4853 Y_t + 52.210 D_{73} - 70.337 D_{80} \quad (6.3)$$

(23.716) (0.1143) (15.314) (15.841)

$$R^2 = 0.924, DW = 1.56$$

Results still are not really satisfactory. Besides, the coefficient of Y_t is rather high.

Italy

For Italy, the year 1975 yields the clearest outlier. After inclusion of a dummy for this year, reasonable results have been obtained

$$C_t^N = -103.07 + 1.6798 Y_t - 43.515 D_{75} \quad (6.4)$$

(6.503) (0.0407) (8.294)

$$R^2 = 0.990, DW = 1.66$$

The coefficient of Y_t seems rather high compared to other countries. It may be caused by Italy taking over part of other countries' non-tire rubber consumption. Therefore an analysis has been undertaken to aggregate the above four countries, as is shown below.

The aggregated four European countries

Many specifications have been tried in analysing the relationship between non-tire rubber consumption and GDP for these four countries. It has been concluded that no model could take care of

- the data problem for 1973 in West-Germany
- the change in the level of non-tire rubber consumption from 1974 onwards
- the exceptional year 1980.

Dummies have therefore been included and the year 1980 has been left out.

The simple specification proved reasonably successful

$$C_t^N = -351.08 + 1.0964 Y_t + 88.436 D_{73} - 84.992 D_{74-79} \quad (6.5)$$

(48.94) (0.0547) (32.174) (24.636)

$$R^2 = 0.987, DW = 1.69$$

Improvement has been obtained using the partial adjustment model, with adjustment to C_t^N :

$$C_t^N = \alpha_0 + \alpha_1 Y_t \quad (6.6)$$

$$C_t^N - C_t^N = \delta (C_{t-1}^N - C_t^N) \quad (6.7)$$

which is transferred to

$$C_t^N = \delta C_{t-1}^N + (1-\delta) (\alpha_0 + \alpha_1 Y_t) \quad (6.8)$$

Estimation results after inclusion of the dummies are

$$C_t^N = -295.96 + 0.27154 C_{t-1}^N + 0.85361 Y_t + 84.800 D_{73} - 90.345 D_{74-79} \quad (6.9)$$

(55.69) (0.10538) (0.11541) (27.571) (21.718)

$$R^2 = 0.990, DW = 1.91$$

which are satisfactory.

United States and Canada

Non-tire rubber consumption in the USA + Canada is rather integrated. A first glance at figure 6.1 shows an outlier in 1975 which will be represented by a dummy. Applying a simple model gives reasonable results

$$C_t^N = -220.60 + 0.80289 Y_t - 108.45 D_{75} \quad (6.10)$$

(39.28) (0.02512) (33.74)

$$R^2 = 0.984, DW = 1.65$$

A partial adjustment model proved not useful in this case.

Japan

The oil crisis has strongly hit the Japanese rubber industry. There is a dramatic decline in 1974 and since 1975 non-tire rubber consumption seems to have developed at a different level compared to GDP. This conclusion is justified by the regression results:

$$C_t^N = -17.861 + 1.0312 Y_t - 96.370 D_{74} - 153.44 D_{75-80} \quad (6.11)$$

(7.557) (0.0243) (10.977) (8.217)

$$R^2 = 0.994, DW = 2.23$$

No improvement was obtained by using partial adjustment models or other lag specifications.

Brazil

Non-tire rubber consumption in Brazil has developed rapidly over the past decades. The analysis shows that 1973 is a rather exceptional year and that the level since 1974 has been affected upwards by the oil crisis. This gives

$$C_t^N = -19.731 + 0.88887 Y_t + 19.278 D_{73} + 12.345 D_{74-80} \quad (6.12)$$

(3.196) (0.05367) (3.932) (3.965)

$$R^2 = 0.994, DW = 0.993.$$

The aggregated eight countries

Applying the same argument about a changing international distribution of non-tire rubber goods production, the eight countries analysed thusfar have been aggregated. Out of variety of possible specifications, the most acceptable regression equation for the period 1961-1979 is

$$C_t^N = -147.21 + 0.38062 C_{t-1}^N + 0.76977 Y_t - 234.16 D_{74-79} \quad (6.13)$$

(50.63) (0.05735) (0.05938) (27.60)

$$R^2 = 0.997, DW = 1.83.$$

Estimation results are quite satisfactory.

