SYNTHETIC RUBBER VERSUS NATURAL RUBBER

AN ECONOMIC TREATISE

BY

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Chapter I

Introduction

The economy of a modern industrial country would grind to a halt were it deprived of its supplies of rubber. Our dependence upon this "gold on trees" is, in the popular mind, associated almost exclusively with rubber-tired vehicles; and even though our critical reliance upon rubber is much wider than this implies, it would be difficult to exaggerate the importance of the automobile, the truck, and the bus to our way of life. People ride to and from work on rubber; the raw materials which they fashion into finished goods are, to an ever-increasing extent, borne to the factory on rubber; the finished product arrives at its ultimate destination on rubber. The salesman rides to his customers on rubber, the pleasure-seeker to his place of entertainment, the businessman to his office. More and more the housewife uses the family car for her shopping trips; or, if she prefers, she uses the telephone, and has her order delivered by a truck which rides on rubber. Trucks are gradually replacing railroads for short-run hauls -- many branch lines have been abandoned, and numerous communities are now served by truck alone. The truck is even competing with the railways on relatively lengthy hauls. The rural areas are even more dependent upon rubber than the urban communities. Where an extreme tire shortage would be a great inconvenience to the urbanite, it would be a calamity to the rural

dweller, for he has to take not only himself, but his produce, to a market which generally lies at an appreciable distance. The importance of rubber-borne transport to business is well illustrated by a study made by the United States Public Roads Administration, which estimated that, of the millions of miles of driving done annually by the 27,500,000 registered passenger cars in the United States, 47 per cent was devoted exclusively to business.[1] The significance of this statement can only be completely apprehended when it is realized that the investigation did not embrace trucks and buses -- only registered passenger cars were included.

The supreme importance of rubber in the field of transportation is not limited to rubber-tired vehicles. Modern railroading requires rubber for manifold purposes, such as for air and steam lines; and aeroplanes have almost as many uses for rubber as the 700-odd places in which rubber is utilized in the automobile.

Transportation is not the only phase of modern life in which rubber is essential. The electrical goods industry, the products of which are working for us every minute of the day and night, and without which our modern systems of communication would no longer function, is dependent for its continued existence upon rubber, for there is no acceptable substitute for rubber as an insulating material. The mining industry, so important as the source of raw materials in

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1. George S. Armstrong and Company, Inc. An Engineering Interpretation of the Economic and Financial Aspects of American Industry. Vol. IV. The Rubber Industry. p.8.

this metallic age, could no longer operate in its present efficient manner if it were deprived of rubber, for it uses thousands of tons for conveyer belts, air drills, and other equipment. The typewriter in the office, the refrigerator in the kitchen, the radio in the living-room, the washing machine in the cellar, the vacuum cleaner -- all are useless without rubber. The wheels of industry are turned by belts of rubber. The balls with which we play tennis, golf, lacrosse and handball -- all are made of rubber. The very location of our homes has been influenced, in some cases determined, by rubber. Many suburban communities would never have developed had there been no swift means of communication with the centres of business activity. There is hardly an aspect of life which would not be materially changed if rubber were to disappear. In fact, life as we know it would be absolutely impossible.

In addition, the rubber industry is an important employer of men and of capital. In Canada alone, in 1943, there were 51 plants manufacturing rubber goods, with a capital investment of $73,000,000. These plants employed 16,000 persons who were paid $25,000,000 in wages and salaries, and they produced goods valued at $130,000,000 from materials costing $68,000,000.[2] Throughout the world there is an investment of about $2,500,000,000 in rubber plantations, of $1,500,000,000 in fabricating facilities.[3]

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2. Dominion Bureau of Statistics. Report on the Rubber Industry in Canada, 1943. p.1.
3. Armstrong. p.8.

It is important to note that only one-half of the weight of an ordinary passenger tire is crude rubber: about one-sixth is fabricating material and one-third compounding ingredients and wire. The result is that the rubber tire industry, which accounts for between 70 and 80 per cent of the annual consumption of rubber, provides a large market for many primary products, such as cotton and sulphur; and any development which affects the rubber industry will naturally have its influence upon these other industries, and so will react upon the economy as a whole.

The future of rubber is just as crucial a problem to the producing as to the consuming countries. In Malaya and the Netherlands East Indies, both predominantly agricultural, rubber is the largest cash crop; the fiscal systems are to a great extent based on the revenue yielded from rubber export taxes; and any appreciable diminution of the exports of rubber would seriously impair their respective economies. Neither from the standpoint of total tonnage produced nor relative moment to the economy as a whole is rubber as important to Ceylon, French Indo-China, Thailand, Sarawak, Burma and Liberia, the only other countries which grow significant quantities, as it is to the two aforementioned producers. Nevertheless, the loss of a market for crude rubber would not be inconsequential to their welfare.

The last four years have witnessed the development of a synthetic rubber industry in the United States and Canada

which, on the one hand, threatens the existence of the producers of crude rubber, at least in the form and on the scale in which they have operated in the past, and, on the other hand, promises to be a boon to the consuming countries through the lower prices that will be the inevitable concomitant of competition between synthetic rubber and natural rubber. This new industry, the reverberations of which have been heard throughout the entire world, merits the considered attention of every person who has an intelligent interest in the problems which have grown out of the war and in their possible solutions.

The problem of rubber is one of over-production and under-consumption. It has been estimated[4] that by 1950, if no facilities are in the meantime destroyed, the total world capacity for the production of rubber and rubber-like substances will be about 2,900,000 tons. Slightly more than one-half of this total, 1,500,000 tons, will be represented by natural rubber plantations in the Far East, the remaining 1,400,000 tons by synthetic rubber plants, 80 per cent of which will be in the United States and Canada. On the other hand, only four times in history has the total world consumption of rubber exceeded 1,000,000 tons, and only once, in 1941, when the exigencies of war greatly increased consumption, did it reach 1,100,000 tons. Here then is a potential discrepancy between supply and demand of 1,800,000 tons. It is quite possible, even probable, that many new uses will be developed for

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4. News report of the meeting of the "international rubber study group", November 26, 1945.

rubber, that new markets will result from the opening up and industrialization of backward countries, and that part of this slack of almost 2,000,000 tons will be taken up, but even the most optimistic of men have quailed at predicting a more than doubling of annual world consumption once the backlog of demand created by war restrictions has been satisfied. This is the dilemma that the world is facing, and it is with one of its economic aspects that this thesis is concerned.

This work does not pretend to be a definitive treatise of all the economic aspects of synthetic rubber. No attempt has been made to examine the advantages and disadvantages of the scores of varieties of synthetic rubber. No attempt has been made to inquire into the uses of each type and the extent to which each will displace the natural product either in the immediate future or in the long run, for such an undertaking would involve the close cooperation of rubber chemists, manufacturers, chemical companies and governments, and even then the findings could only be of a tentative nature. None but incidental reference is made to the economic consequences of the diversion of the raw materials required by synthetic rubber from their previous uses, to the effects of an expanding synthetic rubber and a contracting natural rubber industry upon international trade, to the secondary industries which may develop around the synthetic rubber plants.

The subject of this investigation is the relative competitive strengths of natural and synthetic rubber in the period immediately following the return of natural rubber

production in the Far East to its pre-war level. All the above and other economic aspects of synthetic rubber are therefore extraneous, are without the purview of this inquiry, and merit only passing attention. This work seeks the answer to the question, Assuming free competition and the effieiencies and productive techniques which present knowledge make possible, which commodity, natural rubber or synthetic rubber, will be superior competitively in the decade following the resumption of large-scale natural rubber production? The fundamental thesis is that if the Far Eastern rubber growers reform their industry, eliminating all high-cost producers, inefficient agency systems and expensive European directorates, if they sedulously follow a policy of unrestricted production, continued planting of high-yielding selected seedlings, and bud-grafting, then they will be more efficient than the synthetic rubber manufacturers of the United States and Canada, their product will be qualitatively the equal of synthetic rubber, and they will be able to usurp the largest part of the world rubber market. This again assumes free competition and presently developed efficiencies and productive techniques.

It is impossible to lay too great a stress on the fact that this work is in no way concerned with extreme long-run prospects. Whether a synthetic rubber far superior to its natural prototype will eventually be produced in a chemical factory 25 or 50 years from now is for the chemist to speculate upon, not the economist.

Ultimately, quality, cost of production and demand are

the decisive factors which allocate the proportions of a free market which two competing products obtain, and which determine the total extent of that market. Therefore this thesis consists of an examination of these three factors, each of which will be considered in the order mentioned.

However, before the main body of the thesis is touched upon it is necessary further to limit its scope. Of the many varieties of synthetic rubber only five -- GR-S[5] (Buna-S[6]), GR-I (Butyl rubber), GR-M (Neoprene), Buna-N and Thiokol -- are at present suitable for commercial production and use. Of these five only one, GR-S, is a general purpose rubber capable of substituting for natural rubber.[7] The other four are special purpose rubbers, in general inferior to natural rubber, but superior to it in one or more special characteristics. Neoprene, for example, is greatly superior to natural rubber in its resistance to gas and oil, and it has many uses which take advantage of this property. Thus Neoprene and the other three special purpose rubbers do not compete with natural rubber; they are complementary to it.[8] Only

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5. Translated, GR-S means Government Rubber, Type S.
6. Buna-S was so christened because butadiene is one of its chief constituents, and the Germans, who first produced it, used sodium, the chemical short form of which is "na", as a catalyst.
7. Butyl rubber is sometimes classified as a general purpose rubber. However, it is markedly inferior to both natural rubber and GR-S except in certain uses to which it is particularly well adapted. Hence it is treated here as a special purpose rubber.
8. It seems certain that Butyl rubber will be preferred to natural rubber in post-war inner tubes because of its superior resistance to gaseous permeation. Similarly Neoprene, Buna-N and Thiokol will replace natural rubber in

GR-S, the one general purpose synthetic rubber, is capable of competing with natural rubber over a large section of the market.

This is illustrated by a calculation of Mr. Davis, of the United States Rubber Co.,[9] who, on the basis of a post-war demand of 1,500,000 tons, estimated that 100,000 tons of the special purpose synthetic rubbers would be used for oil and gas resistant products and for inner tubes, etc., where the synthetics are obviously superior; that 400,000 tons of natural rubber would be used for large-size special-service tires, latex thread and dipped goods, footwear, etc., where it is obviously superior; and that the remaining 1,000,000 tons would be wide open for competition between the general purpose synthetic rubber, GR-S, and natural rubber.

Since it appears that GR-S will provide the only important competition for natural rubber, the following analysis is limited to this particular synthetic.

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other uses where the natural rubber, although obviously unsatisfactory, was heretofore used either because the synthetics were not in existence or because they were available only at uneconomic prices. It may be argued that in these cases the synthetics are competing with natural rubber, and in fact are replacing it. This last is the crux of the problem. The very superiority of the former precludes the competition of the latter. There was a time when, with the synthetic industry in its infancy, the special purpose synthetic types and natural rubber competed with each other in the specialized uses for which the synthetics were best fitted, but the gradual improvement of the latter has effectively terminated competition in these uses.

9. India Rubber World. September, 1945. p.471.

Chapter II

Comparison of the Quality of Natural Rubber and GR-S

It is necessary to say a few words concerning the nature of synthetic rubber before a discussion of its quality can be really grasped. Strictly speaking, there is no such material as synthetic rubber. Chemists have never been able to solve the mystery of the exact chemical composition of natural rubber, and manifestly it is impossible to duplicate in the laboratory something whose chemical composition is not known.

The search for the exact chemical equivalent was long ago given up, its place being taken by a search for materials which had a similar molecular structure as natural rubber, and which therefore had rubber-like properties. The problem was no longer the synthesis of a specific organic chemical, but the production of a physical structure by chemical means. The word rubber is now descriptive of physical properties rather than of chemical composition, and the term synthetic rubber is loosely applied to any substance in which rubber-like properties predominate, and which does not occur in a natural state, but which is produced chemically by man.

The chemist tells us that the natural product is doomed. Just as synthetic dyes manufactured from coal tar have completely supplanted natural vegetable dyes, so synthetic rubber made from petroleum products will eventually replace the

product of the rubber tree. The reason, he says, is that in time the rubber chemist will become so skilful, and his knowledge so complete, that he will be able to "tailor-make" rubber, to produce for each particular use a rubber which will be specially adapted to the requirements of that use. In short, the rubber tree is restricted to the production of a commodity with a fixed chemical composition, and uses must be adapted to the raw material; the factory can vary the chemical composition of its product, and the raw material is adapted to the use.

It is impossible to say with unqualified certitude whether this prediction will ever be fulfilled. Certainly its consummation can only be a very long-run development. Although synthetic rubbers like neoprene and thiokol are superior to natural rubber for specialized uses, especially where resistance to gas, oil, light, air, heat and cold are concerned, no general purpose synthetic rubber has yet proven superior to natural rubber. At present GR-S is the only possible competitor over any large part of the market.

Improvements are being constantly made in GR-S. Six months ago most men familiar with the subject would have agreed that, if the question had been posed to manufacturers, "Which would you prefer to use, natural rubber or GR-S, if they were both selling at the door of your factory for the same price?" the great majority would have replied, "Natural rubber". To-day these same men would not be so sure. On a

quality basis exclusively, ignoring price differentials, it is probable that the average tire manufacturer would use both GR-S and natural rubber in the ordinary light weight tire. Naturally the tire manufacturers, who are operating in one of the most highly competitive fields in the world, and who must use a large proportion of synthetic rubber because of the shortage of natural rubber, are making extravagant claims for synthetic rubber tires, as do the rubber chemists, who are naturally prejudiced no matter how intelledtually honest they may strive to be. The result is that it is an extremely difficult proposition for the layman to assess the relative qualities of the two. However, such must be attempted. It is the author's opinion that <u>at the present time</u>, on a qualitative basis, there is little to choose between natural rubber and GR-S, although the natural rubber may have a slight advantage; that therefore quality considerations may with safety be abstracted from the discussion of which is competitively stronger, and that other factors, the chief among which are cost of production and magnitude of demand, will decide the issue.

Chapter III

Comparison of the Cost of Production of Natural Rubber and GR-S

The purpose of the following study is not only to arrive at what the costs of GR-S and natural rubber have been in the past, but on the basis of these costs and of our knowledge of changed conditions to ascertain what will be the probable costs under conditions of free competition and unrestricted production (say) five years from now, when the Far Eastern growers are back in full production and the high-cost synthetic plants have been eliminated.

A. Cost of Production of GR-S.[1]

The cost of production of GR-S may be classified as follows: 1) cost of materials; 2) operating cost; 3) selling expenses, amortization costs, profit and interest on investment. Since the magnitude of the items in class 3 depends to a great extent on as yet undecided (or unannounced) governmental policies, a discussion of these costs will be deferred until later.

The two main ingredients of GR-S are butadiene and styrene, of which the former is the most important from the standpoint of cost. The many processes for the manufacture of butadiene can be divided into four categories according

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1. Unless otherwise stated, all numerical data in this section are based on the Special Report of the Office of Rubber Director on the Synthetic Rubber Program, August 31, 1944.

to the feed stocks employed. Up until the last year of the war the greater part of the butadiene was produced from alcohol. The operating costs of the alcohol process, which

Table 1. Butadiene, Styrene and Copolymer Plant Operating Costs (cents per pound of product excluding feedstocks, amortization, preliminary expense, research).

	Butadiene				Styrene		Copolymer	
	From Alcohol		From Butylene (dehydrogenation					
	Present	Post war	Present	Post war	Present	Post war	Present	Post war
1.Chemicals (excluding feedstocks	0.18	0.13	0.57	0.50	0.42	0.42	2.10	1.90
2.Operating labour	.14	.12	.48	.44	.27	.25	.52	.45
3.Utilities	.95	.75	1.20	1.20	.46	.46	.26	.26
4.Other costs[2]	.66	.70	1.73	1.71	.83	.89	1.43	1.32
5.Royalties and management	.51	.63	.65	.63	.68	.63	.52	.51
6.By-product credit	.23	.14	....	....	.14	.14	....	....
Total out-of-pocket costs.	2.21	2.19	4.63	4.48	2.52	2.51	4.83	4.44

Source. Data from the Special Report of the Office of Rubber Director on the Synthetic Rubber Program, p.7.

are slightly over 2¢ per pound (see table 1), are small in comparison to the cost of the alcohol itself, which during the war skyrocketed to as much as 90¢ per gallon because most of the alcohol was produced from high-cost grain. The post-war cost of alcohol produced from cheaper agricultural products like corn and

2. Other costs include supervision, repairs and maintenance, operating supplies, laboratory expense, shipping cost, and plant overhead.

molasses will be much lower, but it is doubtful if they will fall much below the 1931-40 average of 27¢ and 19½¢ per gallon, respectively. As the price of alcohol would have to fall to at least 15¢ per gallon before this process would become competitive with the others, it is unlikely to be used to any great extent after the war-time emergency.[3]

All other processes for the production of butadiene use petroleum products as a feed stock. The most important of these processes is based on the dehydrogenation of butylene. The higher operating costs of 4½¢ per pound (see table 1) are more than compensated for by the lower cost of butylene. With yields (utilization) of 0.65 and butylene at 6¢ per gallon, the post-war cost of butadiene by this process should be as low as 6.4¢ per pound.

The butane dehydrogenation process was used only to a small extent during the war, but indications are that its post-war cost will approximate that of the butylene dehydrogenation process. The naphtha cracking process gives such a small yield of butadiene (from 2½ per cent to 5 per cent) and such a large number of by-products that it is unwieldy, and unlikely to compete with the two previous processes except for relatively small quantities.

The other major ingredient of GR-S is styrene, which in turn is manufactured from ethylene and benzol. At present prices (ethylene at 6¢ per pound and benzene at 16¢ per

3. The United States Government has already closed two of the high-cost alcohol butadiene plants.

gallon) styrene costs about 6.6¢ per pound. At estimated post-war prices (ethylene at 2¢ to 3¢ per pound and benzene at 8¢ to 12¢ per gallon), styrene should have an out-of-pocket cost (that is, the cost of the feed stocks plus the operating cost) of from 4¢ to 5¢ per pound.

The most efficient copolymer plants should be able to produce GR-S for an out-of-pocket cost of 10.7¢ per pound if butadiene and styrene are available, respectively, at 7¢ and 5¢ per pound.

Up to this point the influence of selling expenses, amortization costs, profits and interest on investment has been discounted. Selling expenses have been a negligible factor to date because of the assured market. What they would be if the plants were turned over to private interests it is difficult to say. Much would depend upon the government's rubber policy. They would be virtually nil, for example, if the government forced all rubber manufacturers to use a certain percentage of GR-S in all products. Even in a perfectly free market it is not unreasonable to expect that they would be relatively small. This follows from the very nature of the commodity and the products in which it is used. No huge advertising campaign is going to induce a tire manufacturer to by more of a particular kind of rubber than he needs. Nor is an advertising campaign going to persuade him to buy one kind of rubber when another kind, for his purpose just as suitable or even more suitable, is available at the same or a lower price.

Amortization costs are a different proposition. Plant investments in the synthetic rubber industry are heavy, as is evidenced by the $700,000,000 investment of the United States Government in synthetic rubber plants, and the investment per long ton of estimated capacity in United States Government owned GR-S plants of $587. Thus amortization costs are extremely burdensome. It has been computed that with amortization on a ten year basis the cost of production would be more than 12½ per cent higher than with no provision for amortization, and with amortization on a five year basis costs would be about 25 per cent higher than with no provision for amortization.[4]

It should be noted that the construction costs of these plants were inflated by war-time scarcities, that many of the plants are fast becoming obsolescent, and that many of the general service facilities have a life in excess of 10 years. Having taken these factors into consideration, Bradley Dewey, the former American Rubber Director, estimates that, with plants running at full capacity, and with depreciation on a 15 year basis, amortization charges will be approximately 1.05¢ per pound of GR-S.[5] This is a conservative estimate. Factories

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4. United States Tariff Commission. Rubber. pp.79-80. The Tariff Commission computed the percentage which costs would be reduced if amortization were neglected. I translated their results into the percentage by which costs would be increased by the addition of amortization costs. Hence the discrepancy between the 10 per cent and 20 per cent of the Tariff Commission and my figures of 12½ per cent and 25 per cent.
5. Chemical and Metallurgical Engineering, Vol.50, No.12. December, 1943. p.101.

do not usually run at full capacity in peace-time, especially rubber factories, for the cyclical fluctuations in rubber consumption are exceedingly violent. Also, the rate of obsolescence in synthetic rubber plants is so high that many of the facilities will be outmoded long before the 15 years are up.

