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LORENZO RUNEBERG

THE FUTURE FOR FOREST-INDUSTRY PRODUCTS IN THE UNITED KINGDOM

ISON-BRITANNIAN METSÄTEOLLISUUS-TUOTTEIDEN KÄYTÖN TULEVAISUUS

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FOLIA FORESTALIA 168

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Lorenzo Runeberg

THE FUTURE FOR FOREST-INDUSTRY PRODUCTS IN THE UNITED KINGDOM

Ison-Britannian metsäteollisuustuotteiden käytön tulevaisuus

Suomenkielinen tiivistelmä sivulla 5

FOREWORD

In 1966 the Forest Research Institute started a research project concerning the interaction between plastics and wood. The question has since then taken on more and more important and complicated aspects, and this is the fifth publication covering the field. Also FAO has in the last few years given the development more consideration.

I am greatly indebted to many people both in the United Kingdom and in Finland who have helped me during the sampling of the material which has made this publication possible. During the final shaping of the manuscript valuable advice has been given by the head of the economics department, Professor LAURI HEIKINHEIMO, Doctor J.T. GALLAGHER from ICI:s Corporate Research and Development Unit, and Mr. H. LÜHR from SITRA.

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Helsinki, January 1973.

L. Runeberg

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TAULUKKOLUETTELO

ISON-BRITANNIAN METSÄTEOLLISUUSTUOTTEIDEN KÄYTÖN TULEVAISUUS

1. JOHDANTO

Tutkimuksen tarkoituksena on valaista metsäteollisuustuotteiden tulevaisuutta taustana Länsi-Euroopan puuraaka-aineen kasvava vajaus. Iso-Britannia valittiin kohteeksi brittiläisten markkinain tärkeyden vuoksi Suomelle. Erikoisesti valaistaan muovien tunkeutumista Britannian metsäntuotteiden markkinoille ja tästä johtuvia muutoksia ja integroitumista tuotantokoneistossa.

Terminologiaa, joka varsinkaan muovipaperin osalta ei vielä ole vakiintunut, pohditaan luvussa 12. Sivulla 15 on luettelo tavallisimpien muovilaatujen nimilyhennyksistä.

2. YLEISSILMÄYS ISON-BRITANNIAN METSÄTEOLLISUUTEEN JA METSÄNTUOTTEIDEN KAUPPAAN

21. Paperi- ja kartonkiteollisuus

Ison-Britannian paperituotos on määrällisesti samaa luokkaa kuin Ruotsin tai Suomen tuotos, mutta viime vuosikymmenen investointien vähyys on vakavasti heikentänyt tuottavuutta. Tuonnin osuus on täten huomattavasti lisääntynyt ja saavutti vuonna 1971 39.2 % kokonaiskulutuksesta. Tärkein toimittaja on Suomi, jonka markkinaosuus oli viime vuonna 773 000 tonnia. Muovilla päällystettyä paperia ja pahvia tuottaa Isossa-Britanniassa 5 paperitehdasta ja 8 pakkausyritystä, joilla on käytettävissään yhteensä 20 suulakepuristusasennusta. Suuri kotimainen paperituotanto edellyttää huomattavaa puumassan tuontia ulkomailta, mikä vähitellen käy yhä vaikeammaksi. Tuonnin jakaantuminen maittain ilmenee kuvasta 4 s. 19, jossa nähdään Pohjoismaiden tärkeä asema.

22. Paneeliteollisuus

Paneelituotteiden tuotos ja tuonti ilmenevät taulukosta 4 s. 20. Isossa-Britanniassa tuotetaan suuressa määrin vain lastulevyjä, joskin myös tällä alalla tuontimäärät ovat viime vuosina ohittaneet kotimaisen tuotannon. Vaneripuolella tuonti vuonna 1971 ylitti jopa 1 milj. m^3, mutta tuonnin kasvuvauhti 1960-luvulla näyttää huomattavasti hidastuneen. Vain pintakäsiteltyjen laatujen tilastoissa on todettavissa vahvaa kasvua. Vanerin loppukäyttöryhmät ilmenevät taulukoista 5 ja 6 s. 21–22. Tärkeimmät ryhmät ovat odotetusti rakenne- ja huonekaluala.

Lastulevyjen käyttö Isossa-Britanniassa 1960-luvulla jäi huomattavasti alle Länsi-Euroopan keskiarvon, mutta viime vuoden tuontinumerot osoittavat elpymisen merkkejä (taulukko 7 s. 23). Myös lastulevyn tärkeimmät loppukäyttöalat ovat rakennus- ja huonekaluteollisuus. Suomi on tärkein vanerin ja lastulevyn tuoja Isoon-Britanniaan. Kuitulevyjen markkinat eivät ole osoittaneet kasvua viimeisen 5 vuoden aikana.

23. Sahatavara ja muovipuu

Sahatavaran valtavat tuontimäärät ilmenevät taulukosta 11 s. 27 ja loppukäyttöjakautuma taulukosta 12 s. 27. Tuontimäärät ovat parhaina

vuosina ylittäneet 10 milj. m^3, josta yli 90 % on ollut havusahatavaraa. Ison-Britannian oma sahatavaran vuosituotos on enimmäkseen pysynyt 800 000 m^3:n paikkeilla. Loppukäyttötaulukosta ilmenee, että rakennusteollisuus on ylivoimaisesti tärkein käyttäjä (71 %).

Kokeilua muovipuutuotteilla on suoritettu ainakin vuodesta 1967 lähtien, mutta varsinainen markkinointityö on alkuvaiheessa. Muovipuuparketin teoreettinen tuleva markkinaosuus on 6 milj. m^2:n luokkaa (30 000 m^3).

3. YLEISKATSAUS ISON-BRITANNIAN MUOVITEOLLISUUTEEN

31. Raaka-ainetuottajat ja kokonaistuotos

Ison-Britannian muoviteollisuus on hyvin kehittynyt ja sillä on seitsemäs sija maailmantilastossa 1.6 miljoonan tonnin vuosituotoksella v. 1971. Perusmuovien valmistus on pääasiassa 5 yrityksen käsissä, ja näistä ICI Ltd:n markkinaosuus on 40 %. Taulukosta 14 s. 32 ilmenee tuotoksen jakautuminen tärkeimpiin muovilaatuihin. Suurimmat ryhmät muodostavat polyolefiinit ja PVC.

32. Loppukäyttökatsaus

Eri muovilaatujen tuotos ja loppukäyttöalat nähdään taulukoista 15–19 ss. 32–34. Tärkeimmät ovat pakkaus- ja rakennusala, jotka molemmat ovat viimeisten viiden vuoden aikana kasvaneet 17–18 %:n vuosivauhdilla. Pakkausalalla on varsinkin filmin käyttö yleistynyt. Rakennusalalla on muoviputkien ja -viemärien menekki vahvasti lisääntynyt, joskaan suoranaista korrelaatiota puutuotteisiin tuskin voidaan osoittaa.

4. TUOTE- JA TARVEANALYYSI

42. Paperi- ja pahvituotteet

Luvussa on tuotannon kehitystä analysoitu huomioonottaen varsinkin muovin käyttö yhdessä puutuotteiden kanssa ja niiden kanssa kilpaillen. Paperituotteissa pakkausalalla erityisesti paperin ja muovin etupiirit ovat joutuneet ristiriitaan. Pussi- ja säkkialalla kehitys kohti muovia on ollut hitaampaa kuin monessa muussa Euroopan maassa, mutta vuonna 1971 käytettiin Isossa-Britanniassa kuitenkin jo 300 miljoonaa muovisäkkiä. Markkinoilla toimii 6 huomattavaa tuottajaa, joista British Visqueen (ICI) on ylivoimaisesti tärkein. Tilanne pussipuolella ilmenee taulukosta 22 s. 38.

Kutistefilmin vaikutusta pahvilaatikoiden käyttöön on valaistu taulukossa 24 s. 39. Vuonna 1971 käytettiin 9 500 tonnia kutistefilmiä, mikä merkitsee 120 000 tonnin paperituotteiden syrjäyttämistä. Kuitenkin esiintyy huomattavasti myös yhteistyötä muovin ja paperin välillä. Tärkeimmät tämän puolen tuotteet ja tuottajat on lueteltu sivulla 41. Koska muovipaperin kehitysnäkymä ilmeisesti on keskeinen kysymys metsäntuotteiden tulevaisuudelle, tarkastellaan asiaa erikseen luvussa 423. Voidaan todeta, että kehitys toistaiseksi on keskittynyt muovifilmipaperiin, jonka tuotannossa käytetään suulakepuristimia. Näin jäävät tuotantomäärät vähäisiksi. Kaikki merkit viittaavat siihen, että on kehitettävä sopiva muovikuitulaatu, millä voidaan valmistaa muovipaperia tavallisilla paperikoneilla. Tutkimus tällä alalla onkin vilkasta ja mm. Crown Zellerbach Corporation markkinoi jo tämäntapaista tuotetta. Muovisellun merkitys paperiteollisuudelle on ennen kaikkea siinä, että sekoittamalla sitä tavalliseen puumassaan voidaan tuotosta nostaa sekä mää-

rällisesti että laadullisesti. Jos esim. sellukeiton hukkaprosenttia voidaan alentaa 30 %, merkitsee tämä miljoonan tonnin raaka-ainelisäystä Suomen paperiteollisuudelle.

Ison-Britannian paperintuottajat ovat osoittaneet hyvin vähän mielenkiintoa muovipaperin kehittämiseen. Kuten taulukosta 26 s. 44 ilmenee, on sen sijaan kymmenkunta muoviyritystä pyrkinyt tälle uudelle tuotantoalalle. Myös nonwoven -puolella on vähintäin 10 yritystä toiminnassa.

43. Rakennus- ja puuseppäalan tuotteet

Rakennus- ja puusepänteollisuuden puolella kehitys johtaa selvästi kiihtyvään kilpailuun ei vain muovin vaan myös eri puutuotteiden välillä. Muovin etuna on mahdollisuus keveämpiin materiaaleihin ja valmiisiin rakennuselementteihin, mutta puulla on myös paljon hyviä puolia. Muovin kulutus Ison-Britannian rakennusteollisuudessa ilmenee taulukosta 27 s. 47. Huonekaluteollisuuden puolella muovit ovat edenneet nopeasti. Jopa 25 muoviyritystä työskentelee eri tuotantomenetelmillä tällä alalla. Luultavaa on, että puuteollisuus tällä vuosikymmenellä suurelta osalta menettää huonekalutuotannon muoviteollisuudelle. Toisaalta pintakäsittelyt ja lamineeratut paneelituotteet ovat nykyisin suuren mielenkiinnon kohteena, joten laaja yhteistyöala on kehittymässä. Tärkeimmät tämän alan tuotteet ilmenevät taulukosta 31 s. 51. Esimerkkinä voidaan mainita, että lattiamateriaali "Purldeck" sisältää vaneria, uretaanivaahtoa, ja PE-päällystettyä voimapaperia sahatavaralla kehystettynä, joten ensimmäisen kerran historiassa samassa tuotteessa yhtyvät metsäteollisuuden kaikki kolme päälinjaa ja muovi.

5. PUUN JA MUOVIN HINTAKEHITYS

51. Raaka-ainelähteet ja hintakehitys

Muovi- ja puutuotteiden hintakehitys on ilmeisesti sangen tärkeä tulevalle kulutukselle. Kehitys 1960-luvulla on pääasiassa ollut epäedullinen metsäteollisuudelle, kuten taulukoista 34 ja 35 s. 54–55 voidaan havaita. Vain lastulevyt ovat välttäneet huomattavan hinnannousun. Ottaen huomioon jatkuvasti vaikeutuvan raaka-ainetilanteen on tuskin pitkiin aikoihin odotettavissa kehityssuunnan muutosta. Toisaalta muovin raaka-ainetilanne ei anna aihetta huolestumiseen tällä vuosisadalla. Sitä paitsi muovin raaka-aineen osuus lopputuotteen hinnassa on vähäinen. Muovien hintojen kehityssuunta oli maailmassa 1960-luvulla laskuvoittoinen.

52. Hintalaskelmointi empiirisen aineiston perusteella

Tuleva hintakehitys voidaan ennustaa esim. regressioanalyysien avulla. Koska kuitenkin muovituotteet ovat hyvin voimakkaassa kehitysvaiheessa, ovat Gompertzs-funktion parametrit vaikeasti arvioitavissa. Hintakehitystä on sen sijaan tarkasteltu sellaisen teorian pohjalta, että hinta laskee vakioprosenttimäärällä joka kerta kun kumuloitu tuotos (siis kokemus) kaksinkertaistuu. Tärkeimpien muovilaatujen hinnat, jotka tutkittiin Ison-Britannian markkinoilla tämän menetelmän perusteella, osoittivat hintalaskuja 17 ja 23 %:n väliltä tuotoksen kaksinkertaistuessa. Maailman kumuloitu sulfaattisellun tuotos näyttää 17–18 %:n hintalaskua. Koska kuitenkin muovin kumuloitu tuotos kaksinkertaistuu joka neljäs vuosi ja sellun joka kymmenes, muovin hinta laskee nopeammin. Nämä laskelmat edellyttävät, että rahanarvon huonontuminen on eliminoitu. Tulevia hintoja laskettaessa on tietenkin inflaatio otettava huomioon. Jos tällä menetelmällä verrataan sulfaattisellun ja LDPE:n hintoja vuonna 1980, on ero pienempi kuin 30 % puun hyväksi.

6. TULEVAISUUDEN NÄKYMIÄ

61. Muoviteollisuuden tulevaisuus

Tässä luvussa tarkastellaan muovin tähänastista kasvuvauhtia ja tiedossa olevia laajentumissuunnitelmia. Vaikuttaa siltä, että tasapaino tuotannon ja kulutuksen välillä säilyy kohtalaisen hyvin tämän vuosikymmenen aikana. Suurin kasvuvauhti on odotettavissa polyolefiiniryhmässä, jossa maailmantuotannon v. 1980 lasketaan nousevan 23 milj. tonniin. Myös PVC-muovin kulutuksen ennustetaan huomattavasti kasvavan ja se saavuttanee 15 milj. tonnia v. 1980. Näissä arvioissa ei kuitenkaan ole otettu huomioon muovipaperin raaka-ainetarpeita paitsi Japanissa, jossa tämän laadun valmistamisen on laskettu vuosittain vaativan 2.2 miljoonaa tonnia muovia 1980-luvun alkupuoliskolla.

62. Erinäisiä tulevaisuuden suuntaviivoja (sosiaalinen rakenne, metsänhoito ja ympäristön suojelu)

Ison-Britannian sosiaalinen rakenne on liukumassa teollistuneen yhdyskunnan jälkikehitysvaiheeseen, jolle ovat ominaisia suuria pääomia vaativat erikoistuotantoalat. Tämä johtaa helposti siihen, että yksinkertaisten massatuotteiden, kuten sellun, tuonti lisääntyy.

Kotimaisia hakkuita Isossa-Britanniassa ei ole mahdollista lisätä siinä määrin, että vaikutus tuntuisi tuontitarpeiden pienenemisessä. Mitä tulee ympäristön saasteongelmiin, voidaan todeta, että muovi- ja metsäteollisuus ovat samassa veneessä. Ilmeistä on, että muovijätteiden talteen ottaminen on taloudellisesti erittäin hankalasti järjestettävissä muovilaatujen lukuisuudesta johtuen.

63. Ison-Britannian metsäteollisuustuotteiden tuleva tuontitarve

Viime vuosien aikana ovat Ison-Britannian taloudelliset vaikeudet olleet valtavat, mutta elpymistä odotetaan, minkä pitäisi vaikuttaa myös metsätuotteiden kysyntään. EEC:n lopullinen ryhmittymä ei ole vielä selvä, mutta on kuitenkin todennäköistä, että 1970-luvun loppupuolella Länsi-Eurooppa kokonaisuudessaan tulee muodostamaan teollisuustuotteiden vapaakauppa-alueen. Ison-Britannian EEC-jäsenyys tuskin vaikuttaa paljoakaan metsäntuotteiden tuontiin, koska kaikki alkuperäiset EEC-maat potevat puupulaa.

Taulukosta 43 s. 64 ilmenee yhteenvetona tämän hetken tilanne puun ja muovin käytön eri loppukäyttöaloilla. Rakennusalalla on sahatavaralla vielä varsin ylivoimainen asema verrattuna muihin tuotteisiin. Pakkausalalla on paperilla vielä tärkeä asema, mutta muovin osuus on voimakkaasti kasvamassa. Metsäntuotteiden tuonnin kasvun voidaan odottaa tyrehtyvän ainoastaan siinä tapauksessa, että tapahtuu huomattava muoviraaka-aineen käytön laajeneminen sellaisten tuotteiden valmistamiseen, joissa aikaisemmin puu oli raaka-aineena. Jos näin käy, niin Isolla-Britannialla on Pohjanmeren öljylöydöissä omat raaka-ainevaransa.

Muovipaperimarkkinat Isossa-Britanniassa vuosina 1975–76 on arvioitu 1 %:ksi kokonaistarpeesta. Kuitenkin kuva voi nopeasti muuttua sitä mukaa, kuin muovisellua ryhdytään myymään maailman markkinoilla. Ei vaikuta todennäköiseltä, että Iso-Britannia kehittäisi omaa muoviselluteollisuutta, koska nykyinenkin perinteellinen selluntuotanto on vaatimaton. Tämä kuitenkin edellyttää, että entiset ulkomaalaiset puukuitusellun toimittajat pystyvät hyvissä ajoin myymään tätä uutta laatua.

Paneelituotteiden tulevaisuus on arvioitu taulukossa 47 s. 69. Pääasiallinen kasvu keskittyy lastulevyihin, joiden kulutus todennäköisesti kolminkertaistuu 1970-luvulla. Toiselta puolen vanerin käyttö pintakäsiteltyjä laatuja lukuunottamatta kasvanee huomattavasti hitaammin. Mitä tulee kotimaiseen tuotantoon, niin ainoastaan lastulevyn osalta on odotettavissa kasvua.

Sahatavaran tuontia ei käsitellä yksityiskohtaisemmin tässä tutkimuksessa, mutta ilmeistä on, että huomattava tuotevalikoiman supistaminen on nopeasti toteutettava kustannusten alentamiseksi.