The rest of the world

For the rest of the world data do not allow an analysis as has been undertaken for the above countries. Studying scattered information from various sources, we have come up with the conclusion that, while non-tire rubber consumption for the above mentioned 8 countries is about 40 % of the total (cf. table 6.4), for the rest of the world, tires will take a smaller share and non-tire rubber consumption is about 55 % of total rubber consumption for the rest of the world. Analyzing the relationship between C_t^N and GDP the result is

$$C_t^N = 54.5 - 1.10 Y_t \quad (6.14)$$

which completes the analyse of world non-tire rubber consumption, outside the Asian Centrally Planned Economies.

Projections

Projections are derived on the basis of the above equations and the three economic scenarios G1, G2 and G3 as described in appendix A. Table 6.6 gives projections based on equations (6.1), (6.2), (6.3), (6.4), (6.10), (6.11), (6.12) and (6.14). The effect of the aggregation of the four European countries is shown in table 6.7 where projections are based on equations (6.10), (6.11), (6.12), (6.9) and (6.14). Finally, table 6.8 presents the results for the world (excl. Asian CPEC) divided into the eight countries and the rest: equations (6.13) and (6.14). They come out at a somewhat higher level. Because of the superiority of the approach for the aggregated eight countries with respect to

- problems concerning international redistribution of production
- quality of the estimation results

it has been decided to use the results of table 6.8 for projection purposes.

Table 6.6 Projections of world non-tire rubber consumption (excl. Asian CPEC)
in 1000 tons, see text

		1985	1990	1995	2000
United States + Canada eq. (6.10)	G1	1,403	1,536	1,680	1,788
	G2	1,499	1,780	2,108	2,426
	G3	1,567	1,962	2,444	2,958
Japan eq. (6.11)	G1	622	821	1,069	1,341
	G2	658	943	1,325	1,789
	G3	691	1,043	1,538	2,176
Brazil eq. (6.12)	G1	156	207	273	351
	G2	163	233	333	456
	G3	170	254	377	546
Sum four non-European countries	G1	2,181	2,564	3,022	3,480
	G2	2,320	2,956	3,766	4,671
	G3	2,428	3,259	4,359	5,680
Germany, F.R. eq. (6.1)	G1	396	500	625	750
	G2	420	582	787	1,021
	G3	443	648	923	1,256
France eq. (6.2)	G1	168	186	207	228
	G2	172	202	238	279
	G3	177	215	265	324
United Kingdom eq. (6.3)	G1	198	225	255	276
	G2	220	280	350	417
	G3	235	320	424	534
Italy eq. (6.4)	G1	307	368	439	507
	G2	325	423	546	680
	G3	340	468	635	831
Sum four European countries	G1	1,069	1,279	1,526	1,761
	G2	1,137	1,487	1,921	2,397
	G3	1,195	1,651	2,247	2,945
Rest of the world (excl. Asian CPEC) eq. (6.14)	G1	3,573	4,295	5,195	6,174
	G2	3,730	4,813	6,250	7,977
	G3	3,870	5,234	7,124	9,536
World total (excl. Asian CPEC)	G1	6,823	8,139	9,744	11,414
	G2	7,186	9,255	11,934	15,044
	G3	7,493	10,144	13,730	18,160

Table 6.7 Projections of world non-tire rubber consumption (excl. Asian CPEC)
in 1000 tons, see text

		<u>1985</u>	<u>1990</u>	<u>1995</u>	<u>2000</u>
Sum four non-European countries (table 6.6)	G1	2,181	2,564	3,022	3,480
	G2	2,320	2,956	3,766	4,671
	G3	2,428	3,259	4,359	5,680
Aggregated four European countries (eq. (6.9))	G1	1,094	1,363	1,681	1,991
	G2	1,167	1,600	2,150	2,762
	G3	1,232	1,795	2,540	3,427
Rest of the world (excl. Asian CPEC) (table 6.6)	G1	3,573	4,295	5,195	6,174
	G2	3,730	4,813	6,250	7,977
	G3	3,870	5,234	7,124	9,536
World total (excl. Asian CPEC)	G1	6,848	8,222	9,898	11,645
	G2	7,217	9,369	12,166	15,410
	G3	7,530	10,288	14,023	18,643

