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Spatial Implications in the Competition between Natural and Synthetic Products: with special reference to the case of rubber

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1. Introduction

Although increasing attention has been paid to the competition between natural and synthetic products since the second world war, the studies that have resulted have been mainly economic in nature. Stress has been laid primarily upon demand and supply estimates, market structures and possible forms of price regulation as some of the central issues involved. But the question of competition from synthetic substitutes is in many respects wider and involves much more than the economic side of life. Trends over time have also been emphasised with relatively little attention given to the spatial implications involved.

Although the spatial patterns of this competition can only be understood in terms of factors such as the structure of the synthetics industry or the size and diversity of the market, the form they take and the ways in which they develop pose in many respects a relevant aspect of the problem. For example the demand for rubber varies considerably from area to area (largely according to the type of industrial structure developing) and it is by no means static. As it changes, and as petrochemical technology spreads further and further afield, so the patterns, and in some cases the importance of the competition between natural and synthetic rubber has also tended to change. An overall picture of the problem must therefore view it both over time and from place to place, interrelating these two dimensions.

But these patterns also have somewhat deeper significance. It is important that natural production is concentrated in the underdeveloped countries whereas the synthetic counterpart is being produced as a direct substitute in the industrially advanced areas of the world. Vast areas are dedicated to out-put of the natural product. 1.6 million acres under cotton in the U.A.R. or 4.9 million acres under rubber in Indonesia represent a large portion of the cultivated areas of these nations. Whether on estates or smallholdings the production of these crops implies a very intimate part of everyday life. In many cases not only the economic, but the social, administrative and spatial structure of their societies has been shaped historically by the production and export of these crops. Their fortunes hold considerable political importance in the countries concerned. It is in fact because of the degree to which producer countries are dependent upon these crops, and because of the extent to which its production is engrained in their societies that the development of synthetic substitutes has become a problem of such concern. It is therefore relevant that the implications of this competition for the overall development needs of the low income countries should also form part of the context within which the problem is to be seen. It seems quite likely indeed that delimitation of the problem can in fact clearly influence the type of conclusions that are reached. It is also noteworthy that the degree of dependence involved, whether for export earnings or solely as a means of livelihood, and the potential impact of the competition from synthetic substitutes also varies not only from country to country but within each country, and has serious implications for the nations concerned.

The rapid development and acceptance of synthetic products is generally considered to have been the result of at least the following factors:

i. the rapid and consistently growing world demand in the post-war period which natural producers were not sufficiently equipped to exploit;

ii. the fluctuating price and output of natural products which led main consumers to seek alternative and more reliable supplies;

iii. the growing need of many producers for more uniformity of product;

iv. rapid advances in the chemistry and technology of synthetic production;

v. the possibility of developing particular qualities for specified end-uses;

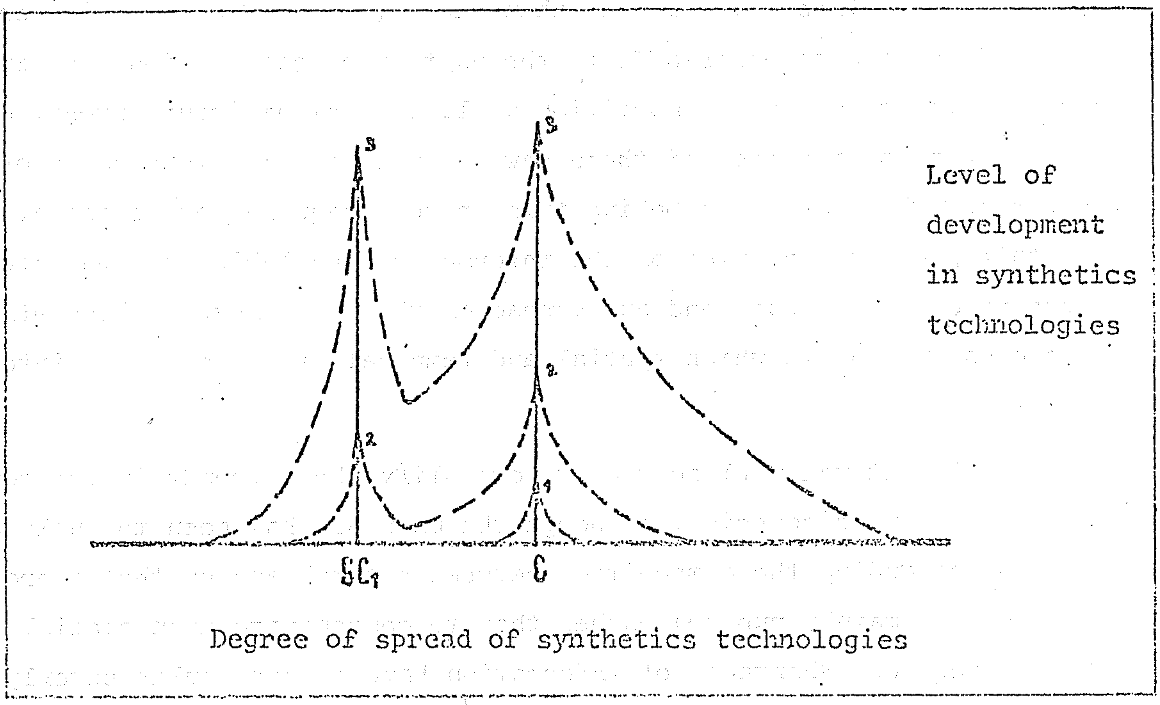
vi. the loss of vital raw material sources during the second world war;

vii. the interests of petroleum producers in developing outlets for their various by-products and wastes.

These are the general reasons for their growth within which certain general patterns can be discerned. The growth has been differentiated firstly according to the types of product involved and secondly according to the demand for the various end-uses to which they are put. This has in turn had a definite pattern. With developments in the forefront of synthetics production and its continued expansion in leading areas there has, at the same time, been this gradual diffusion and spread of new technologies. More and more synthetics industries have sprung up in more and more countries.

Although they will not be abstracted so much for individual emphasis in the course of following pages spatial trends have received little discussion up to now and it would seem interesting to generalise about the patterns that seem to have occured as a guideline for the ensuing discussion. These patterns can be illustrated with the aid of the following diagram.

Diagram 1: Patterns in the development and spread of technologies over time



Numbers refer to the time period of the contour (t+1, t+2, etc.)
C = centre SC_1 = sub-centre

The basic pattern is shown in diagram 1. Developments in the production of synthetics were initially extremely concentrated, principally in the United States (time 1), while during their continued development since these early days the number of firms and the number of producer countries has increased. Technologies have diffused and major interests have emerged in other areas, particularly throughout western Europe and more recently in the developing world. Advanced research is being carried out in the newer (secondary) centres which could side-step the initial research stages and gain other advantages typical of being a late-comer (time 2). As the number of producer countries has increased less specialised technologies, such as general purpose synthetic rubber production have become both widespread and fairly standard and the technological gap between the initial centre (C) and the secondary centres (SC) has tended to narrow.[1)] Developments in synthetics production have in turn stimulated action on the part of the natural producer and new techniques in natural rubber production have spread in a similar pattern. In general, as implied in diagram 1, the situation has tended to be one of domination by the centre possessing the resources, facilities, organisation and information to be the decision-making core, but the situation in both the centres and the periphery have been subject to continual change.[2)] As already mentioned, changing patterns of consumption and the spread of new technologies affects the pattern of competition, and in some cases the impact of this competition will, to a significant extent, depend upon the rate of adoption of these new techniques in various parts of the world. The mechanisms behind this process require more elaboration than this paper can provide on the information available, but the study of expansion on the one hand and spread on the other nevertheless offers an interesting way in which spatial and temporal patterns can be interpreted.

An attempt will be made to exemplify these trends in the course of the following discussion, although the main aim has been to analyse the situation regarding the competition between natural and synthetic products (in this case mainly rubber) rather than to concentrate upon spatial features per se. Shortages of information have in particular severly limited the scope of the paper which remains primarily an economic geography

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1) The diagram can of course be extended to include other sub-centres such as SC_2 by-passing the first two levels of technology.

2) To be more accurate the model must also of course allow for SC_1 to overtake C_1 and become the centre itself. Synthetic rubber is a case in point. Until 1940 German production was far larger and expanding far more rapidly than that in the U.S. By 1943 (coinciding with the sharp decline in natural rubber availability from S.E. Asia) the U.S.A. had reversed the situation, and moved further ahead in the post war period. More recently, however, the technological gap between the U.S.A. and Western Europe has again narrowed.

and must be seen as a general attempt to analyse some of the economic and spatial implications involved. Nor can it analyse the processes of development and spread in as detailed a fashion as they deserve.

The structure of the paper, however, is as follows. Section 2 is concerned with the nature and distribution of the synthetics industry, the nature of the industry influencing very considerably the spatial patterns of the development which are elaborated in a later section. The remainder of the paper concentrates upon the competition between natural and synthetic rubber as a case study, section 3 discussing market trends while section 4 turns to some of the implications that these hold for the countries producing natural rubber. It is hoped that in looking at the nature of the synthetics industry on the one hand and at the situations of natural rubber producers on the other a fairly broad, if incomplete picture, of some of the geographical implications of this competition can be obtained.

Appendix to section 1

It would also seem relevant at this point to present a simple classification of the main types of synthetics involved to facilitate the following discussion. Though not all will be dealt with in the text it seems useful to include in this the three main fields in which synthetic substitutes have been developed.

1.1. Rubbers

Synthetic rubber can be separated into three main classes:[1)]

i. styrene-butadiene rubber (S.B.R.) comprises the bulk of the present output of synthetic rubber. A general all-purpose rubber, it in fact has many variants obtained by varying specific elements of the production process;

ii. special purpose rubbers such as butyl, neoprene and nitrile have been developed for their specific qualities that are valuable in particular end-uses. Neoprene, for example, is heat and flame resistant and nitrile is able to withstand contact with oil or gas;

iii. stereo-rubbers such as polyisoprene (P.I.) and polybutadiene (P.B.). The former, which is still only being produced in relatively small quantities, almost exactly duplicates natural rubber, while a 50-50 polybutadiene/natural rubber is considered a major challenge to the one exclusive preserve of natural rubber, heavy duty types. Their development almost certainly poses the major threat to natural rubbers.

The position at the present time seems to be that although synthetic rubbers are, or can be made considerably superior in terms of their uniform quality, general resistance and fast curing qualities, the majority being produced still fall short in terms of their resilience and heat build-up. The range of synthetic rubbers now on the market means, however, that they are competing with natural rubber in all its main outlets, and that with increases in stereo-production this is likely to become more and more the case.

1.2. Man-made Fibres

Though the range of man-made fibres is again extremely wide, they can nevertheless be classified into three main groups:

i. cellulosics such as viscose and acetate rayon which are not generally classed as synthetics as they are derived from naturally occuring

1) See 'The Science of Rubber', Information Service, Dunlop Ltd. London 1968; F.A.O., 'Synthetics and their Effects on Agricultural Trade', Commodity Bulletin Series No. 33, Rome 1964, pp.11-12; F.A.O.op.cit.1967,p.314.

polymers in wood pulp and cotton waste.[1]

ii. non-cellulosics such as the polyamides (nylon etc.), the polyesters (Terylene, Dacron etc.), the acrylics (Acrilan, Courtelle etc.) and less important, the polyvinyls. These are characterised by two technical features: they are individually formed by extruding a single polymeric viscous mass through a hole and are mainly produced for textile yarns[2];

iii. polypropylene and high density polyethylene which are relatively cheap substitutes for jute and allied fibres in their main end uses as bags, woven carpet backings etc.

The respective qualities of these products vis-à-vis their natural counterparts are relatively complex. In general terms the synthetics can be said to have a lighter weight, higher tensile strength and greater crease resistance while cotton and wool have a greater absorbency and resistance to pilling. In the apparel fibre field no individual synthetic can as yet replicate all the qualities of a natural fibre. Though man-made fibres all have some of these qualities in certain measure they tend also to have other desirable and/or undesirable qualities either in terms of their relative versatility and breadth of use or as regards consumer preferences.

1.3. Synthetic detergents

The case of synthetic detergents is relatively simple in that it implies competition with natural oils and fats (mainly incdible tallow, coconut oil and palm-kernel oil) in only one main outlet even though this is internally quite differentiated. The main raw materials are again mainly propylene, ethylene and olefins derived from a petrol base.[3] With the exception of synthetic resins which are being introduced in competition with drying oils in paints and varnishes, and in the partial displacement of linoleum by other floor coverings, natural fats and oils have not faced encroachment of synthetic substitutes in other industrial end-uses, nor in the major food outlets to any meaningful extent. In the main field of competition of household and industrial soaps, however, synthetic detergents are quite superior in terms of their technical qualities.

1) A.B. Thompson, 'A Third Generation of Synthetic Fibre Material', Advancement of Science, December 1967, pp. 150-161.
2) Thompson ,op.cit. 1967, p.152.
3) See F.A.O. op.cit.,1964, pp.45-50; R.C. Taring, 'Progress in the Chemistry of Detergents and its Social Consequences', Impact of Science on Society, Vol. XVI, No. 4, 1966, pp.277-295.

2. The Nature and Distribution of the Synthetics Industry

In terms of the competition that is developing between natural products and their synthetic substitutes three important elements fall under this heading:

i. current trends in the location of the synthetic industry;

ii. its internal structure and

iii. its research and developmental activities.

Each of these aspects impinges very strongly, if in different ways, upon the problem under duscussion and will therefore be the subject of individual discussion.

2.1. Location and cost factors in the production of synthetics

The synthetic products that come under the present discussion have in common the fact that their large-scale commercial production is directly associated with the petrochemical industry as the source of basic inputs. Indeed in the modern world oil refining, petrochemicals, production of synthetics and often their main consumers are highly integrated and their structure associated with the large-scale industrial complex.[1)]

As for their world distribution these complexes have until recently been almost entirely concentrated in the industrially advanced nations where they have grown to be an essential and integrated part of the industrialised economy. Until 1961 synthetic rubber production was concentrated, for example, in North America, Western Europe, Japan and, to a minor extent, in Australia. These were the major market areas, and here competition for the natural producer was strongest. However, since the early 1960s the production capacity of synthetics in the developing countries has increased significantly, particularly in Brazil, Argentina, Mexico and India. The nature of the synthetics industry has been particularly important in influencing this spread which may, at least in the short run, have an important bearing upon the position of the natural producer.