The view is held in some quarters that these plants are akin to battleships in that they are expendable. They were built in response to a national emergency; without them that emergency would never have been survived; having served their purpose they should be written off as a cost of the war.

At best this is merely an argument designed to support a policy which for other reasons is felt to be in the national interest; at worst it is an ingenious sophistication devised for the express purpose of influencing the government toward a course of action which will work to the aggrandizement of certain interests. In either case it is fundamentally in error from the standpoint of calculating the true costs of production. No matter what decision the American government (and the Canadian government too for that matter) comes to in this regard, the fact remains that these plants have a certain value, difficult though it be to arrive at it, and that before a true cost of production can be reckoned, allowance must be made for depreciation. The truth of this statement may be made plainer by a consideration of the conditions under which new capital will be persuaded to enter an industry. No man will invest in a company unless he feels that he will receive the going rate of interest plus a

compensation for risk. Now if dividends are paid without depreciation being charged against the assets, then the investor is not receiving a true dividend: his principal is being returned to him in the guise of a dividend. Ultimately this policy will terminate in bankruptcy. There can be no other end when dividends are paid not on the basis of true profits, but on the basis of bookkeeping profits which in reality do not exist. Depreciation is an item of cost and must be so considered. If the government hands over the synthetic rubber industry to private interests for anything less than the true value it is in effect subsidizing it. The aim of this analysis is to arrive at the cost of production of GR-S in order to evaluate its chances in free competition with the natural rubber growers, and therefore provision must be made for amortization costs.

How much will have to be added to costs per pound in order to allow for a return on investment will also, in the short-run, depend on government policy as to the value of plant investment. However, just as allowance for amortization must be based on the true, not a fictitious, value, so must profits and interest on investment be based on real investment. If this be not so, there exists no basis for comparison between the costs of the natural and synthetic producer.

Although royalties, which have been only nominal during the war, will be of considerable importance in the post-war period in the cases of the special purpose rubbers, they will

be of negligible significance in the case of GR-S, as the Rubber Reserve Company has instituted a system of licensing and cross-licensing into which the great majority of patents relating to GR-S have been brought.

When the estimated 2¢ to 4¢ by which these four factors -- amortization, return on investment, selling expenses and royalties -- will increase costs have been added,[6] it appears that the most efficient producers in the post-war picture will have a cost of production of from 13¢ to 15¢ per pound.

It is not meant to be implied that the cost of production of GR-S will remain at this level indefinitely. The rubber chemist is continuously striving both to improve the quality of his product and to lower its costs. Eventually it may be possible to produce at a lower cost a general purpose synthetic rubber superior to natural rubber. This, however, can only be a lengthy process, stretching over several decades, and it must be emphasized that this thesis is concerned, not with the extreme long-run possibilities, but with conditions as they will be in the period following the return of natural rubber production to its pre-war level.

On the other hand, other factors may work to raise the cost of synthetic rubber. The price of the light petroleum petroleum fractions from which butadiene and styrene are produced will be influenced by the price of high octane gasoline, which is to some extent derived from the same fractions, and by the price of ordinary gasoline, the quantity of which

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6. Special Report of the Office of Rubber Director on the Synthetic Rubber Program. p.12.

produced is considerably decreased when the lighter fractions are removed. It is possible that the demand for these other products will increase, with the result that the price of the lighter fractions, and therefore the cost of production of butadiene and styrene, will also increase. This is all in the realm of speculation, however, and in the light of present knowledge, 13¢ to 15¢ is the best estimate that can be made of the cost of production of GR-S.

B. Natural Rubber Costs

It has been the custom in the last year or two for persons writing or speaking about the future of the synthetic rubber industry to quote the New York wholesale price of plantation ribbed smoked sheets, or some analagous price, to compare this with the costs of the most efficient synthetic rubber plants, and on the basis of this information to make a prediction as to the outcome of future competition between natural and synthetic rubber. Any such calculation is grossly misleading. For the purpose of judging competitive strength, it is almost as great a fallacy to quote the New York wholesale price of natural rubber as it would have been in 1944 to quote the average cost of GR-S, which was more than double the cost of the most efficient producers because of the preponderant influence of high-cost alcohol-produced butadiene. Averages indiscriminately used are more deceiving than valuable.

The two major growing countries, British Malaya and the

Netherlands East Indies, between them account for 80 per cent of total capacity. The only other important producers are Ceylon, Thailand, French Inde-China, Sarawak, Borneo, India and Burma. In each of these countries there are two broad classes of producers -- estates and natives. Each of these classes can in turn be further sub-divided into high- and low-cost producers. Hence any sane estimate of natural rubber costs must consider the quantity, quality, and cost of production of each category.

Before making a detailed examination of the cost picture, I wish to make a few remarks which will serve both as a background for what I wish to add later and as an introduction for the reader who knows little or nothing about the subject.

Some idea of the complexity of the problem under consideration can be derived from even a cursory glance at table 2, which lists the New York wholesale prices for natural rubber from 1913 to 1942. At first glance it would seem that rubber prices have fluctuated wildly, with neither rhyme nor reason to guide them. Although it is not revealed by this table, which lists only averages, the yearly range of rubber prices has been as much as 88.8 ¢ per pound, and even the yearly averages show huge price differentials. Thus average annual price declined from 72.2¢ in 1916 to 16.5¢ in 1921, rose to a high of 73.0¢ in 1925, declined to 3.4¢ in 1932, and rose to 19.4¢ in 1937. It is against these huge fluctuations that rubber manufacturers have for long and with good reason inveighed. When hundreds of thousands of dollars are tied up

Table 2. New York Wholesale Rubber Prices, 1913-42.
(cents per pound)

Year	Price	Year	Price	Year	Price
1913	82.0	1923	30.7	1933	5.95
1914	65.3	1924	26.4	1934	12.93
1915	65.7	1925	73.0	1935	12.37
1916	72.5	1926	48.7	1936	16.51
1917	72.2	1927	38.1	1937	19.42
1918	60.2	1928	22.6	1938	14.70
1919	48.5	1929	20.6	1939	17.91
1920	35.9	1930	11.94	1940	20.24
1921	16.5	1931	6.20	1941	22.34
1922	17.3	1932	3.47	1942	22.50
1913-22	53.61	1923-32	28.17	1933-42	16.49

Source. Everett G. Holt. Special Report of Office of Rubber Director on The Synthetic Rubber Program. Appendix A. Pre-War Costs of Production for Plantation Rubber. p.13.

in inventory stocks, a rapid fall in price may cost a fortune. It may of course be replied that a corresponding increase may net one, but this does not remove the difficulty. Rubber manufacturers are not speculators; they wish to make their profit on their manufacturing business, not on the possibility of correctly forecasting price movements.

However, we should not allow the extent of these fluctuations to blind us to everything else that the table illustrates. Of just as much import as the price fluctuations is the long-term downward trend, as shown by the ten-year averages. The average price of 53.6¢ in the decade of 1913-22 fell to 28.2¢ for the next ten year period, and to 16.5¢ in 1933-42. This long-term decline is highly significant. The standard-bearers of synthetic rubber have a penchant for assuming that natural rubber production costs will be static from this point on, whereas, if prices are any indication of costs,

no matter what they are not, they are certainly exceedingly dynamic. They continually rise and fall, remaining at one level for only short periods.

It should be carefully noted that from 1922, when prices reached their post-World War I nadir, until 1942, when World War II brought to an unpleasant end both the need and the possibility of such activities, there was only one period of four years when rubber production was not arbitrarily restricted. The Stevenson plan operated during the years of the British Rubber Restriction Era from 1922 to 1928; the International Rubber Regulation Committee held sway from 1934 to 1942. Only from November 1, 1928, until June 1, 1934, during the worst years of the depression, were all growers free to produce in unlimited quantities as their individual self-interest dictated.

The importance of this fact can hardly be over-exaggerated either from a theoretical or practical viewpoint. The Stevenson scheme coincided with, and to a large extent was the cause of, the end of Malayan domination of rubber production. Under this scheme, the Malayan growers agreed to restrict their output until the price of rubber reached a certain level. They were temporarily successful in raising prices, but the net effect was the stimulation of production in those countries which refused to subscribe to the scheme. Producers in the Netherlands East Indies were especially successful in taking the market away from their Malayan counterparts.

The import of the scheme was felt in other ways. It

served to encourage and aggravate an already strong anti-British attitude on the part of many Americans, especially those whose pocketbooks were hit. The restrictions of the IRRC, even though they applied to all Far Eastern growers, did not do anything to alleviate this Anglophobic prejudice. This may seem unimportant now, but such a widespread feeling finds expression in many diverse and seemingly unrelated fashions. To-day it is of great importance in the discussion of subsidization of American synthetic rubber plants.

One result of these schemes, of theoretical importance at least to the writer, is the impossibility of obtaining any satisfactory demand or supply curves. If it were possible to draw such curves, my task would be greatly simplified. A supply schedule in a case like rubber can only be derived from an historical study. One can only report what happened under certain conditions in the past, and on this basis what will happen in the future (ceteris paribus). Even though economic phenomena are dynamic, studies of past conditions are, in general, valuable for present use. In the case of rubber, however, conditions have changed to such an extent that any supply curve gleaned from an historical study would be worse than useless to-day. A supply price[15] defined as the amount a producer is willing to offer at that (given) price, and if the amount which he offered at a certain time in the past and at a certain price was arbitrarily determined by some external authority, there remains no basis of comparison between what happened at that time and what will happen at some future

time when the market is free.

Nevertheless, some general statements can with confidence be made with regard to the supply of and the demand for rubber. Generally speaking, the supply of rubber is very inelastic, both in the short- and the long-run. (see table 2a, p.27, for the startling example of the way in which rubber production actually rose from 1929 to 1933 while prices fell from 10.3 pence per pound to 3.2 pence per pound). The causes of this inelasticity of supply can be classified as biological (that is, related to the nature of the tree itself) and economic (that is, related to the responses, choices and decisions that the producers make as a result of changes in price).

Once the rubber tree has attained maturity, its yields are remarkably constant: it is impossible to increase markedly the yield without materially damaging the tree; nor does the suspension of tapping substantially increase the yield when tapping is resumed. This is the biological basis of inelasticity of supply in the short-run.

Even more important than the nature of the rubber tree in producing this short-run inelasticity of supply is the behaviour of the producers themselves. It is necessary to differentiate here between the two bread classes of producers, the estates and the natives, who, although usually reacting similarly to price changes, rarely do so for the same reason.

Because of the relatively high proportion of fixed or overhead costs among the estates, unit costs appreciably increase as output falls, decrease as output rises. In addition,

local labour is used only to a very limited extent. Labour is largely imported, usually from densely populated India or Java, and often under contract, so that producers are reluctant to disband their staffs because of the heavy expense entailed in reassembling them. For these reasons only the exceptional estate strikingly reduces output as prices fall. The tendency is to adjust costs, rather than supply. Nor do the estates raise their output quickly as prices rise, for they are usually already producing at close to capacity, over-tapping is uneconomic, and the expense of recruiting additional labour for what may be only a temporarily increased demand is exorbitant. Thus the supply of estate rubber is inelastic for both rising and falling prices.

Table 2a. Estate and Native Rubber Production in Thousands of Tons in Malaya and the Netherlands East Indies, and Average Price of Standard Quality Ribbed Smoked Sheets at London in Pence per Pound, 1929-33.

Year	Estates		Natives		Price
	Malaya	N.E.I.	Malaya	N.E.I.	
1929	246	152	201	106	10.3
1930	237	151	199	89	5.9
1931	239	163	196	87	3.1
1932	240	149	178	60	2.3
1933	242	170	219	114	3.2

Source. George Rae. The Statistics of the Rubber Industry. Journal of the Royal Statistical Society, 1938. Vol. CI, Pt.II, p.324.

As rubber is the only source of income in British territories, especially in Malaya, for the native smallholders,

these producers tend to keep their production at a high level even though unit returns fall, for they must maintain a certain minimum income, whatever be the cost or disutility measured in terms of their labour. Instead of curtailing output in reply to falling prices during the last depression, some producers actually raised it in order to compensate for the lower prices (see table 2a, p.27). In the Netherlands East Indies, on the other hand, the small holders are in a much stronger position economically, as their agriculture is diversified, and rubber is only a supplementary source of cash income. Hence here, as prices decline, output falls sharply, and as they rise, output quickly recovers. However, as the natives of the Netherlands East Indies are the most efficient of all rubber producers, prices have to descend to a very low level before their output is greatly affected. Thus the supply of the industry as a whole is very inelastic in the short-run.

The supply of rubber is also very inelastic in the long-run. Rubber is a tree crop, and a period of five years must elapse between the planting of the tree and its first tapping, and even then the tree does not attain maturity until several years after this event. Hence it takes at least five years for a change in demand to be reflected in an increased capacity. This gap of five years between the making of a decision and its fulfilment places a premium on forecasting, and human frailty being what it is, errors are, to say the least, common. Rubber producers are not omniscient, and more than once in the past have great acreages of rubber reached maturity just

in time to magnify the effects of a fall in price. The most notable example is the expansion of capacity undertaken as a result of the high prices of the late 'twenties. The trees planted in the expansion programme matured in the depths of the depression.

Just as bad, if not worse, than the forecasting errors consequent upon human fallibility is the slowness with which redundant capacity, once achieved, is reduced. The extremely long life of the rubber tree, about twenty-five years, coupled with the high initial investment, makes disinvestment an exceedingly slow, and an exceedingly costly, procedure. The natives too reduce excess capacity only slowly, for there are no alternative uses for the rubber tree. This long-run inelasticity of supply is probably a greater problem than the short-run inelasticity.

A consideration of the demand for rubber opens up a whole field of investigation which it is not my intention to touch at this point. However, it is a propos to notice that the demand for rubber is inelastic. Approximately three-quarters of the rubber marketed is used in the manufacture of tires and tubes. The amount of rubber used for these purposes is determined more by the demand for automobiles and trucks than it is by the price of rubber itself. In other words the demand for the rubber used in motor vehicles is a joint demand, and as the cost of rubber is inconsequential in comparison to the cost of its complement, the demand for rubber used in automobiles and trucks is inelastic. In addition, about one-half of the remaining 25 per cent is used in such articles as

automobiles, aeroplanes, electrical equipment, machinery, houses, etc. That is, the demand for rubber used in these articles is a derived demand, and is therefore inelastic. On the whole then, the demand for crude rubber is very inelastic, varying with the changing level of business activity, not with changes in the price of rubber.

Having digested these introductory remarks, the reader will be in a better position to appreciate and to evaluate the more detailed study which follows.

Only general reference will be made to rubber costs prior to 1929, for these are of little value to-day, except in so much as they provide data for the calculation of long-term trends. It is the post-1929 data that are important, for they give an indication of what the Far Eastern producer is now capable.

As was previously intimated, producers may be classified as either estates or native smallholders. There are two methods of calculating the costs of production of rubber estates. The first method, which was used in the preparation of table 3 (p.32), is "based on over-all considerations and practical experience in the principal markets."7 In rough, the theory is that the total income received by each estate divided by the total production will yield the cost per pound. In table 3, for example, "the method used was to tabulate the annual rubber output in pounds, the income realized, the reported

7. E.G.Holt. Special Report of Office of Rubber Director on The Synthetic Rubber Program. Apendix A. Pre-War Costs of Production for Plantation Rubber. p.18.

all-in-cost, the revenue distributed through dividends, reserves and 'carried-forwards', and to calculate the over-all out-of-pocket expense per pound."[8] Even though this method does not exclude the influence of profits and losses from sources other than rubber, it is felt that "the results approximate the average net cost of production ..... and that confidence can be placed in the general accuracy of cost trends indicated."[9]

The other method, that of the International Rubber Regulation Committee, utilizes an accounting formula. To each item of cost -- capital cost, revenue cost f.o.b., freight and selling, head office expenses, depreciation, profit sharing arrangements -- is ascribed an estimate so that the total cost so calculated will form a "fair and equitable"[1] basis for a price level which will be "reasonably remunerative to efficient producers."[2] All tables reproduced from IRRC sources are based on such an accounting formula.

The estates never had to worry about their costs until after the first World War. The falling prices of the 1919-1921 period were reflected in economies which, as table 3 (p.32) shows, were made permanent. From 1922 until 1928, the era of the Stevenson scheme, costs rose slightly due to curtailed production, increased liberality in bonuses, and increased wages, ocean rates, brokerage fees, directors' fees, etc.

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8. Ibid. p.15.
9. Ibid. p.15.
1. International Rubber Regulation Agreement. Cited by United States Tariff Commission. p.41.
2. Ibid. p.41.

Table 3. Cost of Production Trend of Malayan Estates, 1921-33.

	Malayan Estates			London market price ribbed smoked sheets
	Approximate net cost of production (cents)	(pence)	Average sales price (pence)	(pence)
1921	19.61	12.23	12.26	9.56
1922	15.29	8.29	11.18	9.13
1923	18.14	9.52	13.33	15.31
1924	16.70	9.08	14.34	13.88
1925	17.05	8.48	25.99	35.06
1926	19.83	9.86	23.82	23.77
1927	20.88	10.30	18.10	18.44
1928	17.05	8.41	11.90	10.69
1929	12.69	6.28	9.72	10.25
1930	10.17	5.02	5.02	5.91
1931	5.61	2.97	2.99	3.13
1932	3.61	2.47	2.41	2.44
1933	4.34	2.46	2.90	3.25

Source. Rubber News Letter, Circular #3546, United States Department of Commerce. Cited by Holt. p.15.

With the abandonment of restriction on November 1 of that year production rose and prices fell drastically. The drop was magnified by the depression, and prices continued to fall until they reached their all-time low in 1932. In response to this drastic fall in price, costs were rapidly scaled down in three ways: wages and salaries were drastically reduced, only essential maintenance work was continued, and efficiency in general was increased. Nevertheless, if these excessively low prices had remained in force over any extended period, the industry would have dwindled away, for, as maintenance and depreciation costs had been arbitrarily underestimated, and as profits were negligible or non-existent, no new capital

would have been drawn in. Revenues were sufficient to cover primary costs and a portion of supplementary costs, and as long as this condition obtained, operations would have continued, but no new capital would have been drawn into the industry.

This was not to be, however. Even before the signing of the International Rubber Regulation Agreement prices had begun to rise. The policies of the International Rubber Regulation Committee, which came into force on June 1, 1934, speeded up this rise, and the upward movement continued until prices reached 19½¢ per pound in 1937. Costs rose accordingly.

There is very little information available with regard to the costs on Dutch estates. Dutch production was not of great importance prior to 1922, but with the Stevenson scheme it rose to the place where Dutch capacity is just about equal to Malayan capacity. Information released by the IRRC indicates that the costs on Dutch estates are slightly lower than on Malayan. This slight difference would seem to suggest that the trend in costs in the Netherlands East Indies has closely paralleled that in Malaya.

Heretofore this review has dealt exclusively with average costs, which give a very good idea of general trends. However, in the advent of unrestricted competition, individual costs would be just as significant as average costs. The high-cost producers, both synthetic and natural, would go by the board, and the low-cost efficient producers would be left to supply

the market. Hence it is necessary to study the costs of each class of producer.

Such an underteking entails the study of a particular period, which in this case will be the years 1935-37 for the estates of Malaya, the single year 1937 for those of the Netherlands East Indies. The period from 1935 to 1937 was as "average" or "normal" as any in the rubber industry after 1929 (see table 3a). Prices had recovered from the low of the

Table 3a. Exports of Crude Rubber and World Absorption of Crude Rubber, 1929-40.
(in thousands of tons)

Year	Exports	Absorption
1929	868	809
1930	826	715
1931	800	686
1932	709	692
1933	854	821
1934	1,019	922
1935	873	937
1936	856	1,044
1937	1,135	1,092
1938	872	934
1939	990	1,097
1940	1,395	1,[illegible]00

Source. For the years 1929-37 Rae, pp. 335,338. For the years 1938-40 K.E.Knorr, World Rubber and its Regulation, pp. 248-49.

depression, world rubber absorption had once more resumed its upward trend, and the larger demands of 1939-41 had not yet made their appearance. It is true that exports in 1937 are out of line, but this cannot be helped. 1937 must be included to get a fair picture of costs in the Netherlands East

Indies, as the Dutch guilder was in the process of devaluation in the two preceding years.