Table 6.8 Projections of world non-tire rubber consumption (excl. Asian CPEC)
in 1000 tons, see text

		<u>1985</u>	<u>1990</u>	<u>1995</u>	<u>2000</u>
Aggregated eight countries (eq. (6.13))	G1	3,904	4,672	5,609	6,543
	G2	4,155	5,428	7,079	8,935
	G3	4,349	6,020	8,268	10,964
Rest of the world (excl. Asian CPEC) (table 6.6)	G1	3,573	4,295	5,195	6,174
	G2	3,730	4,813	6,250	7,977
	G3	3,870	5,234	7,124	9,536
World total (excl. Asian CPEC)	G1	7,477	8,967	10,849	12,717
	G2	7,885	10,241	13,329	16,912
	G3	8,219	11,255	15,392	20,500

6.3 Rubber demand in the tire sector

6.3.1 Rubber demand for passenger car tires

Deriving rubber demand for passenger car tires from the number of tires presented in the previous chapter, is a rather straightforward exercise: multiplying tires and their respective rubber weight. Some questions need to be answered:

- what is the average rubber weight of a passenger car tire;
- what is the difference between conventional tires and radial tires;
- is a change in rubber weight to be anticipated;
- what is the reduction in elastomer use when retreading a tire?

A major problem in this exercise is to derive good estimates of the rubber weight of different types of tires. Scattered information is available in published and unpublished sources showing rubber weight of various types of tires by country and over time. These statistics indicate that there is considerable variation among countries but not much variation over time except for such countries as the USA in recent years. We used these sources to obtain estimates for passenger car tires in the major countries, including the United States, Japan and certain EEC countries. These estimates vary by country depending on the average size of passenger cars. For countries or regions for which no adequate information has been obtained, elastomer weight per tire has been estimated by assessing average car size. As additional information, radial tires have been estimated to contain 10 per cent more rubber per tire than conventional tires. The estimation results on elastomer weight are presented in table 6.9. A small decrease is anticipated for the USA, Canada and Australia and New Zealand because of a reduction in car size.

Elastomer content of retreaded tires has to be dealt with separately since these tires absorb far less (new) rubber. The reduction in elastomer requirement has been estimated at 55 per cent, based on various statistical sources and discussions with experts.

The results of the multiplication of numbers of tires and their respective rubber weights are presented in table 6.10 for all scenarios.

Table 6.9 Rubber weights of passenger car tires (in kg).

			<u>1980</u>	<u>1985</u>	<u>1990</u>	<u>1995</u>	<u>2000</u>
1.	United States	C	5.5	5.4	5.3	5.1	5.0
		R	6.0	5.9	5.8	5.7	5.6
2.	Canada	C	5.4	5.2	5.1	5.0	4.9
		R	5.9	5.8	5.7	5.6	5.5
3.	Japan	C	4.2	4.2	4.2	4.2	4.2
		R	4.7	4.7	4.7	4.7	4.7
4-5.	Oceania	C	5.3	5.2	5.1	5.0	4.9
		R	5.9	5.8	5.7	5.6	5.5
6.	Germany, Fed.Rep.	C	4.9	4.9	4.9	4.9	4.9
		R	5.3	5.3	5.3	5.3	5.3
7.	France	C	4.8	4.8	4.8	4.8	4.8
		R	5.2	5.2	5.2	5.2	5.2
8.	United Kingdom	C	4.8	4.8	4.8	4.8	4.8
		R	5.2	5.2	5.2	5.2	5.2
9-14.	North-West Europe I	C	4.8	4.8	4.8	4.8	4.8
		R	5.2	5.2	5.2	5.2	5.2
15-18.	North-West Europe II	C	4.7	4.7	4.7	4.7	4.7
		R	5.1	5.1	5.1	5.1	5.1
19.	Italy	C	4.5	4.5	4.5	4.5	4.5
		R	5.0	5.0	5.0	5.0	5.0
20-25.	Southern Europe	C	4.4	4.4	4.4	4.4	4.4
		R	4.9	4.9	4.9	4.9	4.9
26-32.	Eastern Europe	C	4.2	4.2	4.2	4.2	4.2
		R	4.7	4.7	4.7	4.7	4.7
33-58.	Rest of the world	C	4.2	4.2	4.2	4.2	4.2
		R	4.7	4.7	4.7	4.7	4.7