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1. INTRODUCTION

11. Purpose and scope of the investigation

Forestry and forest products in the traditional sense are entering a period of immense adjustment. Population growth, urbanization and environmental conservation are more and more limiting the possibilities of forestry's natural expansion. At the same time, synthetically manufactured products have begun to assume an increasingly important position as complementary as well as alternative raw materials in the production processes of the forest industries. Particularly in the parts of the industrialized world where roundwood resources are already being utilized to their full, the question is what path developments are going to take. Of greatest interest to Finland is obviously the situation in Western Europe, where the timber balance has rapidly deteriorated since the 1950s. By 1970, the deficiency had grown to 46 million m^3 WRME (wood raw-material equivalent), distributed among the following products (FAO/ECE 1971 b p. 4):

	million m^3
Pulpwood	7.2
Sawn softwood	13.3
Plywood	2.0
Chemical woodpulp	12.4
Hardwood logs	6.7
Diverse	4.8
	46.4

If FAO's consumption estimates for forest products hold, the situation will rapidly deteriorate further. There is no substantial possibility of increasing fellings in Europe. Even the existing removal presupposes a rotation period of only 40 years in the forest capital. Concentrated silvicultural measures can, of course, obtain significant results, but not sufficiently quickly nor in pace with the growth in demand. Thus a continued increase in imports of forest products appears to be necessary to maintain the European standard of living. The extent to which this will be possible over a long period is, however, uncertain. Only USSR and South America probably at the present time have large unexploited and partly unknown resources. The seriousness of the situation can be judged by the fact that a trial shipment of roundwood was made to Finland from South America in 1972. The costs of transporting timber products over long distances act as a disadvantage, however, and the needs of those parts of the world for roundwood will in time take an increasing proportion of their resources. In its latest report, FAO writes the following on the future of the paper industry (FAO 1972 p. 43): "The trouble is that the wood is no longer readily available where the industry and the markets are. The only answers in the long run are to use something else, to move the wood to the industry, to move the industry to the wood or to create forests where the industry is." Only the first of these solutions would appear to offer help in time for the European market.

The alternative offered by synthetic products as a raw material or partcomponent for the forest industries appears, therefore, to be particularly welcome from a European viewpoint. Which of the raw materials will be cheapest and most readily available in the future will be discussed more fully in another context later. An open question is clearly how far we can expect a substitution of traditional timber products by synthetic material, primarily plastics, to develop. Europe's requirements of pulpwood in 1985 are estimated at 195 million tons. We might ask if this will hold good if the production of plastic paper seriously begins to shoot forward. How large a proportion of paper production will in this case be synthetic? 10 %?

50 %? Will the progress of particle board in the world continue if plastic boards for the same purposes become cheaper to produce? Will forestry in general survive when we seriously enter the plastics age in the 1980s? These are all questions of primary importance for the European economy and not least for a country dependent on exports of timber products such as Finland.

A detailed analysis of conditions in Europe as a whole would clearly require superior resources than are at present available, and consequently this investigation must be suitably limited. Since a first exploratory investigation has been made dealing primarily with Finland (RUNEBERG 1967), it would seem appropriate on this occasion to take as a case study a major wood-importing country. The most interesting from a number of viewpoints is clearly the United Kingdom. In its deficiency of forest resources, it is comparable with Japan, where the production of plastic paper has been developt primarily to help the rawmaterial situation and also as a means of saving foreign exchange, obvioulsy a matter of interest to the UK with its chronically poor trade balance. Furthermore, the British market is Finland's most important export market for forest products. Nevertheless, a detailed examination of the situation in one country can scarcely be undertaken without a further background discussion of related questions. The intention is therefore to deal in this investigation with problems which have not been touched upon in detail in earlier studies or where developments have already led to new aspects appearing.

An analysis of the future of the forest industry in the UK requires not only a general examination of the wood-processing industry and product development but also a survey of the British plastics industry. As the production of plastic paper grows, for example, the manufacture of the necessary plastic raw material must naturally be secured. It seems more natural if the plastic raw material is manufactured within the country, but it is possible also to think of plastic fibre pulp being imported alongside or instead of cellulose. The question is whether the plastic raw-material industry in Europe generally and in the UK particularly can be expanded at a sufficiently rapid pace to meet an "exploding" development in the use of plastics for forest products.

Special attention must obviously be paid to the price developments of natural and synthetic fibre products. It is true, as FAO points out, "that price considerations have often been less important than properties of the product" (FAO 1971 p. 1), but this properly applies only to special products. A possible massive infiltration of plastics in bulk as a material for wood-processing presupposes an unfavourable price development of wood fibre. A thorough study will be made of this question.

All of the forest industry's three main branches – paper manufacture, panel products and sawnwood – have experienced in different ways the infiltration of plastics. In the production phase of the paper industry, the following areas of use can be distinguished:

1) Coating of plastic film on paper or paperboard
2) Use of plastic dispersion for the surface-treating of paper or paperboard, or for the manufacture of non-woven products
3) Manufacture of plastic film for paper purposes
4) Manufacture of plastic paper or paperboard from plastic fibre

Plastic is currently used in the sphere of panel production as follows:

1) Glue for boards manufactured from wood fibre
2) Surface treatment of boards manufactured from wood fibre
3) Raw material for purely plastic boards

In the sawmill industry, plastic occurs in the production phase only in connection with wood-plastic composite products.

The situation can also be examined from the viewpoint of the products' spheres of use. The greatest changes have occurred or can be expected in the following branches:

1) Packaging branch
2) Building branch, including furniture and carpentry products
3) Printing branch

As has been mentioned, both competing and co-operative tendencies are apparent in production changes. In many cases, a composite structure can be used to obtain properties which are unattainable by the use of either material alone. As an example of such products in the packaging branch can be mentioned plastic-

coated milk cartons. Obviously competitive are sacks and bags manufactured solely of plastic film. On the other hand, a forestry enterprise can itself start producing purely plastic products which are used for similar purposes as products manufactured previously from wood fibre. Such production clearly cannot be regarded as competing from the enterprises viewpoint, although it is from the point of view of timber versus synthetic raw material. In some cases, the question of competition or co-operation cannot be unequivocally settled, for example in the case of cellular plastic which is used as additional protection in cartons, or in the case of shrink film used with a cardboard base tray.

In certain branches where previously the wood-processing industry was unchallanged, the field has been virtually lost for timber raw materials. As examples can be mentioned beer crates and boat hulls. It was already apparent in an investigation in 1967 (RUNEBERG 1967 p. 59) that the consumption of timber in several areas of the carpentry branch had declined by more than 50 % within 10 years. At the present time, the furniture industry has clearly come into the danger zone. Considering that machines for the injection-moulding of standardized furniture have been developed and reached sufficient capacity figures, a cheaper method of production has become possible than the traditional wood-based industry can accomplish. It is possible that within a decade only a small proportion (10—20 %) of high-quality furniture will be manufactured of timber, at least in industrialized countries with a deficiency of timber (cf. BP 1972, Jan. p. 54).

The involved situation that has arisen through the partial convergence of the plastics and the forest industries in the same field of production is indicated in Figure 1.

The only untried combination seems to be the obtaining of an interest in forest enterprises by plastics enterprises. Competition also occurs between different branches of the forest industry. Products earlier made of wood, for example, are changing to paperboard. Particularly within the panel industry such product competition is common (cf. OSARA 1972, p. 3).

The aim of the present investigation, therefore, is to illustrate conditions in the sphere of forestry and the forest industry in a typical importing land such as the UK against the

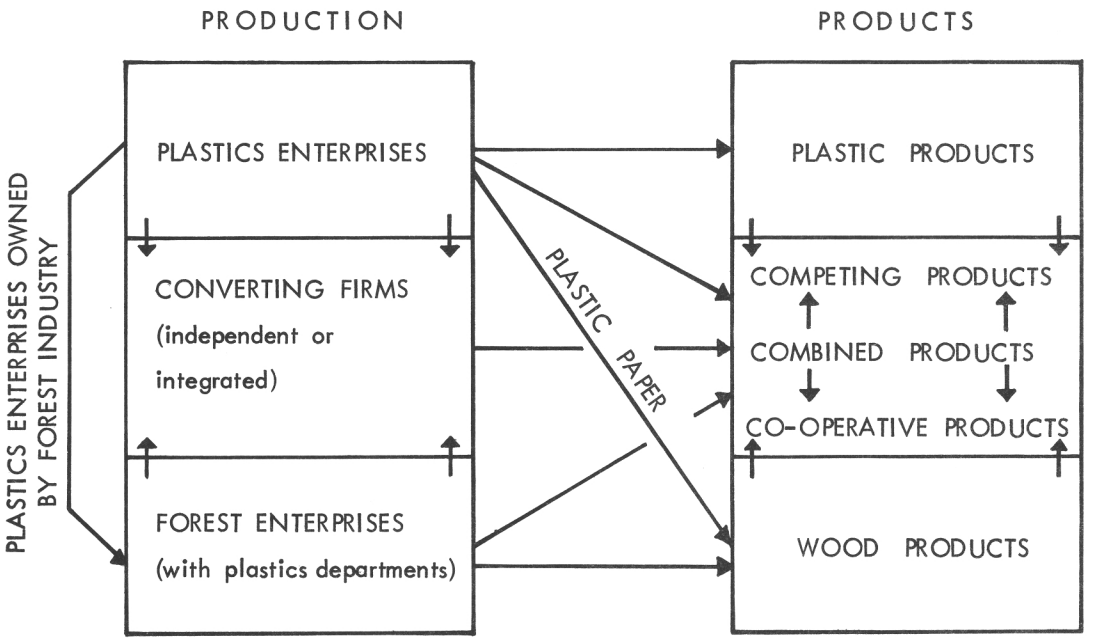

Figure 1. Interaction of plastic-based and wood-based production.
Kuva 1. Muovin ja puun tuotosten sekä tuotteiden keskinäinen vuorovaikutus.

background of the shortage of wood raw material and the progressing infiltration of plastics. Of particular interest are the endeavours at horizontal or vertical integration of the wood-processing industry with plastics enterprises. Emphasis is also laid on a detailed examination of the product development in these industries. An attempt is made on the basis of a thorough analysis of empirical material to appraise developments in the present decade and to assess the necessary adjustments in Finnish export trade with Great Britain.

12. Collection of material and terminology

The collection of material was undertaken primarily during a research visit made to the UK and France in spring 1972. With the assistance of the respective central organizations and not least the willingness of the industrial enterprises, a first survey could be made of the integration attempts of the forest and plastics industries. The new products which are not yet covered by official statistics can be given at least preliminary illumination from material received in reply to written enquiries sent to the main producers in the branch. A large number of interviews with leading people within the field of investigation were also carried out.

Terminology on the forest products side is in general well established, and only the following points need to be noted:

- Only metric tons are used if not otherwise indicated.
- The term panel products comprises plywood, particle board and fibreboard.
- In the UK wood particle board is also called chipboard.
- The paper industry includes both paper and paperboard manufacturing where not otherwise specified.

The border between paper and paperboard cannot be defined unequivocally. For customs purposes, all paper weighing more than 220 g/m^2 is regarded as paperboard in the UK. Within the packaging industry, however, cases are manufactured of a variety of lighter materials such as testliner and fluting, although the final product must be regarded as constituting paperboard cases. These products are termed in the UK fibreboard cases, which depending on the raw material used are divided into corrugated (fibreboard) cases and solid (fibreboard) cases. To avoid confusion with FAO's definition of fibreboard, i.e. hardboard and insulation board, the term *cardboard cases* will be used in this study.

Regarding statistics for the plastics field, it should be noted that national differences in classifications, etc., still exist. Plastic-based lacquers, glues and coating materials are treated in a variety of ways. Consumption figures may include raw materials semi-procressed in one country and used in another. An example of unconsciously distorted statistics is Finland's high per capita consumption of plastics, one-third of which consists of glue used in panel products which are chiefly exported.

Terminology in the plastics field has been touched on in an earlier connection (RUNEBERG 1967 p. 14), but the following guide lines can be added. Plastic foils are grouped in the following way according to thickness:

0.00–0.20 mm = film
0.20–0.50 mm = foil
0.50–2.00 mm = sheet

The commonest film thickness for particular packaging products are:

plastic sacks	0.20–0.25 mm
carrier-bags	0.05–0.06 mm
shrink film	0.01 mm

The manufacture of plastic paper and pulp is such a new branch of industry that a stable terminology for the various phases of production and for the products is not yet at hand. From a conceptual viewpoint, there is reason to take into consideration the fact that a large part of the plastic film that is extruded is used directly for products which were earlier manufactured solely of conventional paper, in particular bags and sacks. However, plastic paper can only be spoken of when the films is given paper-like properties through further processing. As far as the technology of production is concerned, it is easy to distinguish paper manufacture based on either plastic film or synthetic fibre (cf. RUNEBERG 1971 p. 9). The resulting products can, according to BRIDGE (1972 p. 17) be grouped in the following way:

1) Plastic films with paperlike properties
2) Foamed plastic papers
3) Synthetic fibre papers (including non-woven fabrics and spun-bond structures).

WOLPERT (1972 pp. 182 and 253) suggests a division into "plastic papers", (paper-like HDPE film) consisting of all film-based papers without any additional surface treatment, and "synthetic papers", for all film-based papers subjected to a "paperizing" process. Since such a division is likely to lead to confusion, the present study will use the terms outlined in the following.

The term *plastic* or *synthetic paper* is used to describe the whole field of paper manufactured from polymers. If plastic film without additional treatment is used for products made earlier from conventional paper, it still remains plastic film. To distinguish between production methods, it is logical to use the terms *plastic-film paper* and *plastic-fibre paper.* The only difference between plastic paper and synthetic paper is that synthetic suggests that other materials such as rubber could constitute the raw material, while in fact so far only plastics have been used. The expression synthetic wood pulp is an anachronism and should not be used, *synthetic pulp* being adequate.

The work of standardization in the plastics field in the UK has gone quite a long way, with about 200 published standard patterns, compared with only about 20 in Finland. Standardization obviously facilitates material utilization and statistical presentation.

The abreviations used in the present publication for different types of plastic agree with the International Standardization Committee's proposals, which can largely be considered as generally accepted. The abbreviations used are as follows:

EVA	=	ethylvinyl acetate
MF	=	melamine formaldehyde
PA	=	polyamide
PE	=	polyethylene – LD low density – HD high density
PF	=	phenol formaldehyde
PP	=	polypropylene
PS	=	polystyrene
PTFE	=	polytetrafluor ethylene
PUR	=	polyurethane
PVAC	=	polyvinyl acetate
PVAL	=	polyvinyl alcohol
PVC	=	polyvinyl chloride
PVCA	=	polyvinyl chloride acetate
PVDA	=	polyvinylidene chloride
UF	=	urea formaldehyde
GRP	=	reinforced plastics

The term "polyolefines" comprises PE, PP and their copolymers.

2. GENERAL SURVEY OF THE FOREST INDUSTRY IN THE UNITED KINGDOM AND TRADE IN FOREST PRODUCTS

21. Paper and paperboard industry

The international position of the United Kingdom among the world's paper-producing countries is presented graphically in Figure 2 (source: OECD 1971).

The UK falls in seventh place in world statistics and has about the same paper production, as for example, Finland and Sweden. In 1971 the industry comprised 183 mills operated by 125 companies situated in three main areas, the Scottish Lowlands, Yorkshire and south-east England. The home production is surprisingly large in view of the long-standing difficulties in the availability of raw materials. This factor has given the British paper industry certain special features, including a high degree of waste-paper recycling. Early specialization in various types of high-quality paper has also occurred. Similarly, a rapid development of special industrial paper can be observed, for example filter paper, electronic data-processing paper, self-copying paper, photographic paper, condenser and capacitor tissues, etc.

The per capita consumption of paper has expanded somewhat more slowly in the UK than in many other countries during the last decade, but nonetheless, as Table 1 shows, the UK came 1970 in forth place in world statistics (source: OECD 1971).

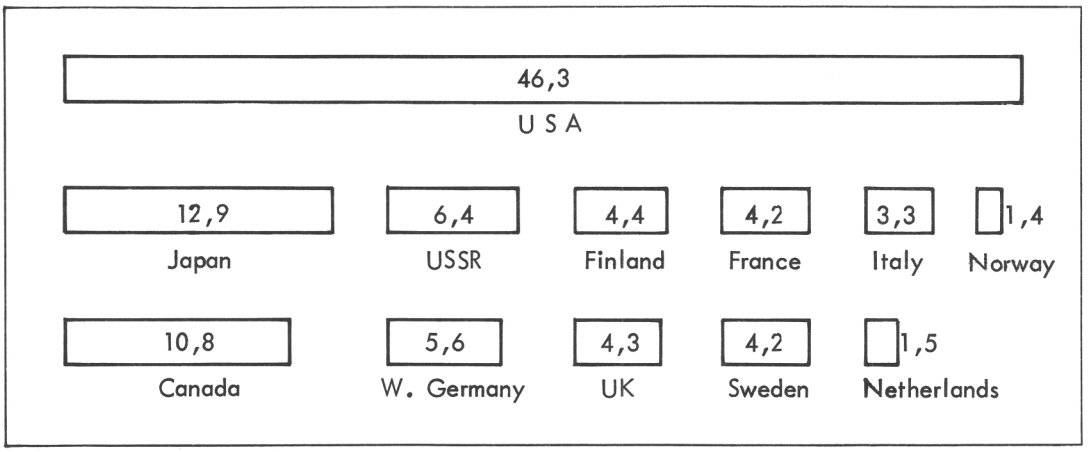

Fig. 2. Paper production in the most important countries, 1971, in million tons.
Kuva 2. Tärkeimpien maiden paperin tuotos v. 1971, milj. tonnia.

Table 1. Per capita consumption of paper and paperboard in selected countries, 1960 and 1970, in kg.
Taulukko 1. Eräiden maiden paperin ja kartongin kulutus henkeä kohti v. 1960 ja 1970, kg.

	1960	1970
USA	188	240
Sweden	120	191
Finland	74	144
UK	102	128
W.Germany	80	125
Japan	46	121
France	59	95
Portugal	12	25

Consumption in the UK has grown by only 26 kg per person, while in Sweden and Finland, for example, there has been an increase of 70 kg. The total production increase in the UK during the 1960s amounted to more than 800 000 tons, representing an average growth of 21 % during the last 10 years. The poor trade situation during 1971 led to a setback and the year's production dropped to 4.3 million tons. The distribution among different paper grades is presented in Figure 3 (source: BPBMA reference tables of paper statistics).