Table 4. Frequency Distribution of All-in Costs of Malayan Estates 1935-37 and Netherlands East Indies Estates 1937, Showing the Percentages Produced at Various Costs.

Production costs in pence per pound	Cumulative percentages of production			
	Malaya			Netherlands East Indies
	1935	1936	1937	1937
Under 4.75	----	----	----	22.8
5.00	2.5	1.4	----	34.1
5.25	12.1	1.4	15.9	62.4
5.50	12.1	12.2	15.9	70.7
5.75	31.6	26.9	27.1	77.8
6.00	47.0	53.7	43.5	81.8
6.25	71.4	74.7	78.4	90.6
6.50	88.2	74.7	78.4	95.3
6.75	88.2	92.2	84.4	95.3
7.00	92.6	92.2	84.4	96.8
7.25	96.2	95.8	88.4	98.0
7.50	97.6	96.6	94.3	98.4
7.75	97.6	96.6	94.3	98.9
8.00	99.0	96.6	97.3	99.0
8.25	99.0	98.5	98.1	99.2
8.50	99.0	98.5	98.1	99.5
8.75	100.0	98.5	98.1	99.6
9.00	100.0	98.5	100.0	99.7
9.25	100.0	100.0	100.0	100.0
9.50	100.0	100.0	100.0	100.0
9.75	100.0	100.0	100.0	100.0

Source. Statistical Bulletin of the International Rubber Regulation Committee. Cited by Holt. p.20.

The range of costs of Malayan estates from 1935 to 1937 is considerable, extending from about 5 pence to 9 pence per pound (see table 4). The mode is 6.01 pence (see table 5 and

Table 5. All-In Costs of Malayan Estates 1935-37 and Dutch Estates 1937.

Pence per pound	Percentages of Production			
	Malaya			Netherlands East Indies
	1935	1936	1937	1937
Up to 4.75	0.0	0.0	0.0	22.8
4.76-5.25	12.1	1.4	15.9	39.6
5.26-5.75	19.5	25.5	11.2	15.4
5.76-6.25	39.8	47.8	34.1	12.8
6.26-6.75	16.8	17.5	23.2	4.7
6.76-7.25	8.0	3.6	4.0	2.7
7.26-7.75	1.4	0.8	5.9	0.9
7.76-8.25	1.4	1.9	3.8	0.3
8.26-8.75	1.0	0.0	0.0	0.4
8.76 and over	0.0	1.5	1.9	0.4
Total	100.0	100.0	100.0	100.0

Source. Statistical Bulletin of the International Rubber Regulation Committee. Cited by Holt. p.20.

and chart 1). 88 per cent of the rubber was produced for 6.75 pence per pound or less. 67 per cent was produced at a cost of between 5.5 pence and 6.5 pence. Thus in Malaya the average cost of production, which varied from 6.03 pence to 6.15 pence, is a good indication of costs of production. Although the range is wide, the amount produced at each of the extremes is small.

The range of costs for Dutch estates in 1937, 4.50 pence to 9.25 pence, is even more extensive than the Malayan. The average cost is about 5.25 pence, the mode is 4.96 pence (see table 5 and chart 2). Fully 62 per cent of the output was produced at costs between 4.5 pence per pound and 5.5 pence

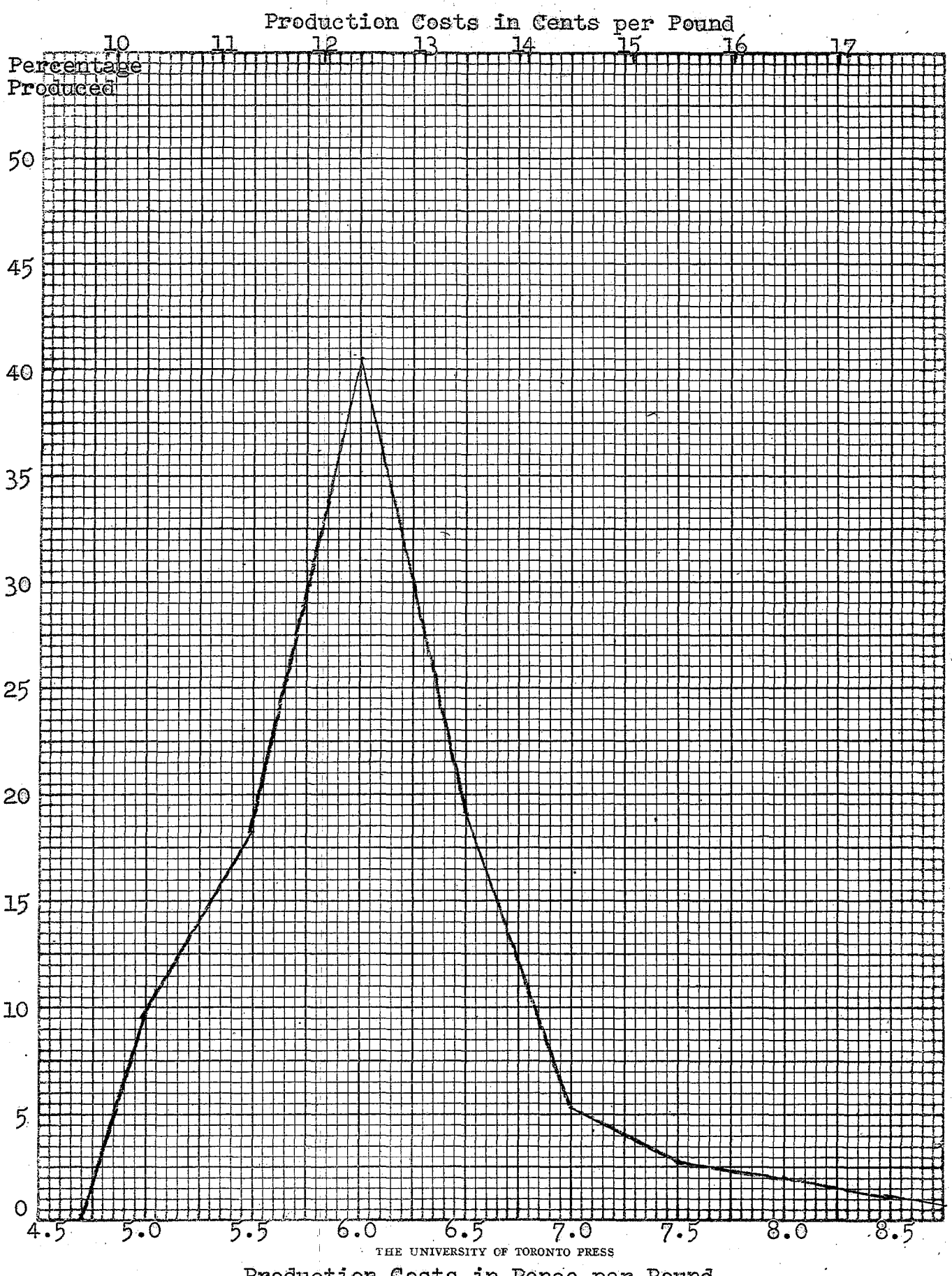
per pound. Here again the average cost of 5.25 pence is a good indication of costs of production. The configuration of the curve of distribution of all-in costs in the Netherlands East Indies is very similar to that of Malaya, except for the heavier concentration at the lower extreme. (see chart 3, p.40).

A discussion of costs of production of native small holders must be prefaced by a description of the conditions under which they operate.

The fixed costs of the native small holders in the Netherlands East Indies are virtually non-existent, and for those in Malaya, who have small charges for quit rent and taxes, are negligible. The variable costs are subjective costs, referring mainly to the disutility of his labour to the native. That is, the native's costs consist of the value which he places upon his labour. Hence the only useful interpretation of the term "cost of production" when it is applied to the native producer is that which takes it to mean the price which induces him to sell his rubber to the exporter or to the remilling factory. When prices are low (say 1¢ per pound), he does not feel that it is worth his while to tap the trees, and we conclude that his costs are more than 1¢ per pound. When prices rise (say) to 4¢ per pound, many natives begin to produce, and we conclude that these particular natives have costs of 4¢ per pound or less.[3]

3. This sentence and the preceding one refer more specifically to the Dutch natives, for most of whom rubber is a source of supplementary cash income, and who therefore do not produce the rubber if they feel it is not worth their while. In Malaya, on the other hand, where rubber is the only source

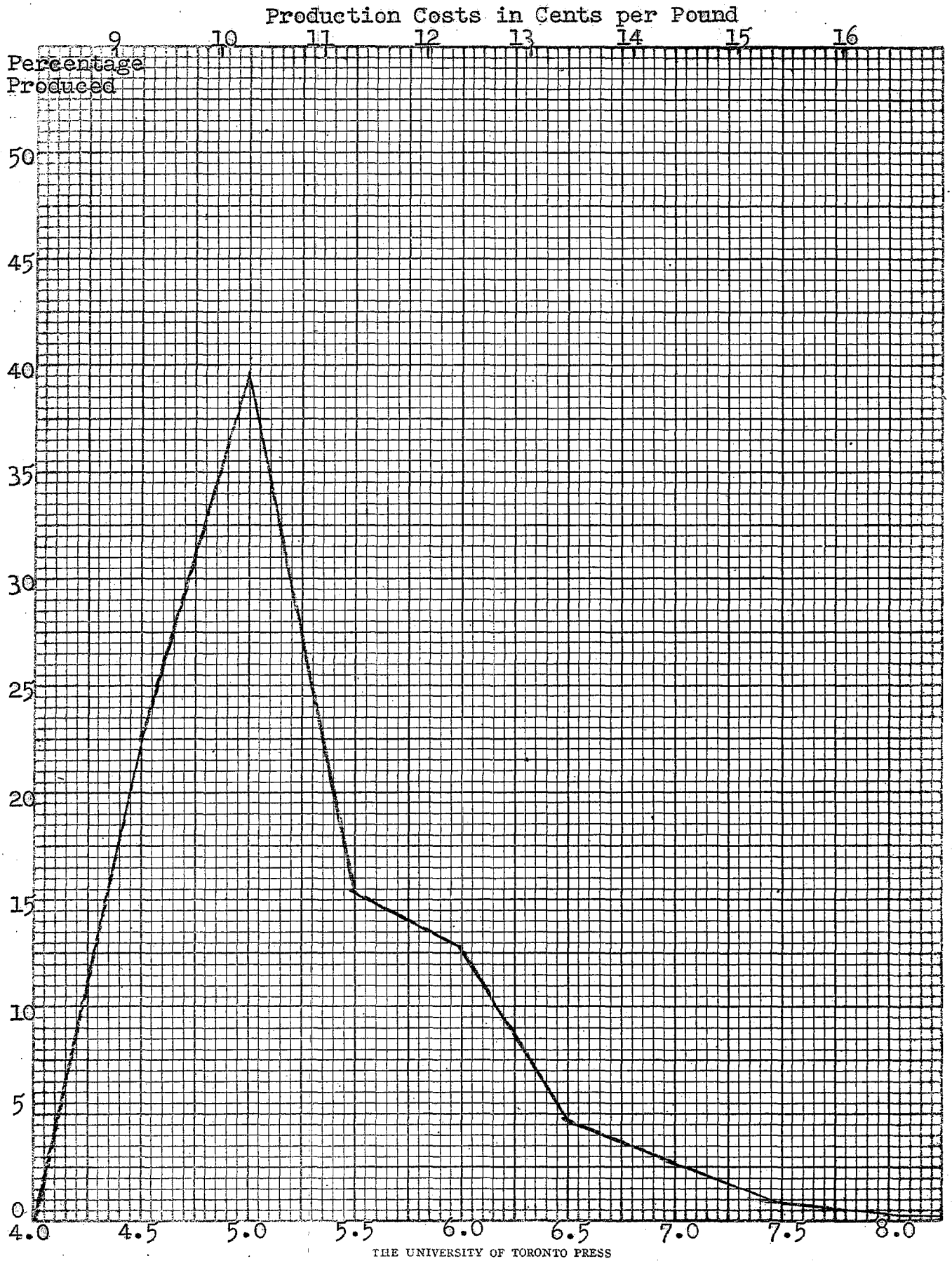
Chart 1. Percentage of Estate Output Produced at Various All-In Costs, Malaya, 1935-37.



£1=$4.939

Source. Table 5.

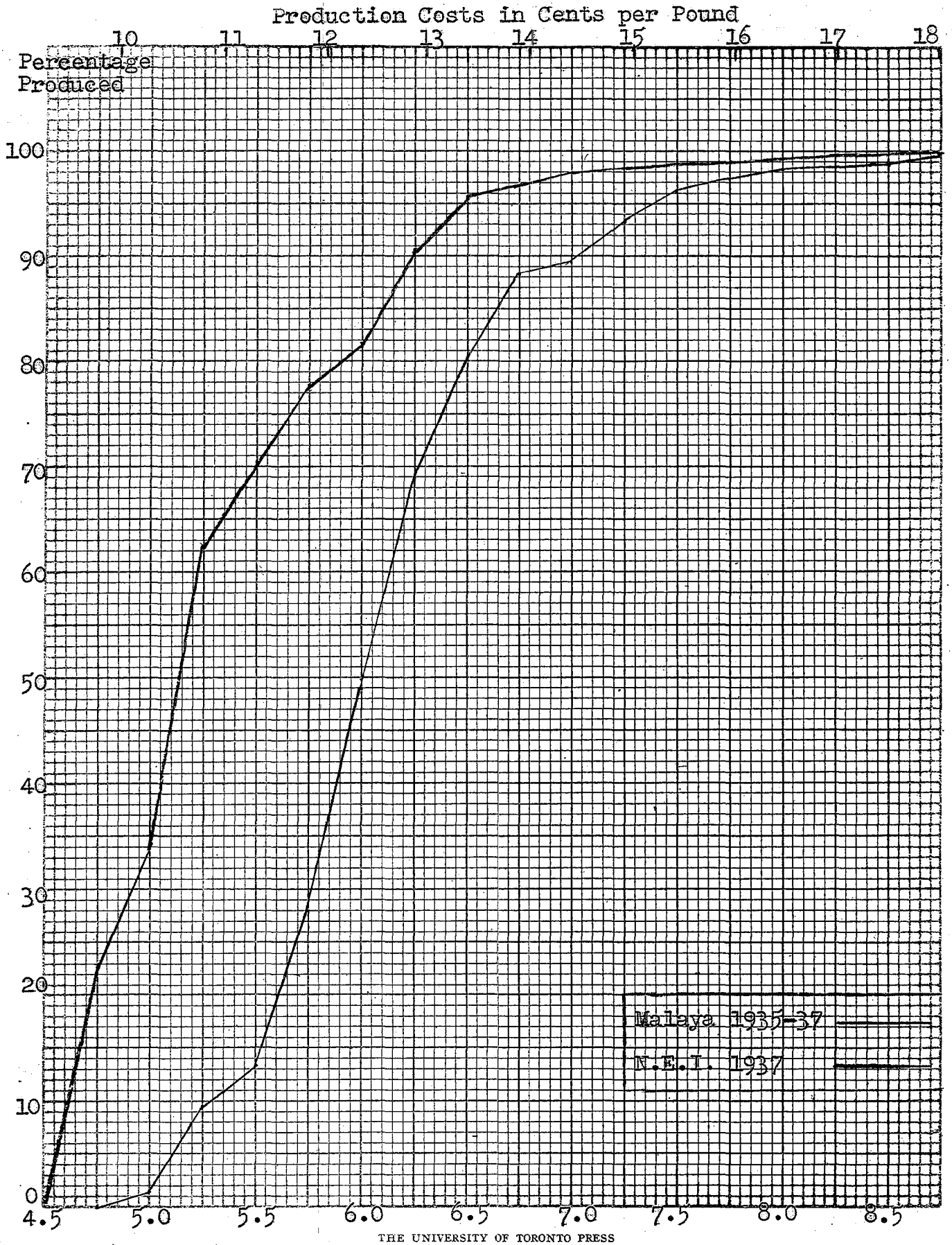
Chart 2. Percentage of Estate Outputs Produced at Various All-In Costs, Netherlands East Indies, 1937,



£1= $4.939

Production Costs in Pence per Pound

Chart 3. Cumulative Distribution of All-In Costs of Malayan Estates 1935-37 and Netherlands East Indies Estates 1937, Showing Percentages Produced at Less than Stated Amounts.



£1=$4.939

Production Costs in Pence per Pound

As has been shown above, the supply curve of the Dutch natives is quite elastic, and when prices fall to a certain level, output is drastically curtailed. This is what happened from 1931 to 1934 (see table 6). The quality of native

Table 6. Income of Dutch Natives from Rubber, 1931-1936.

Year	Exports in metric tons	Calculated Income	
		Guilder cents per kilogram	U.S. cents per pound
1931	89,000	15.40	2.80
1932	61,000	6.72	1.23
1933	116,000	10.77	2.53
1934	144,000	11.53	3.52
1935	145,000	12.24	3.76
1936	153,000	13.07	3.82

Source. Data from Holt. p.17.

rubber is much lower than the estate rubber, and naturally commands a lower price. In addition, remilling and repacking charges amount to at least 1¢ per pound, probably slightly more. Insurance and freight charges amount to at least 0.5¢ per pound. When these facts are taken into consideration, it is easy to see that, rubber prices being what they were, the return to the native would be no more than table 6 indicates from 1931 to 1934. But by 1936 prices had risen to an average of 14.93¢ per pound in New York, and yet the native received only from 3.5¢ to 4¢ per pound. What is the explanation?

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of cash income, the lowest possible cost of production will be that price which nets the native a bare subsistence. Nevertheless, the concept of the cost as that price which induces the native to sell his rubber is valid for both types of native producer.

When the International Rubber Regulation Agreement came into operation in June, 1934, rubber prices were extremely low, stocks of rubber were large in all countries, and rubber growers, both native and estate, were producing at a high rate. The International Rubber Regulation Committee set out to reduce stocks and to raise prices by restricting production. Each member country was given a certain quota beyond which it was not allowed to export. It was left to the governments of each of the member countries to restrict the production of the producers within their borders in the way that each saw fit. The Dutch authorities in the Netherlands East Indies divided their quota in such a way that the share of the natives was set low in proportion to their productive capacity, the share of the estates high. The result was that some means of rigidly curtailing native production had to be devised. The method decided upon was a special export tax of 10 guilder cents per pound on native rubber, a tax which gradually increased until it reached over 50 guilder cents per pound in October, 1936.[4] Thus the native income per pound of rubber sold remained very small. If the income per pound be interpreted as the native cost of production, it is apparent that the native cost of less than 4¢ per pound in 1935 and 1936 compares very favourably with the average estate cost of over 12¢ per pound in these years, even when allowances are made for poorer quality of the native rubber, remilling and repacking costs, and transportation charges to Batavia.