Notes: C = conventional tires
R = radial tires

Table 6.10 Projections of rubber demand for passenger car tires (in thousand tons)

	<u>scenario</u>	<u>1985</u>	<u>1990</u>	<u>1995</u>	<u>2000</u>
I. North America	a	1087.	1062.	999.	945.
	b	1128.	1117.	1047.	988.
	c	1148.	1167.	1112.	1055.
	d	1180.	1199.	1130.	1069.
	e	1192.	1247.	1198.	1144.
II. Asia, developed	a	150.	171.	166.	159.
	b	158.	174.	168.	158.
	c	156.	187.	182.	174.
	d	163.	188.	184.	173.
	e	167.	203.	199.	188.
III. Oceania, developed	a	67.	69.	69.	67.
	b	70.	74.	73.	70.
	c	70.	77.	78.	76.
	d	72.	81.	80.	77.
	e	73.	84.	85.	82.
IV. North-West Europe	a	475.	439.	401.	362.
	b	483.	449.	415.	375.
	c	496.	467.	436.	397.
	d	505.	475.	448.	408.
	e	519.	493.	471.	431.
V. South-West Europe	a	196.	196.	194.	193.
	b	204.	211.	212.	219.
	c	206.	218.	220.	228.
	d	214.	229.	236.	255.
	e	216.	235.	243.	262.
VI. Eastern Europe	a	127.	146.	170.	194.
	b	134.	167.	210.	260.
	c	134.	167.	210.	260.
	d	141.	185.	245.	317.
	e	141.	185.	245.	317.
VII. Latin America + Caribbean	a	210.	262.	330.	401.
	b	227.	319.	457.	635.
	c	227.	319.	457.	635.
	d	244.	371.	582.	891.
	e	244.	371.	582.	891.

Table 6.10 (cont.)

	<u>scenario</u>	<u>1985</u>	<u>1990</u>	<u>1995</u>	<u>2000</u>
IX. South Asia	a	22.	28.	35.	42.
	b	23.	32.	42.	53.
	c	23.	32.	42.	53.
	d	24.	35.	48.	63.
	e	24.	35.	48.	63.
X. South-East + East Asia	a	48.	72.	104.	155.
	b	49.	79.	123.	196.
	c	49.	79.	123.	196.
	d	51.	85.	139.	232.
	e	51.	85.	139.	232.
XI. Middle East + North Africa	a	38.	45.	49.	55.
	b	41.	53.	65.	81.
	c	41.	53.	65.	81.
	d	43.	60.	79.	105.
	e	43.	60.	79.	105.
XII. Other Africa	a	80.	97.	116.	134.
	b	82.	102.	124.	146.
	c	82.	102.	124.	146.
	d	83.	105.	130.	157.
	e	83.	105.	130.	157.
World total (excl. Asian CPE countries)	a	2499.	2587.	2633.	2707.
	b	2599.	2777.	2936.	3181.
	c	2631.	2867.	3049.	3304.
	d	2721.	3013.	3301.	3747.
	e	2754.	3104.	3419.	3873.

6.3.2 Rubber demand for commercial vehicle tires

The determination of rubber demand for commercial vehicle tires follows the same system as in the case of passenger car tires. The same problems are encountered as well.