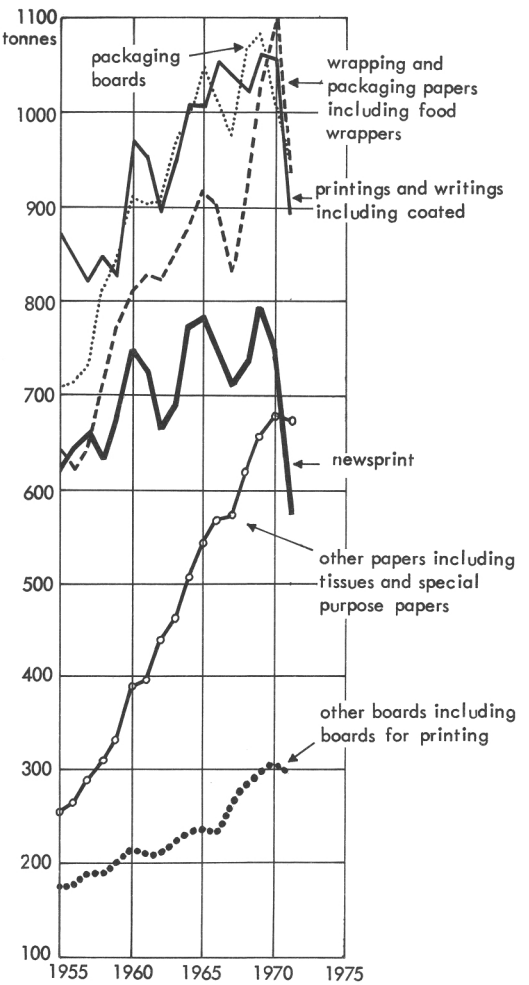

Fig. 3. Paper and paperboard production in the UK according to grades, 1955–71, in 1000 tons.
Kuva 3. Ison-Britannian paperin ja kartongin tuotos v. 1955–71, 1000 tonnia.

The total production in 1970 comprised 37 % newsprint and other printing and writing papers, 43 % wrapping and packaging papers and boards, and 20 % tissues and papers and boards for industrial and special purposes. The growth rate in the last group has been around 34 % during the last 10 years. On the other hand, newsprint production has virtually stagnated. The total production of the paper industry has been valued at £ 580 million.

The substantial home production, however, is insufficient to satisfy consumption, and c. 1/3 of the total used each year has to be imported. The growth of consumption and the share of imports is shown in Table 2 (source: BPBMA reference tables of paper statistics).

It can be seen that the share of imports has gradually increased in recent years, with a specially large jump in 1971. The largest imports consist of bulk grades such as newsprint, case-making materials (semi-chemical fluting and kraft liner) and grades for wrapping and packing. The total import rose in 1971 to 2 861 000 tons, valued at £ 228 million, and came mainly from the following 5 countries:

	1970	1971
Finland	656 000 tons	773 000 tons
Canada	684 000 "	647 000 "
Sweden	564 000 "	603 000 "
USA	270 000 "	269 000 "
Norway	188 000 "	194 000 "

Approximately 5 % of the paper production has been exported primarily to the EEC and the traditional Commonwealth markets of Australia and New Zealand as well as South Africa. The main export grades consist of high-quality printing and writing papers and industrial and special-purpose papers.

With regard to coated papers, a total of 14 companies with 22 mills are operating in this field. The number of coating machines in operation is 67, of which 53 are off-machine coaters. Since no official statistics are available for production from off-machine coaters, it is hard to review the total output, but if one takes as a starting point the production and import of the base paper used for these grades it can be estimated that Britain is the largest producer of off-machine coated paper in the world.

Table 2. Paper and paperboard consumption and imports in the UK 1960–71.
Taulukko 2. Ison-Britannian paperin ja kartongin kulutus ja tuonti v. 1960–71.

	Consumption *Kulutus*		% share of consumption *Osuus kulutuksesta %*				
					Of which imports from: *Josta tuonti:*		
	1000 tons *1000 tonnia*	Kgs per capita *Kg asukasta kohden*	Home Produced *Kotim. tuotos*	Imported *Tuonti*	Nordic Countries *Pohjois-maista*	Canada *Kanadasta*	Other Countries *Muista maista*
1960	5 312	101.4	73.1	26.9	10.3	9.9	6.7
1961	5 326	100.9	72.6	27.4	11.0	9.7	6.7
1962	5 319	99.8	71.3	28.7	11.5	11.0	6.2
1963	5 601	104.4	70.8	29.2	12.9	10.5	5.8
1964	6 097	112.9	69.4	30.6	13.9	9.9	6.8
1965	6 112	112.4	71.8	28.2	13.3	8.6	6.3
1966	6 281	114.9	69.9	30.1	15.6	8.8	5.7
1967	6 371	115.9	67.4	32.6	17.4	9.2	6.0
1968	6 753	122.1	66.4	33.6	17.9	9.4	6.3
1969	7 125	128.3	66.1	33.9	18.2	9.6	6.1
1970	7 179	128.8	65.1	34.9	19.6	9.5	5.8
1971	6 754	121.6	60.8	39.2	23.2	9.6	6.4

If one includes all mills engaged in china-clay coating of printing papers and boards, including NCR (no carbon required) coating the production apparently reached 250 000 tons in 1970. The types of coated papers produced vary over a broad range. Grades range from mechanical-based printing paper to woodfree and esparto-based arts and chromos, from one-side coated label papers to two-side cast coated boards.

The difficulties of surveying the consumption of plastics within the coated-paper branch are also considerable, as the main use takes place at converting factories. According to Table 16, the consumption of coated substrates in 1971 was 23 500 tons, which should include the consumption of plastics on the extruder side. Within the paper industry, only the following 5 enterprises carry on this type of production:

Bowater Packaging Ltd	Gillingham, Kent
Clyde Ltd	Garstang, Lancashire
J.R.Crompton + Bros Ltd	Bury, Lancashire
Dickinson Robinson Ltd	Bristol
St.Anne's Board Mill Co.Ltd	Bristol

Clyde Ltd ended production of paper and board in 1971 and now concentrates entirely on extrusion. In addition, there exist 8 converting packaging firms. LDPE is the main material used in this field. The following quantities of plastic have been used in recent years:

1965	5 215 tons
1969	6 765 "
1970	7 235 "
1971	7 760 "

This would indicate an annual production of 50 000–60 000 tons of plastic-coated paper and paperboard during the last few years, presupposing that the share of plastics is about 15 %. The figures include the share of plastic (in 1971 about 800 tons) in imported coated paper from Scandinavia. A small part, c. 500 tons annually, of the quantities mentioned consist of HDPE. The position in 1971 was that 37 % of the market was met by companies whose main business is paper and 63 % by packaging firms. For comparison, it can be mentioned that the Finnish paper industry used in 1971 in this sphere 16 800 tons of plastic, distributed among 4 firms and 8 installations. The 13 UK enterprises account for altogether 20 installations, which suggests that this relatively new branch of production has also become split into too small production units.

Besides the direct import of ready paper products, the UK must sustain a large import of wood pulp to supply the home industry. Table 3 illustrates the development of this during the 1960s, as well as showing other imported raw materials for paper manufacture (source: BPBMA reference tables of paper statistics).

Table 3. Mills' consumption of imported pulp in the UK 1961–71, in 1000 tons.
Taulukko 3. Ison-Britannian paperitehtaiden tuontimassan kulutus v. 1961–71, 1000 tonnia.

Year *Vuosi*	Chemical and semi-chemical *Kemiallinen ja puolikemiallinen*	Mechanical *Mekaaninen*	Total wood pulp *Puumassa yht.*	Esparto pulp *Esparto-massa*	Esparto grass *Esparto-ruoho*	Rags, waste, ropes etc. *Rievut, köydet jne.*
1961	1 607	699	2 306	n.a. [1]	214	126
1962	1 612	646	2 258	16	192	121
1963	1 694	665	2 359	30	181	114
1964	1 790	748	2 538	24	159	112
1965	1 869	764	2 633	26	136	107
1966	1 812	729	2 541	31	102	96
1967	1 772	708	2 480	27	71	87
1968	1 862	669	2 531	29	57	80
1969	1 960	657	2 616	27	44	71
1970	1 933	607	2 540	24	26	62
1971	1 680	464	2 144	19	19	58

1) not available

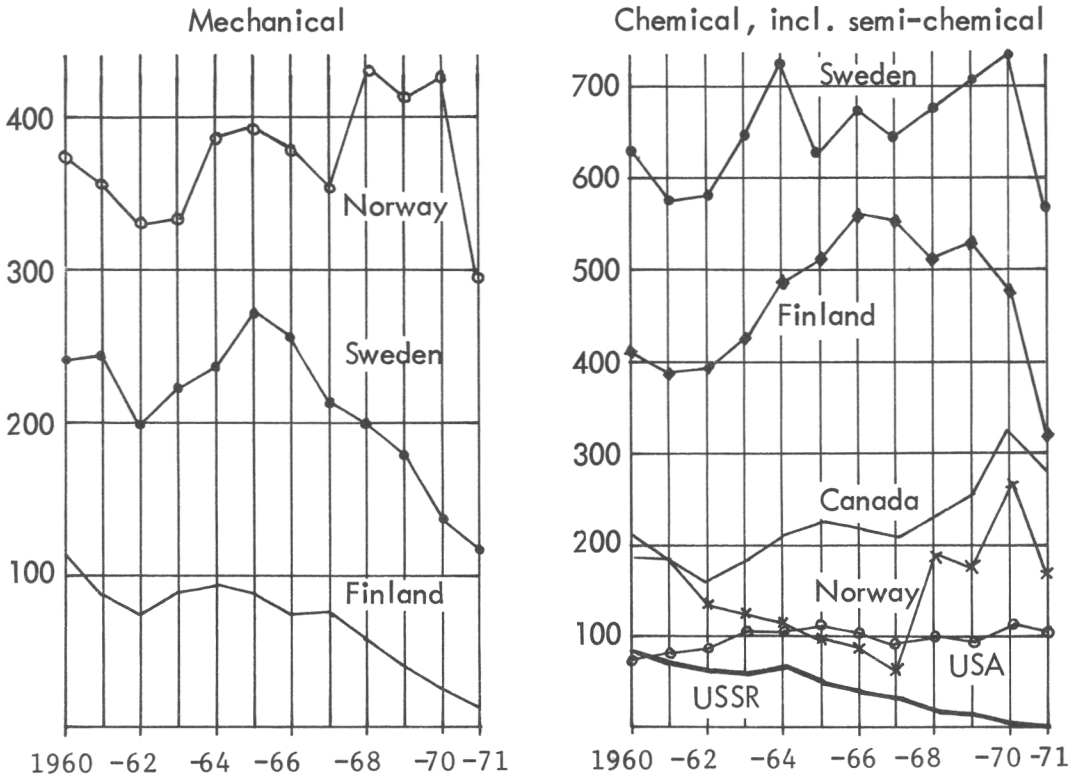

Fig. 4. Imports of wood pulp to the UK from chief countries of supply, 1960–71, in 1000 tons.
Kuva 4. Ison-Britannian puumassan tuonti tärkeimmistä maista v. 1960–71, 1000 tonnia.

The import of wood pulp has been around 2.5 million tons annually, and the share of chemical pulp has remained at about 75 %. The import of other raw materials, however, has declined considerably during recent years, primarily because of rising prices for these materials. The distribution of wood-pulp imports according to the main countries of supply is shown in Figure 4.

It can be seen that the Scandinavian countries have an important position in this contex. Their combined deliveries of chemical pulp rose in 1970 to 1.5 million tons, or 62 % of the total. Canada and the USA have, however, expanded their sales to the UK market in recent years. As far as mechanical pulp is concerned, Norway is a present the only considerable supplier, while the Finnish share has declined to practically nil. It can be noted that the total value of wood-pulp imports in 1970 amounted to £ 167 million. The figures for 1971 give a somewhat distorted picture of development due to the poor business cycle.

In addition to wood-pulp imports, home production of wood pulp is carried on at 5 integrated paper mills. These use a high percentage (c. 70 %) of home-grown timber, both hardwood and softwood. With the help of imported pulpwood, home production of wood pulp is about a half million tons annually.

Profitability in the British paper industry has shown a steady worsening during the last decade. There is no doubt that a contributory factor has been the EFTA agreements, with the consequent duty-free imports from the Scandinavian countries. However, the real reason is to be found in the structure of the British paper industry. Thus in 1969 there were some 570 paper machines in Britain, compared with some 100 in Finland producting the same amount of paper. While it is true that 15 large companies with about 90 mills accounted for

over 80 % of the total production of paper and board, it means that the mean production of several hundred machines is only a few thousand tons a year. Practically no new capital investments have been made in recent years for the rationalization and enlargement of production units, with the result that the industry is becoming hopelessly outdated. The only conversions that have taken place have been former newsprint mills which have been converted to produce waste-paper fluting and liner. The catastrophic consequences of the lack of investment was particularly evident during the recession of 1971, when no less than 55 paper machines, involving 10 mills, ended production.

The structure of the British paper industry and its heavy dependence on imported raw materials should make it especially responsive to new ideas in respect of both grades and the raw-material base. It appears, however, that the initiative regarding the development of plastic-paper production lies at present entirely in the hands of plastics enterprises. Since the future of plastic paper is clearly a question of probably decisive importance for forest products, this will be dealt with fully later.

22. Panel industry

The main groups of panel products are plywood (including blockboard), particle board and fibreboard. In addition, a special quality of particle board is flaxboard, which has a limited but important area of use in the construction industry. Plywood, blockboard and fibreboard stand in marked contrast to paper products in that home production in the UK is insignificant compared with imports. A general survey of these products must therefore concentrate on import and end-use statistics. Table 4 shows the production and import quantities for panel products during the 1960s (source: Yearbook of Forest Products Statistics and Timber Bulletin for Europe).

Table 4. Production and imports of plywood, veneer sheets, particle board and fibreboard in the UK, 1961–1971.
Taulukko 4. Ison-Britannian vanerin, viilujen, lastulevyjen ja kuitulevyjen tuotos ja tuonti v. 1961–71.

	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971
	Production – *Tuotos*										
Plywood (including blockboard) 1000 m^3 *Vaneri (ja rimalevy) 1000^3*	41	37	35	39	44	38	33	31	29	28	28
Particle board 1000 tons *Lastulevy 1000 tonnia*	50	74	92	126	150	165	150	183	193	183	160
Fibreboard – *Kuitulevy*											
Compressed 1000 tons *Kova 1000 tonnia*	34	25	22	37	39	30	20	20	21	20	16
Non-compressed 1000 tons *Huokoinen 1000 tonnia*	36	36	32	36	38	29	17	17	18	18	15
	Imports – *Tuonti*										
Plywood 1000 m^3 *Vaneri 1000 m^3*	574	673	701	863	859	774	1001	1075	955	1096	971
Veneer sheets 1000 m^3 *Viilut 1000 m^3*	28	22	26	31	32	30	39	44	41	41	40
Particle board 1000 tons *Lastulevy 1000 tonnia*	26	38	45	58	81	92	138	246	224	262	374
Fibreboard 1000 tons *Kuitulevy 1000 tonnia*	209	234	254	275	250	223	290	290	268	289	273

The total value of imports has now (1972) risen to over £ 100 million annually. The per capita consumption of all wood-based panels on average during 1968–70 was 0.04 m^3, and showed a growth of 82 % during the 1960s. This was still the lowest growth rate in Europe. West Germany and France, for instance, showed figures of 284 % and 150 % respectively.

221. Plywood and blockboard

Home production of plywood has gradually fallen during the 1960s an appears to be stagnating around 30 000 m^3, divided between two factories. Imports, on the other hand, have risen on average during the last 10 years by 4.5 % a year. However, the import trend during this period shows a discernable weakening, indicated by the following figures:

Annual average	Quantity in 1000 m^3	% change over previous average
1959–61	567.4	+ 59.9
1964–66	831.8	+ 46.6
1969–71	1007.3	+ 21.1

The rate of expansion has thus fallen from 60 % to 21 % during the last decade. Imports from the five most important countries is presented below (source: TTF yearbooks of timber statistics):

	1970	1971
Finland	322 000 m^3	291 000 m^3
Canada	276 000 "	206 000 "
USSR	109 000 "	97 000 "
Malaysia	62 000 "	63 000 "
Israel	34 000 "	30 000 "

Beginning in 1963, the statistics published by the Timber Trade Federation have included a separate column for plywood and blockboard containing material other than wood and bonding material. Imports in this category have developed in the following way:

1963	4 200 m^3	1968	10 000 m^3
1964	4 700 "	1969	12 100 "
1965	4 500 "	1970	19 200 "
1966	2 800 "	1971	34 200 "
1967	4 300 "		

These figures obviously mainly include plywood with plastic coating, but since other materials such as minerals and metals are also combined with plywood, it is not possible to make a more exact analysis. Significantly, however, this group showed a growth rate of 80 % in 1971, despite the fact that imports as a whole fell. Since customs duties on the import of this group of boards from countries outside EFTA decreased

Table 5. Plywood and blockboard consumption according to end-use in the UK, 1968, in 1000 m^3.
Taulukko 5. Ison-Britannian vanerin ja rimalevyn kulutus v. 1968 loppukäyttöryhmittäin, 1000 m^3.

	1000 m^3	%
Construction – *Rakennustyö*	344.1	32.0
Joinery – *Puusepäntyö*	105.4	9.8
Repair and maintenance – *Korjaus ja kunnossapito*	18.3	1.7
Shopfitting – *Myymälänsisustukset*	39.8	3.7
Flush doors – *Ovet*	34.4	3.2
(All construction sectors – *Rakennusala yhteensä*	542.0	50.4)
Huonekalut – *Furniture*	175.2	16.3
Packing – *Pakkaus*	75.3	7.0
Vehicles – *Kulkuneuvot*	94.6	8.8
Ship and boatbuilding – *Laivan- ja veneenrakennus*	22.5	2.1
Displays – *Näyttelyt*	12.9	1.2
Mould and pattern makers – *Muottien ja mallien teko*	5.4	0.5
Toys – *Leikkikalut*	7.5	0.7
Railways – *Rautatiet*	16.1	1.5
Do-it-yourself – *Tee-se-itse-artikkelit*	62.4	5.8
Others – *Muut*	61.3	5.7
Total – *Yhteensä*	1075.2	100.0

by half to its present level of 10 %, Japan has particularly succeeded in pushing into the market. Traditionally, imported boards are treated for decorative and panelling purposes after they have arrived in the UK.

Table 5 shows the end-use consumption of plywood according to an investigation made by the University College of North Wales at Bangor in 1968. This investigation analysed about 60 % of all plywood used in the UK and should thus give a reliable picture (Shea 1972 b).

The distribution of imports in 1968 according to wood types was as follows: 41 % temperate hardwoods, 31 % softwoods, 14 % West African species and 7 % Far Eastern species. In recent years, a minor change to direct sales from shipper to end-user has occured. All in all, developments since the investigation of 1968 have led to changes of scarcely more than 5 %, and the 1968 figures can hence be used as a basis for assessing the present-day situation (cf. SHEA 1972 p. 45).