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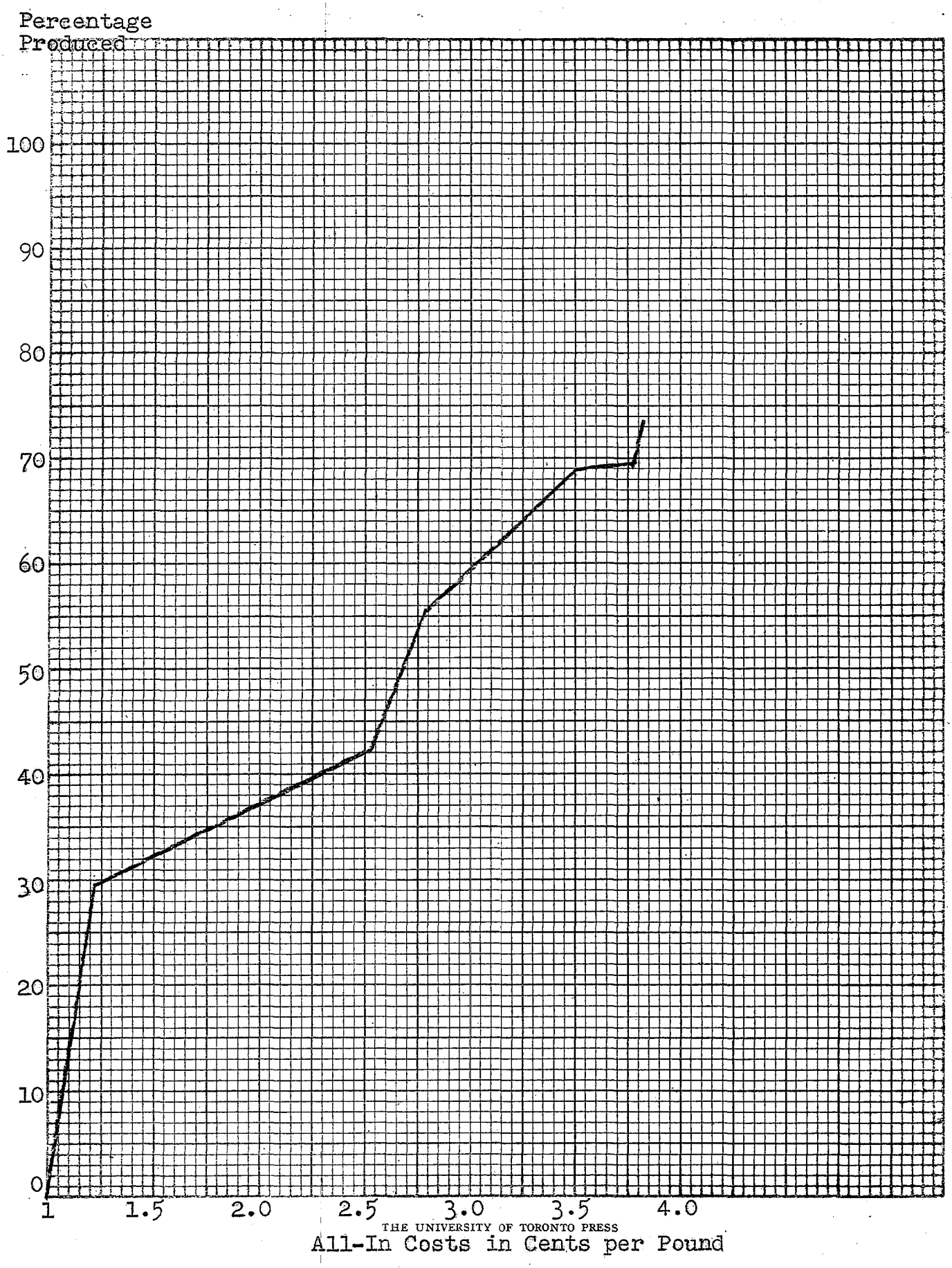
4. Holt. p.17.

A better indication of the competitive strength of the Dutch natives would be gained if it were possible to set up some kind of frequency distribution as was done for the Malayan and Dutch estates. Table 7 attempts to do this. This table is based on table 6, which lists the average income received by Dutch natives from the sale of rubber for each year from 1931 to 1936. These average incomes (although they are in reality only supply prices) are equated with costs of production, as explained above. Viewed in this light, in 1931 89,000 metric tons of rubber were produced at costs of 2.80¢ per pound or less; in 1932 61,000 tons of rubber at costs of 1.23¢ per pound or less; in 1933 116,000 tons at costs of 2.53¢ per pound or less; and so on. If these data be arranged in order of magnitude as in table 7 (p.44), the result is of the nature of a frequency distribution.

It is admitted that the technique is faulty, that the data should all be for one year, that in order to compare it with tables 4 and 5 the data should be for the years 1935-37. This is impossible, however, with the information available. Table 7 is the best indication which can be gained of the amounts of native rubber which are produced at various all-in costs, and it is presented here as such. It can give no more than a rough indication of the competitive strength of the native producers, but it is not valueless. It shows that a large percentage of native production is carried on at an extremely low unit cost, and that under conditions of free competition it would be almost impossible to out-compete them.

Chart 4. All-In Costs of Netherlands East Indies Natives 1931-37, Showing Percentages Produced at Less than Stated Amounts.



Source. Table 7.

Table 7. Outputs of Dutch Natives at Various All-In Costs.[5]

Production costs (in U.S.cents)	Production (in metric tons)	Percentage of capacity output
1.00	____[6]	____[6]
1.23	61,000	29.2
2.53	89,000	42.1
2.80	116,000	55.5
3.52	144,000	68.9
3.76	145,000	69.4
3.82	153,000	73.2
7.00[7]	209,000	100.0

Source. Data from table 6.

Although I have no information available as to the costs of Malayan native small holders except the general statement that "the natives are in general probably the cheaper producers",[8] it is a fair assumption that their costs bear approximately the same relation to those of their counterparts in the Netherlands Indies as the costs of Malayan estates bear to Dutch estates' costs. In this case the cost range of Malayan native rubber is from 3¢ to 9¢ per pound. This of course is only an approximate estimate.

The costs of production of natural rubber as reported in the post-1934 era are not a true indication of the prices at which the most efficient producers can profitably sell their

5. The output in 1937 of 206,000 long tons (209,000 metric tons) is assumed to be equal to capacity production. This is in error, but the error is on the side of underestimation, so that in reality the competitive position of the natives is even better than the table would lead one to believe. Chart 4 is a graphical representation of table 7.
6. Not available.
7. It has been estimated elsewhere (Holt. p.17) that a return of 7¢ per pound would assure maximum production
8. Holt. p.19. Citing a meeting of the International Rubber Regulation Committee.

output. First, rubber estates have high fixed costs, and when production is arbitrarily restricted to a certain percentage of capacity, as it was in this period (see table 8), costs per pound are materially raised. The importance of

Table 8. Percentages of Basic Quotas as Fixed by the International Rubber Regulation Committee for each Quarter Year, 1935-41.

Quarter	1935	1936	1937	1938	1939	1940	1941
1	75	60	75	70	50	80	100
2	60	60	80	60	50	80	100
3	65	65	90	45	60	85	100
4	60	65	90	45	75	90	120
Average	67½	62½	83¾	55	58¾	83¾	105

Source. Statistical Bulletin of the International Rubber Regulation Committee. October 1941, VII,1.

this factor is attested to by the estimate of Mr. James J Newman of the B.F.Goodrich Co., in November, 1936, that "at 75 per cent permissible exports an estate with a 100 per cent yield of 400 pounds per acre could deliver rubber in New York at a cost .98¢ lower than at 60 per cent permissible exports."[9] No estimate was made as to the extent to which costs would be reduced by capacity production, but it would certainly be substantial, in the light of the low rate of permissible exports which were the rule during this period.

Secondly, the quotas were applied mechanically to high- and low-cost estates alike, thus raising the average cost.

9. Holt. p.18.

Thirdly, the quota system suspended competition not only between different estates, but between estates and natives, and between different countries. Although it is impossible to give a quantitative estimate to this factor, it should not be discounted. Competition is of the utmost value in reducing costs.

Hence it appears that even without any increase in efficiency the costs of the natural rubber producers would be reduced by at least a cent per pound, probably more, if competition were free. Increased efficiency, however, is possible even without any new scientific progress. A thorough reorganization of the expensive agency system and of the complicated European directorates is well within the bounds of imagination. In addition, the smaller units could be amalgamated, the very large unwieldy ones broken up. K.E.Knorr has estimated that with unrestricted production and the introduction of these efficiencies, the most efficient estates could make profits at 8¢ per pound.[1]

How low the costs of production of plantation rubber will go in the long-run it is impossible to foretell, but the probabilities are that the long-term trend will continue down. New improved strains of Hevea brasiliensis, by far the most important variety of rubber tree, had before the war made possible yields of as high as 2000 pounds per acre, as compared with anaverage of from 400 to 500 pounds for all rubber

1. India Rubber World. August 1943. Vol.108, No.5. p.465.

in bearing.[2] The estates were gradually being modernized, as disease-resistant, high-yielding bud-grafted stock replaced the older lower-yielding trees (see table 9).

Table 9. Rubber Acreage by Type of Planting Stock, 1940.
(in thousands of acres)

Age in Years	Ordinary Seedling		Bud-Grafted		Clonal Seed		All Kinds	
	Estate	Native	Estate	Native	Estate	Native	Estate	Native
0-5	160	283	453	19	47	43	660	345
6-10	38	204	249	1	3	..	290	205
11-15	585	1,527	369	..	1	..	955	1,527
Over 15	2,604	2,199	79	..	..	..	2,683	2,199
Total	3,387	4,213	1,150	20	51	43	4,588	4,276

Source. Knorr. p.20. Citing Sir Andrew McFadyean, The History of Rubber Regulation 1934-43. p.224.

This process had just got well under way before the war, and its continuance after the war will no doubt increase yields and reduce costs per unit of output. Again, there is a great field for technical assistance to the native producers. In connection with the long-term trend, it is interesting to note the opinion of Mr. C.A.Gehlsen, that "in the future 4.5 U.S. Dollar cents per pound will be a profitable price for all rubber produced".[3] Although this may be an optimistic estimate, it does indicate that costs will continue to fall.

However, as with the eventual costs of synthetic rubber, we are little concerned here with extreme long-run possibilities.

2. The IERC quota was based on a yield of 400 pounds per acre.
3. India Rubber World. July, 1945. Vol. 112, No.4. p.453. Citing C.A.Gehlsen. World Rubber Production and Trade, 1935-1939. p.12.

C. Influence of Exchange Rates.

There is one aspect of the problem of the relative costs of production of natural rubber and synthetic rubber which has been rarely if ever touched upon. This is the question of exchange rates. Its omission is the more remarkable because its influence may be of paramount importance in the coming years.

Natural rubber is widely used in almost every country in the world, but especially in the more highly industrialized temperate zone. Its production is concentrated in a few tropical countries where its use is definitely restricted. The result is that almost every pound of rubber grown is consumed in countries other than that of its origin. Changes in exchange rates can be of the utmost importance in the marketing of such a commodity.

This is illustrated by the events of the years 1935-37. On September 26, 1936, the Dutch government suspended the gold standard. The exchange rate of the Dutch guilder immediately fell from 68 United States dollar cents to 54 United States dollar cents,[4] and this drop was at once reflected in the costs of production of the rubber growers of the Netherlands East Indies which, in terms of foreign currencies, fell to about the same extent as the value of the guilder. The average costs of large Dutch estates was 6.66 pence in 1935, 6.20[5] pence in 1936 and 5.24 pence in 1937. The costs of

4. Federal Reserve Bulletin, 1936. Vol.22. p.1028.
5. Since the guilder was devalued in September 1936, the influence of the devaluation was felt for only part of the year.

large Malayan estates for the same three years were respectively 6.03 pence, 6.13 pence and 6.15 pence.[6] Thus the result of the devaluation of the guilder was that the competitive position of the Dutch producers was greatly strengthened.

The synthetic rubber programme was restricted exclusively to the United States and Canada, and the Canadian share was only a minor one.[7] On the other hand the bulk of the natural rubber supply comes from countries whose currencies are closely linked with the British pound or the Dutch guilder. Hence it is necessary to consider only the relationship of the British pound and the Dutch guilder to the United States dollar.

The future movements of the exchanges will be the resultant of innumerable forces. The success of the International Monetary Fund and of the International Bank, the efficacy of the work of the United Nations Relief and Rehabilitation Association, the speed with which the economies of England and of Europe recover, the extent to which England is able to expand her exports, the passage or rejection of the British loan by Congress, the abolition or continuation of wartime exchange controls -- all these and many more factors will have their influence. This being the case, it is felt that it is impossible even to sketch future possibilities in this work. All that can be said here is that, on the

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6. Holt. p.18.
7. The rated capacity of the Sarnia plant is 30,000 tons per year, that of all American plants 705,000 tons per year. (Special Report of Office of Rubber Director on The Synthetic Rubber Program. p.5.).

whole, present indications are that if the exchanges are freed any movements that take place will be in the direction of the appreciation of the dollar relative to the pound and the guilder. This would strengthen the position of all exporters from British and Dutch currency areas, including of course the rubber growers.

It is a propos at this point to mention another factor which is related to the above but which may be profitably considered separately. This is the chronic shortage of United States dollars. Even if it should happen that the synthetic rubber producers have a competitive advantage on the basis of cost and/or quality, it is quite possible that countries short of dollars would buy natural rubber, for this would be paid for in pounds and guilders, which are definitely not in short supply, whereas the synthetic rubber would have to be paid for in dollars. Other countries might not be willing to allocate part of their limited dollar store for the purchase of synthetic rubber when an adequate substitute could be obtained elsewhere. This tendency would be especially strong if there were little to choose between natural rubber and synthetic rubber cost- and quality-wise.

This possibility is only mentioned here, and no weight will be given to it incoming to a decision relative to the problem posed in the first chapter, for strictly speaking it cannot be reconciled with the assumption of free competition. Exchange rates are in a different category, however. There is no contradiction between a consideration of their

influence upon costs and the basic assumption of this thesis.

B. Conclusion.

What then is the relative competitive strength of natural and synthetic producers in a free market, with unrestricted production and absence of governmental interference, on the basis of efficiencies which have been developed at this time? This review indicates that the generality of natural rubber producers will have a considerable advantage as far as cost of production is concerned.

Native producers account for about 50 per cent of the rubber produced. About 40 per cent of this (20 per cent of all production) has its origin in the Netherlands East Indies, at a maximum cost of 9.5¢ per pound (including remilling and packing costs), with the greater part of it (at least 75 per cent) having a cost of less than 6.5¢. Another 40 per cent of the native rubber (20 per cent of all production) is produced in Malaya, with costs no more than 2¢ per pound higher than in the Netherlands Indies. The remainder of the native production is scattered throughout the other producing areas, with no information available as to cost. The probabilities are that native costs in other countries approximate those in Malaya and the Netherlands East Indies, for there is little difference between estate costs in the latter and the former.

The Netherlands East Indies and Malaya between them account for about 40 per cent of estate production. Even under the International Rubber Regulation Committee, with

production drastically curtailed, quotas mechanically imposed and competition suspended, 93 per cent of the estates in the Netherlands Indies, 75 per cent in Malaya, had a cost of less than 13¢ per pound. The proportions are approximately the same in other countries.

The influence of transportation charges, dealers' charges and insurance is not inconsequential. In the 1935-38 period the former amounted to about .67¢ per pound; the latter ranged from .5¢ to .75¢ per pound.[8] This additional cost of approximately 1.25¢ would be more than counterbalanced by the decreased costs which would accompany unrestricted competition. What the freight charges from New York to the manufacturing site are varies, but in any case they would exceed the corresponding charge for synthetic rubber only in exceptional cases.[9]

The magnitude of the savings in estate costs which would be effected by the reorganization of the agency system and the complicated European directorates, and by the regrouping of the estates to make the majority of them of optimum size, is uncertain, but there is no doubt that it would be substantial. Even without the introduction of these reforms, all native producers, amounting to about ½ of the whole, and the great majority of the estates, at least ¾ of them, can grow the rubber, ship it to New York, pay the dealers' charges, and sell it to the manufacturer for less than 13¢ per pound, the minimum estimate of the cost of production of the most efficient synthetic rubber producer. The amelioration

8. Holt. pp. 24-25.
9. Special Report of Office of Rubber Director on the Synthetic Rubber Program. p.12.

of inefficient methods in the estate industry would raise this figure not a little. The extent to which the over-all position would be strengthened can only be surmised, but it could easily amount to a reduction in the average cost of production of the estates of 2¢ per pound. A depreciation of the pound and guilder in terms of the dollar would still further strengthen the position of the natural rubber industry.

Chapter IV

Post-War Demand For Rubber

Other factors besides quality and costs of production will have large parts in determining the roles which natural and synthetic rubber will play in the post-war market. Of these the most important is the probable level of post-war consumption. The picture which the cost data reflect is not complete unless it is considered along with, or in the light of, the magnitude of demand. To illustrate: if the total world consumption were only 750,000 tons, it is quite conceivable that under favourable conditions the natural rubber producers of the Far East would be able to produce this entire amount at costs less than those of the most efficient synthetic rubber producers. On the other hand, if the total amount demanded were to rise to 2,000,000 tons annually, as one observer predicts,[1] then the chances are that the natural rubber producers would only be able to grow a part, albeit a large part, of this amount at low costs, that a considerable section of the synthetic rubber industry as presently constituted in the United States and Canada would be able to manufacture the remainder at lower costs than those of the less efficient natural rubber growers, and that consequently the synthetic rubber industry would step in and take over part of the market. For this reason a discussion of probable

1. John L Collyer, President of the B.F.Goodrich Co. New York Times, December 5, 1945.

world absorption[2] must be included if the competitive picture is to be complete.

The consumption of rubber has been drastically curtailed in all major consuming countries (except Japan) during the war. Only the military and essential civilian uses have been adequately supplied. Rubber for all non-essential uses has either been cut off completely or rigidly restricted. Thus there is a huge pent-up demand which will devour all supplies reaching the market in the next year or two. It is expected that if sufficient rubber is available world absorption will be in the neighbourhood of 1,500,000 tons for the next two or three years.[3] By that time the backlog of demand will have been satisfied, the transition period will be nearing its end, and it is assumed that world rubber consumption will resume its pre-war trend.

Of course the duration of the transition phase will vary in different countries. Those like the United States, Canada, New Zealand and Australia, which were almost untouched by the physical destruction of war, will almost certainly be the first to resume pre-war consumption trends. At the other extreme are defeated countries like Germany and Japan, which will probably remain economically blighted areas for a considerable time, especially if the victors prove incapable of agreeing as to the policy which they wish to put into operation

2. By absorption is meant the quantity of crude rubber turned into manufactured rubber goods.
3. Report of the meeting of the Rubber Study Group, January, 1945. Bulletin (United States State Department) February 4, 1945. XII, 61.

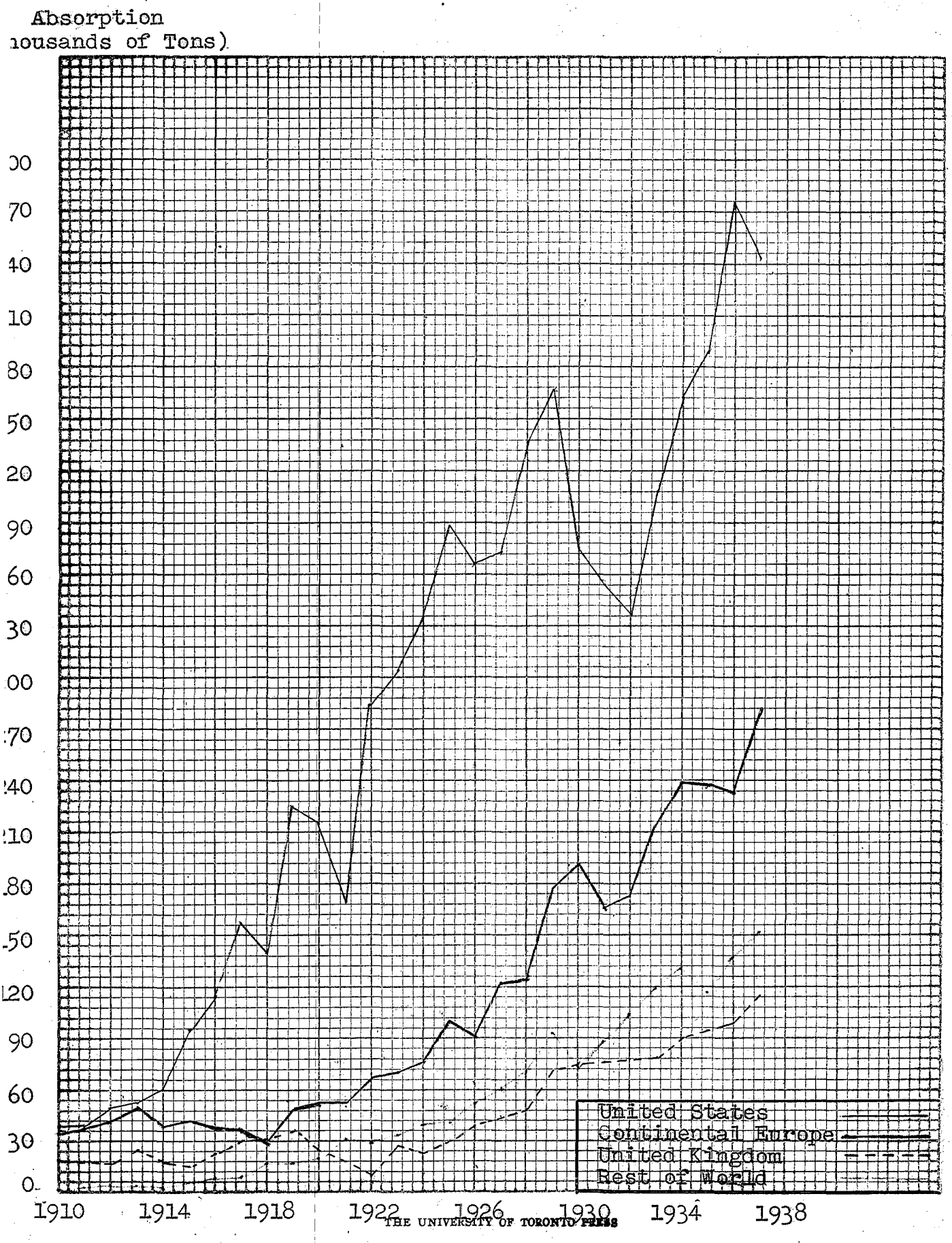
in these countries, as seems to be the case at present. Between these two extremes are countries like France, Belgium and The Netherlands, which were ravaged by war, but which are slowly recovering from it, although with varying degrees of success. Hence it is impossible to state dogmatically that at some specific future time the transition phase will have been completed in all countries. On the whole, however, it is true that by 1950, perhaps earlier, the pre-war trend of absorption will once more be in evidence. But what was this trend?