The degree of vertical integration involved in these industries has meant that the factors underlying this distribution are somewhat complex, but at the same time it means that the synthetics industry cannot simply be considered in isolation as an independent unit. Brief

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1) The basic material may in fact be either petroleum oils or natural gas, the former being the more important.

mention must therefore be given to factors underlying the location of refining and petrochemicals.

A general feature of the refining industry since 1945 is that the majority of world capacity has tended, in world terms, to be market oriented. Two economic reasons seem to favour this tendency: firstly the cost of transporting crude oil is considerably below that for finished products due to the economies of scale that can be employed, and sizeable markets for 90-95% of the refinery output means that these cost differentials can be exploited to fullest advantage[1)], and secondly because the industrial linkages in the developed areas also tend to lower costs. This trend has also been reinforced by government and company policy which, after the difficulties, for example, of the Anglo-Iranian and Suez incidents of the 1950s also favours market location for strategic reasons. The same factors of course have tended to work against the favourability of the developing countries for refinery location.

The distribution of world production and the main locational factors of the petrochemical industry are again very similar even though it concerns only a very small portion of the petroleum market. Three factors would appear of major importance: firstly transportation costs on petroleum inputs favour proximity to the refining process, secondly that the extremely high capital investment has made it dependent upon large-scale production and, thirdly, the fact "that a sound chemical venture is generally based on the bulk of its production being sold in local markets[2)]". The general effect of these factors has been to make production very dependent upon a high level of industrial activity to consume its specialised products as raw materials, and this has largely meant on the one hand plastics, synthetics and fertiliser production, and on the other concentration in developed areas. A propulsive force in the development of synthetics has also been the desire of petroleum and petrochemical companies to utilise "waste products".

As mentioned already, however, these trends have recently seen some reversals, and whether for developmental or for largely political reasons more and more nations now want, and are getting refineries and

1) For a more detailed discussion see in particular P.H. Frankel and W.L. Newton, 'The Location of Refineries', Institute of Petroleum Review, July 1961, pp. 197-201 and P. Odell, Economic Geography of Oil, London 1963, chapter 6, pp. 109 f. See also G. Alexandersson, Geography of Manufacturing, New Jersey, 1967, pp. 113 f.

2) E.T.G. Toxopeus, 'Some Aspects of the Manufacture of Chemicals from Petroleum', Institute of Petroleum Review, July 1961, p. 227. Regarding locational factors for the individual firm, see W. Isard and E.W. Schooler: Location Factors in the Petrochemical Industry, U.S. Dept. of Commerce, July, 1955.

related complexes of their own. The reasons for this are mainly three-fold. On the one hand the internal market is now just about large enough and sufficiently diverse in many instances to support an economically viable refinery/petrochemicals/synthetics and/or fertiliser complex, while on the other hand such an integrated complex has had the added attraction of substituting imports and of utilising national resources to establish a propulsive core for development.[1] It is therefore a very attractive proposition, and almost regardless of the short-term economics involved these policies seem to be increasingly favoured by the government of oil- and natural-gas producing nations. In contrast, however, this trend has also been due in part to direct political or prestige considerations on the part of these producer nations, the oil companies having been pressured into defensive investments. These three elements are largely responsible for the recent growth in synthetics production in developing countries.

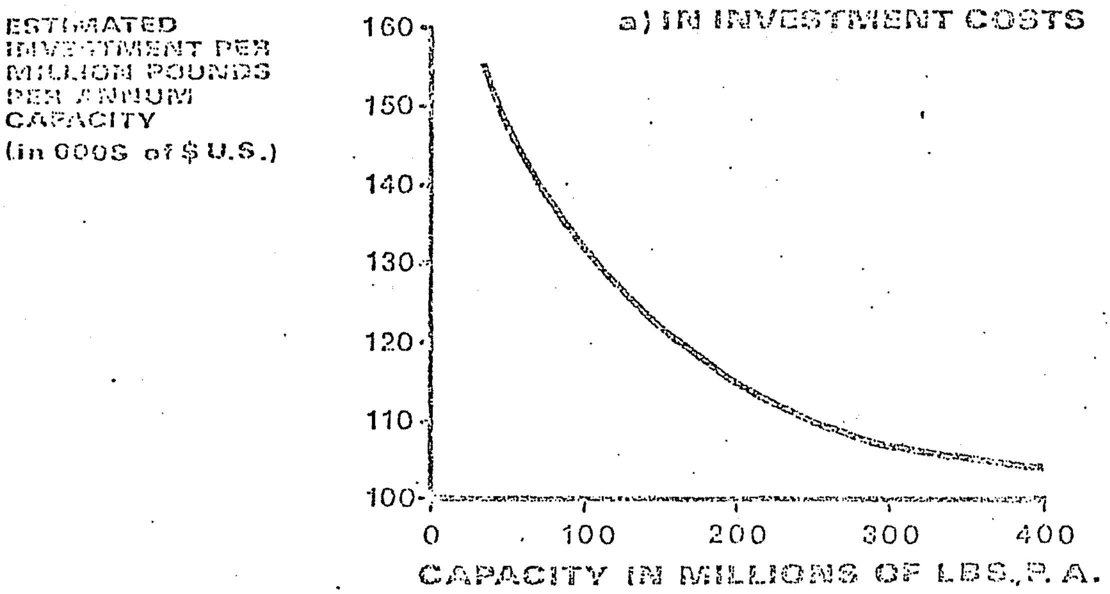
Bearing in mind these factors as a whole, the importance of viewing the synthetics industries as part of a complex should be quite apparent, the economics and location of refining, petrochemicals and synthetics production so often being closely interrelated. This point has also been reinforced by the fact that the petroleum giants that have gone into petrochemicals have always shown a certain distaste for the physical problems of distributing products to a wide array of industrial consumers, much prefering guaranteed bulk outlets where large-scale handling is more feasible, and this the complex provides.[2]

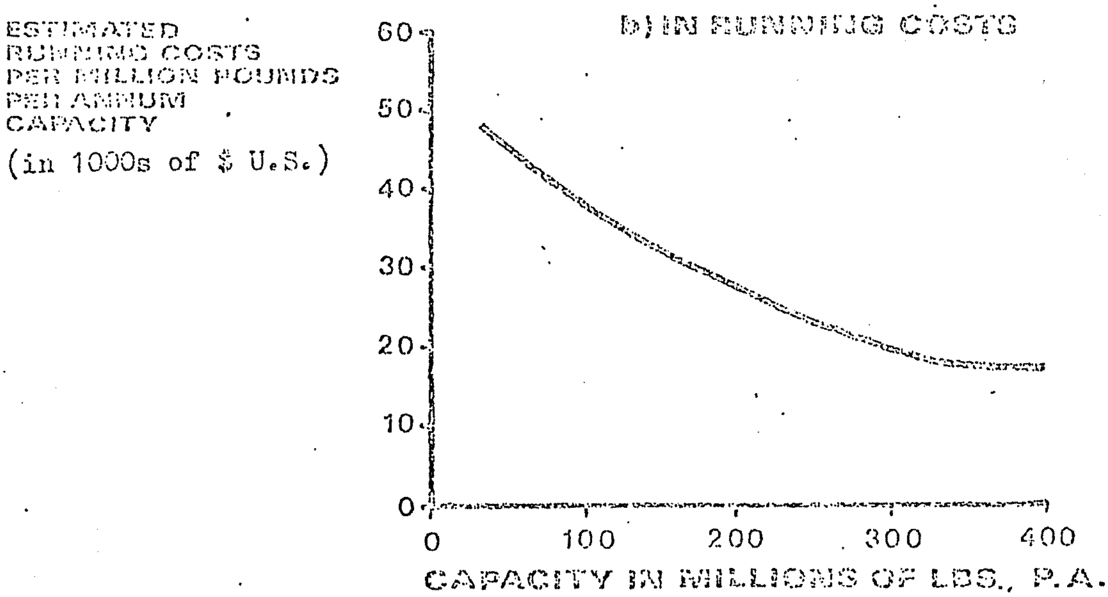
A basic assumption of the competitive synthetics industry has therefore been the availability of low cost chemical intermediates as raw material inputs and a higher degree of technical integration, and this, minimising transport costs and the chances of contaminating sensitive products has meant location near the petrochemical complex.

In terms of their location and competitiveness, however, the cost side of synthetics production cannot be understressed. Three features stand out in this respect: the capital costs involved, economies of scale in production and the costs of running below capacity - each underlining again the reasons why production is concentrated in the developed nations and the importance in particular of market size.

1) See for example, W. Isard, E.W. Schooler and T. Victorisz, Industrial Complex Analysis and Regional Development, M.I.T., 1959.
2) A.L. Waddams, 'Trends in Petrochemicals', Petroleum Review, February 1968.

Graph 1. ECONOMIES OF SCALE IN THE PRODUCTION OF S.B. RUBBER





Source: ISARD and SCHOOLER op.cit. 1955 p.88

As regards the first point it is to be noted (1) that the capital costs involved are extremely high and (2) that they are not proportionate to the scale of output. This is shown for the case of S.B. rubber in graph 1. They also tend to increase over time. However, in practice the situation is more complicated in that these costs are also to a large extent relative to the type of industrial context that is implied. For example, the case of polypropylene shows that there is no obvious relation between investment costs and capacity per se.

Table 5: The capacity and capital costs of certain polypropylene investments by year of completion

Country	Producer	Completion date	Capacity in 000s of metric tons p.a.	Cost in millions of US dollars
U.S.A.	Avi-Sun	1961	46	20.0
Britain	I.C.I.	1961	11	8.4
Japan	Yawata	1961	10	7.0
Austria	Danubia Petro-chemie A.G.	1962	5	9.6
Netherlands	N.V.Rotterdamse Blyolefinen	1963	10	20.0
Japan	Chisso Petro-chemical	1963	13	21.4
India	West Polymer Wks.	1965	7	31.4

Source: G.C. Hufbauer, Synthetic Materials and the Theory of International Trade, p.151.

A similar example is given by Toxopeus regarding S.B. rubber production[1]:

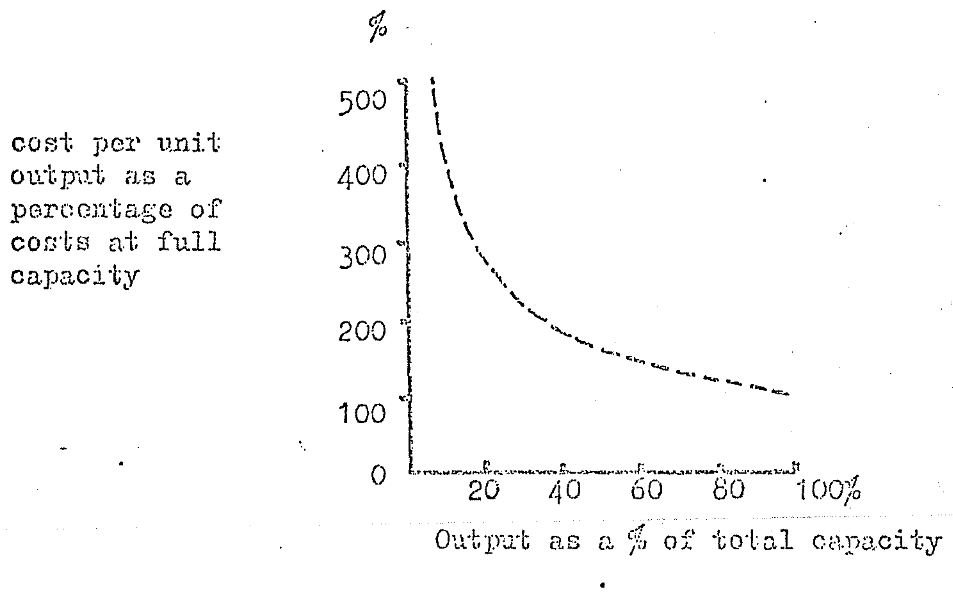
> "The capital outlay can vary between \$20 and \$35 million (i.e. \$400 - \$700 per annual ton) for a 50,000 tons/year unit according to the availability of base materials or whether they have to be manufactured separately. On the other hand, a unit of 20,000 tons/year capacity (i.e. 40 per cent of the capacity) will cost between \$10 and \$20 million (i.e. \$500 and \$1000 per annual ton)".

1) Op.cit., 1961, p.227. 50-100,000 tons per annum is generally considered the minimum economic size for a general purpose synthetic rubber plant. Rubber World, November 1966 and Rubber Journal, September 1968, p.16.

These are very significant differences in the cost of a ton output that could make all the difference in a highly competitive market. In many cases the need to distribute fixed costs of capital equipment over a given output determines the minimum economic scale of production. But not only is the scale of output important in influencing costs[1], the context within which the industry is placed is often equally significant. The latter factor is unfortunately rarely given sufficient stress.

What is more, the cost of running below capacity is also extremely high, as variable costs are relatively low as a percentage of total costs, and has contributed largely to the desire for integrated industrial planning and development[2]. In turn this trend has had a noticeable effect upon the way markets have been structured often to the disadvantage of the natural producer. The importance of running at or near full capacity when fixed costs are so high can be judged from the example of polypropylene given below:

Graph 2: The effects of capacity upon manufacturing costs for polypropylene production for a plant of given capacity



Source: E.S. Wilson, 'The pricing of plastics', British Plastics, August 1963, p.434.

1) Operating costs in the smaller plant can also be proportionately up to 20% higher than in the larger one.
2) This also applies to the economies to be gained in agglomeration, including social infrastructural costs.