Elastomer weight estimates of commercial vehicle tires, however, are even more difficult to obtain. About half of commercial vehicles use big passenger car tires. The rest differ considerably, depending on vehicle size. Information for some countries for some sizes of commercial vehicle tires has been obtained. Using weighted averages and introducing some adjustments we arrived at the figures presented in table 6.11. Countries and regions for which no information was available were treated in the same way as in the case of passenger car tires.

Afterwards rubber demand for commercial vehicle tires can be calculated. Results are shown in table 6.12 for all scenarios.

Table 6.11 Elastomer weight of commercial vehicle tires (in kg).

			<u>1980-2000</u>
1.	United States	C	18.6
		R	20.5
2.	Canada	C	18.6
		R	20.5
3.	Japan	C	11.2
		R	12.1
4-5.	Oceania	C	18.6
		R	20.5
6.	Germany, Fed.Rep.	C	22.3
		R	24.7
7.	France	C	20.5
		R	22.3
8.	United Kingdom	C	19.5
		R	21.4
9-14.	North-West Europe I	C	21.4
		R	23.3
15-18.	North-West Europe II	C	19.5
		R	21.4
19.	Italy	C	18.6
		R	20.5
20-25.	Southern Europe	C	16.7
		R	18.6
26-32.	Eastern Europe	C	18.6
		R	20.5
33-36.	Latin America	C	11.2
		R	12.1
39-43.	S. Asia	C	10.2
		R	11.2
44-52.	E. + S.E. Asia	C	11.2
		R	12.1
53-54.	Middle-East + N. Africa (oil)	C	12.1
		R	13.0
55-58.	Other Middle East + Africa	C	10.2
		R	12.1

Notes: C = conventional tires
R = radial tires

Table 6.12 Projections of rubber demand for commercial vehicle tires (in thousand tons)

	scenario	1985	1990	1995	2000
I. North America	G1	1270.	1368.	1365.	1397.
	G2	1405.	1664.	1834.	2035.
	G3	1513.	1885.	2208.	2579.
II. Asia, developed	G1	315.	374.	445.	510.
	G2	337.	435.	559.	692.
	G3	359.	485.	656.	852.
III. Oceania, developed	G1	68.	69.	69.	71.
	G2	71.	76.	81.	90.
	G3	73.	82.	92.	108.
IV. North-West Europe	G1	351.	414.	442.	470.
	G2	409.	463.	530.	603.
	G3	426.	503.	603.	718.
V. South-West Europe	G1	153.	160.	166.	178.
	G2	162.	183.	206.	238.
	G3	170.	201.	239.	290.
VI. Eastern Europe	G1	309.	313.	322.	327.
	G2	313.	325.	343.	361.
	G3	317.	335.	361.	390.
VII. Latin America + Caribbean	G1	171.	186.	205.	225.
	G2	177.	202.	238.	280.
	G3	182.	216.	265.	327.
IX. South Asia	G1	30.	37.	44.	52.
	G2	31.	41.	53.	69.
	G3	33.	45.	61.	83.
X. South-East + East Asia	G1	64.	80.	98.	128.
	G2	67.	91.	119.	166.
	G3	70.	99.	137.	200.
XI. Middle East + North Africa	G1	32.	35.	36.	40.
	G2	33.	39.	43.	52.
	G3	34.	42.	48.	62.
XII. Other Africa	G1	91.	114.	140.	168.
	G2	99.	138.	183.	238.
	G3	106.	156.	219.	298.
World total (excl. Asian CPE countries)	G1	2894.	3149.	3331.	3566.
	G2	3104.	3656.	4189.	4822.
	G3	3285.	4049.	4890.	5906.

6.3.3 Rubber demand for other tires

Thusfar, rubber demand has been derived and projected for passenger car tires and commercial vehicle tires. This leaves untreated those groups of tires as well as all tubes used for tractors, airplanes, motorcycles, scooters and bicycles. They may be estimated at about 8 % of tire rubber consumption for the group of 8 countries listed in section 6.2 and about 15 % of tire rubber consumption for the rest of the world (excluding Asian Centrally Planned Economies). We relate this end-use to GDP for the two groups. For the 8 countries

$$c_t^0 = - 79 + 0.08 y_t \quad (6.15)$$

and for the rest

$$c_t^0 = - 120 + 0.18 y_t \quad (6.16)$$

Using the GDP-scenarios from appendix A, one arrives at projections presented in table 6.13.