The consumption of rubber has been constantly increasing, although with different speeds at different times, since the discovery by Goddyear of the secret of vulcanization in 1939. In 1850 shipments of wild rubber first reached 1,000 tons, and by 1900 wild rubber production had increased to 54,000 tons without, however, being able to satisfy the rising volume of demand. Prices skyrocketed, and in 1910 averaged $2.09 per pound. In the 1880's rubber was first cultivated in south-east Asia, and during the first decade of the present century the volume of plantation rubber produced was large enough to exert an appreciable influence upon the market. By 1914 exports of plantation rubber exceeded those of wild rubber, and since that time the plantation industry has expanded to such an extent that wild rubber production is negligible in comparison. In 1921 the exports of wild rubber were less than 10 per cent of total exports, in 1930 less than 2.5 per cent.

The advent of plentiful supplies of plantation rubber gave a terrific impetus to rubber absorption, for it meant that for the first time ample supplies of rubber were available at prices low enough for large-scale use. From this time rubber absorption increased at an unprecedented rate (see table 10, p.59, and chart 5, p.58). Between 1910 and 1920 rubber consumption more than doubled; between 1920 and 1940 it more than tripled. The rise has not always been steady. On the contrary the cyclical fluctuations have been extremely violent. World absorption has been known to increase by as much as 45 per cent in one year, to decrease by as much as 13 per cent. However these fluctuations have in truth been no more than fluctuations, and the upward trend has never shown signs of halting.

The rapid increase in the absorption of rubber is largely a result of the growth of the automobile industry. Although no data are available for the distribution of rubber absorption among the various groups of products for the world as a whole, records have been kept for the United States, and a perusal of these will be very helpful, for as the United States absorbs by far the largest part of the world total (see table 10, p.59, and chart 5, p.58), information gleaned from data applying to the United States alone gives a general indication of world-wide conditions. Table 11 shows to what a great extent increased American consumption has been the result of the constantly increasing demands of the automotive industry for tires and tubes. Since 1921, the first

Chart 5. Absorption of Rubber 1910-37.



Source. Table 10.

Table 10. Absorption of Rubber, 1910-1940
(in thousands of tons)

Year	United States of America	United Kingdom	Continental Europe	Other Countries	Total
1910	39	19	34	2	94
1911	40	18	37	3	98
1912	50	17	41	4	112
1913	53	25	49	4	131
1914	60	17	38	3	118
1915	95	15	41	6	157
1916	115	23	37	8	183
1917	157	30	35	9	221
1918	140	31	28	17	216
1919	225	36	49	17	327
1920	215	24	51	20	310
1921	170	18	50	31	269
1922	285	10	67	28	390
1923	305	27	70	33	435
1924	335	23	76	39	473
1925	388	30	100	40	558
1926	366	39	90	51	546
1927	373	45	121	60	599
1928	437	49	124	70	680
1929	467	72	177	93	809
1930	376	75	191	73	715
1931	355	77	166	88	686
1932	337	78	173	104	692
1933	409	79	214	119	821
1934	462	90	239	131	922
1935	489	95	236	117	937
1936	575	99	233	137	1,044
1937	543	115	281	153	1,092
1938	437	107	390		934
1939	592	123	382		1,097
1940	649	...	...		1,100

Source. For the years 1910-37, Rae, p.338. For the years 1938-40 Knorr, p.249; citing McFadyean, p.236.

year when the data for total absorption were broken down into the absorption of each of the various groups of products,

Table 11. United States Absorption of Crude Rubber by Groups of Products, 1921-40.

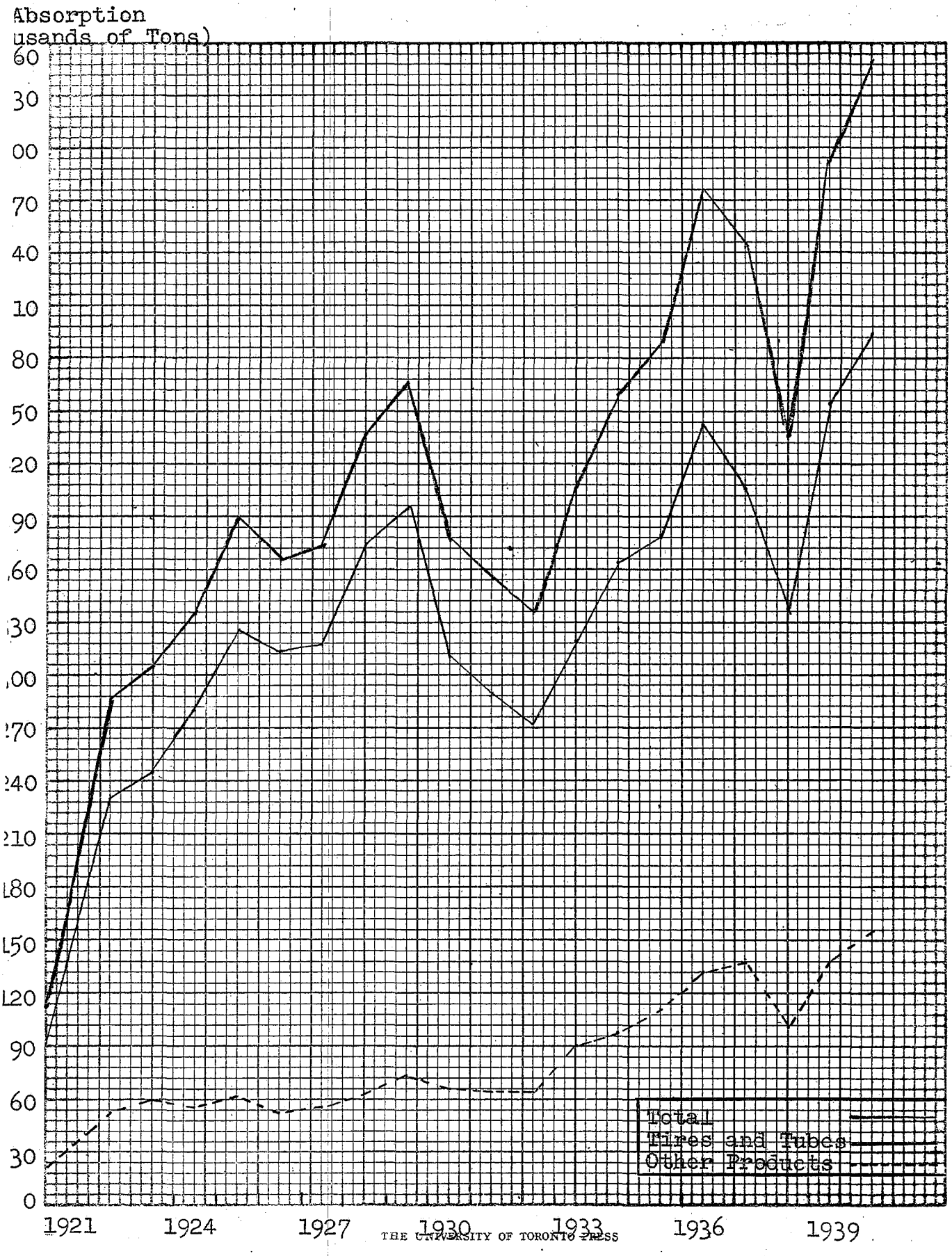
Year	Volume of Absorption in Thousands of Tons		Absorption as a Percentage of Total American Absorption	
	Tires and Tubes	Other Rubber Products	Tires and Tubes	Other Rubber Products
1921	138	32	81.2	18.8
1922	232	52	81.4	18.6
1923	245	60	80.3	19.7
1924	279	56	83.3	16.7
1925	326	62	84.0	16.0
1926	313	53	85.6	14.4
1927	317	56	85.0	15.0
1928	374	63	85.6	14.4
1929	394	73	84.4	15.6
1930	310	66	82.5	17.5
1931	290	65	81.7	18.3
1932	272	65	80.7	19.3
1933	319	90	77.9	22.1
1934	364	98	78.9	21.1
1935	378	111	77.3	22.7
1936	443	132	77.0	23.0
1937	406	137	75.3	24.7
1938	336	101	77.0	23.0
1939	455	137	76.8	23.2
1940	494	155	76.1	23.9

Source. Data from 1921-37, Rae, p.338. Date from 1938-40, Knorr, pp.249,254; citing McFadyean, p.236 and Statistical Bulletin of the International Rubber Regulation Committee, October 1941, VII, 20.

the rubber used in the manufacture of tires and tubes has never constituted less than 75 per cent of the total American absorption. Chart 6 (p.61) gives a vivid visual picture of the extent to which increased rubber absorption in the United States has been the direct result of increased sales of tires and tubes.

As the consumption of rubber in tires and tubes is such

Chart 6. United States Absorption of Crude Rubber by Groups of Products, 1921-40.



Source. Table 11.

a large proportion of total consumption, it would be wise to examine the factors which determine the long-run demand for automobiles, trucks and buses.

For the world as a whole the passenger automobile is a durable consumer's good in the luxury class. It is only purchased when supernumary income -- that which is left over when taxes and general living expenses have been paid -- is of sufficient magnitude to finance the expenditure. Only in a few countries is the supernumary income of a large part of the population sufficient to allow the purchase of automobiles. The United States is the wealthiest country in the world, with the largest per capita income. Consequently there are more automobiles, both per capita and absolutely, in the United States than in any other country. Only such wealthy countries as New Zealand, Canada and Australia even approach the United States in this respect. In 1936 the number of inhabitants per automobile in the countries with the highest per capita registration was:-[4]

United States	4½	United Kingdom	21
New Zealand	7	Union of South Africa	31
Canada	9	Sweden	37
Australia	10	Belgium	41
France	19	Germany	49

In China there were 10,000 people for each automobile.

When the national income of a country, and therefore the supernumary income of its inhabitants, rises, it does not necessarily follow that the registration of passenger cars

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4. Rae. p.343

will increase proportionately. In a country like Canada, where the supernumary income is already high, a small increase in the national income may put a large number of people in a position to buy a car. In a country like India, on the other hand, it would take an enormous increase in the national income to make possible the purchase of cars by a large section of the population, for the supernumary incomes of the great majority of the people are virtually nil, or even negative. The general level of supernumary incomes before an increase in national income takes place is one of the most important factors in determining whether the increase will be followed by a corresponding increase in the registration of automobiles.

The position with regard to trucks is somewhat different. The level of national income is still probably the most important factor, but it does not take such a large increase in the national income to be reflected in an increase in the number of trucks, for a truck is a producer's good, and as such is more intimately connected with the national income. In fact there is a two-way causation here.

Other factors such as higher prices and higher servicing costs are of importance in restricting the number of automobiles and trucks outside the United States. In addition the lack of roads in many countries, the shorter distances to be traversed in the smaller and more densely populated countries, and differences in consumption preferences all play a part. It is interesting to note that for the average

American in certain income groups the automobile is classed as a necessity and a visit to the opera a luxury, and that precisely the opposite holds for his counterpart in many European countries. However, these factors are relatively of minor influence. Differences in wealth and national income are of preponderant importance in explaining the huge disparity in the registration of automobiles and trucks between the United States and other countries.

The overwhelming importance of tires and tubes in the consumption of rubber should not blind us to the part that other rubber goods have played in the expansion of rubber absorption. These latter have more than kept up to tires and tubes in the United States since 1926, and although this is not true for the rest of the world, one reason is that they were more important to start out with, as will be shown later. The number of uses for rubber which come under the heading "other rubber products" is almost legion, and it is impossible to examine them individually for the causes of their respective expanded consumptions. It can only be said that, generally speaking, here too larger national incomes are the cause of the increased usage. It may be argued that most rubber products apart from tires and tubes are relatively cheap consumers' goods. This is admittedly true. But if one glances over the various headings of "Other rubber products" in the statistical bulletins of the Rubber Manufacturers of America -- mechanical rubber goods, insulated wire compounds, boots and shoes, heels and soles, druggists' goods,

stationers' goods, bathing apparel, rubber clothing, automobile fabrics, other rubberized fabrics, rubber flooring, sporting goods -- it will be found that the majority of them refer to products which have greatest usage in the countries which are economically most highly developed.

Table 12. Comparison of Canadian Real National Income and Rubber Absorption, 1919-37.

Year	National Income in Millions of Dollars	Index Number (1926 = 100)	National Income Adjusted to 1926 Prices	Imports[5] of Rubber (1,000 tons)
1919	3,816	134.0	2,848	6.4
1920	4,598	155.9	2,962	11.7
1921	3,507	110.0	3,188	8.1
1922	3,671	97.3	3,773	9.2
1923	3,847	98.0	3,926	13.3
1924	3,865	99.4	3,889	14.3
1925	4,239	102.6	4,136	19.7
1926	4,507	100.0	4,507	20.2
1927	4,738	97.7	4,850	26.4
1928	5,270	96.4	5,446	30.9
1929	5,273	95.6	5,515	35.5
1930	4,452	86.6	5,141	28.8
1931	3,580	72.1	4,965	25.3
1932	2,813	66.7	4,217	20.0
1933	2,723	67.1	4,057	19.3
1934	3,147	71.6	4,395	28.4
1935	3,371	72.1	4,676	26.9
1936	3,827	74.6	5,134	27.9
1937	4,368	84.6	5,163	36.1

Source. The Canadian national income and the index of wholesale prices are taken from The Canada Year Book, 1945, pp.905 and 895 respectively. The imports of rubber are taken from Rae, p.336.

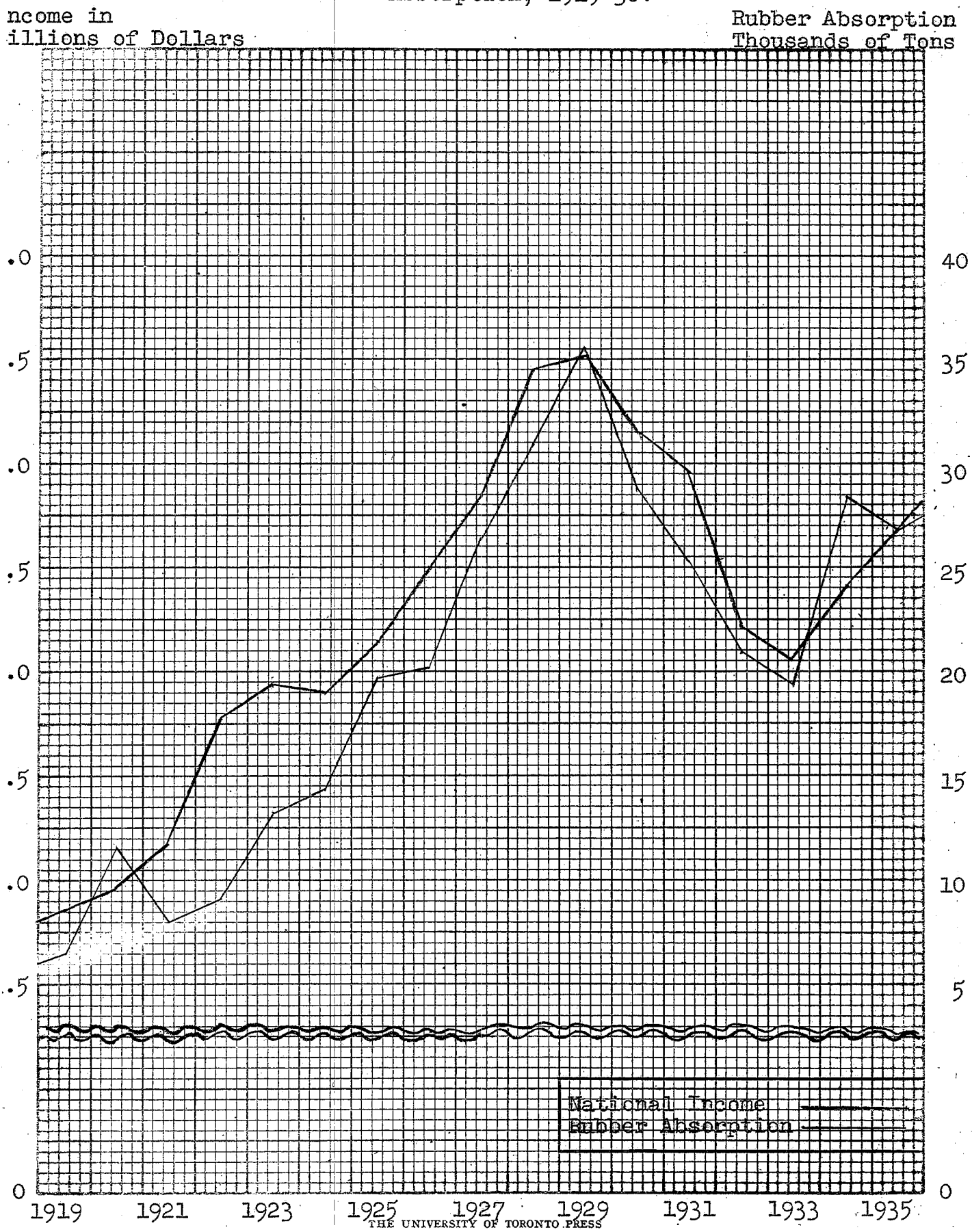
This close connection between the absorption of rubber, both in tires and tubes and in other products, and national

5. In the absence of any figures for the absorption of rubber as such in Canada, I have taken the figures for Canadian rubber imports. As Canada produced no rubber herself during the period referred to, these figures are substan-

income is an historical fact. Generally speaking in any country rubber absorption increases as the national income increases, decreases as the national income decreases. Tables 12 (p.65) and 13 (p.69) illustrate this plainly (see also charts 7 and 7a, pp. 67 and 68 respectively). In table 12 the national income of Canada from 1919 to 1937 and the Canadian index of wholesale prices for the same period with 1926 = 100 are listed, the national income is adjusted to the 1926 price level, and the resulting measure of real income is compared with Canadian rubber absorption for the same period. It is evident that there is a close relationship between real national income and rubber absorption, both in the short-run and in the long-run. In fact, the Pearsonian coefficient of correlation is +.93, with a probable error of ±.02. This unusually high correlation bears ample witness to the close relationship between national real income and rubber absorption in the case of Canada.

The same is true of the United States, although to a lesser degree, as table 13 (p.69) shows. (see also chart 7a, p.68). In this table the American national income is adjusted to the 1926 price level and the adjusted income compared with rubber absorption for the years 1919-40. Here again rubber absorption increases as (real) national income rises, decreases as the national income falls. The Pearsonian coefficient of correlation is +.77, with a probable error of ±.06. Although this correlation is not as high as in the case of Canada, it is nevertheless a high degree of correlation,

Chart 7. Canadian National Income in Terms of 1926 Prices and Canadian Rubber Absorption, 1919-36.