Table 5 indicates that the most important end uses are in general construction, furniture, vehicles and packaging. If the whole of the construction sector is included, these uses account for more than 82 % of the total consumption. The uses in general construction are examined in detail in Table 6 (SHEA 1972 b).

The construction market as a whole is dominated by Finnish birch and Douglas fir, which account for c. 75 % of all plywood and blockboard consumed in this sector. It is significant that more than 65 % by volume of the boards used were more than 16 mm thick. This brings out the importance of shuttering, which accounts for 55 % of the total general-construction market. Large firms employing more than 100 people use over 80 % of their plywood for shuttering, while small firms (with less than 10 employees) use only 10 %. The main part of the plywood consumed by small firms is used for build-in fitments, partitions and claddings. Two-thirds of the volume of all work done in the construction industry is undertaken by builders with more than 100 employees and thus shuttering accounts for a considerable part of plywood consumption. This market is unlikely to face any significant competition from plastic materials, except indirectly if whole plastic houses win ground.

Table 6. Applications of plywood in the construction industry in the UK, 1969.
Taulukko 6. Ison-Britannian vanerin käyttö rakennusteollisuudessa v. 1969.

	% of total plywood consumed *% koko vanerin kulutuksesta*	Main material used *Tärkein raaka-aine*
Built-in fitments – *Kiinteät kalusteet*	16.9	Finnish birch West African
Partitioning and cladding – *Väliseinät ja vuoraus*	11.0	West African Finnish birch
Flooring – *Lattiat*	4.5	Douglas fir Finnish birch
Roofing – *Katot*	2.2	Douglas fir Finnish birch
Site usage – *Rakennusalueen käyttö*	3.9	Douglas fir
Shuttering (Concrete formwork) – *Suojaukset (Betonimuotit)*	55.4	Douglas fir Finnish birch Malaysian
Hoardings – *Rakennustelineet*	5.8	Douglas fir
Doors – *Ovet*	0.3	West African Lauan
Total – *Yhteensä* (344 100 m^3)	100.0	

Furniture continues to be the next most important use for plywood. Smaller firms generally use more plywood than bigger firms, which consume more particle board. Manufacturers of upholstered furniture use plywood for arms, sides, front facings, backs and seats. The whole of this sphere of use is in the danger zone, depending on how the production of moulded plastic chair shells develops. Developments in this field have occurred mainly in the last 5 years. However, chair manufacture has used primarily plywood from the USA and Canada, so that a worsening of the market for this item, at least, will not affect Finnish plywood exports. The total use of plastic in the furniture branch amounted in 1971 to 47 000 tons (cf. Table 18), which can be estimated to be equivalent to c. 72 000 m^3 or about 40 % of the total plywood used in furniture.

Cabinet makers use a considerable amount of plywood from temperate hardwood species, in particular birch and beech for carcass backs and sides, for drawer bottoms and sides and for doors. Here, competition with both particle board and plastic can be expected. Furniture makers for schools, hospitals, etc. use at present a great deal of plywood because of conservatism, but one can expect this field to become dominated by plastic at a later stage.

The furniture industry continues for the moment to be interested primarily in interior plywood, but as the price differential of exterior in relation to interior grades falls exterior grades can be expected to increase. At present, the percentage uses are 81 % interior and 19 % exterior. The thickness of the boards used naturally varies within wide limits, but more than 80 % is thicker than 13 mm.

Within the third important consumption group, vehiclebody building, the manufacture of caravans is a major component. In addition, plywood is used in the non-caravan sector for floors, fascias, door-linings and supporting panels. This market is dominated by Douglas fir.

No less than 82 517 caravans were produced in 1970, of which 67 % were tourers. Of the total, 50 % were exported, especially to the EEC countries. A further growth of production can thus be expected as a result of the UK's entry into the EEC.

Closely related to the vehicle-body group is the building of containers, in which glass-fibre-strengthened boards are breaking through as an important building material (cf. HALL 1971). In 1971, 2500 tons of polyester resin were consumed in this branch.

Packaging continues to take 7 % of the total plywood used, but an increase in this sector is unlikely in view of the attempts to find better packaging materials. Plywood can only be expected to retain its position in the packaging of heavy engineering components.

222. Particle board and fibreboard

The particle board market in the UK is in a state of rapid development, as in most

Table 7. Consumption of particle board (all grades), 1960–71, in the UK in 1000 tons.
Taulukko 7. Ison-Britannian lastulevyjen (kaikki laadut) kulutus v. 1960–71, 1000 tonnia.

Vear *Vuosi*	Imported *Tuonti*	Home produced *Kotim.tuotos*	Total *Yhteensä*	% share of imported *Osuus tuonnista %*
1960	34.4	33.2	67.6	50.9
1961	26.1	50.7	76.8	34.0
1962	37.0	70.0	106.9	34.6
1963	44.5	90.2	134.8	33.0
1964	66.8	121.6	188.4	35.5
1965	82.5	140.5	223.0	37.0
1966	90.5	149.1	239.6	37.8
1967	135.7	162.8	298.4	45.5
1968	225.4	175.9	401.3	56.2
1969	204.9	172.7	377.6	54.3
1970	239.8	193.2	433.0	55.4
1971	374.4	170.7	545.1	68.7

industrialized countries. Qualitative improvements in the product have undoubtedly been brought about by the introduction of plastic glues, and at the same time the product has succeeded in maintaining a relatively low price. A considerable home industry was built up during the 1960s, but imports have grown even faster and since 1968 overtaken home production. This is now divided among 6 companies, of which one large company accounts for 75 % and one medium one for 10 % of the production. Two of the factories are situated in Scotland. Table 7 illustrates the development of consumption (source: TTF yearbooks of timber statistics).

The particle board used in the UK was still a few years ago only 1/3 of the equivalent per capita consumption in, for example, West Germany, France or Italy. During the most recent years, this difference has begun to disappear, as the following comparisons of imports indicate:

Annual average	Quantity in 1000 tons	% change over previous average
1960–63	22.4	n.a.
1964–67	58.7	+ 162
1968–71	201.7	+ 243

These comparisons only concern imports of wood particle boards, imports of other grades being of minor importance. If this rate of growth continues, the UK's consumption will gradually reach the level of other European countries.

The shares of the five main exporting countries in particle-board imports to the UK are presented below:

	1970	1971
Finland	69 300 tons	99 200 tons
Sweden	19 100 "	37 900 "
Norway	17 000 "	31 200 "
Portugal	15 400 "	30 600 "
Irish Republic	23 500 "	34 700 "

Statistics of imported surface-treated particle board are not available.

It can be mentioned that the UK is the world's largest importer of particle board. A total of 97 firms deal in imports of this product, with 60 % of the business in the hands of only 10 firms. About 10 % of the imports go direct to the veneering and plastic-laminating industry. Statistics of end-use are presented in Table 8 (RAO & RICHARDSON 1972 a).

Table 8. Wood particle board consumption in the UK according to end-use, 1970, in tons.
Taulukko 8. Ison-Britannian puusta valmistettujen lastulevyjen kulutus v. 1970, loppukäyttöryhmittäin, tonnia.

	tons – *tonnia*	%
Construction – *Rakennustyö*	137 700	36.9
Joinery manufacture [1] – *Puusepäntyö*	7 300	2.0
Furniture – *Huonekalut*	156 300	41.9
Shopfitting – *Myymälänsisustus*	15 600	4.2
Caravans – *Asuntovaunut*	7 500	2.0
Coffins – *Ruumisarkut*	9 400	2.5
Packaging – *Pakkaus*	3 500	0.9
Shipbuilding – *Laivanrakennus*	1 000	0.3
Audio-visual equipment [2] – *Audio-visuaaliset laitteet*	6 100	1.6
Exhibition and display – *Näyttelyt*	4 000	1.1
Do-it-yourself sales – *Tee-se-itse-myynti*	20 300	5.5
Other uses [3] – *Muu käyttö*	4 200	1.1
Total – *Yhteensä*	373 000	100.0

Notes:
1) Includes wood particle board directed to manufactures of joinery items such as toilet cubicles, doors, prefabricated partitions etc.
2) Includes cabinets for radiograms, record players, television sets, etc.
3) Includes shuttering grade particle board of 800 tons.

Table 9. Consumption of wood particle board in the UK by thickness and grade, 1970.
Taulukko 9. Ison-Britannian puusta valmistettujen lastulevyjen kulutus v. 1970 läpimitta- ja laatuluokittain.

Thickness in mm *Paksuus mm*	Volume tons *Määrä tonnia*	% of total *% kokonaismäärästä*	Grade *Laatu*	Volume tons *Määrä tonnia*	% of total *% kokonaismäärästä*
Less than *Alle* 12	12 200	3.3	Flooring – *Lattia*	64 900	17.4
12	51 000	13.7	Standard – *Standardi*	241 000	64.6
15	98 000	26.3	Painting – *Maalattu*	22 000	5.9
18	187 800	50.3	Veneered – *Viilutettu*	37 700	10.2
22	5 500	1.5	Melamine – *Melamiinipäällysteinen*	1 874	0.5
Over 22 *Yli*	18 500	4.9	Fire retardant – *Palosuojattu*	3 835	1.0
			Marine – *Laivanrakennus*	863	0.2
			Exterior & shuttering – *Ulkokäyttö ja suojaukset*	828	0.2
Total – *Yhteensä*	373 000	100.0	Total – *Yhteensä*	373 000	100.0

It can be seen that the furniture and construction industries are the largest consumers. This is helped by the product's favourable price development in relation to both sawnwood and plywood (cf. Table 35). Other contributory factors have been the growing assortment of decorative veneers and laminates available and the introduction of machine-finished melamine boards. More will be said on this question in the context of the product and price analysis in Chapter 4 and 5.

Table 9 gives a picture of the distribution of total consumption according to thickness and grade (source: RAO & RICHARDSON 1972 a).
Board thickness varies, but it can be seen that the thickness range 15–18 mm covers 76.6 % of total consumption. A certain trend towards thinner boards has been observable recently, for example in the kitchen-cabinet industry. Not surprisingly, the standard grade dominates, with 65 % of the total market.

With regard to end use, the construction industry consumes in first place flooring grade (43.5 %), followed by standard grade in second place (33.4 %) and veneered and laminated grade in third place (15.2 %). Consumption in the shop-fitting branch is of special interest in that up to now it has consisted entirely of veneered or plastic laminated grades. Particle board has here replaced blockboard.

Other areas of use for particle board include coffin manufacture, do-it-yourself sales, the caravan industry, the manufacture of radio and television cabinets, etc. In several of these areas, considerable infiltration by plastics has occurred.

Alongside wood particle board has grown a certain use of flaxboard. This product is entirely imported, home production being non-existent. Imports have expanded from 15 200 tons in 1960 to 58 200 tons in 1971, although the increase has fallen off in recent years. This appears to be due primarily to the inability of the exporting countries to expand this industry because of a lack of raw materials. Belgium supplies 76 % of the imports. It is probable that wood particle board will continue to expand at the expense of flaxboard. The flaxboard used in construction (41.5 %) is generally faced with various surface materials, including plastic laminates, and offers therefore a limited market for co-operative products.

Among the panel products, the use of fibreboard in the UK is not at the present time especially marked for a growing market, as Table 10 indicates (source: TTF yearbooks of timber statistics).

Table 10. Imports of fibreboard into the UK, 1960–71, in 1000 tons.
Taulukko 10. Ison-Britannian kuitulevyjen tuonti v. 1960–71, 1000 tonnia.

	Insulation board *Eristyslevy*	Hardboard *Kovalevy*	Other *Muut*	Total *Yhteensä*
1960	21.7	184.7	3.4	209.7
1961	25.6	180.9	4.7	211.1
1962	28.0	202.3	2.1	232.4
1963	30.7	219.7	3.2	253.6
1964	39.8	230.9	5.7	276.5
1965	45.0	200.6	4.4	250.1
1966	33.1	185.7	5.4	224.2
1967	49.1	236.6	6.9	292.6
1968	48.6	236.4	5.6	290.5
1969	45.2	215.5	3.2	264.0
1970	46.7	335.2	2.5	284.2
1971	46.1	223.3	3.6	272.9

It can be seen that hardboard is the most important grade, but that imports as a whole remained more or less stagnant for the last 5 years. Mean comparisons give the following growth-rate figures:

Annual average	Quantity in 1000 tons	% change over previous average
1960–63	226.7	n.a.
1964–67	260.9	+ 15.1
1968–71	277.9	+ 6.5

To this must be added home production, which has declined from c. 70 000 tons in the mid-1960s to 32 000 tons in 1971. Production is undertaken by three enterprises, of which two manufacture hardboard and the third insulation board.

The main import suppliers are as follows:

	1970	1971
Sweden	126 100 tons	118 300 tons
Finland	47 200 "	48 100 "
Rep.S.Africa	20 400 "	28 800 "
Norway	20 600 "	23 900 "
Irish Republic	12 600 "	12 900 "

The main part of the imports come from EFTA countries, an 18 % customs duty applying on non-preferential consignments.

23. Sawnwood and wood-plastic composite

No substantial production of sawnwood has been able to be maintained in the UK, since a large part of the country's forests were devastated during the 17th century. Requirements are covered by a considerable import, which in the 1960s amounted to around 10 million m^3 annually. The situation is presented in Table 11 (source: Yearbook of Forest Products Statistics and Timber Bulletin for Europe).

Per capita consumption based on mean figures for 1968–70 was 0.18 m^3, indicating a 2 % growth compared with 1959–61. During the 1960s, many European countries showed a decline in per capita consumption of sawnwood, for instance Finland with a 16.6 % decline.

Imports are dominated by coniferous softwood, in which Swedish and Finnish suppliers hold an important position as the following figures for the 5 main suppliers show:

	1970	1971
	1000 m^3	1000 m^3
Sweden	1 873	2 299
Finland	1 666	1 893
USSR	1 726	1 571
Canada	1 463	1 100
Poland	489	391

Table 11. Production and import of sawnwood, including boxboards, in the UK, 1961–71, in 1000 m^3.
Taulukko 11. Ison-Britannian sahatavaran (mukaanluettuna laatikkolaudat) tuonti v. 1961–71, 1000 m^3.

Year *Vuosi*	Production – *Tuotos*			Imports – *Tuonti*		
	Coniferous *Havupuu*	Non-conif. *Lehtipuu*	Total *Yhteensä*	Coniferous *Havupuu*	Non-conif. *Lehtipuu*	Total *Yhteensä*
1961	217	764	981	7 611	843	8 454
1962	193	674	867	7 304	703	8 007
1963	208	667	875	7 935	790	8 725
1964	266	729	995	9 480	946	10 426
1965	250	666	916	8 991	946	9 937
1966	238	618	856	7 933	821	8 754
1967	246	555	801	8 435	803	9 238
1968	274	586	860	9 180	918	10 098
1969	294	573	867	7 814	772	8 586
1970	309	513	822	8 008	804	8 812
1971	310	535	845	8 098	746	8 844

Three year mean comparisons give the following picture of the development of imports:

Annual average	Sawn and planed 1000 m^3
1960–63	7 838
1964–67	8 711
1968–71	8 274

The peak consumption in the mid-1960s has changed to a downward trend. An end-use analysis of imported sawn softwood is provided in Table 12 (source: RIDDINGTON et al. 1971).

Construction and joinery account for 84 % of the consumption. Sawnwood thus has an extremely strong position, despite the continuing relative reduction in the use of timber in house-building. Direct competition with plastic products occurs more in the less important areas of use such as furniture and boat-building. Pallets, packaging and containers are relatively important and constitute an area in which the use of timber in the near future could diminish greatly.

An area of co-operation between sawnwood and plastics has grown up through wood-plastic composite products. The impregnation of timber with plastic monomer has taken place in the UK at least since 1967. This operation has been undertaken by the United Kingdom Atomic Energy Authority at the Wantage Research Laboratory. A number of minor products, such as wooden-handled cutlery,

Table 12. Imported sawn softwood consumption in the UK, 1968, according to end-use in 1000 m^3.
Taulukko 12. Ison-Britannian havusahatavaran tuonti v. 1968 loppukäyttöryhmittäin, 1000 m^3.

	1000 m^3 – *1000 m^3*	% of total *% kokonaismäärästä*
Construction – *Rakennustyö*	6 436	71.4
Joinery – *Puusepäntyö*	1 131	12.5
Ship/boatbuilding – *Laivan/veneenrakennus*	43	0.5
Cars/vehicles – *Autot/kulkuneuvot*	73	0.8
Furniture – *Huonekalut*	269	3.0
Portable buildings – *Siirrettävät rakennukset*	170	1.9
Palettes, packaging and containers – *Lavat, pakkaus ja kontit*	723	8.0
Other uses – *Muu käyttö*	176	2.0
Total – *Yhteensä*	9 021	100.0

toilet brushes and drum sticks, have come on to the market. Recently, this material, called Curifax wood, has been used for wood-plastic walkways at a new chloride plant of B.P. Chemicals International, the material being employed for its chemical-resisting properties (cf. Timber and Plywood 1972 4.10.).

The considerable potential market for wood-plastic flooring has, however, not so far been greatly exploited. This is probably a consequence of the UK's well-developed import of hardwood, which offers suitable and sufficiently hard types of wood for parquet flooring. The wood-processing industry has also had few possibilities to include polymer chemistry in their research programmes. A contributing circumstance may have been the unstable market conditions as new floor coverings, e.g. mats, have come on to the market. In view of the considerable production of wood-plastic flooring which has developed in the USA and Japan, for example, it is clear that British flooring requirements offer a potential market. The most important use is in public building such as (cf. TAMMELA–PINOMAA 1972 p. 2):

Airport buildings	Offices
School corridors	Exhibition halls and galleries
Concert halls	Dancing halls
Department stores	Pubs and coffee bars

On the basis of an earlier estimate of a theoretical market of 100 000 m^2 per million inhabitants (RUNEBERG 1971 p. 11), the UK has a possible market of nearly 6 million m^2. If the average thickness of plastic-impregnated parquet is estimated at 5 mm, this would be approaching a total requirement of 30 000 m^3, valued at £ 200/m^3. With an average weight of 1150 kg per m^3, plastic's share (50 %) would amount to 17 250 tons.

3. GENERAL SURVEY OF THE PLASTICS INDUSTRY IN THE UNITED KINGDOM

31. Raw-material producers and total production

Before a detailed examination of conditions in the UK is made, some general background information will be given. As far as world production of plastics is concerned, about 80 % continues to be concentrated in the 7 countries shown in Table 13 (source: Kunststoffmitteilungen 1972 no. 7).

Table 13. Production and consumption of plastics in selected countries, 1971.
Taulukko 13. Eräiden maiden muovin tuotos ja kulutus v. 1971.