Constant costs are such that in the modern synthetic fibre plant the break-even point is at least 70-80% of capacity, and this would appear to be typical for quite a number of petrochemical and synthetics operations. The fact that synthetic rubber production in Argentina and Brazil continues to run at just over half capacity[1] illustrates the significance of these factors which have a considerable limiting influence upon the spread of synthetics industries.

Although for technical reasons costs per unit output may be expected to decline over time in the newer plants[2], the initial capital costs are extremely high. The overall investment required to build a fully integrated complex is liable to reach as high as the ¼ billion US dollar range, involving some of the most capital intensive manufacturing industries. These features, together with the overall tendency for costs to be somewhat higher in developing countries, underlines the political element in the industrial complex approach to regional development.

The net result of these factors has been not only to reinforce the tendency for localisation in the industrialised countries where markets are particularly large, but to limit the number of specialised producers even there. It is significant, for example, that in 1968 only the United States produced all ranges of synthetic rubber, Canada producing all but neoprene, polyisoprene and EPDM. Belgian specialisation in butyl production for the markets of the E.E.C. of which France is the only other butyl producer, is typical of the type of pattern that is emerging and where, on the other hand, all types of synthetic rubbers are nevertheless being made in one or other European country.[3] Market size is therefore critically important.

There are finally three other factors that impose an important, if partly indirect influence upon the relation between location and competitiveness and which warrant at least mention in passing. These are firstly the not unimportant rôle of exports of synthetics from main producer countries, secondly the protective measures taken by governments to support developmental measures, and finally the legal aspects

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1) Ruebensaal, op.cit., p.915.
2) See F.A.O., 'Impact of Synthetics on Jute and Allied Fibres', _Working Paper of the Study Group on Jute, Kenaf and Allied Fibres_, Fourth Session, July 1968, p.17.
3) See C.F. Ruebensaal, 'World Synthetic Rubber: its manufacture and market', _Rubber and Plastics Age_, October 1968, appendix A, p. 914.

of patent licensing which may in some ways influence the spread of technologies and which often include stated export restrictions[1]. The extent to which these various factors together come to bear upon the competitiveness of natural and synthetic products is the next issue, and this will be under discussion in section 3.

2.2. <u>Structural characteristics of synthetic industries</u>

As section 2.1. has implied, extensive forward and backward integration forms one of the main structural characteristics of the synthetics industries, although in practice these vary considerably both among the three main types of synthetics produced and also from firm to firm. The various costs and economies involved have tended to encourage strong vertical integration - forwards to establish markets for main and subsidiary products and backwards to control the cost and reliability of raw material supplies.

This is particularly true, for example, of synthetic rubber production in the United States which is closely integrated with the international oil companies on the one hand and with the main tyre manufacturers on the other. Production is strongly tied to that of the butadiene industry, which provides the main raw material, to the extent that in 1960 46% of the total U.S. butadiene sales represented intra-company transfers while a further 29% was delivered to immediately adjacent but unaffiliated copolymer producers[2]. Though far less significant the same structural characteristics are to be found increasingly in the case of synthetic fibres[3], the main chemical giants producing their own polymers although they are rarely directly involved in the final stage of textile manufacture. The detergents industry would seem to be developing along the same lines, although much less information is available regarding it.

The second structural characteristic, following quite naturally from this and from the structure of production outlined in section 2.1. -, is that it holds a strong inherent tendency towards oligopoly. In 1960 two major tyre producers owned a SBR capacity that exceeded the U.S national natural rubber imports of that year[4]. In Great Britain

1) See F.A.O., op.cit., 1968, pp.12-13.
2) F.A.O., 'Synthetics and Their Effects on Agricultural Trade', <u>Commodity Bulletin Series</u>, No.38, Rome 1964, p.22.
3) See U.N., 'Changes in the Pattern of Production, Consumption and Foreign Trade in Textiles in Western Europe', <u>Economic Bulletin for Europe</u>, Vol. 19, No.1, November 1967, p.69.
4) FAO, op.cit.1964, p.22.

the main SBR plant is owned by a consortsium of tyre manufacturers which also constructed the first polybutadiene factory at Grangemouth on the Firth of Forth. This was also true of the one SBR plant in France while, by way of contrast, Dutch, Italian and West German production is controlled by the major petroleum or chemical concerns. In fact all synthetic rubber plants outside North America and Western Europe are controlled, if not government owned, by international oil or tyre companies, and in 1967-68 approximately one third of world production outside the U.S.A. and communist countries was produced in plants in which Canadian and American rubber and petroleum companies had a financial interest.[1)]

The same picture is found in the man-made fibre industry. In 1964 cellulosic fibre production in the United States was controlled by eight companies and was strongly associated with the giant chemical concerns[2)]. Moreover, fibres are not advertised or marketed as polyamides or polyesters but under legally protected patented trade-marks. I.C.I. 'Terylene' (a polyester) which was a monopoly product in the United Kingdom is typical of the marketing situation, the whole process of production being firmly in the hands of the chemical industry. Though close substitutes have become available the name 'Terylene' is still frequently prefered because it is confused with the type of cloth.

But the most important point for the present discussion is that the increasing scale and vertical integration within the company has meant that the market has also been increasingly structured against the natural producer whose competitive position has consequently been weakened. This means, for example, that in contrast to the captive markets[3)] of synthetic rubber producers, the natural producer who is generally independent of the main tyre companies must now compete on an open market the demand side of which is largely dominated by his competitors. Moreover, if there is a sudden decline in the demand for

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1) Waddams, op.cit., 1968.
2) F.A.O., op.cit., 1964, p.39.
3) When output is consumed in other products manufactured by the same firm or company this is said to be a 'captive market' and the initial production a 'captive operation'. Textile Organon, September 1968, p.155.

rubber it is most likely that, in such a situation, priority will be given to supplies of synthetic rubber. With fibres where vertical integration tends to be less complete this element is also less apparent, synthetic fibres being sold on the open market. However, foreseeable technical advances might well alter this situation very rapidly, the importance of research and developmental activities within the company being in this respect potentially very large.

2.3. Research and developmental activities

The growth of large, integrated and financially powerful complexes has in turn provided excellent opportunities for the concentration of research efforts, the success of which has been adequately reflected in the rapid increase in the size and diversity of output since the second world war. The potential relevance of this for the competitiveness of synthetic products is of course quite tremendous.

The nature of such company backing has meant that the scale of operations and the funds available have both been extensive, for whereas research can be carried out successfully by a small group, commercial development generally implies a substantial and high cost collaborative effort involving not only chemists but engineers, mathematicians, market specialists and probably many other professions as well.[1] The nature of the industry and the costs of research tend in fact to be such that only the large firms can afford to be involved in 'frontier products', and that the newer types of product are likely to be increasingly concentrated in the hands of a few firms and under the kind of patent and restrictive license arrangements that typify the chemical industry. The implications of this, mentioned in section 2.2.2, are therefore likely to become even more pronounced.

Though in practice closely interrelated, the types of activities carried out by such companies can really be broken down into two main parts: the first concerning the type and quality of product and the second production technology. The former, regarding range and quality of product, can again be subdivided into experimental research

1) See H.M. Stanley, 'Research and Development in Petroleum Chemicals', Advancement of Science, December 1968, p.251. It is estimated that expenditure on research and development in the synthetic rubber industry alone amounted to $182 million in 1966. Rubber World, January 1969, p.37.
2) In fact the normal SBR plant usually produces at least 10-20 grades of rubber. Toxopeus, op.cit., 1961, p.227.

on the one hand and, on the other, the market and engineering studies, high power advertising and technical service to customers that characterise the developmental side. This second element is in fact much broader and more relevant than is generally realised. For example, the quality of a synthetic can in many cases only be assessed by its performance in the consumer's processing equipment, in which case an efficient technical service backed by a development division with the ability to make minor changes to meet a customer's specific performance requirements may make all the difference in his choice between natural or synthetic raw materials[1]. This is particularly relevant, therefore, to the present discussion, and it must be stressed that the large companies are well placed to take full advantage of such openings.

In practice research and development in the field of production technologies has proved of almost equal importance, although less obvious and less frequently stressed. At least one commentator has pointed out recently that whereas research activities have for so long tried to develop for example fibres that will compete with the natural product in the existing textile industry, attention is now being turned to new types of technology producing fabrics that are not woven and which can thus by-pass, and be developed entirely outside, the traditional textile industry[2]. The importance such developments might have for the competitiveness of the natural producer can be well imagined. Not all developments on the production side are quite so dramatic, however, and both considerable and important advances have also been made in plant design, lay-out and construction. Process simplification and improved lay-out seem to have been particularly effective in this respect.

The impact of research and developmental activities upon the competition between natural and synthetic products is, therefore, potentially enormous and it is obviously extremely dangerous to try and foresee anything beyond the immediate future, and that only with reservations. The next section, however, will look into the present market structure for these products and, bearing in mind the framework of the present chapter, begin to look rather tentatively ahead.

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1) In fact the normal SBR plant usually produces at least 10-20 grades of rubber. Toxopeus, op.cit., 1961, p.227.

2) See A.B. Thompson, 'A Third Generation of Synthetic Fibre Materials', Advancement of Science, December 1967, pp.150-161 and C.E.H. Baun, 'Horizons for Plastics', Advancement of Science, March 1968, p.292.

3. Market Trends in the Competition between Natural and Synthetic Rubbers

Having discussed the general structure and world distribution of the synthetic industry, more specific attention will now be paid to patterns and trends in the competition between the natural and synthetic rubbers as a case in point.

3.1. Patterns of Production

Two questions are particularly important for the present discussion concerning the production of rubbers. These are trends (i) in the size and location of output and (ii) in their breakdown by type. Regarding the size of output, the most important feature has undoubtedly been the considerable increase in the production of all rubbers since the end of the second world war. This growth has also been characterised by the rapid development of new technologies and by their spread to an increasing number of producer nations. This has been equally true for both natural and synthetic rubbers. The most conspicuous feature regarding the type of product has, in turn, been the rapid growth in the output of synthetic rubbers and the increasing proportion of total rubber production that they have comprised. These trends, however, require elaboration.

In the period from 1960 to 1968 the total output of rubbers from non-communist countries rose by 68% to an estimated 6,653,000 metric tons. This overall trend contained within it an increase in synthetic rubber production of 110% compared to a 31% increase in that of natural rubbers over the same period, and an increase in its relative share of total rubber production of ten percentage points to comprise 59% in 1968.[1] This pattern of growth was, however, quite widespread, 1968 production estimates for synthetic rubber exceeding those for the previous year for every producer nation.[2]

The pattern of production still showed predominant concentration in the United States. Although the spread to, and later development of the synthetic rubber industry in Western Europe, Japan, and more recently further afield, has meant that the relative share of

1) IRSG, Statistical Bulletin, Vol. 23, June 1969, Tables 21 and 56.
2) Ruebensaal, op.cit., 1968, p. 915.

the United States in the total production of the non-communist countries has fallen noticeably from 85% in 1959 to 54% in 1968, its estimated 1968 output of 2,165,000 metric tons was still five and a half times that of Japan which at 381,000 tons was the second largest producer.[1] Nevertheless, the gradual diffusion of various production technologies should not be overlooked. They may yet prove very significant in the longer term for the competition between natural and synthetic rubber, even though as much as 94% of the output of non-communist countries is at the moment concentrated in North America, Western Europe and Japan.

Natural rubber production in fact shows similar patterns, 92% of the output in 1968 coming from S.E. Asia, and 42% from Malaysia,[2] while the development and spread of specialised natural rubbers also warrant close attention for the future. This will be discussed in more detail later.

A general idea of the distribution of this production by country can be gained from the following estimates:

Table 6: The production of synthetic rubbers in non-communist countries in 1968, by country (thousands of metric tons)

Country	Output	As a percentage of the total
U.S.A.	2165	54.4
Japan	381	9.6
Great Britain	237	6.0
W. Germany	237	6.0
France	223	5.6
Canada	197	4.9
Netherlands	163	4.1
Italy	125	3.1
Brazil	59	1.5
Mexico	35	0.9
Australia	30	0.8
Argentina	27	0.7
Spain	26	0.7
South Africa	25	0.6
Belgium	25	0.6
India	25	0.6
Total	3980	100.0

Source: I.R.S.G., Statistical Bulletin, op.cit., June 1969 and the U.N. Monthly Bulletin of Statistics, June 1969.

1) I.R.S.G., Rubber Statistical Bulletin, op.cit., June 1969.
2) Ibid., 1969.

Table 7: Natural rubber production by country for 1968
(thousands of metric tons)

Country	Output	As a percentage of the total
Malaysia	1110	42.3
Indonesia	752	28.6
Thailand	258	9.8
Ceylon	149	5.7
India	69	2.6
Liberia	59	2.2
Nigeria	56	2.1
Cambodia	53	2.0
Viet-Nam	29	1.1
Brazil	22	0.8
Others	70	2.7
Total	2627	99.9

Source: U.N. Monthly Bulletin of Statistics, op.cit., June 1969 and I.R.S.G., Statistical Bulletin, op.cit., June 1969.

Although far less information is available concerning production in communist countries, the general pattern of their synthetic rubber production appears to resemble that outlined above. As an indication of the general size of output, their production in 1964 has been estimated at slightly under 950,000 metric tons.[1] However, it would seem equally significant that the greater part of this was produced in the U.S.S.R. and that there is evidence since then of increasing production in East European countries, and of a more recent spread of production to Bulgaria, Rumania and Mainland China. Moreover, if the overall production trend in synthetic rubbers, synthetic fibres and plastics is accepted as a general indicator of the health of the rubber industry, it can be seen that growth rates are also of the same order, Soviet production registering an average increase of 19% p.a. during the period 1959-65.[2]

1) UNCTAD, 'The International Organisation of Commodity Trade: a case study of natural rubber', Geneva 1966, p.18.
2) R.W. Davies and R. Amann, 'Science Policy in the USSR', Scientific American, June 1969, p.24.