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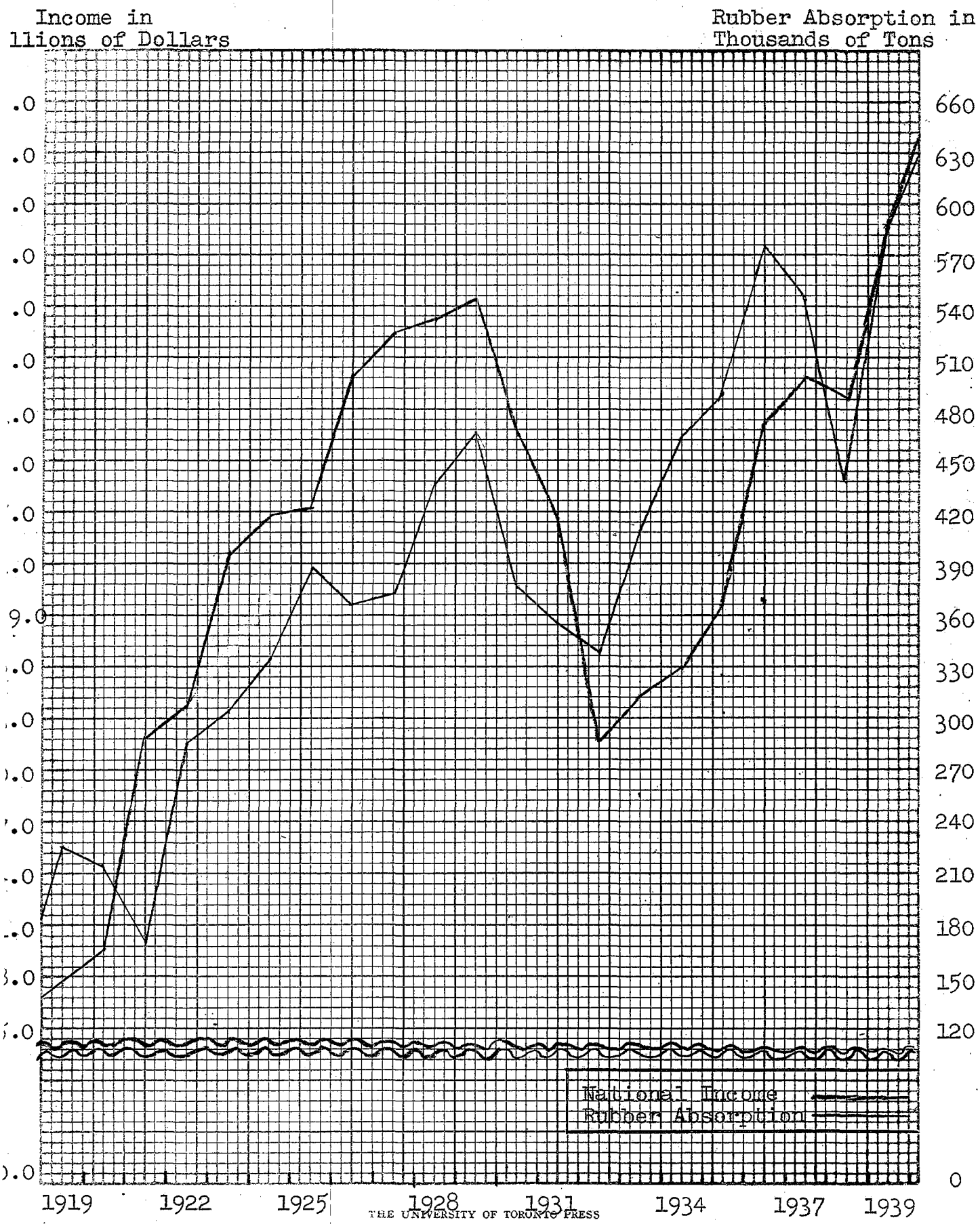
Source. Table 12.

Chart 7a. United States National Income in Terms of 1926 Prices and United States Rubber Absorption, 1919-40.



THE UNIVERSITY OF TORONTO PRESS

Source. Table 13.

Table 13. Comparison of United States Real National Income and Rubber Absorption, 1919-40.

Year	National Income in Millions of Dollars	Index Number (1926=100)	National Income Adjusted to 1926 Prices	Rubber Absorption in Thousands of Tons
1919	65,904	138.6	47,550	225
1920	76,385	154.4	49,472	215
1921	60,304	97.6	61,787	170
1922	61,513	96.7	63,612	285
1923	72,912	100.6	72,477	305
1924	73,380	98.1	74,801	335
1925	77,845	103.5	75,213	388
1926	82,802	100.0	82,802	366
1927	81,397	95.4	85,322	373
1928	83,396	96.7	86,242	437
1929	83,326	95.3	87,435	467
1930	68,858	86.4	79,697	376
1931	54,479	73.0	74,629	355
1932	39,963	64.8	61,671	337
1933	42,322	65.9	64,222	409
1934	49,455	74.9	66,029	462
1935	55,719	80.0	69,649	489
1936	64,924	80.8	80,351	575
1937	71,513	86.3	82,866	543
1938	64,200	78.6	81,699	437
1939	70,829	77.1	91,879	592
1940	77,574	78.6	98,695	649

Source. The American national income is taken from The Canada Year Book 1945, p.905. The index of wholesale prices for the years 1919-21 is taken from the Statistical Abstract of the United States, p.279; for the years 1922-37 from the Statistical Abstract of the United States 1938, p.306; for the years 1938-40 from the Statistical Abstract of the United States 1943, p. 398. The figures for rubber absorption for the years 1919-37 are taken from Rae, p.338; for the years 1938-40 from Knorr, p.249, citing McFadyean p.236.

and well illustrates the close connection between the two phenomena.

Although it has proven impossible to obtain sufficient

information to illustrate the connection between national income and rubber absorption in the same fashion for the other major importing countries, all indications point to its existence, and from an a priori viewpoint, there seems to be no reason why this should not be so.

It logically follows from the exposition given above that the wealthier countries of the world will consume more rubber proportionate to their population than their less fortunate cousins, and, as has been already been shown, such proves to be the case. Thus in 1934 the per capita consumption of rubber was 7.6 pounds in the United States, 5.9 pounds in Canada, 4.5 pounds in the United Kingdom, 2.7 pounds in France, 2.1 pounds in Germany, and 1.9 pounds in Japan.[6] When allowance is made for the population of these countries, it is found the largest consumers are the United States, the United Kingdom, Germany, Japan, France and Canada, in that order (see table 14, p.71).

For purposes of assessing probable post-war demand, of almost equal significance with the constantly increasing volume of absorption is the changing pattern or structure of consumption, both within countries and between countries.

In the United States tires and tubes gradually assumed a more important position relative to other rubber goods

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6. The national incomes of Canada and the United States are taken from the Canada Year Book 1945, p.905; of the United Kingdom, France, Germany and Japan from Whittaker's Almanac, 1943, p.851. The population of Canada is taken from the Canada Year Book 1945, p.128; of the United States from the Statistical Abstract of the United States 1943, p.3; of the United Kingdom, France, Germany and Japan, from Whitaker's Almanac 1943, pp.183-5. Exchange rates are taken from the Federal Reserve Bulletin.

Table 14. Absorption of Rubber by Countries 1910-37 (in thousands of tons)

Year	United States	United Kingdom	Australia	Belgium	Canada	Czechoslovakia	France	Germany	Italy	Japan	Russia	Other Countries	Total
1910	39	19	0	2	1	..	4	14	2	1	7	6	95
1911	40	18	1	2	2	..	5	15	2	1	7	6	99
1912	50	17	1	3	2	..	5	16	3	1	9	6	112
1913	53	25	1	4	2	..	7	16	3	1	13	8	133
1914	60	17	1	1	1	..	5	11	3	1	12	6	118
1915	95	15	1	..	3	..	11	4	5	2	11	7	157
1916	115	23	1	..	4	..	15	2	5	3	11	5	184
1917	157	20	1	..	4	..	17	1	6	4	9	3	222
1918	140	31	3	..	7	..	18	..	7	7	..	3	216
1919	225	36	1	4	6	..	20	5	10	9	0	10	326
1920	215	24	1	3	12	1	16	13	6	6	0	12	309
1921	170	18	1	1	8	1	15	22	4	21	0	8	269
1922	285	10	3	0	9	1	28	28	6	15	3	2	390
1923	305	27	2	2	13	1	29	19	9	16	5	8	436
1924	335	23	3	3	14	1	32	23	9	20	2	8	473
1925	388	30	4	3	20	2	34	34	11	13	8	10	558
1926	366	39	9	3	20	2	34	23	10	18	7	12	543
1927	373	45	10	7	26	3	36	39	12	21	14	14	600
1928	437	49	8	10	31	3	38	38	12	26	18	20	680
1929	467	72	16	9	36	5	62	49	16	34	13	27	806
1930	376	75	5	11	29	5	71	46	19	33	17	27	714
1931	355	77	8	11	25	8	48	39	10	44	31	29	685
1932	337	78	12	10	21	10	42	45	15	56	30	34	690
1933	409	79	14	11	19	11	63	54	19	67	31	40	817
1934	462	90	10	9	28	11	50	59	21	70	47	60	917
1935	489	95	10	8	27	11	52	63	25	58	38	58	934
1936	575	99	14	10	30	9	57	72	16	62	31	54	1,039
1937	543	115	19	15	36	13	60	98	24	62	27	69	1,091

Source. Rae. pp. 336, 338. Except for the United States and the United Kingdom these are the figures for net imports of rubber. Since none of these countries grows any rubber, the data are approximately correct.

from 1910 until 1928, and then slowly descended from the high eminence attained in that year (see table 11, p.60, and chart 8, p.73). With the exception of the year 1917, no comprehensive data are available prior to 1921, but all indications are that tires and tubes were of much less importance in 1910 than in 1920. The data for the single year 1917 support this contention, for in that year consumption in tires and tubes amounted to 70 per cent of total American consumption,[7] as compared with 81 per cent in 1921. This indicates that tire and tube consumption increased between 1917 and 1920, and it is almost certain that the same trend was in evidence from 1910 on. From 1921 to 1928 there is no need to speculate as all the necessary information is available. The absorption in tires and tubes slowly but steadily increased from 81.2 per cent of the total in 1921 to 85.6 per cent in 1928. In this year the trend reversed itself, and by 1940 tires and tubes accounted for only 76.1 per cent of total American absorption, whereas other rubber products accounted for 23.9 per cent as compared with 14.4 per cent in 1928.

The market for tires and tubes can be divided into the market for original tires and tubes and the market for replacement tires and tubes. The increasing importance of tires and tubes up to 1928 was the direct result of the rapid expansion of the automotive industry, which brought with it an expansion both of the market for original sales and of the market for replacement equipment. During the 'twenties the

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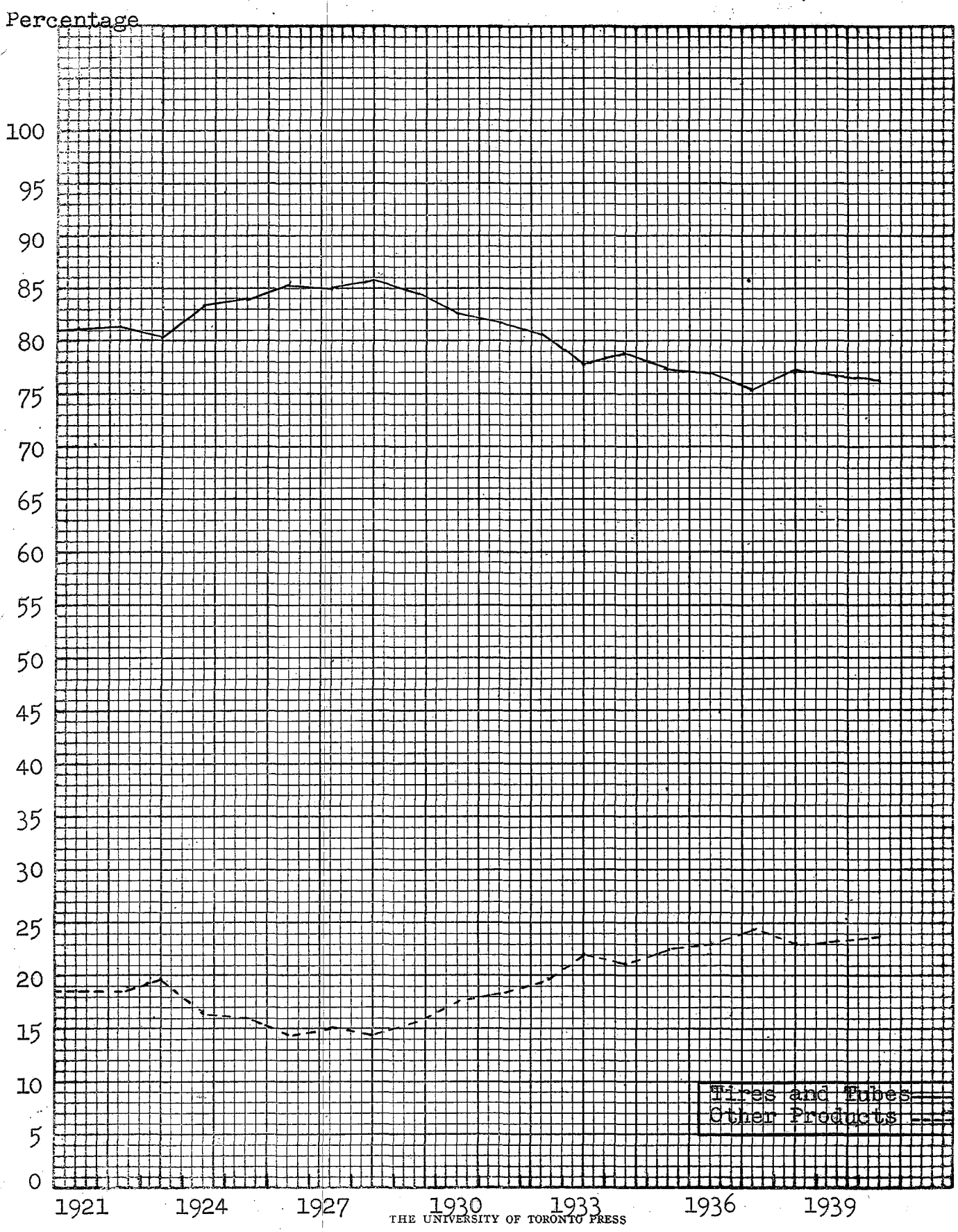
7. Rae. p.338.

Chart 8. United States Absorption of Crude Rubber in Tires and Other Rubber Products Expressed as Percentages of Total United States Absorption, 1921-40.



Source. Table 11.

output of cars and trucks increased enormously (see table 15 and chart 9, p.75). From 1922 to 1929 the registration of

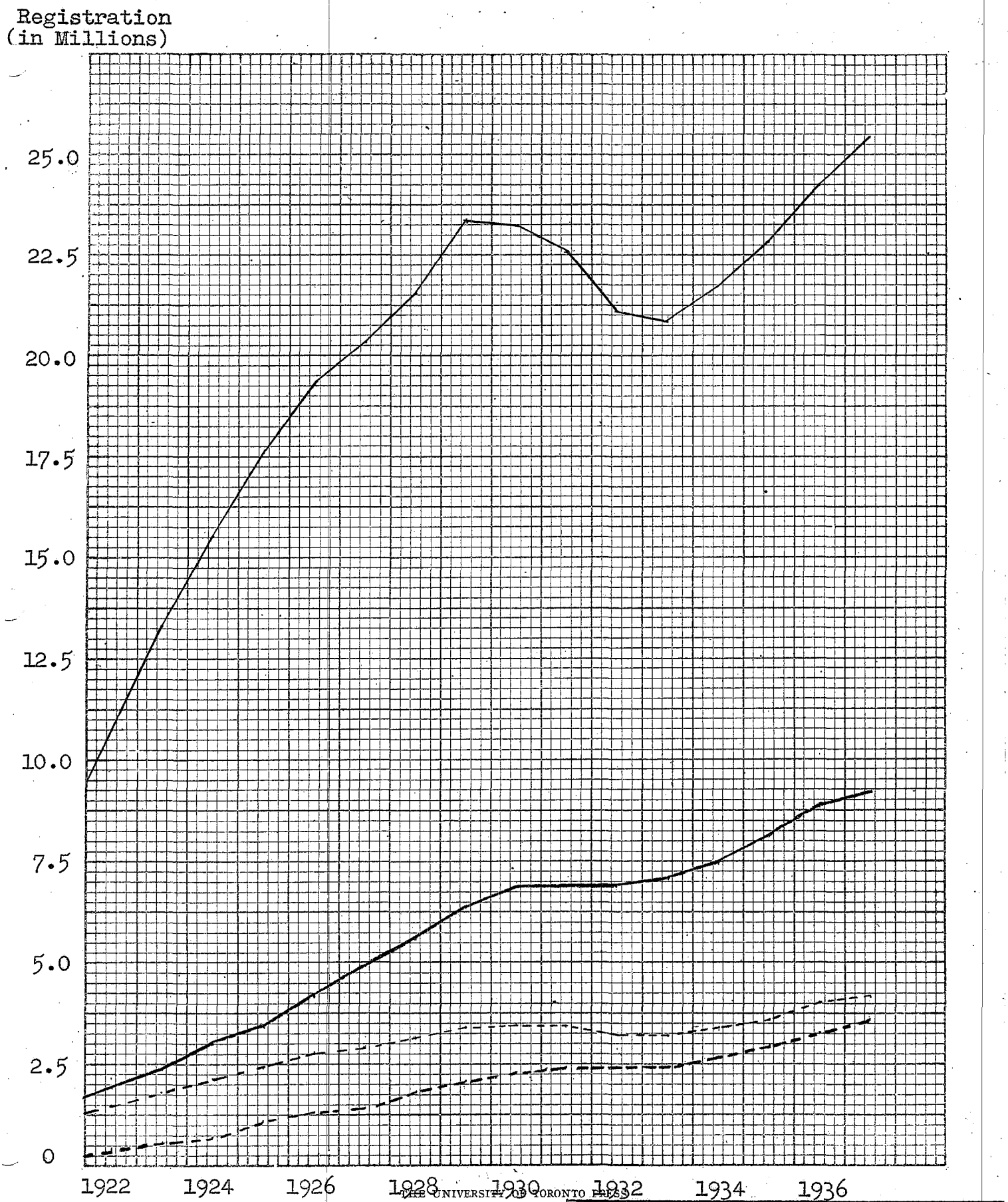
Table 15. Registration of Motor Vehicles 1922-37.
(in thousands)

Year	United States of America			Other Countries		
	Passenger Cars	Trucks and Buses	Total	Passenger Cars	Trucks and Buses	Total
1922	10,750	1,488	12,238	1,969	465	2,434
1923	13,291	1,801	15,092	2,383	548	2,931
1924	15,506	2,131	17,637	3,006	710	3,716
1925	17,609	2,442	20,051	3,448	1,090	4,538
1926	19,373	2,764	22,137	4,227	1,286	5,513
1927	20,365	2,897	23,262	4,963	1,462	6,425
1928	21,516	3,114	24,630	5,612	1,793	7,405
1929	23,273	3,380	26,653	6,394	2,080	8,474
1930	23,233	3,486	26,719	6,838	2,270	9,108
1931	22,538	3,467	26,005	6,844	2,433	9,277
1932	21,066	3,229	24,295	6,831	2,420	9,251
1933	20,830	3,227	24,057	7,076	2,429	9,505
1934	21,744	3,419	25,163	7,477	2,715	10,192
1935	22,801	3,647	26,448	8,122	2,950	11,072
1936	24,246	4,024	28,270	8,807	3,258	12,065
1937	25,460	4,195	29,655	9,200	3,600	12,800

Source. Rae, p.339.

passenger cars in the United States increased from 10,750,000 to 23,273,000, and from 1922 to 1930 the registration of trucks and buses increased from 1,488,000 to 3,486,000. The great depression brought this advance to a halt, at least temporarily. In fact, the number of automobiles registered actually declined from 1929 to 1933, and the 1929 level was not exceeded until 1936. The increase in the number of trucks did not come to an end until 1930, but from 1930 to 1933 the

Chart 9. Registration of Motor Vehicles in the United States and Other Countries, 1922-37.



Source. Table 15.