Table 6.13 Rubber demand (excl. Asian Centrally Planned Economies) for tires other than those for passenger cars and commercial vehicles (in metric tons), for three scenarios.

	scenario	1985	1990	1995	2000
Groups of 8 countries	G1	278	330	392	451
	G2	296	383	493	614
	G3	311	425	575	752
Rest of the world (excl. Asian CPEC)	G1	456	574	721	881
	G2	481	659	894	1,177
	G3	505	728	1,077	1,431
World (excl. Asian CPEC)	G1	734	904	1,113	1,333
	G2	778	1,042	1,386	1,790
	G3	816	1,153	1,612	2,183

6.3.4 Rubber demand in the tire sector

Thusfar, all components of rubber demand for tires have been projected excluding Asian Centrally Planned Economies. By simply adding up results one obtains table 6.14.

Table 6.14 World rubber demand in the tire sector (in 1000 metric tons) for five scenarios

	<u>scenario</u>	<u>1985</u>	<u>1990</u>	<u>1995</u>	<u>2000</u>
World (excl. Asian CPE countries)	G1-a	6,127	6,640	7,077	7,606
	G2-b	6,481	7,475	8,511	9,793
	G2-c	6,513	7,565	8,624	9,916
	G3-d	6,822	8,215	9,803	11,836
	G3-e	6,855	8,306	9,921	11,962

6.4 World demand for rubber

In sections 6.2 and 6.3 world demand for rubber in the non-tire sector and the tire sector has been derived. Aggregating these two sectors by adding the totals of table 6.8 and table 6.14, world demand for rubber, excluding Asian Centrally Planned Economies is obtained. Results are shown in table 6.15. Scenarios b and d have been left out, because of small differences only with c and e respectively.

Table 6.15 World rubber demand (in 1000 metric tons) for three scenarios

	<u>scenario</u>	<u>1985</u>	<u>1990</u>	<u>1995</u>	<u>2000</u>
World (excl. Asian CPE countries)	G1-a	13,604	15,607	17,881	20,323
	G2-c	14,398	17,806	21,953	26,828
	G3-e	15,074	19,560	25,313	32,462

It is interesting to note that differences between scenarios b and c are minor, implying that scenarios for different saturation levels hardly affect future rubber consumption (table 6.12). On the other hand, different levels of economic growth will have an enormous impact on future rubber demand, as can be derived from results of different economic scenarios: G1, G2 and G3 (table 6.13).

Thusfar no attention has been paid to the case of China (and the other Asian Centrally Planned Economies). It needs no further clarification that it is extremely difficult to obtain information on the structure of rubber consumption and its relationship to such indicators as income and production. In order to complete the picture, we might calculate the effects of growth in GDP in China on rubber consumption, assuming an elasticity of 1.5, which presumably is as good a guesstimate as any other. Further basis for the analysis is estimated rubber consumption in 1980, amounting to 450 thousand metric tons. Results are presented in table 6.16.

Table 6.16 Estimated rubber demand in Asian Centrally Planned Economies (in thousand metric tons), for 3 economic scenarios (cf. chapter 2)

	<u>scenario</u>	<u>1985</u>	<u>1990</u>	<u>1995</u>	<u>2000</u>
Asian Centrally Planned Economies	G1	659	1,020	1,590	2,390
	G2	707	1,226	2,138	3,596
	G3	752	1,402	2,636	4,778

Combining tables 6.15 and 6.16 gives total world rubber demand for 1985, 1990, 1995 and 2000, as shown in table 6.17.

Table 6.17 Estimated world rubber demand (in thousand metric tons) for three scenarios

	<u>scenarios</u>	<u>1985</u>	<u>1990</u>	<u>1995</u>	<u>2000</u>
Total world	G1-a	14,263	16,627	19,471	22,713
	G2-c	15,105	19,032	24,091	30,424
	G3-e	15,826	20,962	27,949	37,391

This shows considerable increase in rubber consumption even for the low growth scenario G1. Perhaps the already rather pessimistic scenario G1, drawn up in early 1980, was still a little too optimistic (cf. Appendix A). A revision of GDP growth figure based on 1981-data will be published in the middle of 1982.