These production figures, however, need now to be broken down into the output of specific rubbers, as the differences between the various types have a considerable effect upon their competitiveness. For neither natural nor synthetic rubbers, unfortunately, is complete data at hand regarding the actual output by type. However, a rough indication of this pattern regarding synthetic rubbers can be gained from table 8. It is clear that the bulk of the capacity still represents S.B.R. production which is to be found in almost all producer nations; stereo capacity is less sizeable and less dispersed, and specialised rubbers are less so again.

Although production initially concentrated upon S.B.R. it has gradually become more diversified. One result of this has been that the relative share of S.B.R. in total rubber capacity has fallen, and it seems likely that it will continue to do so. The rate of change is illustrated in the fact that this share is predicted to decline from 66% to 60% during the period 1968-71. This is a trend that can also be traced in production figures. In the United States, for example, the share of S.B.R. in total synthetic rubber output is tending to fall as follows[1]:

1967 - 68.1%
1968 - 67.6%
1969 - 65.1% (estimate)

This is primarily due to the increasing importance of polyisoprenes and polybutadienes which at the moment offer the major threat to natural rubber. Their relative share in U.S. output rose during the same period from 15% to 20% and they are expected to comprise just over 400,000 metric tons this year, while their share of world production capacity is estimated to be 21% by 1971. It is also significant that stereos represent a high proportion of the capacity of countries that have begun to produce synthetic rubbers in more recent years, thus reflecting the major advantage of the late starter.

However, this switch in emphasis towards new stereo rubbers should not be allowed to overshadow the fact that significant increases are likely to occur both in the production capacity and output of all types of synthetic rubbers. Changes are therefore in this

1) Rubber World, op.cit., January 1969, p.37.

respect essentially relative. The United States again provides a useful example. Its percentage increase in output by type over the period 1967-9 is estimated as follows[1]:

S.B.R.	18.0%
Stereos	59.4%
Butyl	12.4%
Neoprene and nitrile	17.3%

1) Rubber World, op.cit., 1969, p.37.

Table 8: Reported World Synthetic Rubber capacity by type and country (existing: 1968 and intended: 1971)

(in thousands of metric tons)

Country	S.B.R.		P.B.		P.I.		E.P.D.M.		Butyl		Neoprene		Nitrile		Total all types	
	1968	1971	1968	1971	1968	1971	1968	1971	1968	1971	1968	1971	1968	1971	1968	1971
United States	1682	1694	316	316	113	164	93	111	181	181	154	210	117	117	2656	2793
Canada	142	142	20	20	-	-	x	-	36	36	-	-	30	30	228	228
West Germany	186	186	56	56	-	-	x	33	-	-	36	51	15	20	293	346
United Kingdom	166	248	51	51	-	-	-	-	24	36	30	30	18	26	289	391
Italy	128	128	20	36	-	20	5	10	-	-	-	-	11	11	164	205
France	145	194	74	79	-	59	-	10	30	30	20	20	14	21	283	413
Netherlands 1)	89	101	-	-	46	66	12	12	-	-	-	-	3	7	150	186
Japan	326	427	66	137	-	30	-	36	-	30	38	54	16	17	446	726
Australia	41	41	20	25	-	-	-	-	-	-	-	-	-	-	61	66
Brazil	77	87	28	28	-	-	-	-	-	-	-	-	-	-	105	115
India	30	51	-	-	-	-	-	-	-	-	-	-	-	-	30	51
Belgium	-	46	10	10	-	-	-	-	27	27	-	-	-	-	37	83
South Africa	38	38	-	-	-	-	-	-	-	-	-	-	2	2	40	40
Argentina	41	49	-	10	-	-	-	-	-	-	-	-	-	-	41	59
Mexico	59 xx	59 xx	10 xx	10 xx	10	10	-	-	-	-	-	-	-	-	79	79
Spain	37	37	4	4	-	-	-	-	-	-	-	-	-	-	41	41
Algeria	-	(25)	-	(25)	-	-	-	-	-	-	-	-	-	-	-	(50)
Venezuela	-	-	-	30	-	-	-	-	-	-	-	-	-	-	-	30
Total capacity in non-communist world	3187	3523	675	812	169	349	110	212	298	340	278	365	226	251	4943	5852
Communist Bloc	713	1924	76	279	76	162	x	(?)	25	51	56	81	27	53	983	1650
GRAND TOTAL	3900	4547	751	1091	245	511	110	212	323	391	334	446	253	304	5926	7502

x pilot plant facilities exist.

xx capacity interchangeable. ( ) capacity reported as "planned" but not included in totals.

Source: Ruebensaal, op.cit., p.914.

1) The 1968 capacity of the Netherlands is underestimated and does not correspond with the output data in Table 6.

There is also a distinction to be made regarding the production of general and technically specified natural rubbers. The latter have been developed within the last decade, showing remarkable increases in output and becoming increasingly widespread.[1] The growth rate of Malaysian output would seem fairly indicative in this respect:

Table 9: Malaysian output of specialised natural rubbers, 1963-8 (in metric tons)

Year	Type				Total
	Nat.com.	Dynat.	Kualakep.	Heveacrumb	
1963	-	132	-	-	132
1964	91	1,138	-	-	1,229
1965	508	4,864	-	363	5,735
1966	990	9,910	914	6,067	17,881
1967+	1,016	11,680	2,291	18,280	33,267
1968+	1,524	13,200	3,657	93,460	111,841

+ estimated

Source: Rubber World, April 1968, p.68.

Their development is now sufficiently advanced for them to have found general acceptance, and by 1968 their production had begun to spread from Malaysia to the majority of natural rubber producing nations in both Asia and Africa. The estimated output of these new process rubbers by country shown in table 10 gives a very rough indication of their spread.

1) These rubbers will be discussed in more detail below.

Table 10: Estimated near future production of new process natural rubbers by country (in metric tons)

Country	Production
Malaysia	250,000
Indonesia	(No figure available but believed to be quite high)
Singapore	15,250
Ivory Coast	7,100
Liberia	4,100
Cambodia	3,100
Nigeria	2,000
Cameroons	1,800
Viet-Nam	500

Sources: Rubber World, April 1968, p.68 and December 1968, p.86.

For the competition between natural and synthetic rubbers the increasing production of these types is particularly significant. The reasons for this, however, are concerned more with consumption than with production.

3.2 Patterns of Consumption

The most significant trend in this respect has been the considerable increase in the consumption of all rubbers since the second world war. Their per capita usage in the industrialised countries has also increased slowly but regularly to reach an estimated all time high in 1968 in all these countries[1], when world rubber consumption reached 6,787,000 metric tons[2].

There was still a general shortage of rubbers in 1968 despite the threatened overproduction of synthetic rubbers[3]. In fact although their relative share in total rubber usage made notable increases,

1) Ruebensaal, op.cit., p.913.
2) I.R.S.G. Rubber Statistical Bulletin, op.cit., June 1969
3) This was expected due to the structure of the synthetic rubber industry as outlined in section 2. See D.A. Littler, 'Synthetic rubber - its future', Rubber Journal, September 1968, p.16 f.

output was still well below capacity. However, the rate of growth of this demand has been sufficient to stimulate the promotion of further research and development in the synthetic rubber industry. Their consumption increased in fact by an average 14.5% p.a. during the period 1960-68. On the other hand, for all years during the same period sales of natural rubber outstripped production, the difference being met by stockpile releases. The consumption of natural rubber increased by an average 4.4% p.a., to reach 2,834,000 metric tons in 1968[1]. In this case competition seems to have been the main stimulant to research and development.

However, these trends were internally very diversified, particularly with regard to end-use and to the spatial patterns of consumption. Two classes of end-use are generally distinguished: (i) tyre and tyre products and (ii) a non-tyre sector. The demand in both cases tends to be highly indicative of the level and type of industrial development in the countries concerned.[2] The tyre sector is quantitatively the most important of the two, particularly in North America, although the precise proportions involved vary considerably from country to country . its average growth rate has been slightly over 5% p.a.[3] The volume of rubber consumed in this sector has been the subject of really considerable fluctuations, the automobile industry having on the whole been very responsive to the general state of the economy. Between 1954 and 1964, for example, fluctuations in the consumption of this sector in the United States accounted for as much as 325,000 metric tons[4]. In this situation of course the structure of the market as outlined in section 2 becomes particularly relevant.

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1) I.R.S.G. Rubber Statistical Bulletin, op.cit., 1969.
2) A regression analysis was carried out regarding the relation between industrial structure and the consumption of rubbers of 13 countries. The relationship assumed was log Y = log a + b log x where Y is the consumption of rubber in pounds per capita, and x the consumption of energy in kilograms of coal equivalent per capita which was considered the best available indicator of the level of industrial development. Both were for 1966. The result of the analysis was found to be $\log Y = \bar{1}.52 + 0.72 \log x$ where $r_{\log x \log y} = 0.95$. However, study of individual cases suggests that a better fit could be obtained if more attention was given to the type of industrial structure involved.
3) A study was also made of the relationship between the output of the tyre sector and the consumption of all rubbers for the period 1953-68. A correlation coefficient of $r_{\log x \log y} = 0.99$ was found to apply to this relationship. This indicates that the rubber consumption is extremely sensitive to the fortunes and development of the tyre industry.
4) F.A.O., op.cit., 1964, p.16.

The relative importance of synthetic and natural rubbers in the tyre sector in any one country seems to be largely a question of three factors: (i) the availability of rubbers in the required types and amounts, (ii) their related price and quality and (iii) the ratio of passenger cars to commercial vehicles. Because of variations in these factors and in the very nature of their demand the spatial patterns of consumption are quite differentiated. Moreover, the development and spread of new technologies also means that this pattern is by no means set. Thus although the main competitor on the synthetics side has been S.B.R., the share of stereos is perhaps, as already suggested, more important for the future. The use of cis-polybutadiene in heavy duty tyres, for example, is generally considered to be the major threat to natural rubber in what has hitherto been the one important bulk outlet to remain unchallenged by synthetics. However, it is also interesting to note that so far stereos seem in fact to be displacing S.B.R. rather more than natural rubbers.

A considerable variety of uses is included in the non-tyre sector, the most important being footwear, foam rubber products, belting and electrical wire and cables[1]. It is also characterised, perhaps more importantly, by two additional features, firstly by the fact that synthetic rubber is a particularly suitable raw material for the majority of these products and secondly in that they also imply a rather different market structure to that typical of the tyre sector. Except in the case of end-uses for which specific qualities are necessary, general S.B.R. is also the most important synthetic rubber involved. As a whole the rate of consumption has kept abreast of that in the tyre sector although again both this growth rate and the relative importance of natural and synthetic rubbers has varied considerably from country to country. Again this appears to have been largely a matter of availability and the type of industrial structure. It would seem necessary, therefore, to look rather more closely at the spatial patterns of consumption that are developing even though the information is not at hand to make a detailed breakdown.

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1) See ibid., p.18.

World rubber consumption is still in fact also very concentrated although in recent years this has been much more pronounced in the case of synthetic than of natural rubber. The United States, for example, accounted for almost 40% of all rubber consumption in 1968, 52% of all synthetic and 18% of all natural rubber consumed[1)], followed by the USSR and Japan. Consumption is associated with the highly industrialised economy. However, as might be expected from this, the concentration is also weakening in that the demand for rubbers is increasing much more rapidly outside North America[2)]. The corresponding figures for 1960, for example, reveal that the United States then commanded as much as 89% of all synthetic and 23% of all natural rubber consumed[3)]. Moreover, this also means that changes can be expected in the pattern of market structures. Not all countries will have as important a tyre industry as that in North America and Europe nor probably will they be dominated by the type of restricted rubber markets outlined in section 2, at least not in the early stages of their development. The tyre sector as it develops is also likely to be geared first to commercial vehicles rather than passenger cars thus tending to favour natural rubber.

The consistent increase in per capita consumption of rubbers in other areas and an estimated breakdown of consumption by country are given in the following tables:

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1) Rubber World, op.cit., January 1969, p.37.
2) A study was also made of the relationship between G.D.P. per capita and the consumption of rubber for 13 nations. An elasticity of demand for rubber of 1.05 was obtained which can be considered fairly significant for the future. The correlation coefficient was found to be $r_{\log x \log y} = 0.97$. Other studies suggest that among developing countries alone the elasticity may well be considerably higher.
3) F.A.O., op.cit., 1964, p.16.

Table 11: The per capita consumption of rubber in selected countries, 1961-68

Nation	Total Rubbers										Synthetic Rubbers									
	1961		1963		1965		1967		Est. 1968		1961		1963		1965		1967		Est. 1968	
	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2	1	2
USA	18.7	100	21.0	112	23.7	127	23.8	127	27.0	144	13.5	100	15.5	115	17.7	131	18.3	136	20.8	154
Canada	11.4	100	14.2	125	15.9	140	16.9	148	17.8	156	7.6	100	9.9	130	11.0	145	11.9	157	12.6	166
Australia	11.4	100	14.0	123	14.5	127	14.3	125	14.9	131	5.1	100	6.6	129	7.3	143	7.4	145	7.8	153
U.K.	12.3	100	12.9	105	14.9	121	15.0	122	16.3	133	5.2	100	5.8	112	7.4	142	7.9	152	8.7	167
France	10.8	100	11.8	109	12.1	112	13.4	124	14.4	124	4.7	100	5.8	123	6.6	140	7.8	166	8.7	185
W. Germany	10.2	100	11.4	112	14.2	139	12.9	127	14.8	145	4.8	100	5.8	121	8.1	169	7.6	158	8.8	183
Italy	4.9	100	7.8	159	8.5	173	10.7	218	11.2	229	2.0	100	4.0	200	4.8	240	6.5	325	7.0	350
Japan	6.1	100	5.4	121	8.5	139	11.4	187	12.7	208	2.0	100	2.9	145	4.0	200	6.0	300	7.0	350
Netherlands	6.5	100	6.5	100	7.4	114	7.6	117	8.3	128	2.4	100	2.8	117	3.7	154	4.2	175	4.7	196
U.S.S.R.	Estimated at 7.0 ± 0.5										Estimated at 4.5 ± 0.5									
Brazil	1.9	100	2.0	105	1.7	89	2.3	121	2.5	132	0.66	100	0.97	145	1.0	190	1.5	227	1.7	258
India	0.31	100	0.35	113	0.40	129	0.42	136	0.44	142	0.05	100	0.06	120	0.09	180	0.11	220	0.11	220
Argentina	5.2	100	3.6	69	6.1	117	4.8	92	5.0	96	1.9	100	1.6	84	3.0	158	2.6	137	0.28	147

Key: 1. Lbs per capita

2. Index of (1), 1961 = 100

Source: C.F. Ruebensaal, Plastics and Rubber, op.cit., 1968, p.913.