	Production 1000 tons *Tuotos 1000 tonnia*	Consumption kg/person *Kulutus kg/henkilö*
USA	9 560	42
Japan	5 200	42
W.Germany	4 800	54
USSR	1 840	7
Italy	1 750	29
France	1 680	29
UK	1 580	24

As can be seen, the UK is included in the list, but during the last 5 years it has dropped two places. Furthermore, Japan and West Germany have changed places in recent years. Per capita consumption, however, is greatest in West Germany, with Sweden in second place. In the UK, on the other hand, consumption is so far relatively small, perhaps partly due to the British people's traditional conservatism. It can be seen that the plastics industry in Europe is well developed, with four of the world's seven largest producers. The graph in Figure 5 shows total world output and how West European production has overtaken production in the USA during the 1960s.

The various types and properties of the plastics which have infiltrated wood industries have

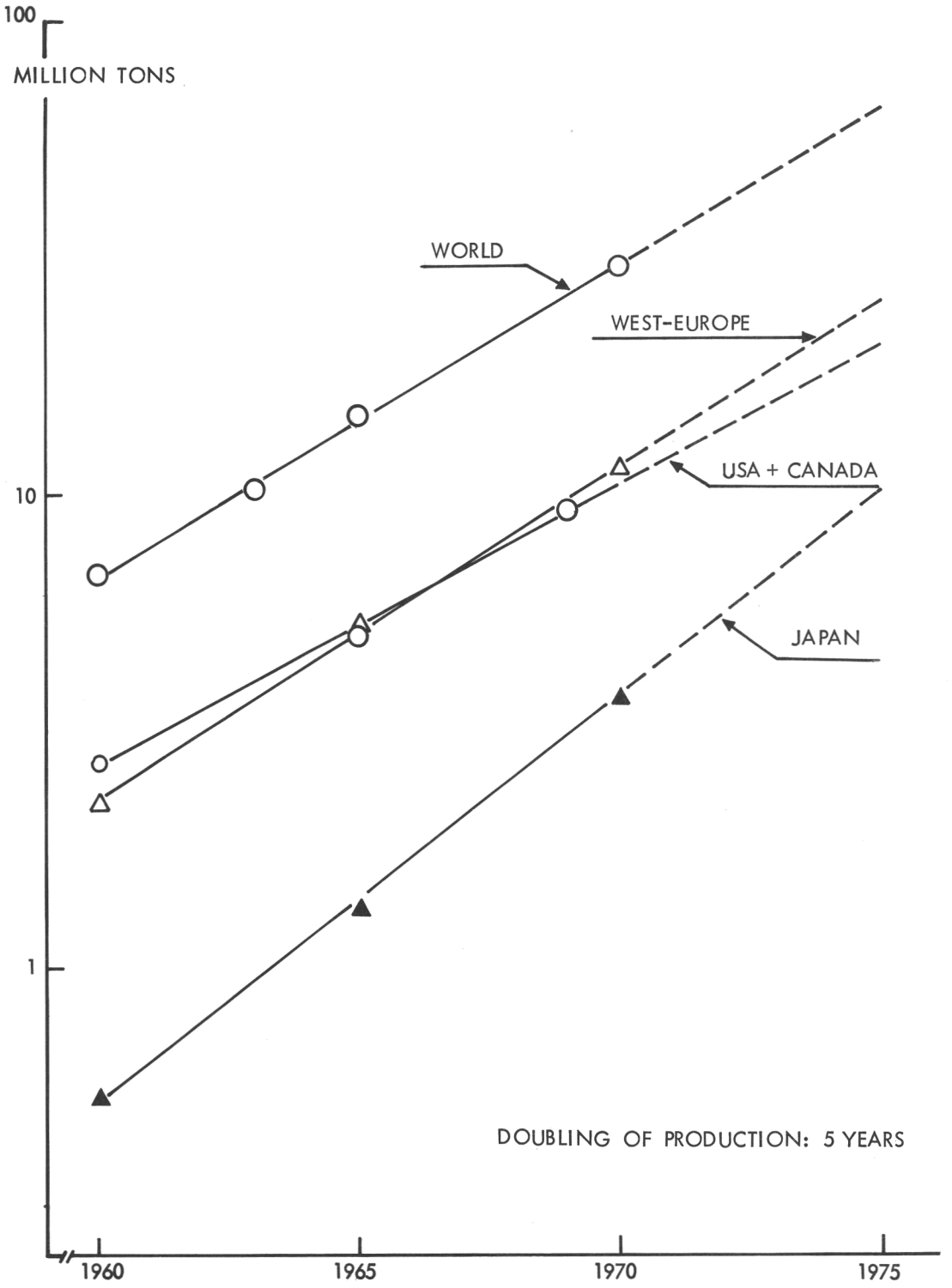

Fig. 5. World production of plastics in the main countries and trading blocks, 1960–71, in million tons.

Kuva 5. Maailman muovin tuotos tärkeimmissä maissa ja kaupparyhmittymissä v. 1960–71, milj. tonnia.

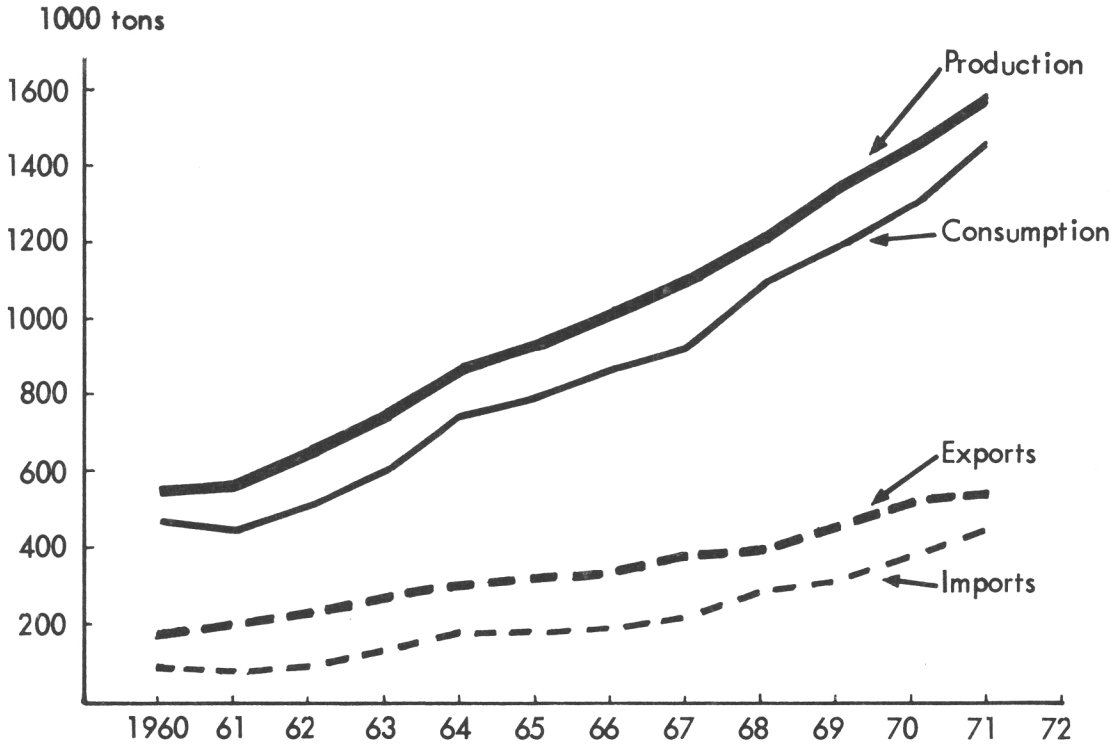

Fig. 6. Production, consumption, exports and imports of plastics in the UK, 1960–71, in 1000 tons.
Kuva 6. Ison-Britannian muovin tuotos, kulutus, vienti ja tuonti v. 1960–71, 1000 tonnia.

been dealt with in an earlier investigation (RUNEBERG 1967 p. 29) and thus need not to be examined in detail here. The main types of plastics competing or being used in co-operation with forest products remain as they were some years ago: PE, PVC and PS. It can be mentioned that the world consumption of polyolefines is continuing to rise and has grown from 7 % in 1955 to 27 % in 1970 of total plastics consumption. Only LDPE shows a falling trend, from 81 % to 63 % in the last decade. Its lost share of the market has been taken over by HDPE and PP.

The graph in Figure 6 gives a picture of the development of the plastics industry in the UK during the last decade (source: BP statistics for different years).

It is evident that a considerable import as well as export of plastic raw material takes place. However, home production has expanded even faster, having trebled in the last 10 years. Exports have consistently remained nearly 100 000 tons greater than imports, although a slight worsening in the balance has occured in the 1970s.

As a general assessment, it can be stated that the plastic raw-material industry in the UK is well developed and characterised by a high rate of growth and strong competitiveness both at the national and international levels. The distribution of market shares among the big five in the field is as follows:

	% share of total production
ICI	40
BP Chemicals	23
Shell Chemicals	15
Monsanto	10
Bakelite-Xylonite	8
Others	4
	100

The industry's structure is either oligopolistic or monopolistic, depending on the product, and competition between the enterprises is more concentrated around product selection and to a lesser extent on price level. The construction of large units has resulted in the cost level for the base products, ethylene, styrene and vinyl

chloride, being greatly reduced and keeping the enterprises competitive. The share of the large international oil companies in production is strongly marked.

On the processing side, the structure of the industry is completely different. The working of the raw material is undertaken by a large number of small and medium firms which are often subsidiaries of large engineering and packaging companies. Reliable information on the number of firms is not available, but the British Plastics Federation had some 350 members in 1971.

The processing of plastic raw material is done mainly by one of the following fabrication methods:

1) Compression moulding
2) Injection moulding
3) Extruding
4) Blow moulding
5) Vacuum forming
6) Dip coating

Methods 2, 3 and 5 are those primarily used for the manufacture of products in competition or co-operation with wood.

Fig. 7. Interrelationship among methods of plastics processing, end products and applications.
Kuva 7. Muovin tuotannon sovellutuksien ja lopputuotteiden kehityskaavio.

Table 14. Production of synthetic resins in the UK, 1970 and 1971, in 1000 tons.
Taulukko 14. Ison-Britannian muovin tuotos v. 1970 ja 1971, 1000 tonnia.

Main thermoplastics	1970	1971
Polyolefines	433.0	446.0
PVC (polymer)	302.0	335.0
Polystyrene	174.0	144.0
ABS	28.0	28.0
Polyvinyl acetate	40.0	40.0
Cellulosics	10.9	10.0
Acrylics	16.5	15.0
Main thermosetting		
Aminos	140.0	169.0
Alkyds	63.0	63.0
Phenolics	76.0	74.0
Epoxides	13.5	13.5
Polyesters	42.5	37.6
Polyurethanes – non-rigid	40.0	41.0
Polyurethanes – rigid	7.0	7.0

The variety of applications and processing methods of plastic materials has led to a complex interrelationship of semi-prosessed and end products. The situation is illustrated graphically in Figure 7.

An examination of the distribution of the production of raw material according to different types of plastic gives the figures shown in Table 14 (source for tables 14–19: BP statistics for different years).

It can be seen that production is dominated by the three large groups, polyolefines, PVC and PS. On the thermosetting side, only aminos are of major significance.

The relatively small rates of growth from 1970 to 1971 shown in the table are related to the general trade recession during 1971 and are not to be considered as providing norms for future development. In fact, as a general criterion, the following rule can be applied. The rates of growth of the general economy, chemicals and plastics stand in a relationship of 1:2:4. During 1971, the industrial index in the UK rose only 1.7 %, while plastics production increased by 7.8 %. This has been the pattern for many years, with plastics production rising more rapidly than that of industry generally.

32. End-use survey

A detailed end-use survey is practically impossible to undertake for more than about the last 6 years, due to lack of statistical information. The major areas of use for synthetic resins in the UK are listed in Table 15. More than 60 % of plastics production is used in field where competition or co-operation with wood products is in question. Economically, it has veen verified that despite the advantages of large production units the prices of the final products have fallen faster than production costs, so that profits as a percentage of sales have been gradually reduced.

Table 15. Consumption of plastics in the UK according to end-use, 1967 and 1971, in 1000 tons.
Taulukko 15. Ison-Britannian muovin kulutus v. 1967 ja 1971 loppukäyttöryhmittäin, 1000 tonnia.

	1967 1000 tons *1000 tonnia*	%	1971 1000 tons *1000 tonnia*	%
Packaging – *Pakkaus*	170	17.2	312	21.1
Building and construction – *Rakennustyö*	105	10.6	166	11.2
Housewares and toys – *Kotitaloustavarat ja leikkikalut*	64	6.5	123	8.3
Electrical and electronics – *Sähköala ja elektroniikka*	86	8.7	101	6.8
Transport – *Kuljetus*	38	3.9	69	4.7
Furniture – *Huonekalut*	32	3.3	47	3.2
General industrial – *Yleinen teollisuuskäyttö*	31	3.1	36	2.4
Others – *Muut*	460	46.7	626	42.3
Total – *Yhteensä*	986	100.0	1480	100.0

Table 16. Consumption of plastic packaging materials in the UK, 1967 and 1971, in 1000 tons.
Taulukko 16. Ison-Britannian muovista valmistettujen pakkausaineiden kulutus v. 1967 ja 1971, 1000 tonnia.

	1967 1000 tons *1000 tonnia*	1971 1000 tons *1000 tonnia*	% growth *Kasvu %*
Film – *Kalvo*	59.0	106.5	80.5
Coated substrates – *Pintafilmi*	9.0	23.5	161.1
Shrink wrapping – *Kutistefilmi*	5.0	9.5	90.0
Sacks – *Säkit*	23.7	34.6	46.0
Small containers – *Pienet säiliöt*	20.4	34.9	71.1
Large containers – *Suuret säiliöt*	8.3	19.1	130.1
Closures and caps – *Sulkijat ja korkit*	20.1	26.8	33.3
Foodstuffs – *Elintarvikkeet*	8.5	23.8	180.0
Cosmetics and pharmaceuticals – *Kosmetiikka ja apteekkitavarat*	13.0	23.1	77.7
Others (string, strapping, reels and bobbins) – *Muut (narut, hihnat kelat ja puolat)*	3.4	10.7	214.7
Total – *Yhteensä*	170.4	312.5	83.4

Packaging is at present clearly the most important end-use group, and consumption has almost doubled during the last 5 years. A detailed examination of the packaging group is shown in Table 16.

A closer analysis of the packaging branch will be made in connection with the product analysis in Chapter 4. It is sufficient here to note the following. Film manufacture dominates this group, especially when it is considered that coated substrates, shrink wrapping and sacks also use films as a base material. The whole of this manufacturing branch affects in various ways the manufacture of paper. More than 50 % of the material used is LDPE, while the shares of the other important groups, PS, HDPE, PP and PVC, is only 10–15 % each.

End use in the building and construction group appears in Table 17.

The largest group is composed of various sorts of pipes and fittings and has more than doubled during the last 5 years. Use for constructional uses has also increased greatly. Floor coverings, on the other hand, appear to have lost ground in recent years. The material used most in this group is PVC, which in 1971 accounted for more than 60 % of total consumption. The remaining share is divided among

Table 17. Consumption of plastic building and construction materials in the UK, 1967 and 1971, in 1000 tons.
Taulukko 17. Ison-Britannian muovista valmistettujen rakennusaineiden kulutus v. 1967 ja 1971, 1000 tonnia.

	1967 1000 tons *1000 tonnia*	1971 1000 tons *1000 tonnia*	% growth *Kasvu %*
Gutters, pipes and fittings – *Viemärit, putket ja liitokset*	31.2	71.9	130.4
Sanitary ware (cisterns) – *Saniteettitavarat (vesisäiliöt)*	7.2	9.9	37.5
Rooflights and roofsheets – *Kattovalaisimet ja -levyt*	10.1	9.3	– 7.9
Cladding and wall coverings – *Vuoraus ja seinän päällysteet*	7.7	13.7	77.9
Constructional uses – *Rakenteet*	12.8	29.2	128.1
Ceiling tiles – *Kattotiilet*	4.0	4.9	22.5
Doors – *Ovet*	0.5	0.5	0.0
Floor covering – *Lattian päällysteet*	31.5	27.0	– 14.3
Total – *Yhteensä*	105.0	166.4	58.5

Table 18. Consumption of plastics in furniture in the UK, 1967 and 1971, in 1000 tons.
Taulukko 18. Ison-Britannian muovin kulutus huonekalualalla v. 1967 ja 1971, 1000 tonnia.

	1967 1000 tons *1000 tonnia*	1971 1000 tons *1000 tonnia*	% growth *Kasvu %*
Drawers – *Vetolaatikot*	*0.2*	0.5	150.0
Decorative laminates and veneers – *Koristepinnoitus ja viilut*	7.2	10.2	41.7
Chair shells – *Tuolien rungot*	1.2	4.6	283.3
Coverings – *Verhoilu*	4.7	6.1	29.8
Mattresses and cushioning – *Patjat ja tyynyt*	14.2	15.3	7.7
Carpet backing – *Mattojen pohjat*	4.1	9.8	139.0
Total – *Yhteensä*	31.6	46.5	47.2

a surprisingly large number of different qualities. In all, no less than 16 different plastic materials are used.

Closely connected with buildings is the furniture industry, which has recently in many countries been exposed to a particularly rapid infiltration by plastics. The figures in Table 18 give a picture of the development of the end-use situation.

These figures do not indicate an especially rapid development in the UK. It is true that the consumption of material for chair shells has nearly quadrupled in the last 5 years, but as a whole the furniture branch shows a 47 % increase. Consumption is distributed among a large number of different plastic types, of which PU foam and PP are important. PU foam is used, however, mainly for mattresses and cushioning, which do not have any direct connection with wood requirements. With furniture should perhaps be included the production of TV and radio sets, in which the consumption of plastics in 1971 amounted to 4400 tons.

Within the household and toys group comes a great deal of infiltration by plastics, although this is difficult to survey as it is distributed among a large number of products. It can be mentioned that in 1971 more than 35 000 tons of plastic were used for toys, resulting naturally in a reduced share of the market for wooden toys. Seen as a whole, however, the forest industry's interest in this field is of secondary importance.

In the transport branch, a considerable penetration by plastics is taking place, although

Table 19. Consumption of plastics in "shipping" and in "handling and storage" in the UK, 1967 and 1971, in 1000 tons.
Taulukko 19. Ison-Britannian muovin kulutus laivanrakennus- ja varastointitarkoituksiin v. 1967 ja 1971, 1000 tonnia.