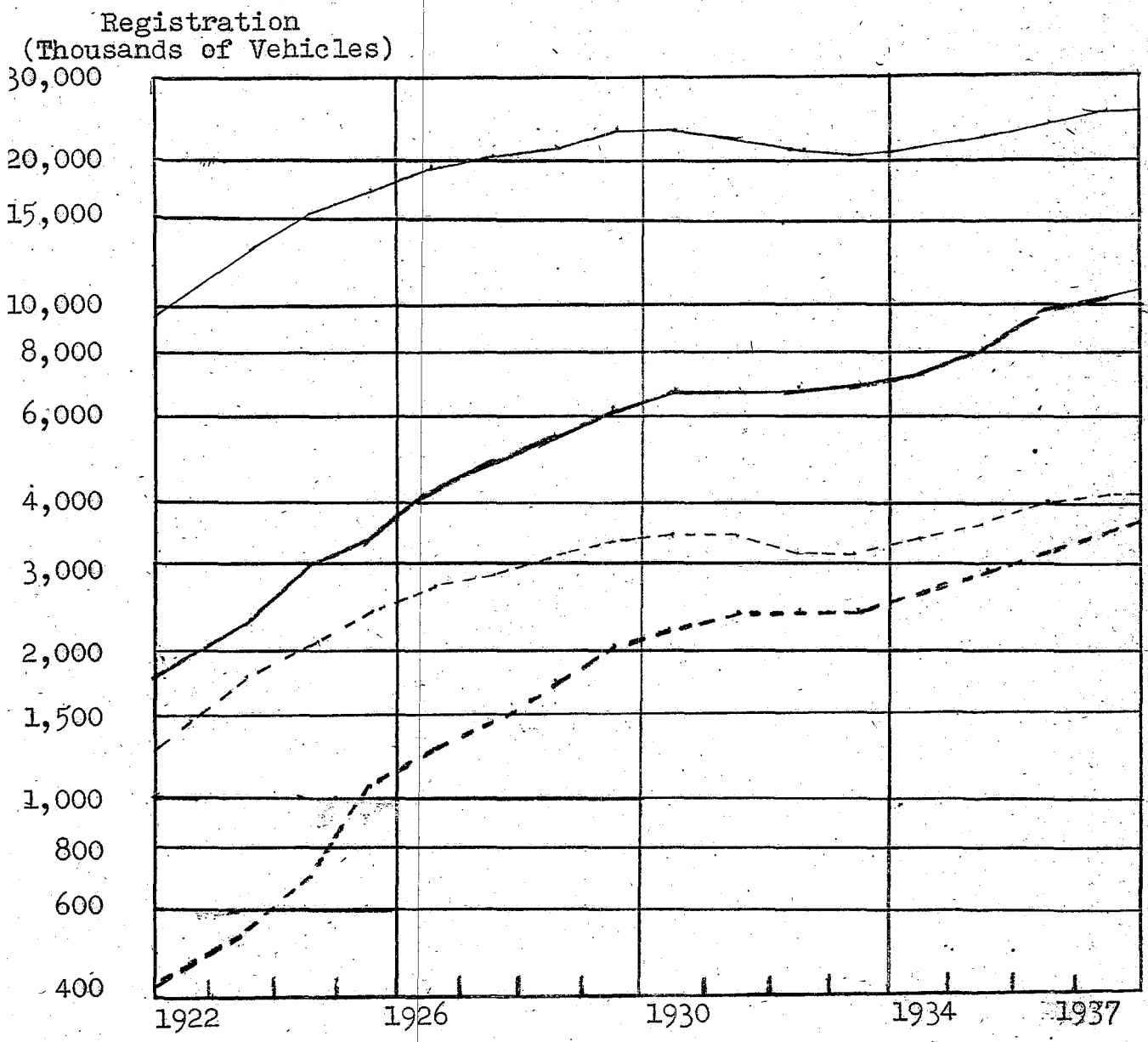
number of trucks registered in the United States declined too, although not to such an extent as did the number of automobiles.

This was more than a cyclical phenomenon: the depression only magnified its extent and hastened its development. In 1926 the rate of increase of passenger automobiles had already begun to fall, in 1927 the rate of increase of trucks. Never since this time has the rate of growth of either passenger cars or trucks exceeded the pre-1926 rate (see chart 10, p. 77). This decline in the rate of growth is reflected in the absorption of tires and tubes as a percentage of total American absorption, which from 1926 to 1928 only held its own against other rubber products. Even without the depression the relative decrease in the importance of tires and tubes would have occurred — it preceded the depression, it persisted during the recovery phase, and it continued right on until 1940.

The influence of the falling rate of increase in the production of the automotive industry in lessening the relative importance of tires and tubes was accentuated by other forces which were at work even prior to 1926. Improved techniques of vulcanization and compounding, improved methods of tire construction and improved highways all worked together to increase the life expectancy of the average tire from 0.73 years in 1910 to 1.28 years in 1920, 2.47 years in 1930 and 3.42 years in 1938.[8] The result was that during the late 'twenties

8. Knorr. p.52. Citing Rubber News Letter. United States Department of Commerce. October 15, 1939. p.199.

Chart 10. Registration of Motor Vehicles 1922-37.
(logarithmic vertical scale)



Source. Table 15.

and all of the 'thirties replacement sales were contracting relative to sales of original equipment. Hand in hand with higher quality in increasing the life expectancy of the average tire were improved repairing techniques, such as tire recapping and retreading.

Only the operation of forces which partially counteracted the influence of better quality tires and superior repairing techniques prevented the amount of rubber used in tires from decreasing absolutely. The most important of these forces were the gradual increase of rubber used in the manufacture of each tire — from 7.22 pounds in 1922 to 13.73 pounds in 1937[9] — faster driving, increased annual mileage of the average motor vehicle, and a larger proportion of trucks and buses, which use heavier tires.

The same forces were at work in decreasing the replacement sales of tubes, and here they were even more effective. The secular decline of the sale of tubes in the later 'twenties and in the 'thirties is one of the more significant developments in the rubber industry during this period. From 1922 to 1937 the amount of rubber used in tubes fell from 15 per cent of total American consumption to less than 10 per cent.[1] Here again only the use of more rubber per tube — 2.2 pounds in 1937 as compared with 1.78 pounds in 1922[2] —

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9. Ibid, p.53. Citing Rubber News Letter, January 31, 1940 p. 20, and September 15, 1940, p.160. Also United States Tariff Commission, p.12.
1. Ibid, p.50. Citing P.W.Barker, Rubber Industry of the United States, 1839-1939, p.25.
2. Ibid. p.53. Citing Rubber News Letter and United States Tariff Commission.

prevented a larger percentage drop.

At the same time that the rate of growth of rubber consumption in tires and tubes was slowing down, consumption in other rubber products continued strong. New uses were constantly being discovered, and many of the old ones were expanding. Nor were there forces at work which tended to decrease the amount of rubber used in these products even when the national income was growing (see also pp.64,65).

It is impossible to give as complete a treatment to the trend within other countries as was given to that within the United States, because the information simply is not available. There is absolutely no direct information before 1920 as to the proportions of rubber consumed in tires and tubes and in other products in countries other than the United States, and even after 1920 what information there is is sketchy to an extreme. However, from such facts as have been published it is possible to construct a fairly adequate picture.

In 1920 of a total absorption of 95,000 tons outside the United States, tires and tubes accounted for about 35,000 tons (37 per cent), other rubber products for about 60,000 tons (63 per cent). By 1937 the position had almost been reversed. 336,000 tons (60 per cent) of the 549,000 tons consumed outside the United States went into tires and tubes, 213,000 tons (40 per cent) into other products.[3] Thus in these 18

3. In 1920 the absorption in goods other than tires and tubes was about 100,000 tons for the whole world (Rae, p.344). If it be assumed that the ratio of consumption in tires and tubes to that of consumption in other products was the same in 1920 as in 1922, and this is approximately so, then

years absorption in tires and tubes multiplied 9½ times. During the same period the number of registered passengers cars and trucks increased to almost the same extent, from 1,287,000 to 12,800,000, or 7½ times. As consumption of rubber in tires and tubes depends, fundamentally, on the number of cars and trucks being used, and as the number of registered vehicles increased to about the same extent as the absorption in tires and tubes between the beginning and end of this period, it is a fair conclusion that the consumption of tires and tubes increased at about the same rate as the registration of vehicles all during this period. As a glance at chart 10 (p.77) shows, with the exception of the years 1930-33, the rate of growth of the registration of automobiles and trucks was almost constant from 1920 to 1937. The conclusion is that from 1920 to 1937 the consumption in tires and tubes as compared with total consumption gradually increased, at a fairly constant rate, except for the years 1930-33, from about 37 per cent of total consumption to about 60 per cent, and that the consumption in other rubber goods gradually decreased from about 63 per cent of total consumption to about 40 per cent.

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then absorption in other rubber goods was 40,000 tons in the United States in 1920 (tables 10,11). Subtracting the 40,000 tons from 100,000 tons, we find that absorption in the rest of the world in other rubber goods was 60,000 tons, which leaves 35,000 tons for tires and tubes (table 10). Similarly in 1937 of a world absorption of 350,000 tons in goods other than tires and tubes (Rae, p.344), the United States accounted for 137,000 tons (table 11), which leaves 213,000 tons for the rest of the world. Subtracting 213,000 tons from the total of 549,000 tons which the rest of the world absorbed (table 10), we find that the rest of the world absorbed 336,000 tons in tires and tubes.

The changing structures of consumption within the United States and the other countries of the world is reflected in the constantly changing structure of consumption as between countries (see table 16, p.82, and chart 11, p.83). In 1910 the United States absorbed 41.5 per cent of the total world absorption, continental Europe 36.2 per cent, the United Kingdom 20.2 per cent, and the rest of the world 2.1 per cent. Gradually the relative absorption of the United Kingdom and Europe fell and that of the United States and the rest of the world rose. This development was hastened and accentuated by the war, and by 1922 the United States absorbed 73.1 per cent of the world total, the United Kingdom and continental Europe 2.6 per cent and 17.6 per cent respectively, while the absorption of the rest of the world had increased to 7.2 per cent. From this time the relative absorption of the other three groups has risen at the expense of the United States, although this latter country held its own fairly well until 1926. In that year the slowly changing trend really began to make itself felt, and by 1932 American absorption was less than 50 per cent for the first time since 1913. From 1930 to 1939 it varied within the extremes of 48 per cent and 55 per cent, only rising to 59 per cent in 1940 because of war influences. Looking at the picture in its entirety, it is seen that American consumption increased from about 40 per cent of the total in 1910 until it reached its high point in 1922 of almost 75 per cent, from which it slowly fell to slightly more than 50 per cent in the 'thirties. British consumption fell

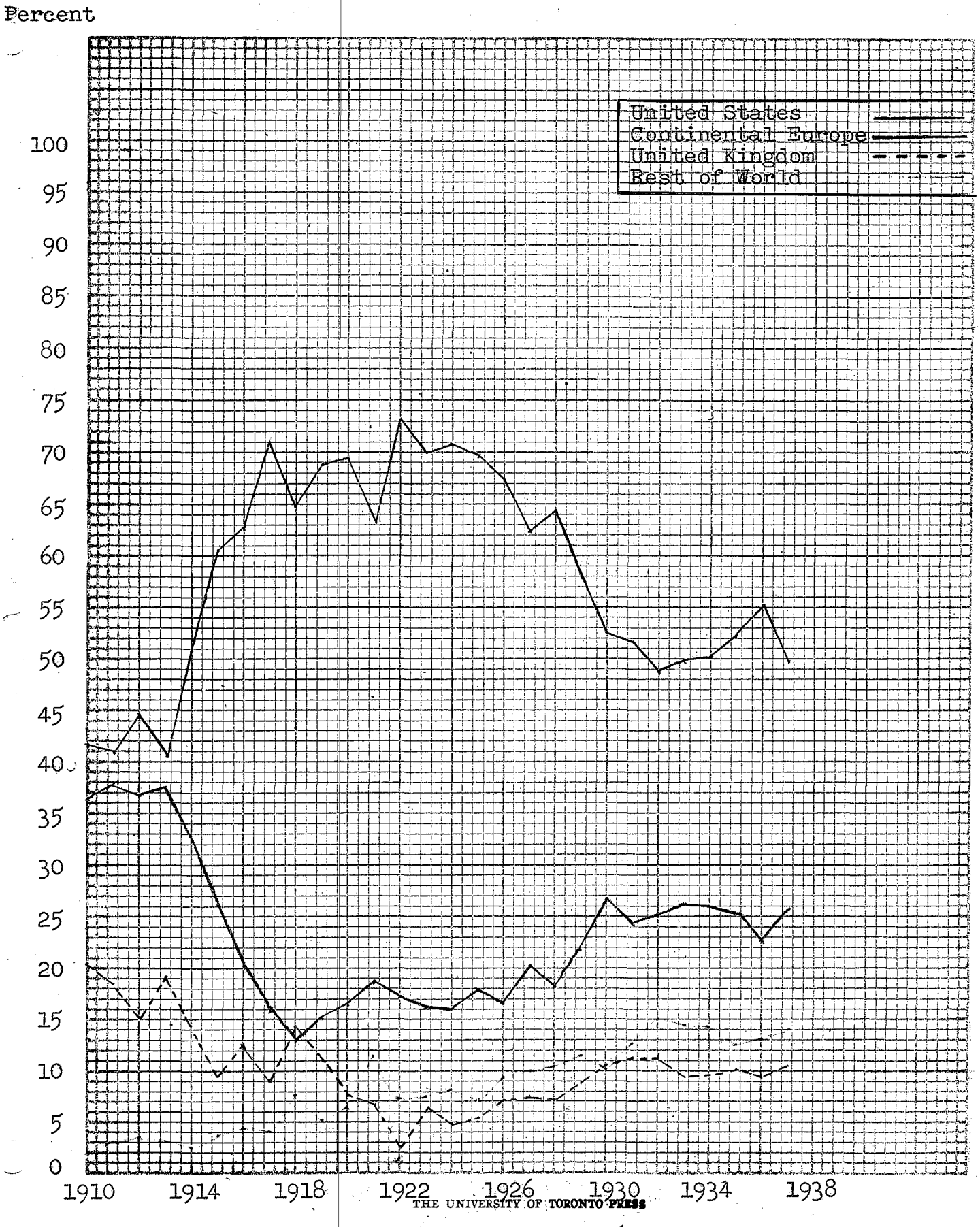
Table 16. Absorption of Crude Rubber as a Percentage of Total World Absorption, 1910-40.

Year	United States	United Kingdom	Continental Europe	Rest of World
1910	41.5	20.2	36.2	2.1
1911	40.8	18.4	37.7	3.1
1912	44.5	15.2	36.7	3.6
1913	40.4	19.1	37.4	3.1
1914	50.9	14.4	32.2	2.5
1915	60.5	9.6	26.1	3.8
1916	62.9	12.5	20.2	4.4
1917	71.0	9.1	15.8	4.1
1918	64.8	14.3	13.0	7.9
1919	68.8	11.0	15.0	5.2
1920	69.3	7.7	16.5	6.5
1921	63.2	6.7	18.6	11.5
1922	73.1	2.6	17.2	7.2
1923	70.1	6.2	16.1	7.6
1924	70.8	4.9	16.1	8.2
1925	69.5	5.4	17.9	7.2
1926	67.1	7.1	16.5	9.3
1927	62.3	7.5	20.2	10.0
1928	64.3	7.2	18.2	10.3
1929	57.8	8.9	21.8	11.5
1930	52.6	10.5	26.7	10.2
1931	51.8	11.2	24.2	12.8
1932	48.7	11.3	25.0	15.0
1933	49.8	9.6	26.1	14.5
1934	50.1	9.7	25.9	14.3
1935	52.2	10.1	25.2	12.5
1936	55.0	9.6	22.3	13.1
1937	49.7	10.5	25.7	14.0
1938	46.8	11.5	41.7	
1939	54.0	11.2	34.8	
1940	59.0	....	....	....

Source. Table 10.

steadily from 20 per cent of the total in 1910 until it reached less than 3 per cent in 1922. It gradually rose from then

Chart 11. Absorption of Crude Rubber Expressed as a Percentage of World Total, 1910-37.



Source. Table 16.

until 1930 when it reached 10 per cent, remaining at approximately this level during the entire 'thirties. European absorption of 36 per cent in 1910 had been more than halved by the end of World War I, and remained at this low level until 1926 when it rose rather rapidly until during the 'thirties it averaged about 25 per cent. The consumption in the rest of the world has gradually and steadily risen from its 1910 level of 2.1 per cent until from 1931 to 1937 it varied between 12 per cent and 15 per cent.

Ultimately the amount of rubber that a country consumes is determined by its wealth and the stage of economic development which it has attained. From 1910 on the United States was consuming an ever larger share of the world total because it was the wealthiest country in the world and because economically it was further advanced than the others. By the middle 'twenties this situation had begun to change. The United States was still the wealthiest country in the world, but other countries were gradually converting to what may be called a wheeled economy, and the influence of this change, which was taking place in almost every country in the world, but especially in the United Kingdom and continental Europe, was so great that the American share of world absorption began to decline.

This completes the survey of conditions of demand up to the beginning of World War II. All the factors which must be taken into consideration in estimating post-war rubber demand have been mentioned -- the level of national incomes and

supernumary incomes, the trend towards the decreasing importance of the United States relative to the rest of the world as a consumer of rubber, the speed with which the war-ravaged countries of Europe recover, new uses and expanded old ones, the trend in the United States towards greater importance of other rubber goods, the trend outside the United States towards greater importance of tires and tubes, and the possibility of technical developments which will perhaps double the life of the average tire. Has the war so changed any of these factors as to alter significantly the world absorption trend?

The war has had little direct influence upon the last four mentioned factors -- new uses and expanded old ones, technical developments, and the trends within the United States and within other countries -- and it will be convenient to deal with their influence on post-war rubber demand before taking up those factors that were greatly affected by the war.

The most important of these is the first mentioned, and here the war has had a powerful although indirect effect. In the past one of the greatest obstacles to greater rubber absorption has been the violent fluctuations in rubber prices. A manufacturer could never be sure that, if he introduced a product in which the cost of rubber was an important part of the total cost, rubber prices would not skyrocket and so raise the cost of his product to exorbitant heights. After a few such experiences he usually became exceedingly wary of commodities made of rubber when some satisfactory substitute material would suffice. It is said that the automotive industry

has consistently refused to introduce rubber springs for exactly this reason.

The advent of relatively inexpensive, high quality, synthetic rubber has reduced this risk to a minimum. Rubber prices can never again soar as they have on so many occasions in the past. There is now an effective ceiling, somewhere between 15¢ and 20¢ per pound, on rubber prices. If they go beyond this point the synthetic producers will surely step in and capture the market.

The result is that there is going to be a great expansion in absorption of rubber in the category "other rubber goods". This is not the place to list some of these new uses. It is sufficient to say that Dr. Dinsmore of the Goodyear Rubber and Tire Company estimates that rubber absorption in new uses will be from 63,000 to 191,000 tons annually in the United States alone.[4] When to this is added the increased absorption which will take place in old uses for this same reason, it is seen that stabilized rubber prices are of great importance.

As has been previously explained, the gradual improvement in the quality of tires and in methods of repair has been one of the factors at work tending to lower the rate of increase in the absorption of rubber in tires and tubes. It has not been unimportant, neither has it been overwhelmingly important, and there is no reason to believe that this state of affairs will not continue. However, the suggestion has been voiced on more than one occasion that a synthetic rubber will be evolved of so superior a quality that the life of

4. R.P.Dinsmore. Future Prospects in Rubber. pp.8-9.

the average tire will be more than doubled. If this should come to pass, there could be only one answer to the question raised in the first chapter: synthetic rubber would easily win the competitive race. But one of the underlying assumptions of this thesis is that no such development will be forthcoming in the near future. Therefore for present purposes such an occurrence is deemed impossible. It isassumed (and there can be no other assumption until it is proven incorrect) that tire quality will improve slowly and steadily as in the past.

There is no good reason to believe that the trend which was so manifest in the United States in pre-war years towards the decreasing importance of absorption in tires and tubes in comparison with absorption in other rubber goods will not continue. All those forces mentioned in the previous discussion will still be at work, and they will be strengthened by a powerful ally, stabilized rubber prices. This trend may be temporarily halted by a sudden surge in the level of the United States national income, which would probably greatly increase the consumption of rubber in tires and tubes, but as the consumption in other rubber goods is also very sensitive to changes in the national income, a reversal for this reason is unlikely. What might have more influence is the growing absorption of rubber in other than automobile, truck and bus tires. The pronounced trend towards the mechanization of agriculture is especially important in this connection. 10,000 tons of rubber were absorbed in tractors

in the United States in 1940, and it is expected that this figure will be increased at least twofold by the end of the transition phase.[5] Again, before the war the amount of rubber consumed in aeroplane tires and tubes was negligible, but it was steadily growing, and the possibility of a post-war boom in air transportation should not be completely discounted. These are the two most important examples, and it is doubtful that their influence will be enough to change the trend.

Similarly it is unlikely that the trend towards the greater importance of tires and tubes at the expense of other rubber goods in the rest of the world will be reversed. Both will be slowed down to the extent that the national incomes of the European countries are decreased, but their relative position will remain the same.

In summary, the influence of three of these factors upon world absorption trends has not changed significantly, while that of one of them, steadier rubber prices, will measurably increase consumption in other rubber goods.