Table 12
Estimated rubber consumption by country in 1968
(thousands of metric tons)

Country	Natural	Synthetic	Total Rubbers
U.S.A.	591	1925	2516
Canada	45	106	151
Great Britain	194	229	423
West Germany	170	206	376
France	133	195	328
Italy	100	160	260
Other W.European	180	126	306
Japan	255	348	603
Australia	38	45	83
Communist bloc	704	76	780
India	84	31	115
Brazil	38	57	95
Indonesia	24	-	24
Malaysia	19	-	20
Others	259	448	707
T o t a l	2834	3953	6787

Source: I.R.S.G. Statistics Bulletin, op. cit., June 1969, and information published in editions of Rubber World cited in the text.

An overall impression of their relative importance in the tyre and non-tyre sectors is given in the following tables:

Table 13
The relative importance of the tyre and non-tyre sectors in selected countries for 1960 and 1968.

Country	Percentage of total consumption accounted for by the tyre industry 1960	1968
United States	64	65
Canada	69	74
Great Britain	53	70
France	57	60
Italy	53	51
Japan	43	50

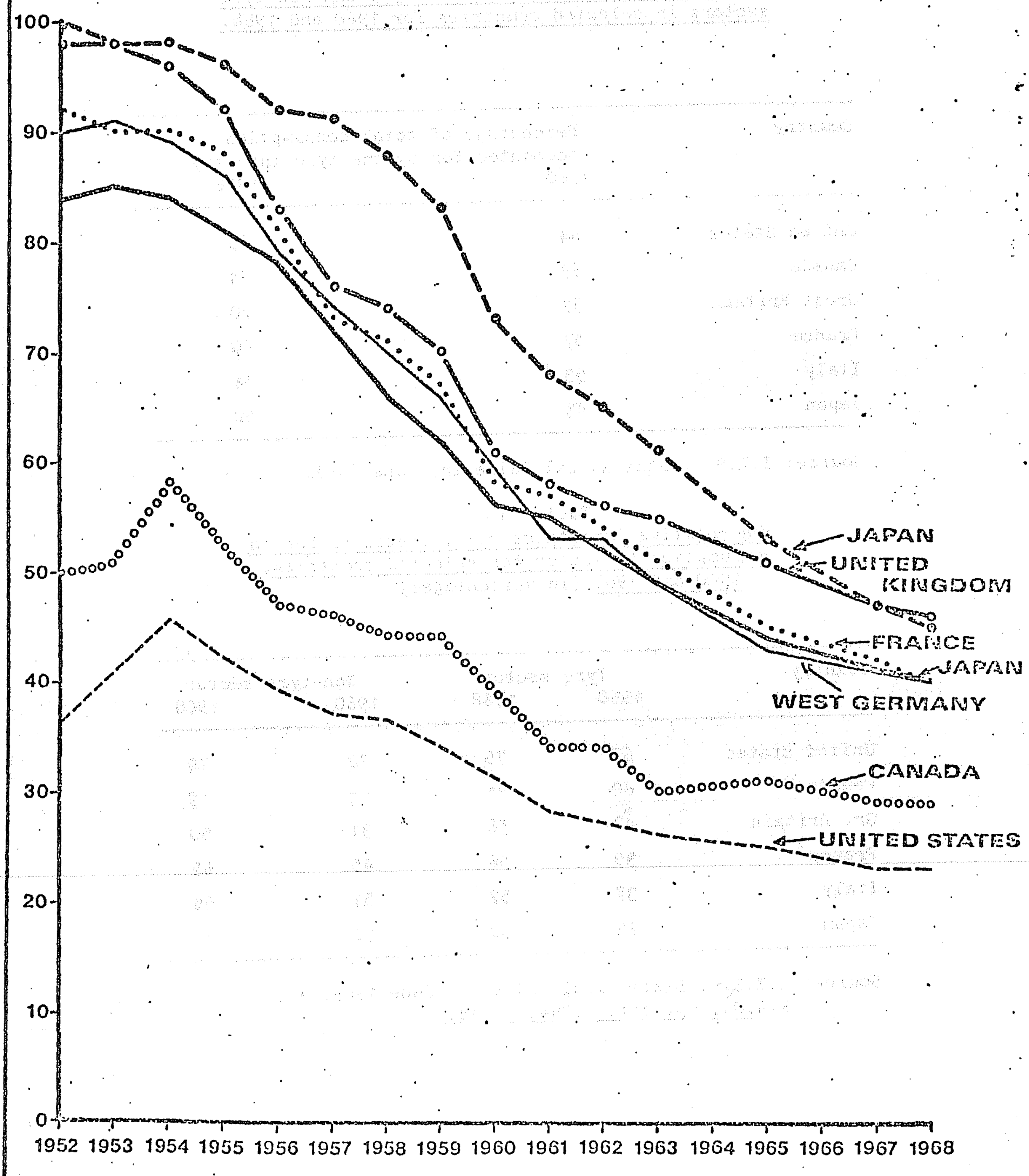
Source: I.R.S.G. Statistical Bulletin, June 1969.

Table 14
The relative importance of synthetic rubber in consumption by sector for selected countries, 1960 and 1968 (in percentages)

Country	Tyre sector 1960	Tyre sector 1968	Non-tyre sector 1960	Non-tyre sector 1968
United States	67	75	72	79
Canada	60	71	64	68
Gr. Britain	47	58	31	50
France	39	56	45	65
Italy	37	57	51	66
Japan	22	58	30	57

Source: I.R.S.G. Statistical Bulletin, June 1969, and F.A.O., op. cit., 1964, p. 18.

Graph 3. PERCENTAGE OF TOTAL CONSUMPTION TAKEN UP BY NATURAL RUBBER 1952-1968. (By weight)



Sources: F.A.O. op.cit. 1964 p.16; RUEBENSAAL op.cit. 1968 p. 913

These also imply the relation between rubber consumption and the level of industrialisation. This is partly reflected in comparison with G.D.P. figures, but more precisely with the type of industrial structure concerned. The United States, for example, with a long established automobile industry and a G.D.P. per capita in excess of $ 3000 also consumes 27 pounds of rubber per capita per annum, whereas India with a weak industrial structure and G.D.P. of around $ 80 per capita consumes less than half a pound per head. Moreover, where there has been an acceleration or decline in industrial growth this has also tended to be reflected in the growth rate, if not always in the actual amount of rubber consumed. In other words it seems likely that as countries become increasingly industrialised their demand for rubbers will also increase and that the pattern of consumption will become more dispersed.

The question as to what extent this pattern of demand is being and is likely to be met by natural and synthetic rubbers is for the present discussion quite basic. As far as the industrialised countries are concerned the increasing relative importance of synthetic rubber and the gradual spread of their production is also shown in graph 3. The evidence seems to suggest that their consumption of natural rubber will continue to rise in the near future, although in a few cases it may level off or even decline.[1] The increasing availability of technically specified types may also mean changes in the proportions imported from individual producer countries. The increase of Malaysian rubber from 25-35% of total U.S. rubber imports in 1967 was largely, for example, the result of such trends.[2] However, the increasing output of these rubbers also means that they are becoming more vulnerable to particular competitive pressure, and that they are unlikely to make major inroads into markets already held by synthetic rubbers.

However, whether or not a deliberate policy, there has been a tendency for natural producers to shift away from markets in which competition from synthetics is particularly strong. A case in point is that of Ceylon shown in table 15:

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1) Notably the United States. See Rubber Statistical Bulletin, op. cit., June 1969, table 6, p. 9.
2) See <u>Rubber World</u>, June 1968, p. 75.

Table 15
Shifts in the destination of Ceylonese rubber exports 1949-68
(in percentage and excluding latex)

Destination	1949	1968
U.S.A.	44.3	7.1
Great Britain	18.5	2.7
West Germany	9.0	6.1
Mainland China	1.5	55.6
Eastern Europe*	-	13.3
Others	16.7	15.2
Total	100	100

*also including the USSR, Bulgaria, Rumania and Yugoslavia.
Sources: E. Goonewardene, "Natural rubber in bilateral agreement II", in the RRIC Bulletin, op. cit., 1967, p. 94 and I.R.S.G. Statistical Bulletin, June 1969.

Malaysia and Singapore have also in recent years been making particular efforts to promote closer trade ties with the communist bloc and to win the markets developing from their general industrial expansion.[1) In general these tend to be medium term 5-10 years agreements and the amounts involved can be quite substantial. The importance of these markets in the communist countries can be shown from the fact that in 1968 imports of Malaysian rubber to the USSR amounted to 242,800 metric tons and those to Mainland China 130,900 tons.[2) Though relatively little was under such agreements there seems a lot to be gained in this direction. Between January and July 1968, for example, 37% of Malaysian and Singapore exports went to the communist bloc.[3)

The important point, however, is that the stakes are high, and where specific quantities of goods are negotiated, definite contracts signed and the responsibility for their execution formally organised these agreements may prove to be of considerable importance.[4)

1) Rubber World, November 1968, p. 104.
2) I.R.S.G. Statistical Bulletin, July 1969.
3) Rubber World, op. cit., November 1968, p. 104.
4) See A.S. Navaratnarajah, "Natural rubber in bilateral agreements - I," in the RRIC Bulletin, op. cit., p. 91-2.

The third part of this pattern of course refers to the developing countries. Here the future demand promises to be considerable. However, two factors tend to complicate interpretation of the emerging patterns. Firstly is the fact that synthetic rubber capacity promises to spread to at least ten developing countries in all continents by 1971[1]. Moreover, where production is already underway synthetic rubber generally represents a high percentage of total rubber consumption[2]. The proportion of stereo capacity in new plants also promises to be significant, there being a strong incentive to construct interchangeable capacities for the usual small one plant industry of these countries[3]. Secondly is the fact that where these countries still lack the ability to supply their needs from their own production the major producers are only too keen to develop new export openings. As table 16 shows, such exports are by no means insignificant. Nevertheless, the demand from the less industrialised countries is expanding rapidly, natural rubbers commanding a considerable share[4].

However, the consumption of synthetic rubber is also likely to be quite important even in these areas and where political factors and particular development efforts do not intervene, the most critical feature is also likely to be cost.

Table 16: Estimated exports of synthetic rubber from non-communist countries in 1968 (thousands of metric tons)

United States	305
Netherlands	132
Canada	129
France	102
W. Germany	71
Japan	71
Great Britain	61
Italy	51
Belgium	25
Brazil	2
Argentina	2
Total	951

Source: Ruebensaal, op.cit., 1968, pp.916 and 917.

1) These include Mexico, Brazil, Argentina, Venezuela, Spain, Algeria, India, Egypt, Iran, Israel and Turkey.
2) The 1968 figures for Brazil and Argentina respectively were 65% and 56%.
3) See Ruebensaal, op.cit., 1968, p.918.
4) See graph 6 in section 3.3 below.

3.3 Cost and price factors

Patterns of production and consumption are therefore such that cost and price factors are assuming a growing importance. Under the increasing pressure, particularly of stereos, natural rubber is proving less and less able to maintain its old price premium over synthetic rubbers, even for specific end-uses.

The general features of this are indicated on graph 4. Trends in the price of S.B.R. and natural rubber reveal firstly a definite price convergence during the 1960's, with S.B.R. gaining the upper hand in recent years.[1] The considerable fluctuations in the demand for rubbers has tended to have a major rôle in determining price partly because the supply of natural rubber is so inelastic and partly because of the structure of the synthetics industry. It has followed from this that, as shown on graph 3, natural rubber has borne the brunt of this variation, particularly in good years when production has been very high. Illustrations of this are not difficult to find. For example, natural rubber exports from Malaysia and Singapore reached a record 1.3 million metric tons in 1967, while demand and prices tumbled to 54.1 Malay cents per lb., compared to the highest price of 169.5 ¢ per lb. in 1951 during the Korean War.[2] However, increasing synthetic production and the use of government stockpiles have succeeded in preventing the most dramatic fluctuations that characterised natural rubber prices in the past, and talks are now underway between Indonesia and Malaysia regarding the development of a joint marketing system for natural rubber that is also hoping to include both Singapore and Thailand.[3]

The relation between price and competitiveness is perhaps the most interesting, however. According to FAO sources it is generally thought that natural rubber can compete at average prices as low as 18 US cents f.o.b. Singapore and that this is well within the reach of efficient producers, even if less efficient ones might be priced out of the market.[4]

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1) SBR and RSS No. 1 are deliberately taken as examples. It must be stressed that price comparisons can only be really meaningful when discussing (1) a specific end-use, (2) a specific country or market area and (3) the grades of natural rubber and types of synthetic rubber concerned.
2) See Rubber World, op.cit., April 1968, p. 68, and Ruebensaal, op.cit., 1968, p. 913.
3) See Rubber World, February 1969, p. 89.
4) FAO, op.cit., 1967. The cost price of natural rubber in Malaysia at this time was around US$ 15 cents, though this has since fallen. Report of the Bank of Indonesia 1960-65, Djakarta 1966, p. 154.