Appendix A. Scenarios for population, income and energy

Any model deals with two types of variables: variables whose development are explained by the model (e.g. car ownership) and variables which are very important to the model but whose development must be analyzed in a greater context (e.g. income growth). Some of these variables basically are macro scale variables and will be discussed in this appendix.

The ultimate determinants of world demand for rubber are population, national incomes and their respective growth rates. The basic connection between these key variables and such rubber-using products as vehicles, tires and other rubber goods is self evident. Projections of these fundamental demand determinants is however the most vulnerable part of rubber demand projections. The plausibility of the assumptions with respect to population and income growth determines the validity of the result of any study.

a. Population

The population projections used in the present study are the so-called United Nations medium variant, as adjusted in certain cases by other international organizations (see United Nations, Population Division (1975)). Some further adjustment have been included by us to account for recent developments in population growth. Detailed projections are presented in Smit (1980). A summary for XII broad regions (cf. table 2.1) is given below in table A.1.

Table A.1 Population estimates and projections by broad regions (in millions)

	<u>1975</u>	<u>1980</u>	<u>1985</u>	<u>1990</u>	<u>1995</u>	<u>2000</u>
I. North America	236.3	246.2	257.7	268.4	276.8	284.4
II. Asia, developed	111.6	117.0	120.7	123.2	125.2	127.2
III. Oceania, developed	16.8	17.7	18.5	19.2	19.7	20.1
IV. North-West Europe	233.6	234.4	235.3	236.5	237.4	237.8
V. South-West Europe	172.3	182.4	193.3	204.7	216.1	226.8
VI. Eastern Europe	363.0	378.9	394.7	409.0	421.8	434.4
VII. Latin America + Carribean	317.6	364.1	416.9	475.8	539.7	608.0
VIII. Asia, Centr.Planned	987.3	1056.9	1121.5	1176.9	1231.3	1283.7
IX. South Asia	806.4	897.5	996.4	1098.6	1197.9	1290.6
X. South-East+E.Asia	293.7	329.6	368.1	407.3	445.3	480.7
XI. Middle East+N.Afr.	130.7	149.4	170.1	193.1	217.1	241.2
XII. Other Africa	321.2	370.7	430.4	501.1	584.4	679.6

b. Income

There is considerable controversy over the future of world income levels. Because of this controversy surrounding such long-term projections, we have devised three alternative scenarios of future economic growth, projecting Gross Domestic Product (GDP) in 1975 prices, in 1975 U.S. \$ by country or region:

Scenario G1 - low rate of economic growth

G2 - medium rate of economic growth

G3 - high rate of economic growth.

The assumptions behind these scenarios are as follows:

- growth figures for 1980 are based on OECD projections and/or on the pattern of recent years;
- all growth figures for 1981 and later are rounded at 0.5 %;
- growth figures for 1981 are assumed to be
 - slightly less or equal to 1980 for G1, except for USA and UK
 - close to 1980 for G2
 - slightly higher than 1980 for G3;
- growth figures for the following years are assumed to increase, reaching a maximum around 1990 with low, medium and high levels for G1, G2 and G3 respectively.

The advantage of these alternative scenarios in projecting world demand for rubber is that they permit the individual reader:

- a. to include his own views concerning the future of the world economy into his projection-based decisions,
- b. to adjust his choice of projection as new information on the world's economic future becomes available, and
- c. to find out how sensitive the demand for rubber is to the rate of economic growth.

The three projected GDP scenarios are presented in detail in Smit (1981). A summary for the XII broad regions (cf. table 2.1) is given in table A.2 below.