We will now turn to those factors -- the level of national incomes and supernumary incomes, the trend towards the decreasing importance of the United States relative to the rest of the world as a consumer of rubber, and the speed with which the war-ravaged countries of Europe recover -- upon the influence of which the war has made a significant change. These factors are so closely related that they will

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5. Knorr. p. 204.

be considered as a group.

There has been a great deal of sanguine talk about the boundless possibilities of the era into which the world is emerging, about new inventions and developments that will raise productivity to unheralded heights, about the opening up and industrialization of the backward nations of the world by their more advanced fellows that will draw all into the whirl of an ever-rising spiral of higher living standards and higher national incomes. It is conceivable that under optimum conditions the advance effected might bear some resemblance to these predictions, but for their accomplishment the present plight of the world augurs ill. To assume that what can be inevitably will be is no more than wishful thinking; to base an estimate of post-war demand on an analysis which ignores fundamental economic and political facts is hopelessly deluding. This is not the place for a long dissertation on the possibilities and/or probabilities of a sudden world-wide expansion of internal economies and international trade. It is permissible to point out that a realistic judgment at this time can hardly be very optimistic.

Before the higher national incomes which technological developments make possible can be realized there must be provided an environment which will allow industry to exploit these developments. One element in this favourable environment is political stability, and it is just this desideratum which is almost completely lacking over large areas of the globe at the present time, and which in all probability

will continue to remain wanting for some considerable time. This is especially the case in Europe, where communism wars with socialism and each of these with the old "right", and where schisms develop in the ranks of all except perhaps the communists. Large sections of Asia are in a state of either actual or potential rebellion against their European overlords. The world is in a state of ferment which bodes ill for expanding trade.

Economic expansion implies increasing specialization and the division of labour, which in turn necessitate a growing volume of trade, both national and international. Intra-national trade is inhibited by the political instability referred to above, international trade by the fear and suspicion which are rampant in the world to-day. Can any realistic appraisal of the international political situation possibly do other than conclude that it hampers and obstructs an expanding international trade?

Nor do the strictly economic factors favour a sudden rise in the level of real national income. It may be true that science has raised the potential level of production to heretofore unapproached, nay unimagined, heights. It is also true that the problem of consumption is still unsolved. It is well to remember that during the 'thirties food rotted in the fields while children starved, that factory wheels were idle while men begged for work and for the goods that technological advances had made theoretically possible. It is still an unpalatable fact that in this age of miracles,

our system of distribution is a millstone hanging on the neck of our system of production; that the American people, as Mr. Vinson, the Secretary of the Treasury, has so aptly stated, are facing the "pleasant predicament of having to learn to live 50 per cent better than before".[6]

It is also true that this predicament is almost completely restricted to the North American continent. Only three countries -- the United States, the Union of Soviet Socialist Republics and Canada -- have greatly increased their productive equipment as a result of the war. One of these, Russia, embraces the economic philosophy of autarky which has in the past dictated the construction of synthetic rubber plants even when better quality natural rubber was available at lower prices, and which in the future will almost certainly continue so to dictate even though natural rubber should remain competitively superior. Hence potential Russian expansion can have little except negative influence upon the world rubber situation. Just as much, if not more, industrial capacity was destroyed during the war than was created in Europe, and in no other country was the gigantic effort necessary to raise substantially productive capacity in such a short time put forward.

It is also possible that the ravages of war in Europe have been so severe that a reorientation of international trade will be necessary, a prerequisite to which is the destruction of present world-wide trade barriers. It is a sad

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6. Economist. August 11, 1945.

commentary on the economic immaturity of leaders the world round that few positive steps in such a direction have been taken if one sets aside the platitudinous utterances of campaigning politicians.

Even if national incomes should greatly rise, there will be many forces at work which will tend to limit the concomitant rise in supernumary income. The chief among them is the higher taxes which are inevitable in every country which played an important part in the war, as did every major importing country.

It should also be noted that in the United States, Canada, the United Kingdom and large parts of Europe it will be politically impossible for any government to survive which allows a large-scale depression to get under way, and that most contra-cyclical policies tend not only to reduce the amplitude of fluctuations and to effect a redistribution of income, but also to reduce its absolute size. Both the redistribution and reduction of national income will of course adversely affect supernumary income and rubber absorption.

This discussion has no more than scratched the surface, but enough has been said to indicate that a substantial rise in the absorption of rubber (above that which the long-term trends would lead one to expect) on a world-wide scale consequent upon vastly increased national incomes and the larger supernumary incomes which this would entail is unlikely to be attained by the end of the transition period.

The foregoing discussion does not imply that the war will have little effect upon absorption trends. It merely makes the point that there will be no sudden, large, world-wide jump in production. The statement that a war that profoundly changed the lives of hundreds of millions of people, that impoverished scores of millions, that destroyed billions of dollars worth of property, that created huge new industrial capacities, and that doubled the national income of the wealthiest country in the world, will not materially modify world absorption trends is silly and foolish. They will be greatly changed, but the change will not take the form of a world-wide jump in rubber absorption beyond what pre-war trends indicated.

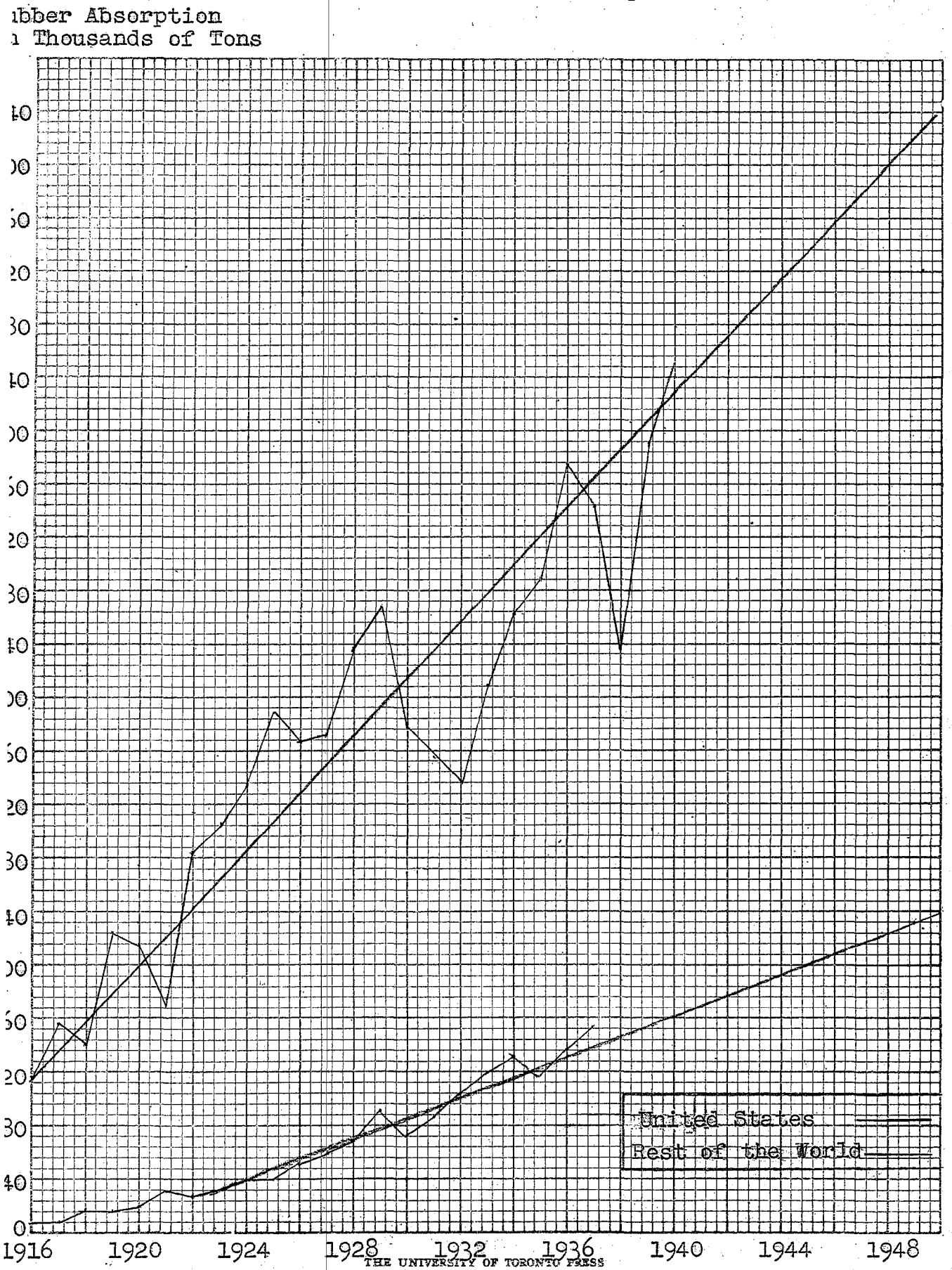
It will be remembered that during the 'thirties the absorption of rubber as a percentage of total world absorption was stabilized at about 10 per cent in the United Kingdom and 25 per cent in continental Europe, that the absorption in the United States was still falling slowly, and that absorption in the rest of the world gradually rose fromabout 10 per cent to 14 per cent. These figures will be drastically changed by the war.

To use a financial metaphor, large parts of Europe are bankrupt to-day, some are financially embarrassed, and some are managing to scrape along on a very meagre working capital. Europe (including the United Kingdom) will not recover from this impoverished condition in five years. By that time her assets, current and fixed, may be greater than her

liabilities, but her position will not be a strong one. It is hopeless then to expect that European absorption of a commodity like rubber, which is so closely related to the national income, will keep pace with absorption in the rest of the world. At the best her consumption will be about the same as her 1939 consumption, while that of all other countries will have steadily risen. This places European absorption of rubber in 1950 at about 250,000 tons.

From 1939 to 1946 the expansion of the American economy proceeded more rapidly than at any other time in her history, and in the light of this amazing achievement, it is not unduly optimistic to expect that by 1950 her national income will reach, and probably will surpass, the level that the secular trend as of 1940 indicated. Since there is no reason to believe that the close relationship between national income and rubber absorption will be broken, and since the influence of those factors which are not related to the level of national income will, if anything, raise rather than lower rubber absorption, it follows that by 1950 American rubber absorption will also reach the level indicated by the pre-war trend. Just what is this level? The data for United States rubber absorption are not amenable to mathematical treatment. The straight-line trend is the most suitable, and it indicates a rubber absorption of 840,000 tons in 1950 (see chart 12, p.95). To this must be added at least 100,000 tons which will be absorbed because of the stabilized rubber prices. This estimate of 940,000

Chart 12. Rubber Absorption Trends in the United States and the Rest of the World (excluding the United Kingdom and Continental Europe).



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tons is quite conservative, and will probably be surpassed, because the American national income will likely be higher in 1950 than the pre-war secular movement indicated. However, it is better to under-estimate than to over-estimate.

Generally speaking, the other countries in the world were forced to speed up their rate of expansion by the war. Some, like the British Dominions and India, put forth a gigantic effort in order to feed the maw of war, and in doing so greatly increased their productive capacity. Others were forced into a measure of industrialization because their traditional sources of supply were cut off by war. Taking this faster than usual development into account, it is no more than realistic to expect that the level indicated by the secular trend for 1950, 225,000 tons, will be reached, perhaps surpassed.

The sum of these estimates for the United States, the United Kingdom, continental Europe and the rest of the world is approximately 1,400,000 tons. If from this be subtracted the 100,000 tons which the special purpose synthetic rubbers will supply, there is left 1,300,000 tons for either natural rubber, GR-S, or both together, to supply.

The influence of this potential demand of 1,300,000 tons upon competition between natural rubber and GR-S will be analyzed in the next chapter.

Chapter V

Conclusion

Before any further progress is attempted toward the solution of the problem to which this thesis is striving to find the answer, it will be helpful to restate the problem, the assumptions upon which all deductions are based, and the conclusions which were reached in the preceding chapters.

The total world capacity for the production of natural rubber and synthetic rubber is far greater than world demand, nor is there any prospect that rubber absorption will increase sufficiently to make up the difference. This disequilibrium of supply and demand can mean only one thing -- the redundant capacity will be removed by the elimination of inefficient high-cost producers. The question is, will this elimination be at the expense of the synthetic rubber producers or the natural rubber producers, or will it be brought about by the expulsion from the industry of the inefficient producers in both classes?

The analysis is based on three assumptions. First, free competition is assumed. This means that natural rubber producers will no longer have their output arbitrarily restricted, and that synthetic rubber producers will not be protected by tariffs, subsidies, or by any other of the myriad sheltering devices.

Second, efficiencies and productive techniques which present knowledge make possible are assumed. This means on the one hand that old developments which have never been

completely utilized, whether by the natural rubber or the synthetic rubber producers, will be completely employed. The impending bitter competition between the two should assure this under conditions of free competition. On the other hand, it means that no cognizance is taken of improvements in the quality or decreases in cost of either natural rubber or synthetic rubber made possible by new discoveries.

Third, it is assumed that the natural rubber industry will be reformed and reorganized. That is, it is assumed that small estates will be amalgamated, that huge uneconomic units will be broken up, and that the expensive and inefficient agency and directoral systems will be reformed.

The second assumption limits the scope of the investigation to what may be termed the intermediate long-run as opposed to the extreme long-run. A second limitation is the restriction of the inquiry to natural rubber and the one general purpose synthetic rubber, GR-S.

In Chapter II the conclusion was reached that generally speaking there is little to choose qualitatively between natural rubber and GR-S. Naturally, since they are not chemically equivalent, they differ in some respects. In uses where these differences are especially important one will be preferred to the other and will command a premium price proportionate to its qualitative superiority for that particular use. In most cases where the difference is significant natural rubber will be the subject of the preference, and to the extent that this is so the conclusion reached

below will be reinforced. Since generally speaking there is little difference between them qualitatively, and since what difference there is cannot be quantitatively measured with the information available, this preferment of natural rubber will not be used in arriving at a judgment, but will be left as a tendency which buttresses it.

In Chapter III it was concluded that cost-wise the natural rubber growers have an advantage, that on the basis of 1935-37 data approximately 87½ per cent of the natural rubber producers can grow the rubber, ship it to New York and pay the dealers' charges for less than the cost of the most efficient synthetic rubber plants. It was also concluded in this chapter that any discussion of the influence of changes in exchange rates upon costs of natural rubber and synthetic rubber could only be of the most general nature, but that it was possible to say with confidence that any long-run movements which do take place will be in the direction of an appreciation of the dollar in terms of the pound and guilder, a movement which would redound to the benefit of the natural rubber producers, to the prejudice of the synthetic rubber manufacturers.

In Chapter IV it was concluded that by 1950, the year in which the natural rubber growers are expected to be producing once more at capacity and at pre-war costs, the demand for general purpose rubber will have reached at least 1,300,000 tons.

We are now in a position to deduce the solution of the

problem posed in the first chapter and restated at the beginning of the present one. Obviously, if synthetic rubber and natural rubber are qualitatively equal, and if the cost of production of most of the natural rubber producers is less than the costs of the most efficient synthetic rubber producers, then no synthetic rubber will be sold unless the natural rubber producers whose costs are less than those of the most efficient synthetic rubber producers are unable to satisfy the demand. It is certain that they will be able to satisfy a large part of it. But all of it? -- it is more than doubtful.

In 1941 the production of natural rubber in Malaysia was 1,500,000 tons.[1] If not the maximum production possible, this was certainly very close to it. During the first three quarters of the year the percentage of permissible exports was placed at 100, in the last quarter at 120, in an effort to extract every possible ounce of rubber from the growers. At the same time prices averaged 22.1¢ per pound. With prices higher than they had been at any time since 1929, with permissible exports averaging 105 per cent during the year, and with the Allies begging for rubber, it is not difficult to believe that 1,500,000 tons represented capacity production for Malaysia in 1941. Under normal conditions this capacity would have increased to 1,600,000 tons through the maturing of younger trees by the end of the war.[2]

1.Knorr. p.248. Citing McFadyean, pp. 226-29.
2.Ibid. p.205.

Contrary to earlier expectations the Japanese did not adopt a policy of extensive destruction of rubber plantations. What depredations they did make were largely for the purpose of increasing food production -- they cut down the rubber trees and planted the area in rice. Also, the hardihood of the mature Hevea is amazing. The result is that losses in productive capacity have been small. It is estimated[3] that losses from all possible sources will be no more than 10 per cent. This leaves Malaysian capacity at 1,440,000 tons.

From this must be subtracted the 12½ per cent (180,000 tons) which was produced at costs of more than 13¢ per pound. This leaves a maximum of 1,260,000 tons which can be produced for less than 13¢ per pound. However, in 1941 the all-time high of 1,500,000 tons was reached only as a result of abnormally high prices, and it is certain that these high prices (38 per cent higher than the 1935-37 average) called forth production of which no account was taken in 1937, and that the proportion of producers with costs of less than 13¢ per pound fell accordingly. This means that the figure of 1,260,000 tons must be reduced to some unknown extent, probably about 250,000 tons.[4] At the same time it must be noted that the figure of 1,300,000 tons was a conservative estimate. Thus even if it be assumed that all of the African

3. Ibid. p. 206.
4. Knorr (p. 209) estimates that a price of 10¢ per pound would have elicited a production of 800,000 tons during the late 'thirties if production had been unrestricted.

and Latin American production of about 85,000[5] tons will have costs of production of less than 13¢ per pound -- which no authority has ever even suggested -- the natural rubber producers will still be unable to meet all of the 1950 demand at prices less than the costs of the most efficient synthetic rubber producers.

The conclusion is that the natural rubber producers will supply the largest part of the 1950 demand -- between 1,000,000 tons and 1,250,000 tons -- and that the remainder will be supplied by the most efficient synthetic rubber plants.

To what extent will the three assumptions be realized in fact? Or, to paraphrase this question, To what extent will the above conclusion based on these assumptions be borne out?

All indications in the United States point to a measure of governmental control for purposes of national security. The prevailing sentiment is that never again must the United States become dependent for so vital a commodity as rubber upon sources of supply distant thousands of miles from her shores. Whether this kind of thinking is outmoded or not in the atomic age is beside the point. If the Americans think that synthetic rubber plants in the United States will safeguard them from the hazards of an atomic war and act on this belief, for the purposes of competition between natural rubber and synthetic rubber it does not matter whether they are right or wrong. The words of Bradley Dewey only echo

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5. Ibid. p.207.

the feelings of millions of Americans. "This country is today independent for its supplies of rubber of other nations, of the effect of wars between other nations, or the destruction of plantations by plant blights. It must so remain."[6] The Inter-Agency Policy Committee on Rubber, representing the Departments of State, War, Navy, Commerce and Justice, the Reconstruction Finance Corporation, the Office of Rubber Reserve, the Rubber Development Corporation, and the War Assets Corporation -- certainly a most influential committee -- recommends that sufficient synthetic rubber capacity to meet at least one-third of the United States rubber requirements should be kept in operation "regardless of cost", and that plants capable of producing 350,000 tons should be kept in stand-by condition.[7]

The natural rubber growers have as yet given little indication that they have awakened from the lethargy induced by the suspension of competition during the 'thirties to a sufficient extent to put their own house in order. Instead of reforming and reorganizing their industry, they seem to be thinking in terms of a new, bigger and better International Rubber Regulation Agreement, including of course the United States, which would give them a share of the American market without having to fight for it.

Chemists are working on synthetic rubber steadily, and there will indubitably be some improvement in its quality

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6. Special Report of Office of Rubber Director on the Synthetic Rubber Program. Introduction.
7. Time. Vol. XLVII, No. 12, March 25, 1946, p.38.

and probably some decrease in its costs.

Thus it certainly seems that the conclusion reached in this thesis will have to be modified as events unroll themselves, but until definite decisions are reached in the United States and definite policies undertaken by the rubber growers, nothing more can be said.

What will happen in the long-run depends on four factors. The first is the extent to which improvements will be made in the quality of synthetic rubber and reductions made in its costs of production. The second is the extent to which new technical and biological advances will improve the quality and lower the cost of natural rubber. The third is the extent to which private capital will be willing to invest in synthetic rubber plants. Up to this point there has been a marked disinclination on the part of those who are now operating these plants in the United States to take them over. If this lack of confidence in synthetic rubber should persist, and if private capital should not be forthcoming, then the chances of natural rubber will be greatly improved. The fourth is the extent to which private capital is willing to invest in natural rubber. Investors may be frightened away by the thoughts of extremely stiff competition from the American and Canadian synthetic rubber plants, and be loth to risk any more money in rubber plantations. How these four factors will work themselves out, how they will react and interact upon each other, no man can with exactitude foretell.

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