This price is significant partly in that it would seem to be approaching the minimum price at which stereo producers can confidently compete at the present moment.[1] Moreover, according to the Rubber Research Institute a decline in costs of over 7 cents per lb. can be expected from new stands producing up to 2000 lbs. per acre p.a., and this will certainly influence competitiveness.[2] U.N. statistics maintain that a decline of one US cent per lb. in the price of natural rubber is associated with an increase in its consumption of roughly 14,200 metric tons due directly to substitution.[3] Gains could be substantial and if these relations do in fact hold then the future for natural rubber may be brighter than is sometimes supposed. However, cost and price trends provide no reliable answers concerning future competitiveness. It has to be recognised that the market is often structured in such a way that, as one commentator has put it, the protagonists of natural rubber may still be deluding themselves if they take this as meaning that "merely by achieving lower costs of production they cannot only survive as a vigorous industry, but also win back business from synthetic rubber putting synthetic rubber firms out of business in the process."[4] The situation is not that simple. Nor does it seem any sounder to view the new stereos "not so much as a threat to natural rubber but as an insurance against rising natural rubber prices and natural rubber shortages,"[5] because potential technical developments could rapidly change this situation and must therefore be seen as a dynamic rather than static element.

The analysis is further complicated by at least three other factors: firstly in that competition differs according to the patterns of demand and availability which vary from country to country; secondly in that

1) M.F.R. Potter, "The rubber trade -- a consumer's view," in A Review of the Prospects of Natural, Synthetic and Reclaimed Rubber, Special paper presented at the 17th meeting of the I.R.S.G., Tokyo, May 1964.
2) Yields in excess of 3000 lbs/acre/year have in fact been attained on experimental farms after a few years of tapping. See Rubber World, op. cit., January 1969, p. 68. It has been suggested in fact that research has concentrated too much upon producing more latex per acre at the expense of finding more uses for rubber and which might in the long run prove equally as important. Rubber World, December 1968, p. 86.
3) Rubber World, op.cit., January 1969, p. 68.
4) Potter, op.cit., 1964, p. 36.
5) UNCTAD, op.cit., p. 26.

quoted prices take inadequate account of discount prices and intra-company transfers which can be quite significant[1] and, thirdly because total cost to the intermediate consumer (which will of course also include points one and two) is really the issue upon which competitiveness hinges. The first two factors have been discussed in the previous sections, only the latter factor will be outlined.

Falling under this heading are questions such as:

i. the quality, state and uniformity of the rubber on arrival;

ii. its practical suitability for certain processes or certain processing equipment; or

iii. its end-use properties.

The significance of such matters can be shown from the fact that[2]:

> "In comparable manufacturing purposes, natural rubber requires more processing steps, more factory area and more inventory stations all of which are additive to the cost of the material and affect the economics of its use."

A similar example lies in the fact that it takes 6-7 hours to unload a conventional railroad car of natural rubber while the same weight of synthetic rubber can be handled in 45 minutes.[3] The importance of these problems is well indicated by the attention that has been focussed on them in recent years by both synthetic and natural rubber producers. Significant advances have been made in at least four aspects:

(i) in specified quality controls;

(ii) in improved methods of shipment;

(iii) in the design of a bale size and packaging that is most convenient for the consumer; and

(iv) in attempts to minimise the number of necessary steps, such as cleaning and cutting, that are necessary before manufacture.

Synthetic rubbers have been fastest in taking advantage of these developments, their price, quality and presentation together enabling them to displace low-grade natural rubbers and to maximise their competitiveness with the high-grade product.

It is also their various steps in this direction that characterise the technically specified natural rubbers,[4] although they still lag behind in a fifth aspect:

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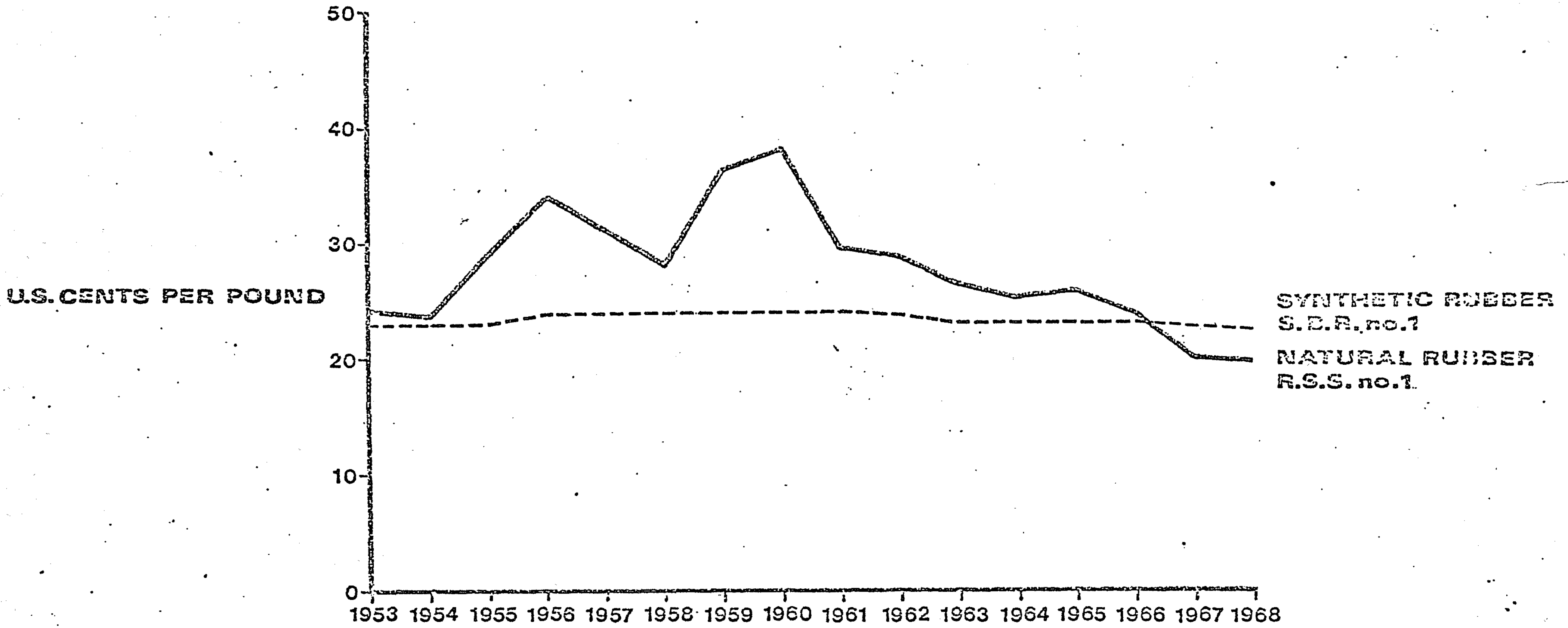
1) Synthetic rubber prices are generally quoted c.i.f. whereas the natural rubber is f.o.b.

2) N.P. Bekema, "Consumer appraisal of natural rubber," in Journal of the Rubber Research Institute of Malaysia, vol. 21, 1968, and reprinted in Rubber Journal, November 1968, p. 27.

3) Ibid., p. 25.

4) See C.W.Thompson, "The progress of Dynat rubber," Rubber Journal, November 1968. The key specification is really dirt content, the 3 technical grades of SMR (Standard Malaysian Rubber) 5, SMR 20 and SMR 50, for example, referring to dirt content limits of 0.05, 0.20 and 0.50% respectively. The product is guaranteed and sold to the consumer polythene wrapped.

Graph 4. AVERAGE RUBBER PRICES 1953 - 1968.
(S.B.R. No.1 and R.S.S. No.1 grades at New York)



Sources: F.A.O. Production Yearbook 1960 and U.N. Monthly Bulletin of Statistics, February 1969.

(v) increased technical contact with the consumer.

It is the need to be comparable to synthetic rubbers in these ways to maintain competitiveness that makes the switch to their production so vital for the natural producer. Their rate of adoption and development in producer countries is also, therefore, a main factor influencing the impact of the competition between natural and synthetic rubbers upon individual countries. This, however, will be discussed more fully in section 4.

Finally, government policies also effect prices to a quite significant extent. These, however, will be discussed separately.

3.4 Government measures

Government measures impinge directly upon the competitiveness of rubbers in at least three ways:

1. through stockpile and marketing policies;
2. through development policies; and
3. through efforts to promote research and development.

The first category of measures has really developed from a concern with fluctuations in the price and availability of natural rubbers and has quite a revealing history.[1] No method has so far been found, however, to promise a long term solution. Moreover, the situation is now rather different than in the past in that policies regarding the production of synthetic rubbers must now also play a meaningful role.

Until 1959 a system of stockpiling was employed by the United States, taking in or releasing rubber according to the market situation. This system was initially structured to meet conditions in the post-war years when supplies were low and synthetic rubber production in its infancy, and it was ended in 1959 when U.S. stocks amounted to 1.2 million tons. The effect of their continually changing disposal policy that has followed since then, and which has varied from an annual release of 40-170,000 tons according to market conditions and the representations of producer countries[2], has been to depress natural rubber prices. This has of course caused a certain amount of concern to the natural producer who sees the danger of his profit-margin dwindling.

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1) See for example P.P. Courtenay, Plantation Agriculture, London 1965. An extensive discussion of possible approaches is to be found in UNCTAD op. cit., 1966.

2) See D. Soysa, "US rubber disposal programme and its effects upon natural rubber prices," in the RRIC Bulletin, op. cit., pp. 81-2.

In its place two other forms appear to be developing. The first is the bilateral trade agreement, and in this respect it is the pattern of agreements that is significant. They appear to be becoming particularly directed to newer markets, and especially to the communist bloc and, such as the suggested benefits of a mutual agreement between India and Malaysia,[1] to other developing countries. These have been discussed above. The second form concerns the establishment of a common natural rubber market to handle all trade and to fix a common price. In early 1969 a meeting of Malaysian and Indonesian officials took place to discuss the possibility of such a joint marketing system. A Joint Commission on Trade and Economic Relations was set up, but as yet nothing more has been announced.[2] However, this holds interesting possibilities following the formation in 1967 of an Association of Natural Rubber Producing Countries. The problem of finding a better market mechanism nevertheless remains quite pressing.

The second way in which government measures take effect is through their development policies. On the one hand this implies interests in synthetic rubber production as outlined in section 2 where even with a general shortage of rubbers, import restrictions or other protective measures may be involved, at least in the early stages of development.[3] In general it seems that the political element that leads to this type of investment and the disappointing rate of growth in these countries are together dousing any premature ideas that natural rubber producers may have held of more open and more rapidly expanding markets. On the other hand general agricultural policy, concerned for example with replantation schemes and support, the establishment of standards, technical training and also policies of diversification to lessen the dependence upon rubber culture are of considerable importance under this heading.

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1) See Rubber World, op. cit., June 1968.
2) Ibid., February 1969.
3) See for example P.J. Rimmer, "The Australian Petrochemical Industry," in Economic Geography, Vol. 44, No. 4, October 1968.

The research and development side of natural rubber production is also becoming increasingly important. Although usually discussed in terms of its technical, management or promotional studies, the most important aspect is perhaps the number and diversity of organisations involved. They include, for example, the Malayan Rubber Fund Board, the Natural Rubber Producers' Research Association, the Rubber Research Institute of Ceylon and the Central Rubber Fund Board of Indonesia. Systematic co-operation is promoted in turn by the International Rubber Research and Development Board.[1] Although only 2% of Malaysia's earnings from rubber went into research in 1967 the evidence suggests that greater reliance is going to be put upon research and development in the future, and that in this governments are going to play a significant rôle.

3.5 Future prospects

Summarising what has gone before, it can be suggested that the competition between natural and synthetic rubbers will probably hinge upon 9 factors:

1. the production costs of synthetic and natural rubber;
2. their diversity and output by type;
3. the rate of change in the patterns of natural rubber productions towards technically specified rubbers, and in the rate of adoption of synthetic rubber production;
4. developments in the marketing system for natural rubber;
5. improved methods of delivery and presentation;
6. technical factors and developments on both the production and demand side;
7. promotional efforts;
8. changes in the size and pattern of demand for rubbers; and
9. the development of other substitutes for rubber.

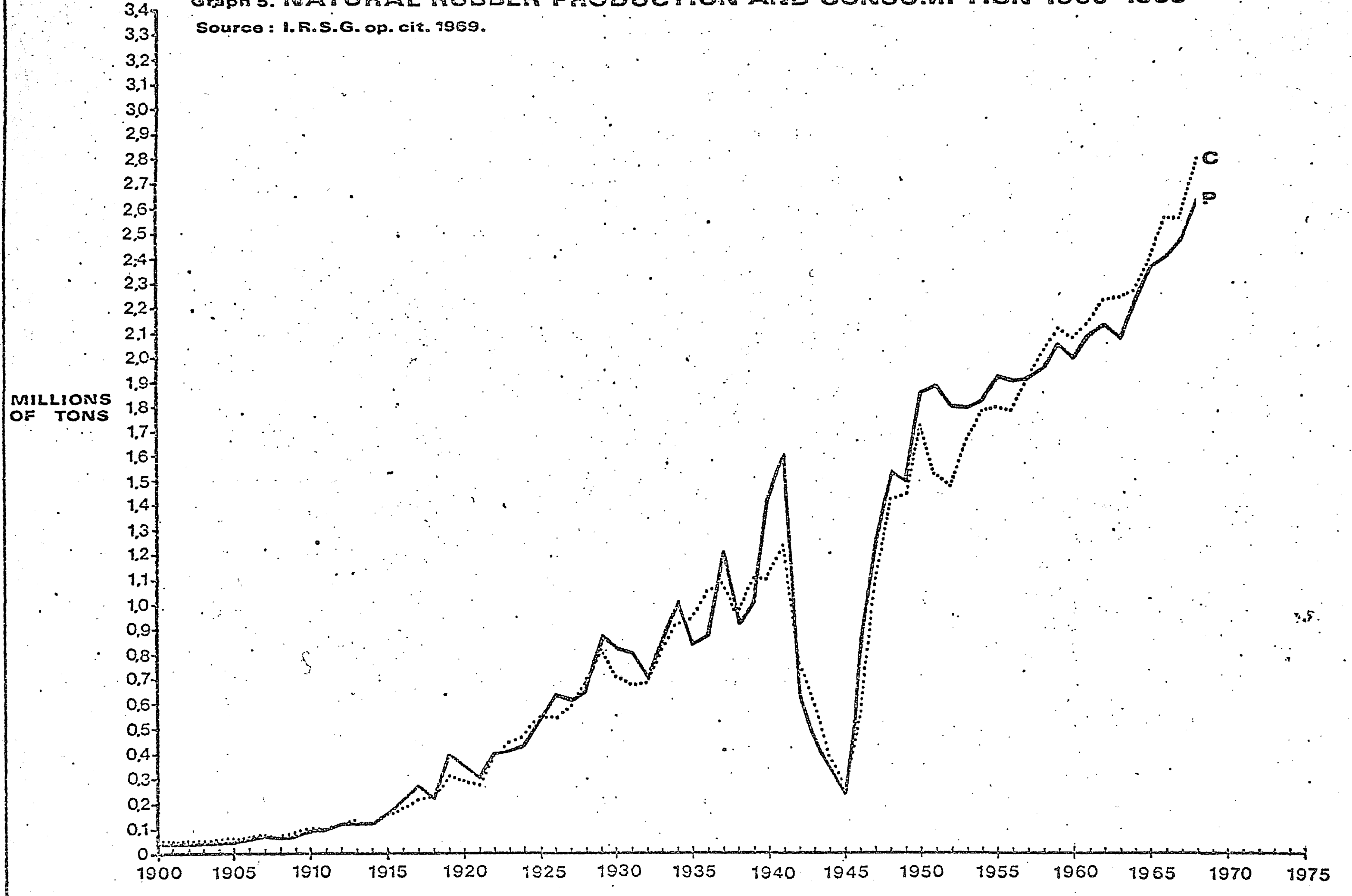
These will in turn also have strong spatial implications, the main trends of which have been discussed above.