Table A.2 Growth in gross domestic product, estimates and scenarios

(in 1975 prices, in 1975 U.S. \$)

			<u>Compound annual growth rates</u>				
			<u>1975-1980</u>	<u>1980-1985</u>	<u>1985-1990</u>	<u>1990-1995</u>	<u>1995-2000</u>
I. North America	G1		3.1	3.3	1.6	1.6	1.1
	G2		3.1	1.4	3.1	3.1	2.6
	G3		3.1	2.2	4.1	4.1	3.6
II. Asia, developed	G1		5.7	4.0	4.5	4.5	4.0
	G2		5.7	4.9	6.0	6.0	5.5
	G3		5.7	5.7	7.0	7.0	6.5
III. Oceania, developed	G1		2.6	3.0	3.3	3.3	2.8
	G2		2.6	3.8	4.8	4.8	4.3
	G3		2.6	4.6	5.8	5.8	5.3
IV. North-West Europe	G1		2.9	2.1	2.9	3.0	2.5
	G2		2.9	3.0	4.4	4.5	4.0
	G3		2.9	3.8	5.4	5.5	5.0
V. South-West Europe	G1		3.3	1.8	2.5	2.6	2.1
	G2		3.3	2.7	4.0	4.1	3.6
	G3		3.3	3.5	5.0	5.1	4.6
VI. Eastern Europe	G1		3.8	3.3	4.0	4.0	3.6
	G2		3.8	4.2	5.5	5.5	5.1
	G3		3.8	5.0	6.5	6.5	6.1
VII. Latin America + Caribbean	G1		4.3	3.8	4.6	4.8	4.4
	G2		4.3	4.7	6.1	6.3	5.9
	G3		4.3	5.5	7.1	7.3	6.9
VIII. Asia, Centr. Planned	G1		4.9	5.1	5.8	5.9	5.4
	G2		4.9	6.0	7.3	7.4	6.9
	G3		4.9	6.8	8.3	8.4	7.9
IX. South Asia	G1		5.3	4.8	5.5	5.5	5.0
	G2		5.3	5.7	7.0	7.0	6.5
	G3		5.3	6.5	8.0	8.0	7.5
X. South-East + East Asia	G1		7.7	5.6	6.3	6.4	5.9
	G2		7.7	6.5	7.8	7.9	7.4
	G3		7.7	7.3	8.8	8.9	8.4
XI. Middle East + North Africa	G1		4.6	3.2	4.0	4.1	3.7
	G2		4.6	4.1	5.5	5.6	5.2
	G3		4.6	4.8	6.5	6.6	6.2
XII. Other Africa	G1		1.9	1.0	1.8	1.8	1.4
	G2		1.9	1.9	3.3	3.3	2.9
	G3		1.9	2.7	4.3	4.3	3.9

c. Energy

The last part of our macro scene is the energy aspect. For passenger cars, commercial vehicles tires, rubber etc. the availability and the price of oil are the most important elements of the energy aspect.

We shall just mention a few sections of the analysis where energy may come to the forefront.

- a - economic growth
- b - passenger car and commercial vehicle park
- c - driving distance and discarding
- d - driving distance and tire wear
- e - increased usage of remoulded tires
- f - production costs and, thus, prices of SR
- g - prices and production costs of NR.

It needs no further clarification that it is very hard to include the energy aspect accurately into the model because

- it is not clear what the relationships are
- it is not clear what the future of energy will be.

For example, energy availability and price affect GDP growth which in turn influence passenger car ownership. But passenger car ownership may be more sensitive to energy (oil) availability than GDP in general. On the other hand, perhaps driving distance rather than car ownership is affected by oil availability and price.

Consequently, quantifying energy scenarios, as has been done above for GDP, and then determining exact relationships with variables like driving distance, seems an impossible venture. We shall therefore confine ourselves to qualitatively mentioning energy (oil) scenarios and assume possible effects wherever necessary. These scenarios may be described along the following lines:

<u>scenario</u>	<u>availability</u>	<u>price</u>
E1	low	high
E2	high	low

Further details shall be tentatively quantified wherever necessary in the subsequent chapters and projections. It goes without saying that not all combinations of GDP scenarios G1, G2 and G3 and energy scenarios E1 and E2 are realistic. E1 might be combined with either G1 or G2 and E2 might be analyzed together with G2 or G3.

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