	1967 1000 tons *1000 tonnia*	1971 1000 tons *1000 tonnia*	% growth *Kasvu %*
Hulls – *Rungot*	6.0	8.2	36.7
Net and ropes – *Verkot ja köydet*	1.8	6.8	277.8
Buoyance – *Kellukkeet*	0.3	1.5	400.0
Total – *Yhteensä*	8.1	16.5	103.7
Crates and tote boxes – *Pakkaus- ja kuljetuslaatikot*	8.1	17.3	113.6
Tanks – *Säiliöt*	1.8	1.2	– 33.3
Shipping containers – *Laivauskontit*	1.5	5.0	233.3
Silos – *Siilot*	–	0.3	–
Fish and produce boxes – *Kala- ja tuotelaatikot*	0.5	1.0	100.0
Total – *Yhteensä*	11.9	24.8	108.4

mainly for cushioning and padding of seat coverings, of little interest for wood consumption. Only in the manufacture of containers and caravans is the use of wood being cut down, although there exist interesting possibilities of using combinations such as plastic-treated panel products.

In the mechanical-engineering and electrical branches, infiltration by plastics has similarly little significance from the viewpoint of wood. Within the miscellaneous group exist some areas of importance, although the total use of plastics in relation to wood is not likely to reach high figures. As examples of fields in which wood has already lost or is in the process of losing the market can be mentioned shipping and "handling and storage". The end-use distribution within these branches is shown in Table 19.

The major part of boat hulls are now polyester, although one can expect a small percentage of wooden boats to survive due to conservatism and taste. Large ships can also now be built of plastic material. However, this development does not have much influence on timber requriements since wood has anyway been used only for interior equippings in large ships.

Within the handling and storage branch, the change-over to plastics has gone forward notably more slowly in the UK than in several other countries, for example West Germany and Finland. During 1971, Coca-Cola changed over to PP crates, while a number of breweries have begun to replace wooden crates by plastic crates. As has been stated in an earlier context (RUNEBERG 1967 p. 56), wood has no chance of surviving in this branch. Significantly, a plastics firm (Paxton Plastics) purchased in 1971 an enterprise producing wooden trays and tote boxes and immediately reorganized operations to comprise only injection moulding machines.

The consumption of plastic boards within general industry is not very considerabel, amounting in 1971 to 1400 tons. In the same size class falls the group "handles and power tools", and "reels and bobbins". These miscellaneous industries, while in themselves important, have a relatively small combined use of wood, and a detailed end-use analysis is not justified.

4. ANALYSIS OF PRODUCTS AND DEMAND

41. General

To understand the changes which are happening within the traditional field of forest products. It is useful to recall that in modern business life only demand-oriented enterprises survive while product-oriented ones go under (cf. LÜHR 1969 p. 1). In other words, there is no use continuing to produce boxboards for packaging purposes when present-day market requirements in fact demand injection moulded plastic crates with better properties. As a general rule, it can be said that plastic competes with wood products with good results if some of the following conditions are fulfilled (BULTRY 1969 p. 18):

1) If a heavier-fabricated structure in wood can be replaced by an integral moulding in plastic which gives sufficient robustness and ridigity.
2) If the cost ratio between the raw material and the end product is particularly high in wood structures.
3) If the end product demands fittings or attachments which can be advantageously included in a plastic moulding.
4) If a special requirement should be satisfied, such as resistance to micro-organism and cleansability.

In view of the fact that the price of plastic has until now been higher than the price of timber, it can be further anticipated that if plastic and timber prices converge a wide field of new applications will open up.

42. Paper and paperboard products

The influence of plastics in the traditional market of paper products can be analysed from

various points of departure. A natural division from the point of view of usage is as follows:

1) Products for packaging
   a) Flexible
   b) Rigid
2) Products for communications media (graphic industry)
3) Products for industrial applications

One-half of total paper production is used for packaging.

When plastic competes with paper, it does not always do so in the same shape and form. As an example, plastic competes against corrugated cases mainly in the form of shrink-wrap packs. These normally incorporate two separate components, shrink film and base tray. It is thus often particularly difficult to make a straight plus-minus assessment.

421. Packaging

A packaging material's suitability is determined by the following factors:

Price
Protection
Presentation

In other words, the relationship between price and performance is decisive, no single factor deciding alone which product will be chosen.

The development of storage and transport methods naturally influences the packaging market. A general endeavour towards lighter packaging can be observed. As an example can be mentioned the change from wooden containers to corrugated cases and now in some cases shrink wrap. Plastics benefit from this trend and also contribute to it, as for example the change to plastic bottles, which are less fragile than glass and thus do not need as much external protection. It can further be noted that the great flexibility in the conversion techniques for plastics gives great freedom to the package designer. As was indicated in Chapter 3, plastics can be processed in at least 6 different ways, while paper is always made in the same way.

The protective properties of plastic and paper materials need not be dealt with further here, since an extensive technical literature on the subject is available. A major reason for the success application of plastics in packaging is their vapour barrier properties.

Regarding presentation, a good pack must satisfy several requirements: for example, it should (READ 1971 p. 4):

"identify the product
be distinctive against other packs
make an attractive retail display
give necessary instruction as to use."

If protective and presentation properties are more or less equal, then price is of course decisive.

A further factor of importance in choosing a packaging material may be the question of disposability after use. This question will be dealt with in connection with the discussion of the effect of environmental conservation in Chapter 62.

For flexible packaging, the field is dominated by plastic film as a base material. The main products are sacks, bags and shrink wrap.

Plastic sacks have steadily dropped in price and can now compete in the market for heavy-duty materials, in particular fertilizers. In the British market, however, plastic sacks have

Table 20. Sales of paper and plastic sacks in the UK 1967–71.
Taulukko 20. Ison-Britannian paperi- ja muovisäkkien myynti v. 1967–71.

	Paper sacks *Paperisäkit*		Plastic sacks PE *Muovisäkit*	
	Production 1000 tons *Tuotos 1000 tonnia*	Consumption million sacks *Kulutus milj. säkkiä*	Production 1000 tons *Tuotos 1000 tonnia*	Consumption million sacks *Kulutus milj. säkkiä*
1967	260	1150	20	100
1968	275		23	
1969	270	1250	26	200
1970	290		28	
1971	255	1100	31	300

only slowly obtained a foothold, as the comparison in Table 20 shows (source: Paper and Packaging Bulletin 1972 Nov.).

On the consumption side there are no official statistics available. The figures are based on trade estimates. Imports of ready made sacks are negligible both in paper and plastics, but for the manufacture of paper sacks the UK is to 80 % dependent on imported kraft paper, while plastic sacks are produced from home made raw material. Up to 1970 there was a rising trend in the production of paper sacks, followed by a heavy drop in 1971. It is very possible that paper sacks now have reached their peak consumption and that the growing packaging demand will in the future be taken over by plastic sacks. In this connection one should remember bulk packaging, which constitutes an alternative to all forms of sacking and is quickly gaining ground.

Table 21. Comparison between plastic and paper refuse sacks in selected European countries, 1970.
Taulukko 21. Eräiden Euroopan maiden muovi- ja paperijätesäkkien hintojen ja markkinaosuuksien vertailu v. 1970.

	Price of plastic sacks in relation to paper sacks % *Muovisäkkien hinta suhteessa paperisäkkeihin %*	Share of total market, % *Osuus kokonaismarkkinoinnista %*	
		Plastic sacks *Muovisäkit*	Paper sacks *Paperisäkit*
Austria	70	95	5
Belgium	65	70	30
Danmark	73	100	0
Finland	95	57	43
France	60	95	5
Ireland	80	30	70
Italy	50	2	98
Netherlands	50	5	95
Norway	65	80	20
Sweden	50	98	2
UK (1971)	60	54	46
West Germany	60	25	75

The growth in production of plastic sacks shows a 50 % increase since 1967. Growth has been much more rapit in unit terms than in tonnage terms, due mainly to the increasing importance of refuse sacks which are made from very light film. In 1971 these accounted for probably 50 % of production, that is 150 million sacks were used for refuse disposals. The number of plastic sacks required by this market alone could amount to 1000 million by 1980. In 1971 the distribution of the end-use market for paper and PE sacks was the following:

Paper sacks		Plastic sacks	
Feedstuffs	25 %	Refuse	50 %
Potatoes	15 »	Fertilizers	20 »
Refuse	12 »	Chemicals	8 »
Chemicals	10 »	Miscellaneous	22 »
Other rock	10 »		100 »
Cement	9 »		
Miscellaneous	19 »		
	100 »		

According to Paper and Packaging Bulletin (1972 Nov.), the actual production on the plastic side is distributed in the following way.

	Market share
British Visqueen (ICI)	35 %
BXL (Union Carbide)	20 »
Courtaulds subsidaries Sherko Films British Cellophane H.J.B.	20 »
Other	25 »
	100 »

Nearly 80% of the manufactured heavy-duty sacks are used for solid fertilizers. Other important areas of use in the British market are horticultural products, chemicals and coal for heating. The market is dominated, as can be seen, by plastic rawmaterial producers. The price differential between heavy plastic sacks and paper sacks amounted in 1971 to one new penny per four sacks, i.e. about 25 % to plastic's advantage. A comparison can be made with other European countries in Table 21, whith regard to refuse sacks (source: Eurosac conference "Refuse Sacks", 29/30. 3. 1971).

Table 22. Production and value of paper bags, carrier bags and film bags in the UK, 1966–69.
Taulukko 22. Ison-Britannian paperipussien, kantopussien ja filmipussien tuotos ja arvo v. 1966–69.

	Paper bags *Paperipussit*		Carrier-bags *Kantopussit*		Film bags *Filmipussit*	
	1000 Tons *1000 tonnia*	Million £ *Milj. £*	1000 Tons *1000 tonnia*	Million £ *Milj. £*	1000 Tons *1000 tonnia*	Million £ *Milj. £*
1966	108.8	18.1	13.4	3.3	7.0	4.6
1967	107.3	17.6	14.5	3.3	6.2	4.0
1968	109.0	18.3	15.1	3.5	6.5	4.0
1969	107.6	19.0	14.1	3.3	6.0	3.7

As can be seen, plastic refuse sacks are in most countries very much cheaper than paper sacks.

The consumption of plastic bags and carrier-bags has not increased substantially in the UK. The British market has apparently put weight on the lack of a sufficiently strong plastic bag which is free-standing. A free-standing bag requires the use of the dearer HDPE, which has a higher molecular weight. So far, therefore, relatively few large stores and supermarkets have abandoned paper bags. A comparison of sales figures in recent years for paper bags, carrier-bags and film bags is presented in Table 22 (source: Business Monitor 1970).

Since a direct comparison of weight is misleading, the values of the various groups have also been given. It can be seen that plastic accounts for 17 % by value but only 5 % by weight. For comparison, it can be mentioned that in West Germany the manufacture of plastic carrier-bags consumed 33 000 tons of raw material in 1970, nearly 10 times the UK total. It is clear that considerable quantities of paper are at risk in this field. According to VINCENT (1973 p. 27) the total market for sacks and bags in the UK was in 1971 valued at £ 119.7 million of which 34 % by value was manufactured from plastics.

The second large field for flexible packaging is shrink film. This form of packaging was introduced into the UK during the middle of the 1960s. Undoubtedly, this new material produced serious apprehension among producers of cardboard casing. Fear of losing large parts of the market drove many carton-converting companies, often subsidiaries of the large paper and board producers, to begin production of shrink film to safeguard for themselves at least the board consumption for the base trays. Later developments indicate that the growth of the packaging sector will leave room for both branches.

Two distinct markets have developed for shrink film:

1) Small retail display packs (e.g. fruit, meat etc.)
2) Transit packs (bottles, jars, tin cans etc., shrink-wrapped on to trays of cardboard or other material.)

The first group represents a completely new type of packaging, and therefore no true competition with other materials can be demonstrated. On the contrary, co-operation with paper products occurs in the form of the cardboard base trays. However, in the case of transit packs, competition with cardboard obviously cannot be avoided. Difficulties arise over the grounds on which comparison can be made between film and cardboard. In extruding, the thickness of the film is of great importance. The range 0.04–0.15 mm is used mainly for shrink film. Thin films give problems of weldability, strength and thickness variation, while the manufacture of thick films provides difficulties in ensuring shrink properties. Film thicker than 0.2 mm is not used in practice. On the basis of this, it has been proposed by the Economist Intelligence Unit Ltd that shrink film as far as weight is concerned should be considered equivalent to 15.6 times the weight of paperboard. It can be mentioned that the plastic material used in transit packs is dominantly LDPE, while retail display packs are normally of PVC. This makes comparisons even more difficult because of the materials' different specific weights.

Despite its many advantages, shrink film also has considerable disadvantages, both technically and economically. Nonetheless, the

Table 23. Production of cardboard packaging cases in the UK, 1960–70, in 1000 tons.
Taulukko 23. Ison-Britannian kartonkipakkauslaatikoiden tuotos v. 1960–70, 1000 tonnia.

	Production 1000 tons *Tuotos 1000 tonnia*	Increase over previous year, % *Lisäys edelliseen vuoteen, %*
1960	813	
1961	833	2.4
1962	894	7.2
1963	972	8.7
1964	1 088	12.0
1965	1 106	1.6
1966	1 156	4.5
1967	1 171	1.3
1968	1 308	11.7
1969	1 368	4.6
1970	1 388	1.5

difficulties have not appreciably weakened its rate of growth, which in the UK has remained around 20–25 % yearly. In 1971, consumption of shrink film rose to 9500 tons, as was seen in the general survey of the plastic industry. According to the method of estimation already mentioned, this is equivalent to almost 150 000 tons of paper products.

The effect of competition from shrink film can be assessed to a certain extent from the Table 23 (source: Fibreboard Packaging Case Manufactures' Association).

The average rate of growth between 1960 and 1965 was 6.3 %, while during the second half of the decade it fell to 4.7 %. It is open to discussion how far this decline can be ascribed solely to shrink film, but the fact remains that the market for cases has decreased by c. 100 000 tons or c. 7 %, if one accepts the estimate of 15.6 tons of cases to 1 ton of film (and that c. 75 % of all shrink film used could have been replaced by cases). A part of the decline can, of course, be attributed to the poor economic development at the end of the 1960s. The correlation between GDP (Gross Domestic Production) and consumer expenditure on goods which have direct repercussions on the consumption of packaging is easy to demonstrate.

The present break-down of end uses between shrink film and cases is shown in Table 24 (Paper and Packaging Bulletin 1972, no. 70 p. 12).

Table 24. Consumption of shrink film and cardboard cases according to end-use in the UK, 1970, in % of total.
Taulukko 24. Ison-Britannian kutistefilmin ja kartonkilaatikoiden kulutus v. 1970 loppukäyttöryhmittäin, % kokonaiskulutuksesta.

Shrink film – *Kutistefilmi*	%	Cardboard cases – *Kartonkilaatikot*	%
Food in tin cans and glass *Elintarvikkeet metallipurkeissa ja lasitölkeissä*	60	Food & drink *Elintarvikkeet ja juomat*	52.5
Soft drinks, beer etc. *Virvoitusjuomat, olut jne.*	12	Consumer durables *Kestokulutushyödykkeet*	10.0
Textiles – *Tekstiilit*	7	Light engineering (metal components, nails, electrical assessories)	
Wall-papers – *Seinäpaperit*	7	*Kevyt metalliteollisuus (metalliosat, naulat, sähkötarvikkeet)*	11.0
Printing – *Painotuotteet*	4		
Shoes – *Kengät*	2	Toiletries & drugs – *Toalettitarvikkeet ja lääkkeet*	4.0
Toiletries – *Toalettitarvikkeet*	2		
Miscellaneous – *Sekalaiset*	6	Detergents – *Puhdistusaineet*	5.5
		Pottery & glass – *Keramiikka ja lasi*	3.0
		Paper goods – *Paperitavarat*	3.5
		Tobacco – *Tupakka*	2.0
		Paint – *Maalit*	1.0
		Clothes – *Vaatteet*	2.0
		Miscellaneous – *Sekalaiset*	5.5
Total – *Yhteensä*	100	Total – *Yhteensä*	100.0

Shrink film does not compete with cases over the whole field, but does so at the most important end, i.e. regarding food and drink already packed in tin cans or glass.

It is evident that in the future casemakers can expect to lose an increasing proportion of the sales in supermarkets and cash-and-carry retail food markets to shrink film. Such sales markets are expected soon to sell at least half of the total food retailed in the UK, and the new packaging method is expected to break though completely.

In certain conditions, however, cases are obviously preferable, as for example if rough-handling is to be expected or if the product is to be stored for a lengthy period. Furthermore, it can be envisaged that the ecological argument in favour of cases will perhaps gain in significance in the future. It would seem natural, therefore, that both methods of packaging will be essentially complementary, the material resorted to depending on the purpose of use.

Shrink wrap saves up to 20 % of the costs of an equivalent corrugated case. This however, presupposes regular products such as tinned goods and glass bottles.

In recent years, a new method of film packing has been developed, known as strech film (cf. Plastforum 1972, no 7/8 p. 43). EVA is admixed with normal LDPE film to obtain a tougher product. It can then be stretched in a cold state by about 10 % around goods to be packaged, the same result being reached as with the warming of shrink film. The method should be profitable, since the warming phase is dispensed with and the material consumption is smaller than in the use of shrink film. Further savings in the cost of plastic packs can thus be expected.

Corrugated cardboard cases are further threatened by a newcomer, namely corrugated plastic boards, from which packing boxes can be manufactured using with relatively few modifications the normal equipment employed for conventional cardboard. This product, however, is so far relatively rare and is not produced in the UK. The future of the product is clearly dependent on the price of plastics, as it is at present 2 to 2.5 times more expensive than normal cardboard. However, its special properties of high dimensional stability and stiffness, absolute insensitivity to water vapour and to practically all chemicals make plastic corrugated board on the other hand a unique product in the field of packaging design. The product has been developed in Japan, while in Europe at least Italy is producing such board from PP copolymer under the trade name of Polionda.

Besides the areas of packaging already mentioned, infiltration by plastics is further detrimentally affecting the consumption of paper and cardboard in the following products (cf. READ 1971 p. 14):

1) pre-packs for shell eggs, fruit, vegetables, meat products etc., principally produced in high-impact and expanded PS;
2) jars and boxes for medical pills, tablets and similar products, in injection- and blow-moulded PVC, PE or PS;
3) cups and tubs for drinking and for products such as mousse and ice cream, in high-impact or expanded PS.

Detailed examination of these fields is not possible, but the following general information is available. For egg packaging, 40 million cases of corrugated cardboard (2.5 % of the total paperboard consumption) and 11 million moulded pulp packs are manufactured annually. The share of plastics is so far about 5 million cases of transparent PS packs (Thermopac Company Ltd., Huntingdon). A considerable expansion of the share of plastics can be expected.