The complexity implied in these factors means, however, that any predictions must be qualified subject to the considerable number of unknowns involved. In the following comparison of estimates this point must be kept clearly in mind.

1) F.A.O., op.cit., 1964, p. 23.
2) Quoted in Rubber World, op.cit., September 1968, p. 114.

Graph 5. NATURAL RUBBER PRODUCTION AND CONSUMPTION 1900-1968

Source : I.R.S.G. op. cit. 1969.



Long term trends in the production and consumption of natural rubbers are shown on graph 5. Three factors are particularly clear:

(1) with the exception of 1939-45 and despite the growth of synthetics since that period, a steady overall rate of expansion has occurred;

(2) since 1957 demand has exceeded production; and

(3) since 1965 the growth in demand has exceeded that of production.

Several estimates of production in 1975 have been collated and can now be compared against these long term trends.[1)]

(i) by the International Rubber Study Group (in May 1968):

1968	2,627,000 metric tons (actual production)
1970	2,854,000
1975	3,566,000[2)]

(ii) by the FAO (in 1967):

1970	3,300,000
1975	3,566,000

(iii) by the United Nations (in 1968)

1970	2,864,000
1975	3,484,000

Judging from past trends these figures appear to be rather high, implying a much steadier and faster growth rate than in the past. However, as the trees that will be yielding in 1975 must now be planted, the figures must be taken as reasonably indicative. Demand estimates for the same period have been given as follows:

(1) by the United Nations (in 1968):

1968	2,834,000 metric tons (actual consumption)
1975	3,515,000

(ii) by the FAO (in 1967):

1975	2,739,000 - 3,350,000

(iii) by D.A. Littler (in 1968):

1975	3,492,000

If these estimates are taken at face value it would seem that only with the lowest production and highest demand will there be a shortage of

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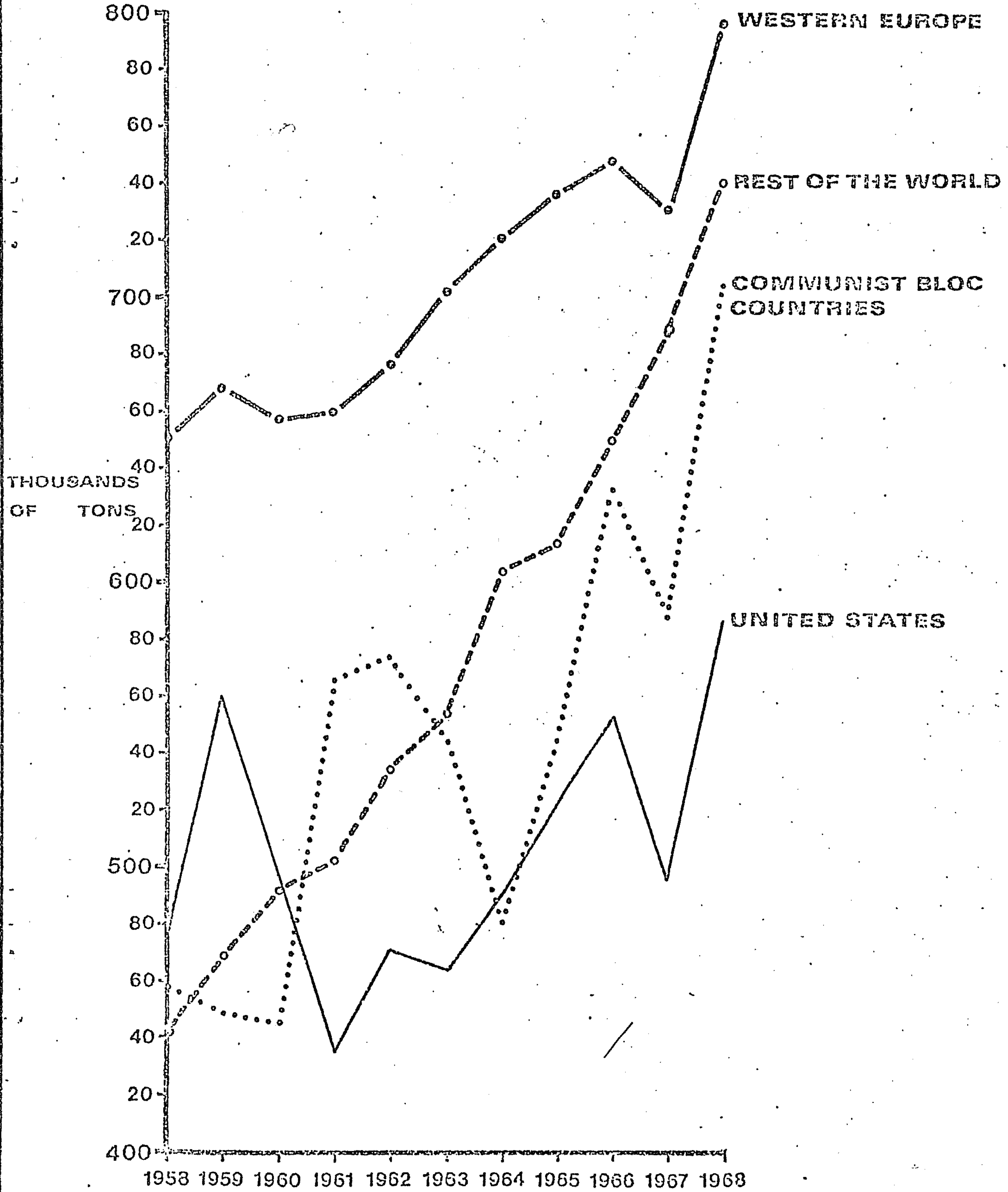
1) Rubber World, op. cit., January 1969, p. 68; FAO, op. cit., 1967, p. 315-6; D.A. Littler, op. cit., 1968, p. 16.

2) This represents a continuation of the present rate of expansion of 3.6% p.a.

Graph 6. THE CONSUMPTION OF NATURAL RUBBER BY AREA 1958-1968



Source: I.R.S.G., STATISTICAL BULLETIN, June 1969, table 6, p. 9.

natural rubbers in 1975. However, it also seems likely that natural rubber could maintain its current rate of expansion of just over 3.6% p.a. and still find markets. This is supported by evidence that the exceptional growth in technically specified rubbers might be maintained and reach as much as 25% of natural rubber output by 1975. If total output rises above this level, however, there is a serious danger that the market will be flooded. There is certainly little doubt that natural rubber production will exceed the total requirements for which it is technically essential or desirable.

An attempt has also been made to break down the global consumption trends by major area. This is shown on graph 6. It is significant that the highest and most consistent demand for natural rubber lies in Western Europe as a whole and the less industrialised areas, and that by 1975 the latter may well prove the most important market area. Based on these trends the following estimates were obtained, the higher estimate being computed from the average growth rate per annum and the lower by underweighting the relative boom in 1968:

Table 17
Projected high and low demand estimates by area for 1970 & 1975
(in thousands of metric tons)

	1968	1970	1975
Western Europe	797	760-820	810-910
Communist bloc	704	710-760	840-920
United States	591	600	630
Rest of the World	742	820	1100
Total	2,834	2890-3000	3380-3560

These figures must altogether be viewed rather tentatively and reservations must be made on at least three accounts. Firstly comparison of the results of table 17 with the long term trend of graph 5 shows that even the lower estimates presume a continuation of the present boom in the demands which may not in fact occur for natural rubber. Secondly demand from the communist bloc must for lack of evidence be considered rather unpredictable as must, thirdly, the potential impact of any technical developments. However, it does seem likely that in 1975 there will be a surplus production of natural rubber of certain grades of up to 5% if these trends continue.

4. Some Implications of this Competition for the Developing Countries.

Thus far the competition between natural and synthetic rubber has been viewed in terms of demand and supply dealing mainly with aggregated data, and with the nature, structure and thus locational trends of the synthetics industries in mind. To complete the picture it must also be seen in terms of the developing countries that produce natural rubber and in the context of their overall development needs. Although the evidence at hand is extremely limited the general lack of attention that has been paid to this side of the problem would seem to warrant its inclusion.

For most producer countries the production of natural rubber has a two-fold importance. Firstly, it is often a major factor in the internal structure of the country. As shown on table 18, for example, rubber comprises a substantial portion of their cultivated area. The mainstay, and often the most generative feature of their commercialised economy, it directly employs a large number of people. For example in 1957 some 614,487 persons or 28.4% of the economically active population of Malaysia was employed in rubber production.[1] Secondly, it is a major source of export earnings upon which these countries depend to pay for the imports necessary for their further development. As can be seen from table 19, in 1966 much of South East Asia was dangerously dependent upon the reliability of rubber markets for such earnings.

Table 18
The area under rubber in producer countries

Country	Year (as of 31 Dec.)	Area (in acres)
Indonesia	1965	4,910,000
Malaysia	1967	4,355,000
Thailand	1965	1,816,000
Nigeria	1967	594,000
Ceylon	1967	572,000
Liberia	1967	255,000
Vietnam	1965	251,000
Cameroun	1967	52,000
Ivory Coast	1967	29,000
Ghana	1967	29,000

Source: I.R.S.G. Statistical Bulletin, op. cit., 1969 and Malaysia: Official Yearbook, Vol. 17, 1967.

1) M.W. Ward, "A review of problems and achievements in the economic development of independent Malaysia," Economic Geography, Vol. 44, No. 4, October 1968, p. 327.

Table 19

The dependence of main producer countries upon natural rubber exports in 1966, by value

Nation	Value in 100,000s U.S. Dollars	As a % of agricultural exports	As a percentage of total export
Indonesia	1926	55	33
Cambodia	250	38	37
Ceylon	709	20	20
Malaysia (Sabah)	104	43	9
" (Sarawak)	155	51	13
" (Western)	4562	81	45
Singapore[1]	2512	55	23
Thailand	921	17	14
Vietnam	260[2]	74	73
Liberia	270	77	18
Nigeria	320	53	4

Source: F.A.O. Yearbook, Vol. 21, 1967 and U.N. Yearbook of International Trade Statistics for 1966, U.N. 1968.

However, it is not true to say that the degree of dependence involved is indicative of the potential impact of competition from synthetics. As section 3 has shown the situation is more complex, but it can be argued that a better, though still incomplete picture, is to be gained from a comparison of the following indicators:

1. the degree of dependence upon rubber;
2. market orientation; and
3. the rate of adoption or of likely adoption of new techniques and types of rubber.

A fourth factor, the quality of rubbers being produced, cannot unfortunately be ascertained from the evidence at hand but should be held in mind.

Table 20 shows the location of the markets of the main producer countries according to the four areas determined in section 3.5.

1) Not grown in Singapore, refined and graded for re-export.
2) 1965 data.

Table 20

The destination of exports of main producer countries in 1968 (in percentages)

Producer	U.S.A.	Western Europe	Communist bloc	Rest of the world		Others (unspecified)
Malaysia	17	26	31	18	(10)	8
Indonesia	27	28	10	25	(-)	10
Ceylon	7	15	69	8	(2)	1
Thailand	14	28	6	52	(1)	-
Vietnam	-	77	-	23	(-)	-
Cambodia	16	64	-	16	(-)	4

Bracketed figures refer to percentages going to developing countries, excluding Singapore. Percentages refer to exports by weight.

Source: I.R.S.G. Statistical Bulletin, op. cit., 1969.

Comparison with table 10 concerning the development and spread of technically specified natural rubbers shows that although Malaysia is heavily dependent upon rubber for export earnings it appears to be taking good advantage of new markets in developing areas and in the production and development of new rubbers, and it has also the best buying, transport and information facilities available. Ceylon, though by contrast less dependent upon rubber for its foreign exchange earnings, has clearly committed itself to the communist markets, 56% of its custom coming from Mainland China, with weakly developed alternatives. In the case of a marked decline in this somewhat unpredictable market Ceylon might well be in a rather difficult position. The other countries of Southeast Asia, which are peripheral to Malaysia as regards rubber production, appear to be relying mainly upon the [illegible] rising demand of Western Europe and, to a lesser extent, the United States. In varying degrees, however, they also appear to be at a disadvantage vis-à-vis Malaysia in that they command less adequate information and buying facilities, are subject to uncertainties of shipment due to the fact that less shipping space is available to them, and because of the occasional risk to claims.