Plastics have already broken through in the field of cups. Of an annual production of 2500 million vending cups, 85 % are made of high-impact PS, while of 600 million disposable dairy cups less than 10 % are paper. This whole field is growing with a speed of more than 20 % annually.

As was seen in Table 16, the consumption of plastic materials in all these areas in 1971 rose in the UK to more than 80 000 tons, equivalent to at least 120 000 tons of lost paper products.

The competitive aspects between plastic and paper products for the packaging field are hence considerable. This does not, nonetheless, prevent successful co-operation. Examples include PE-lined cartons for liquids, laminated and coated cartons for frozen food etc., plastic display packs for cosmetics, boil-in-the-bag plastic pouches inside a carton for convenience food, and so on. These combinations have allowed paper products to penetrate markets which they could never have conquered alone.

The liquid-milk market in the UK, unlike Scandinavian conditions, consists mainly of home deliveries in returnable glass bottles. As the price is controlled by the government, PE-lined cartons have not been able to break through. Britain's entry into the EEC may lead to a change in packaging methods.

The following important firms are operating in the co-operative field:

Omega Plastics Ltd, Essex
Packaging Products Ltd, Manchester
Slater Harrison & Co Ltd, West Bollington
Talcon Plastics Ltd, Orpington, Kent

Omega Plastics Ltd supply "Megapack" shock-absorbing expanded PS sheet which co-operates and competes with corrugated cardboard. Packaging Products Ltd are making a product called "Blond Union", which incorporates atactic PP and is used, for instance, between kraft paper in cement sacks to give heat protection. Slater Harrison & Co Ltd are manufacturing a paper and polyester film laminate called "Wantere" for luggage labels, fixture cards, text-book covers and suchlike. Telcon Plastics Ltd is a leading company for coating and laminating. Production consists for instance of 73–98 g/m^2 kraft paper coated with 23 or 34 g/m^2 PE.

Technical improvements in the processing of plastics offer new possibilities for making laminates of PS foam and paper, including sandwich laminates which consist of foam with kraft paper laminated on both sides. Such products have uses both in the packaging and building branches.

422. Communications media and industrial applications

The paper qualities used in this field comprise news-print and printing and writing papers. The products are easier to survey than in the packaging branch, as processing is uniform and the overriding requirement is printability. The main products can be grouped in the following way:

Newspapers
Magazines
Books
General printing (including brochures, leaflets, company reports etc.)

Magazines account for 30 % of the paper consumption within the printing and writing group in the UK, while general printing accounts for 27 %. The figure for books is 10 %. The field can be further divided into submarkets such as postcards, labels, cheques, duplicating etc.

The surface of ordinary cellulose-based paper is too rough to be used directly for finer printing purposes but must be further modified in some way. A better-quality printing paper called art paper is produced by coating a paper substrate with, for example, a fine clay containing an organic binding agent and additives such as TiO_2 to improve whiteness and opacity. Recently, the paper industry has begun increasingly to use plastic solutions for this purpose. To improve the quality further, a coated paper can be passed between polished stainless-steel rolls.

The demand for consumer and technical magazines has grown rapidly in recent years. A particularly significant development has been the inclusion in daily newspapers of weekly colour supplements as an extra to their ordinary editions. In 1971, there were over 100 publishers producing some 800 magazines in the UK. Many of these publishers acted as their own printers. The total consumption of paper in the field is estimated at 250 000 tons.

If the rate of growth during the 1960s is investigated for printing paper, this group shows an annual increase in consumption of 30 %, which has been almost entirely covered by imports.

An important factor is that more and more users of printing and writing paper are becoming interested in the weight of paper due to the continual rises in postal charges. This greatly facilitates a break-through by plastic paper.

To a large extent, the penetration of plastics into the field of the graphic industry has occurred much later than in packaging. The reason for this appears to be the high level of modification required by the polymer to meet the requirements of the market. In price and properties, plastic paper has only recently been able to compete with certain types of conventional art paper. The question of the production of plastic paper will be dealt with more fully in the next chapter.

Industrial products containing paper is a particularly varied field. SOUTHAM (1970 p. 262) has made the following classification:

Furniture	Abrasive sheets
Luggage	Release sheets
Cigarettes	Building boards and
Filters and absorbents	papers
Electrical components	Shoe components
Cables	Clothing
Book covers	Office system software
Tickets	Ammunition
Moulding flong	Photographic and
Gaskets	dyeline papers
Pressure-sensitive and	Security products
gummed tapes	Artificial leather

All these uses require a high degree of specialization, which it has already been seen is one of the British paper industry's greatest assets. Seen as a whole, the field offers relatively few possibilities for co-operation between plastics and paper. Where plastics have obtained a foothold, it has been normally at the expense of paper.

423. Plastic paper

The appearance of plastic paper has in many respects created a new situation for the traditional paper industry. The raw material for paper manufacture has for more than a century been dominated by wood fibre, but it is evident that the next 10 years will be decisive in determining whether this hegemony will remain. The question is whether plastic will drive conventional paper out of the market or whether the two will exist side by side.

As a rich literature is available regarding the technical properties of plastic paper (for instance WOLPERT 1971 and 1972, LEVLIN et al. 1971, IMOTO 1971), this aspect does not need to be more closely analysed here. In brief, it can be stated that the future penetration of plastic paper will be based on its better properties regarding:

dimensional stability,
strength,
surface smoothness,
resistance to water, oil, fat and acids.

The question of plastic paper's future and general possibilities of competition from a business economics viewpoint requires a closer examination, however.

As the earlier analysis indicated, plastic film paper is the product which up to now has competed most strongly with conventional paper, especially in the packaging branch. The manufacture of plastic film paper requires, however, extruder machines, the production capacity of which is only a fraction of that of modern ordinary paper machines. It can be mentioned that a large extruder capacity is at present about 2000 tons a year, with a film width of 3 m. This can be compared with a newsprint machine, which annually produces about 150 000 tons of paper with a width of 7 m. It is of course possible that extruder machines will be enlarged, but the technical problems of a wide film roll, for example, are considerable. It is more probable that as need arises producers will procure new extruder machines of the same capacity as earlier. From an investment viewpoint, this method is naturally cheap in comparison with the procurment of new, conventional paper machines. However, the result will be that the rate of growth of plastic film paper produced by extruders will in all circumstances be slow, with production divided, moreover, into two phases (film manufacture and surface treatment).

A real break-through for plastic paper clearly requires a different production method. There are some 12000 paper and paperboard machines in the world, with a combined capacity of 130 million tons. It would obviously be bad from the business- and national-economics viewpoints not to attempt to use these existing investments 100 %. It follows from this that the natural technical development is to produce a plastic fibre product with properties sufficiently close to wood fibre that conventional paper machines can be used without great reconstruction costs.

A strong development of plastic fibre production, consequently, seems probable. Earlier research has concentrated on the production of fibre materials suitable for the textile industry. During the present decade, a synthetic fibre with properties closely resembling cellulose can be expected. Research in this field is going on at a number of different places in the world. The project which has come furthest is probably that being worked on jointly by Crown Zellerbach International Inc and Mitsui Petrochemical Industries Ltd. The project is based on an invention of the Crown Zellerbach Corporation, which developed a method of converting ethylene gas into synthetic fibre pulp directly under the process of polymeri-

zation. The development work, in two stages, has been approved by the Japanese Government.

Among other firms working in this field is another Japanese firm, the Hitachi Chemical Company, which has developed its own process for synthetic pulp production and is building a pilot plant with a capacity of 100 tons a month. The Eltexil Division of Solvay Cie, SA in Italy, is also active in this field.

That a technically acceptable plastic fibre capable of replacing cellulose will be produced this decade needs hardly be questioned. It can also be assumed that this fibre will be manufactured by a direct and therefore cheaper route from the monomer. Another consideration is that the continuous production of a single product will automatically make the product cheaper, as repeated change-overs as well as the costs of selling a variety of products will be avoided. The consequent savings are estimated at 10–30 % of the selling price of the goods. In this way, the first price reductions in relation to wood fibre can be accomplished. The final price levelling will depend on the price development of the respective raw materials. As the next chapter indicates, by 1980 at the latest can one expect that plastic pulp for paper manufacture will be selling alongside conventional cellulose. This will allow a mixing of different fibre materials to obtain particular grade requirements or to upgrade lower conventional materials (cf. IMOTO 1971 who is of the opinion that plastic pulp will be cheaper than wood pulp in 5–10 years). Of particularly great importance in this respect is that the properties of plastic pulp can perhaps directly increase the yield from cooking wood fibre for pulp. The normal loss in cooking is 50 % due to the necessary removal of lignin. With the addition of an appropriate quantity of plastic fibre, it is possible that a considerable amount of lignin can be left in without the final paper grade suffering. Alternatively, it may be possible to mix mechanical wood-pulp with plastic pulp to produce considerably better paper than previously.

Before an examination is made of plastic paper in the UK, a brief survey of the situation in Japan is in place. It is well known that the technology of plastic-paper production has been carried furthest in Japan. A report from 1968 (Japanese Resource Investigation Committee) documents the main reasons why it was considered necessary to develop an alternative base for the production of paper. The main reason is to be found in the vast increase in gross national product and the consequent rise in the need for paper. During the whole of the 1960s, this need rose by an average of 10 % a year. By 1970 the per capita use had increased to 121 kg, and now every increase in consumption of 10 kg per capita means an increase in total demand of 1 million tons. In 1960, Japan's import of pulp and wood for paper-making was 12 % of total required, whereas by 1970 this had risen to 50 %. (It has been seen earlier that the UK's imports amount to 60 %). Besides the direct problems of delivery arising from such a rate of growth in imports, there occurred a large loss of foreign exchange in paying for the imported materials. It was estimated that the production of a plastic paper would save 25–50 % of the import costs. Furthermore, the possibility was provided of using this means to develop the petrochemical industry. The original appraisal of the Resources Commission estimated that 3.5 million tons of plastic paper would be needed in 1978. This first forecast has since been regarded as too optimistic and has been considerably tuned down. However, the Council of the Science and Technology Agency of the Japanese Government continues to predict for 1985 a plastic production of 22 million tons, of which 10 % or 2.2 million is estimated to be for plastic paper.

As several years have already passed since the first forecast of the Japanese Resource Investigation Committee was published in 1968, the actual development can to some degree be compared with the forecast.

WOLPERT (1972 p. 321) considers that, with regard to industrial packaging and paperboard, synthetic products have not so far conquered to any great extent new markets but that a replacement of conventional products by plastic films and plastic foam products has occurred. This process has been assisted by spun-bond materials, certain types of non-woven products, and slit and split fibres made from extruded film.

The forecast for plastic paper for printing and writing materials in Japan in 1973 is shown in Table 25 (WOLPERT 1972 p. 322).

No penetration of plastic paper into the newsprint market is expected in 1973. It appears that tracing paper is the grade most exposed

Table 25. Demand for plastic paper in Japan, 1973, in tons.
Taulukko 25. Japanin muovipaperin kysyntä v. 1973, 1000 tonnia.

	Rate of substition % Tons *Korvausosuus ja määrä* % *Tonnia*		Conversion factor *Muuntokerroin*	Plastic-paper demand Tons *Muovipaperin kysyntä* *Tonnia*
Printing paper – *Painatuspaperi*				
High quality – *Korkeakuokkainen*	3	20 000	0.7	14 000
Medium quality – *Keskiluokkainen*	–	–	–	–
Coated paper – *Päällystetty paperi*	6	25 000	0.8	18 000
Tracing paper – *Jäljennöspaperi*	9	15 000	0.8	12 000
Miscellaneous paper – *Sekalainen paperi*	6	51 000	0.7	36 000
Total – *Yhteensä*		121 000		90 000

to infiltration from plastic, and in Europe, too, plastic tracing paper is considered to be technically superior and competitive in price. Printing paper, which is expected later to provide a considerable market, is so far only 3 % plastic. Apart from price considerations, plastic paper's insufficient stiffness for rapid printing presses is the biggest obstacle. In particular, foamed plastic paper has shown itself to be technically unsatisfactory. Surface treated films have been most successful. Plastic fibre papers have so far not been able to make a major entry, as production methods are too costly. Primarily it should be remembered that the need for plastic paper outlined above is reckoned to be covered by factories whose production capacity still lies well below the optimum from the price point of view. At least 11 firms are engaged to a greater or lesser degree in the field.

Earlier experience has shown that many years must pass before a new product has been perfected and is able to conquer its final share of the market. IMOTO (1971) has worked out the following time table for plastic film paper:

development period 1970–75
market-penetration period 1976–80
popularization period 1981–85.

Only at the end of this development will it become possible to say certainly whether plastic paper is going to co-exist with conventional paper or will become a complete rival. Obviously considerable product improvements can be expected during this time. On the other hand, plastic-pulp paper is scarcely to be considered an entirely new product, as there is no change in production methods and the product may conquer the market relatively quickly.

There is no doubt that the situation in the UK is in many ways similar to that in Japan, although a comparable massive growth in the rate of paper consumption is not to be expected. Both countries spend large sums each year on the import of cellulose and paper (nearly £ 400 million in the UK in 1970) and have

Table 26. Producers of plastic-film paper in the UK, 1971.
Taulukko 26. Ison-Britannian muovipaperin tuottajat v. 1971.

Company – *Toiminimi*	Trade name – *Tuotteen nimi*
British Visqueen Ltd, Stevenage, Herts	Visqueen
C.K. Addison & Co Ltd, Louth, Lancs	Finoplas and Plastissue
Excelsior Plastics Ltd, Hereford	
HJB Plastics Ltd, Leicester	Simulene
M.G.S. Plastics Ltd, High Wycombe, Bucks	
Venus Packaging Ltd, Ilkeston, Derbyshire	
Carter Brothers, Jarrow, County Durham	
Smith and Nephew Plastics Ltd, Welwyn Garden City, Herts	

insignificant forest resources of their own in relation to requirements. Similarly, the petrochemical industry is well developed both in Japan and the UK. It is a question how far the British government will follow the Japanese example and give official support to the development of a plastic-paper industry. There is so far no sign of this happening, although on the initiative of plastic firms several plastic-paper products have made their appearance on the British market. The producers of conventional paper, on the other hand, have hardly become involved in the field at all. Table 26 shows the main firms producing synthetic paper in the UK.

It is apparent that production has so far only been concerned with plastic film paper manufactured from HDPE and PP, primarily for packaging purposes. It is considered that Finoplas is up to 22 % cheaper than conventional wrapping paper because of the product's extreme thinness (10 micron). One ton of Finoplas is equivalent to 4 tons of conventional paper. The product is already exported to many European countries. It is worth mentioning further that Star Paper Ltd (Lancashire), Svenska Cellulosa Ab (Sweden) and Anic S.p.A. (Italy) have signed an option agreement with Nippon Kakoh Seishi K.K. (Japan) to evaluate jointly the possibilities of using technology developed in Japan to market synthetic papers based on polymer films in Europe. Behind the Japanese firm mentioned stands the Japan Synthetic Paper Company Ltd, which produces the already well-established Q-kote and Q-Per papers. For the first time, co-operation has been established among European companies manufacturing and marketing polymer, pulp and paper. Finland is also involved in that Star Paper Ltd is a subsidiary company of Kymin Oy.

Plastic film paper has clearly obtained a fairly considerable foothold in Britain, even though the quantities produced are modest. Wolpert, who without doubt knows the field best in the UK, writes the following (WOLPERT 1972 p. 182): "It is felt that the penetration of plastic paper into the large bags and sacks market will increase considerably the consumption tonnage-wise. . ." This is due to the fact that the film used in this field is somewhat thicker than the film for tissue-like wrapping applications. Wolpert (1972 p. 185) further considers that the UK has advanced the furthest in replacing greaseproof paper with plastic film paper. However, so long as there is no final break-through of plastic fibre paper, the total quantities will remain small. The UK market in 1975–76 can be estimated at 40 000–45 000 tons, which is scarcely 1 % of total requirements.

A comparison with other West European countries indicates that the number of producers of plastic paper in France and West Germany is roughly the same as in the UK. Estimates of the total market in Europe for these products in 1975 vary. The most optimistic figure suggests 350 000 tons, but the English China Clay Sales Co in the UK mentions, for example, 150 000 tons (4 % of 3.8 million tons), while Wolpert is even more cautious and talks of 100 000–120 000 tons. The market for these products in the USA is also in its infancy (0.09 % of total paper sales), but it is estimated that it will have reached 500 000 tons by 1980.

In summary, the position of plastic paper can be described as follows. So long as PS and PE polymers are two to three times dearer than wood pulp, no radical break-through can be awaited. This price relationship is not expected to narrow significantly, at least up to 1975. Without a new technical break-through in the technology of polymer fabrications, no serious threat to conventional printing papers is likely to develop during the next few years. On the other hand, plastic paper does already offer opportunities for speciality applications. At the end of this decade, this situation will probably have changed completely due to the production of plastic pulp and the narrowing of the price gap between wood and plastics (cf. Chapter 5).

424. Non-woven products

The production technique for these products has been dealt with earlier in another context (RUNEBERG 1971 p. 8). Although the main market for non-wovens lies in textile applications, the forest industry has considerable possibilities of expanding its field of activity to include such products. Furthermore, various spunbonded and fibre-reinforced products have gained a foothold in the paper market, especially within industry and packaging. Certain of these

products resemble paper to a high degree, and interesting new applications have been discovered. So far, however, manufacture has concentrated on a score of hospital products such as hospital bedding, examination gowns, surgical drapes and masks, uniforms and apparel. A logical development is a further infiltration in the branch of underclothing.

The development of non-wovens in the UK has gone relatively far, including the sale of spunbonded products, i.e. goods based entirely on plastic fibre. WOLPERT (1971 p. 106) defines these products in the following way: "The spunbonded products are continuous filament nonwoven structures, produced by a method which integrates the spinning of fibres with the formation of sheet products..." This method of production is considered to give better properties than those of many "short-fibre" non-woven products. Spunbonded products fall between paper and plastic film on the one hand and woven fabrics on the other.

Spunbonded products are manufactured primarily by Du Pont de Nemours & Co Inc in the USA and occur in the British market through Du Pont Company (UK) Ltd, London.

The British non-woven products are described satisfactorily by WOLPERT (1971 pp. 105–127; 1972 pp. 284–296) and do not need to be further dealt with here.

Despite the youth of the non-woven industry, the producers in this field have already founded their own central organization established in 1970 and called the British Nonwovens Manufacturers' Association. Membership of this association comprises such manufacturers who are in commercial production: "Bonding by the wet-laid or dry-laid processes, including spunbonded materials made by random laying of textile filaments." (press release 1970 15.9) In December 1972 there were the following 10 members:

Bonded Fibre Fabric Ltd
Bridgwater, Somerset

Bondina Ltd
Halifax, Yorks

Vernon-Carus Ltd
Hoddesden Mills,
Darwen, Lancs.