Somewhat more can be said, however, regarding the spread of newer techniques. In general, full benefit of new ideas requires efforts that are only available to the larger companies where organisation and supervision are more easily achieved. The estate system, for example, can better organise and afford the rejuvenation policy that is necessary to obtain higher yields. The smallholder is unwilling to replant when rubber prices are high and less able to do so when prices are low unless considerable assistance is forthcoming. The estates by contrast usually maintain a regular replantation policy, the rate of change indicating in rough terms the confidence of investors in the area's prospects. Comparison of Malaysia and Indonesia even before the nationalisation of foreign assets is a case in point. Secondly, however, willingness to invest is also likely to be related to the rate of adopting other new practices as they come along, and whereas the smallholder can produce rubber cheaply, he cannot easily produce it to high specification. The latex tapped is in both cases the same, the care taken in preparation determining the quality of the final product. Theoretically, therefore, the smallholder can produce equally good rubber. In recent years the Dynat process has found favour in Indonesian smallholder operations, field latex being coagulated in individual field stations and delivered more easily and cleanly to the central factory for processing.[1] However, in practice this does not yet seem the answer. For example, the process is useful only when problems surrounding the establishment and organisation of the central factory are solved, and these may be numerous[2]; costs are not light, a small Dynat plant producing 100 tons per month costing US$ 14,450[3]; nor are smallholders always willing to co-operate. It has to be borne in mind, therefore, that methods that are efficient on estates are not always as efficient when they are applied to smallholder production, although the quality of smallholder rubber may still be rising in some areas as a result of their diffusion.

An indication of the relative importance of estates is shown in table 21.

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1) Rubber World, op. cit., November 1968, p. 104.
2) J.D. Hastings: "New Forms of Natural Rubber," <u>An Address to the Technical Meeting</u>, Kesetsart Agricultural University, 1968.
3) Rubber World, op. cit., February 1969, p. 89.

Table 21

The percentage of the area under rubber production in estates[1]

Country	Year	Percentage under estates
Malaysia	1967	41
Indonesia	1965	26
Ceylon	1967	49
Thailand	1965	0
Vietnam	1965	74
Liberia	N.D.	66
Camerouns	N.D.	98

Source: I.R.S.G. Statistical Bulletin, op. cit., 1969.

Producers in Africa would seem therefore to be well placed in this respect, though their output is small. In southeast Asia the impact of the Vietnamese war is reported to have disrupted production[2] while otherwise Ceylon and Malaysia are apparently better placed than Indonesia or Thailand.

The percentage of the area under high yielding cones producing 3-4 times the amount gained from unselected trees also varies from 86% on Malaysian estates to 27% in Thailand, and from 79% in Liberia to a modest 59% in Ceylon where the adoption of new cones seems to have lagged behind.[3] Moreover, while 43% of the area under smallholdings in Malaysia in 1967 were producing about 300-350 lbs per acre which was thought uneconomic, in Indonesia 70% of the trees on similar holdings came under this category.[4] Average yields in Indonesia have in fact decreased markedly since 1956 from 553 lbs per acre to 463 lbs. in 1965[5], and even the optimistic projection for estates of 705 lbs/acre average yield in 1973/74[6] is well below that of Malaysian smallholdings in 1967 which was 772-790 lbs per acre.[7] Regarding new process rubbers,

1) These figures should be taken as roughly indicative as there is no real uniformity in the definition of estates.
2) See the Sunday Times, London, August 10th.
3) I.R.S.Q., op. cit., 1969.
4) Ibid., 1969; Rentjana Pembangunan Lima Tahun 1969/70-1973/74, Djakarta 1969 and C. Chanmugam, "The need to replace obsolete capital in Ceylon's rubber industry," R.R.I.C. Bulletin, op. cit., 1967.
5) Report of the Bank of Indonesia for the period 1960-65, Djakarta 1966.
6) Rentjana Pembangunan Lima Tahun, op. cit., 1969.
7) Yearbook of Malaysia, op. cit., 1968, p. 49. Malaysian estates averaged 898-920 lbs/acre in 1967.

12 plants had been commissioned for installation by 1968 by Indonesia, each with a crumb rubber capacity of 2,500 tons per month, while 20 were in operation in Malaysia, 6 due in 1968 and 10 more in the planning stage.[1] The situation is, therefore, extremely differentiated. In each case Malaysia is in the better position. Indonesia and Ceylon appear to be now suffering from various degrees of mismanagement or lethargy in the past while Thailand is almost entirely smallholder production.[2]

Historically, increasing competition in rubber production has resulted in the weeding out of the least efficient producers and producer areas, and it seems reasonable to suggest a similar pattern for the future. If this is the case, and if the trends suggested above do hold for the future, then the prospects for Ceylon, Indonesia and Thailand would appear to be increasingly gloomy in that order. Vietnam is of course a peculiar case, but must still be considered badly placed vis-à-vis Malaysia.

The potential impact of this competition is, however, far more complicated. Thus while Thailand has seven times the area under rubber than Vietnam, while the former is smallholder production and war-ridden Vietnam largely estates, rubber comprises only 14% of their export earnings compared to 73% in Vietnam. Smallholder production is sometimes thought to be more flexible in hard times while estates often imply a stigma that is politically difficult to accept. A third factor that is equally difficult to assess is the success of government diversification policies which are just beginning to bear fruit. The potential impact of the competition from synthetic rubbers is, therefore, something that cannot really be judged from the evidence at hand.

Finally, however, it must also be noted that the ability to meet and thus to offset this impact is also likely to vary and to present different problems in different parts of individual countries. In Malaysia, for example, the size, ownership and spatial patterns of rubber are significantly distinct. The estates are primarily concentrated in the south and west where facilities are in every respect best; smallholdings on the other hand are fairly ubiquitous, although the average size of holding appears to decline outwards to the east and northeast.[3]

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1) Rubber World, op. cit., November 1968.
2) In Ceylon the proportion of smallholder rubber production is in fact increasing. See D.R. Snodgrass, <u>Ceylon: an export economy in transition</u> Illinois 1966.
3) See J.C. Jackson, "Smallholding cultivation of cash crops," in N. Gungwu (ed.) <u>Malaysia- A Survey</u>, London 1964, table 26, and M.W. Ward, op. cit., 1968.

This situation is further compounded by the pattern of ownership. Estates, for example, are mainly owned and controlled by immigrant people. In the early 1960's, 14 leading agency houses controlled more than one million acres of rubber land in Malaysia, the majority of this being British owned.[1] This is also reflected in size, 85% of all Asian-owned estates being below 500 acres in area compared to less than 10% of the European owned. The latter have also a much higher productivity than their Asian (mainly Chinese owned) counterparts whose smaller estates have been less able to take advantage of new techniques.

The pattern of smallholding is similarly distinct. For example, 66% of medium sized smallholdings varying from 25-100 acres were Chinese, and only 5% Malay owned in the 1950's. On the smallest holdings of less than five acres, however, 55% were Malay.[2] The areas in which Chinese ownership predominated also surrounded the main urban centres where access to information and various facilities were more forthcoming while Malays tended to predominate in the more isolated peripheral areas.[3] With the average Chinese smallholding being twice the size of its Malay counterpart, it has obviously been much easier to replant and to introduce new ideas without seriously reducing income. During the period 1953-61 over 40% of the Chinese owned smallholdings were in fact replanted with new stock compared to less than 20% of the Malay owned.[4] Moreover, there is no evidence that these patterns have changed significantly in more recent years.

As the competition with synthetic substitutes becomes stronger in lower grade rubbers there is little doubt, therefore, that its impact is likely to be very varied in Malaysia and to have strong social and political implications. It seems likely that a decline in natural rubber prices would first effect the Malay smallholder. In turn this might well create social and political tensions generally associated with a depressed area but heightened by racial differences in the patterns of rubber production that may at the same time become more apparent. The way out of the dilemma may also be complicated first by a decline in foreign exchange earnings available, and secondly by the extent to which rubber

1) See D.W. Fryer, "The plantation industries -- the estates," in N. Gungwu (ed), op. cit., 1964, pp. 236-40.
2) J.C. Jackson, op. cit., 1964, table 25, p. 249.
3) Ibid., figures 9 and 10, pp. 251/253.
4) Ibid., p. 260.

is socially engrained in the way of life of the Malaysian people.

By conventional indicators Malaysia is one of the most advanced areas in southeast Asia and is in some ways an extreme case, but at the same time it does illustrate the relevance and importance of placing the competition between natural and synthetic products in a broader perspective. This is the point that this section has tried to make.

Conclusion

An attempt has been made in this paper to analyse the current situation regarding the competition between natural and synthetic rubber and its possible prospects to 1975, and to exemplify some of the typical spatial and economic implications involved.

It would seem that the general patterns are being shaped: (i) by the rapid development and expansion of synthetic rubber production; (ii) by the structure and interests of the industry and (iii) by the movement of more and more countries to its production. In fact it could be argued that prospects for the natural producer have been determined partly by the development, diffusion and rate of adoption of synthetics technology in relation to the size of the market in the various industrialised countries, and partly by the development, diffusion and adoption of new techniques by natural producers themselves. Two practical consequences of this have been, firstly, that 'the best market' for natural rubber has shifted over time from the U.S.A. to, now, western Europe and the communist bloc, and perhaps in the future will shift to 'the rest of the world' in response to this process while its impact has, until now, tended to be offset by the growth of new markets, and secondly that the future impact is likely to be extremely differentiated according to the patterns of ownership and production in the different natural rubber areas. It has therefore been seen necessary to relate trends in this competition to the nature of synthetics production on the one hand and to the situation of natural rubber producers on the other. However, the situation is very open to change. The point is being reached in fact when far more than economic values are at stake. It might be asked for example whether the political implications involved, and their potential impact upon various interests in developing S.E. Asia might not have repercussions in more than this corner of the world, and whether the most relevant question for the future might not require analysis at a totally different level of generalisation. However, this was not the subject of the present paper, and it can only be hoped that a useful introduction has been given to some of the spatial and economic implications of this competition.

Table A1: Breakdown of the production of synthetic rubber 1940-68 by centre and periphery, excluding the centrally planned economies (in 000s of metric tons).

	U.S.A.	Rest	Total
1940	3	40	43
1941	8	71	79
1942	23	90	113
1943	236	120	356
1944	776	139	915
1945	834	46	880
1946 1)	716	104	820
1947	517	51	568
1948	496	45	541
1949	400	47	447
1950	484	59	543
1951	859	64	923
1952	811	81	892
1953	862	153	1015
1954	633	163	796
1955	986	189	1175
1956	1097	207	1304
1957	1136	222	1358
1958	1072	278	1350
1959	1402	348	1750
1960	1459	450	1909
1961	1426	581	2007
1962	1599	676	2275
1963	1634	843	2477
1964	1793	1034	2827
1965	1842	1187	3029
1966	2001	1350	3351
1967	1943	1494	3437
1968	2164	1718	3882

1) excluding East Germany from 1946 onwards.

Source: U.N. Statistical Yearbooks and Ruebensaal op.cit. 1968

Table A2: Breakdown of the production and consumption of natural rubber 1940-68 by centre and periphery (in 000s of metric tons)

	Production			Consumption		
	S.E.Asia	Rest	Total	USA	Rest	Total
1940	1394	46	1440	659	469	1128
1941	1581	45	1626	787	472	1259
1942	583	67	650	383	394	777
1943	384	88	472	323	302	625
1944	258	108	366	146	247	393
1945	159	104	254	107	160	267
1946	762	89	851	282	282	564
1947	1204	76	1280	572	556	1128
1948	1476	73	1549	638	808	1446
1949	1439	75	1514	584	877	1461
1950	1806	83	1890	732	1018	1750
1951	1808	107	1915	462	1077	1539
1952	1709	110	1819	461	1028	1489
1953	1641	117	1758	562	1119	1681
1954	1725	114	1839	606	1202	1508
1955	1821	127	1948	645	1275	1920
1956	1778	145	1923	571	1337	1908
1957	1786	149	1935	548	1383	1931
1958	1819	152	1971	492	1553	2045
1959	1900	173	2073	564	1589	2153
1960	1836	181	2017	487	1612	2099
1961	1953	173	2126	434	1728	2162
1962	1974	181	2154	470	1786	2256
1963	1920	181	2101	465	1802	2267
1964	2073	198	2271	489	1806	2295
1965	2184	196	2380	523	1894	2417
1966	2229	207	2436	554	2031	2585
1967	2299	193	2492	487	2009	2506
1968	2446	196	2642	591	2245	2836

Source: I.R.S.G. op.cit. 1969

Table A3: <u>The consumption of natural rubber 1958-68 by major area</u>

(in thousands of metric tons)

Year	USA	Western Europe	Communist Bloc	Japan	Rest of the World	Total
1958	492	649	458	130	316	2045
1959	564	669	447	161	312	2153
1960	487	677	444	168	323	2099
1961	434	659	568	179	322	2162
1962	470	677	575	193	341	2256
1963	465	703	546	195	358	2267
1964	489	721	481	206	398	2295
1965	523	737	545	201	411	2417
1966	554	749	633	216	433	2585
1967	497	732	588	243	446	2506
1968	591	797	705	256	487	2836

Source: I.R.S.G. op.cit. 1969

Table A4: Prices of synthetic and natural rubber 1952-68
(New York average in U.S. cents per lb.)

	Natural	Synthetic [1]
1952	38.6	23.5
1953	24.2	23.0
1954	23.6	23.0
1955	39.7	23.0
1956	34.2	23.8
1957	31.2	23.9
1958	28.1	23.9
1959	36.6	23.9
1960	38.2	23.9
1961	29.5	23.9
1962	28.6	23.6
1963	26.3	23.0
1964	25.2	23.0
1965	25.7	23.0
1966	23.6	23.0
1967	19.9	22.7
1968	19.8	22.4

Sources: I.R.S.G. op.cit. 1969 and U.N. Monthly Bulletins of Statistics, 1961 and August 1969

") S.B.R. No. 1.