Johnson & Johnson Ltd
Cosham, Portsmouth, Hants.

Kimberley-Clark Ltd
Maidstone, Kent

Lantor Ltd
Runworth Mill
Bolton, Lancs.

Reedbond Ltd
London

Wiggins Teape (Mills Sales) Ltd
Industrial Paper Division
London

Bowater-Scott Corporation Ltd
Textile Replacement Division
London

James R. Crompton & Bros Ltd
Elton Paper Mills
Bury, Lancs.

One half of these firms are directly integrated with paper companies.

It is probable that about 90 % of the fibres used in production are based on regenerated cellulose, while nylon and polyester fibres are consumed in relatively small quantities. More exact information concerning capacity and the quantities of plastic raw material used is, however, not available and can only be assessed indirectly on the basis of the plastic industry's production figures.

As developments also in Finland have shown, paper producers are able to integrate much more easily with non-woven production than with plastic-paper production, at least so long as plastic pulp is not on the market. It is significant that Du Pont's spunbonded HDPE "Tyvek" is sold in the UK by two leading paper-making companies.

43. Building and carpentry products

431. Products for house construction

The building industry is without doubt one of the most important field in which plastic and timber products will in the future fight for a place in the sun. Futurologists are agreed that the age of grey concrete will probably already be a thing of the past by 1985. Endeavours to find lighter building materials give plastics a good starting position, as do attempts to develop ready-made construction units, elements and so on to reduce the high

labour costs on the construction site. Of special interest are the cellular plastics which have been recently developed, combining adequate porosity with great rigidity,

All building materials naturally have both good and bad properties. Timber is easy to work yet tough and solid in relation to weight. Moreover, it is a poor conductor of heat and is pleasant to handel. To a large extent, timber bas been the cheapest available building material. On the negative side are foremost timber's non-homogenous structure and its tendency to swell when damp. The fire danger is also generally considered a disadvantage of timber in the building branch, although it has been shown that wooden beams tolerate fire better than steel girders. Timber also has good possibilities of competing in the form of various types of particle board, including a variety with ordered particles now being developed. Through this technique the tendency of the board to swell is reduced to a minimum. In the future, the most efficient means of isolating air for insulation will be of increasing significance (cf. SCHULZ 1970 p. 3).

The growing importance of the building industry derives from the increasing world population. The population of the UK is expected to reach 70 million in the year 2000, compared with 56 million in 1970. The developing relationship between blocks of flats and single-family houses is of great interest, since single-family houses consume on average 4.5 times more timber than flats. While the average size of household is diminishing, the requirements for comfort increase. Large, old buildings cannot easily be modernized economically, so that further new buildings are needed. Similarly, the need for schools, hospitals and industrial buildings is growing. All this reduces the resources of forest land.

A considerable reduction in the number of enterprises involved in the building industry in the UK has taken place, from 92 000 in 1959 to 77 000 in 1969. Similarly, the number of general builders has fallen by 6 000 to a total of 33 000. A similar concentration has occurred in the whole of Western Europe. The primarily reason has been to achieve bigger sales and production volumes to cover the fixed cost of overheads and equipment (cf. FAO/ECE 1971 a, p. 13). The building industry will plainly change during the coming decade from a labour-intensive, on-site operation to a capital-intensive, largely off-site operation. Such capital-intensive enterprises can be expected to clear the way for the practical application of new structural design in plastics.

Table 27 shows the expected growth in the consumption of plastics by the construction industry in the UK until 1995 (cf. SLEDDON 1970 p. 81 and Europlastics Monthly 1972, Aug. p. 5).

These figures do not include plastic paints and surface coating. The figures of Sleddon and Europlastics are not directly comparable due to different ideas as to which fields should be included in the statistics under the construction

Table 27. Consumption of plastics by the UK construction industry, 1975–95 in 1000 tons.
Taulukko 27. Ison-Britannian rakennusteollisuuden muovin kulutuksen ennuste v. 1975–95, 1000 tonnia.

Polymer	1975 (forecast Sleddon)	1980 (forecast Europlastics)	1995 (speculation Sleddon)
PVC	280	350	800–1000
Plastics in expanded form (PS, PUR etc.)	103	243	600– 800
Phenolics and aminoplasts	90		200– 300
Polyolefines	40	70	120– 180
Reinforced polyester and epoxy resins	20	36	400– 600
Acrylics	14	20	40– 50
PS (excluding expanded forms)	8	11	20– 30
Others (including nylon, acetal polymers, PTFE etc.)	5	10	20– 40
Total	560	740	2200–3000

industry. Until now, the major part of plastics have been used in replacement applications, i.e. a product of another material is replaced by a similar product of plastic. The main fields of use have already been elaborated in the end-use statistics. The use of PVC gutters, pipes and suchlike will evidently continue to grow sharply. Internal plumbing in new houses will be entirely of plastic, as will pipes for sewage and gas distribution. This area of use, however, has no direct effect on the demand for timber in the building industry. A similar field is the electrical-wiring and cable-sheathing market, in which PVC also now dominates. Indirectly, these products are linked with other building materials, in so far as, for example, wall materials with ready-built channels for the installation of pipes and cables are produced. The probable result is that by the 1990s, at the latest, walls will be produced with inbuilt plumbing, ventilation and sanitary services.

Regarding floor-covering, PVC has a dominant position for floors subject to hard wear, but parquet flooring and in particular polymer-wood will have a good chance of competing. For the time being chipboard floors predominate in the supported floors market. In cases where mats are used, these will also be made of plastic materials, primarily nylon or PP.

The application of plastic profiles for door and window frames in the UK has so far not developed. Evidently the use of wood for such purposes is considered relatively cheap and the building trade is more used to handling it.

An important field in the future will be thermal insulation. Many types of cellular plastics are excellently suited for insulation techniques. It is not easy to know how wall material as such will develop. However, it is probable that a high percentage of internal surfaces will be predominantly of plastic materials, possibly in combination with wood-based boards. For external cladding, it is likely that PVC and GRP shiplap systems will replace timber. PVC bricks will also be used for less important buildings such as vacation houses, chalets and room partitions.

Long before the year 2000, large, complex, factory-finished components will dominate the building trade. In buildings for industrial purpose, it is likely that the simple corrugated sheet will be replaced by a composite panel with a cellular plastic core and weathering surfaces possibly also of plastic.

The developments outlined above presuppose that buildings generally in the UK will continue during the next 30 years to look as they do today. The tendency towards mobile homes which is gaining ground in the USA (cf. WHITE 1970 p. 15) is not expected to become common in the UK. A more flexible approach, however, can be expected in the form of vacation houses made, for example, entirely of plastic. Prototypes have already been developed in several parts of the world, including Finland (cf. POHJANPALO 1969 p. 9). In all probability, factory-built units can be reckoned with, bathrooms and cloakrooms, for example, already being produced. It is very likely that standard room units will soon be produced in the factory and assembled on the site to form a house. Undoubtedly, plastics will play a prominant role in this.

The future view described here is, of course, based on already known facts. Obviously, future activities can depend on completely new ideas coming forward, such as the Sea City (described by the Pilkington Group) or the complete domed city in which plastics are the general building materials. In none of these visions of the future has the use of timber a prominant place.

432. Products for furniture

Closely related to the building industry is the manufacture of furniture, in which it appears that plastics will already dominate during the present decade. Consumption in West Germany, for example, is expected to rise from 70 000 tons in 1971 to 500 000 tons in 1980 (cf. BP 1972, Jan. p. 70).

The furniture industry is dominated by a tendency to produce new models with great frequency, and thus production series are normally small. This fact has for long hindered the use of plastics within the industry because the basic costs are high. The breakthrough of rigid plastic foam has, however, changed the situation in that the low costs of moulds enable it to be used economically in short production series. An important contributory factor in the success of plastics is the wood-graining method, which enables an imitation

Table 28. Moulders of PS furniture shells in the UK, 1971.
Taulukko 28. Ison-Britannian PS-huonekalurunkojen valmistajat v. 1971.

Profile Expanded Plastics Ltd	London
H. Baker Ltd, Melofoam Works	High Wycombe, Bucks
S. Greenman Ltd	London
Jackson Mill and Fibreboard	Bourne End, Bucks
Truform Plastics Ltd	Chesham, Bucks
Vencel Products Ltd	Erith, Kent
Varmefoam Ltd	Tangmere, Sussex
Rondopack Ltd	Harpenden, Herts

wood pattern, which is extremely difficult to distinquish from real wood, to be produced on plastic products. In particular, grain-printing, in which the wood pattern is transfered directly on to the board surface without the intermediary of paper, gives furniture manufacturers the advantage of being able to dispense with veneers and veneer substitutes. This considerably facilitates marketing, since a wood surface is agreeable to the eye and wood materials are known and accepted.

The cellular-plastic materials used most in the furniture branch are expanded PS and rigid PUR foams. Expanded PS is used in particular for chair and settee shells. This is partly because it can be formed in complex curves not possible with wood material. Penetration into the cabinet and table fields has been less successful, since the design here is more regular in the form of rectangles and boxes, which can be made more cheaply with traditional materials. The British producers working with expanded PS in the furniture branch are listed in Table 28 (cf. SHAW 1967).

PUR foam is an alternative to expanded PS, and the two materials are comparable for producing chair and settee shells. In general, it is economically more profitable to use PUR for producing small quantities, up to 5000 items. Certain properties of PUR allow rationalized production of upholstered chairs. In this field, technical development is still going on to simplify the production process so that both cover and legs or under-frame can be incorporated into the mould to produce a complete chair in one sequenced operation. Because of the low costs of foam and the relatively long moulding-cycle time, several forms from the same dispensing machine are normally worked on.

A development of great interest for the furniture branch is the introduction of structural foam. The materials used, mainly PE and PP, incorporate a blowing agent which gives a composite material with a solid plastic skin and a cellular plastic interior. It has been shown that by varying the moulding temperatur different surfaces can be obtained on the product. With a low temperature, a grained surface is obtained, similar in texture to wood. A large area of furniture production will clearly be affected by this method, even though the basic investments may be larger than for normal injection moulding.

Mouldings in PUR foam are manufactured in the UK by the enterprises listed in Table 29.

Table 29. Moulders of PUR foam for furniture in the UK, 1971.
Taulukko 29. Ison-Britannian PUR-vaahtohuonekalujen valmistajat v. 1971.

Tangent Foams Ltd	Poynton, Cheshire
Hille Ltd	Watford, Herts
Vitafoam Ltd	Manchester, Lancs
Harrison and Jones (Flexible Foams) Ltd	Middleton Junction, Manchester
Wetherells Plastics Ltd	Selby, Yorks
Vencel Products Ltd	Erith, Kent
Rondopack Ltd	Harpenden, Herts
Freedman Bros Ltd	Ashington, Northumberland

Besides rigid foams, another group of materials of great significance for the furniture industry is reinforced plastics (GRP). These consist of thermosetting resins, such as polyester and phenolic types, strengthened with various materials, for example glass fibre or asbestos as well as wood fibre. The fabrication methods for products manufactured of GRP can be divided into low-pressure moulding, cold-press moulding using matched tools, and hot-press moulding. All these methods have both advantages and disadvantages, depending on the product and the number to be manufactured. If wood particles are used as the base material, the main function of plastic is as a glue and the product approaches hardboard. With the use of curved tools, this process can also be used to produce shaped articles such as chair shells, drawers and television cabinet parts. In such articles, timber is clearly the dominant component.

Two patented German processes based on wood particles can be used to produce three-dimensional moulded shapes with applications in furniture. Through the incorporation of impregnated paper, a surface is obtained in plain colours or wood grain. Applications so far in the UK have been restricted to doors, table tops and working surfaces with moulded edges. In the second of the German methods, no plastic resin is added to the wood particles. The idea is that with a sufficiently high temperature and pressure, the particles themselves become thermo-plastic (cf. ELO's method in Finland for manufacturing wood-plastic composite). The raw material for these methods, based on wood particles, is cheap, but the equipment and the tooling costs are expensive and long production series are required for these methods to be economic.

The firms producing reinforced moulded plastics in the UK are listed in Table 30.

The future role of plastics in the furniture industry has been analysed in West-Germany by two teams under the leadership of VOTTELER and HIRCHE (BP 1972, Jan. p. 70). According to this investigation, furniture in the house of 1980 will be created for living areas or zones and not, as now, for the bedroom or the kitchen. Infiltration by plastics is expected to have conquered large areas. In the sleeping area, the bed will evidently be moulded of structural PS foam. The bath will be designed for thermo-forming of acrylic sheets and will be located in the living area. Shower, WC, bidet and wash basin will be made of ABS, acrylic and PVC. Also the kitchen element, including work surface, fridge, sink and cupboards will mainly be injection moulded from PS foam, with doors from thermo-formed ABS sheets. Some of these products of the future will not especially disturb the use of wood, but in several directions a competitive relationship with panel products is clearly unavoidable.

433. Surface-treated and composite panel products

It has been seen that during the last decade the building and carpentry trades have been subject to considerable infiltration by plastics. In the case of panel products, in particular, far-reaching co-operation has been established. This partly takes the form of the use of plastic glue in the production phase and partly the

Table 30. Moulders of GRP furniture in the UK, 1971.
Taulukko 30. Ison-Britannian GRP-huonekalujen valmistajat v. 1971.

Acrow (Reinforced Plastics) Ltd	Saffron Walden, Essex
BTR Reinforced Plastics Ltd	Camberley, Surrey
Ecko Plastics Ltd	Southend-on-Sea, Essex
Flexo Plastic Industries Ltd	London
Fibreglass Ltd	Bidston, Birkenhead
Osma Plastics Ltd	Hayes, Middx
J.W. Roberts Ltd	Bolton, Lancs
Rubery Owen and Co Ltd	Wrexham, Denbigshire
Spembly Ltd	Chatham, Kent
Thermo Plastics Ltd	Dunstable, Beds

form of surface lamination with plastic. The introduction of plastic glue has greatly widened the possibilities for the exterior use of boards. According to a previous investigation (RUNEBERG 1971 pp. 9–10), standard plywood boards now contain 4.1 % and particle boards 6.8 % plastic by weight.

The surface treatment of boards is undertaken mainly for the following reasons:

1) For more attractive appearance
2) As weatherproof coating for exterior use
3) To improve specific physical properties (e.g. terminal insulation) or structural properties
4) To prepare the wood surface for subsequent finishing processes
5) To give added fire protection.

In principle, surface treatment can be considered at the following stages:

1) At the original manufacture of the board
2) At a subsequent manufacturing process, usually in the country where the product will be used
3) At the point of end use.

Plywood producers, for example, prefer without doubt processes which can take place in the presses, for example, adding resin-impregnated paper films or pre-impregnated glass-fibrecloth to the original product.

As an example of product processing in the UK ICI's "Purldeck" for flooring and roofing or Contiwood's "Durabella" for flooring can be mentioned.

Lamination at the end-use stage is undertaken by various timber-engineering companies. An example is Potton Engineering, which is working on a plywood-plastic house for Milton Keynes Development Corporation.

Continued growth of the demand for composite sheets seems probable, but so far development has been held back by the relatively high prices of plastics, which results in the plastic coating being kept as thin as possible. A typical surface is, for example, a 1.5 mm glass-fibre coating on both surfaces of an 18 mm plywood board. Even this coating raises the price of the board by 100–120 %. On the other hand, increased consumption can be expected on account of the already mentioned decrease in site labour and the falling price of plastics in proportion to wood products.

The market for plastic-treated boards is comparatively young in the UK and its growth

Table 31. Manufacturers of plastic-panel composites in the UK, 1972.
Taulukko 31. Ison-Britannian muovi-paneelilaminaattien valmistajat v. 1972.

Company *Toiminimi*	Trade name *Tuotteen nimi*	Markets *Käyttötarkoitus*	Basic material *Perusmateriaali*
ICI Ltd Billingham	Purlboard	Roofing & flooring	Plywood/urethane/ kraftliner/PE
Contiwood Ltd Rainham, Essex	Durabella	Flooring	Plywood/urethane strip
Technical Panel Industries Ltd Braintree, Essex	Glasonit	Transport & containers	GRP plywood
Flexo Plywood Industries Ltd London		Transport & containers	GRP plywood mainly
Richard Graefe Ltd High Wycombe, Bucks	Various	Housing interior products	Various
Acrow (Engineers) Ltd London	U-Form	Hire concrete formwork	Plastic-faced plywood
Fothergill & Harvey Ltd Littleborough, Lancs.	Flomat	Various	Pre-impregnated glass mat

can be primarily ascribed to new exterior uses. To this must be added the infiltration into the joinery and built-in furniture markets.

Some of the most important British producers dealing with these products are presented in Table 31.

It is difficult to obtain a general view of production in this field, but it was probably in the region of 100 000 m^3 in 1971.

Perhaps the most interesting of these co-operating products are "Purlboard" laminates, which combine a quick-warming wood surface with the best available insulation. For instance "Purldeck" panels are made from exterior-grade birch plywood (4 mm or 6.5 mm) and a vapour barrier liner of PE/kraftliner/PE laminated to a urethane foam core (19 mm). There is no conventional glueline, because the urethane foam is used as the adhesive. All four edges are rebated by wood battens (37 x 19 mm). Here for the first time we have all three of the main forest industries and plastics represented in one and the same product.

Within the furniture industry, veneering – i.e. decorating the surface of timber with a thin layer of another, more attractive timber – has long been of great importance. As this procedure is particularly laborius, various substitute methods have been developed in which both paper and plastics have an important place. Wood grains and other patterns are printed on to plastic film or directly on to boards, giving a wide field of choice for the consumer. The following main types of material are used:

1) Paper films
2) PVC foils
3) Decorative plastic laminates.

The paper films used as substitutes for wood veneers are paper impregnated with resin to improve durability, Two different sorts of paper are supplied, one with uncured resins and the ohter with almost completely cured resins. The four firms in the UK which have this type of production on their programmes are listed in Table 32.

Arthur Sanderson & Sons Ltd in Perivale, Middlesex, supply paper suitable for this type of impregnation.

PVC foils may be classified into two main types: flexible foils, which contain a considerable amount of plasticizer, and rigid foils, compounded with small amounts of plasticizer. The technical details will not be elaborated here, but it can be mentioned that PVC foils are tough and scratch-resistant. The commonest thickness of these foils for use on furniture fronts and exterior surfaces is 0.2–0.4 mm. For interior purposes such as backs of wardrobes etc., 0.1 mm may be sufficient. Perhaps the biggest problem in bonding PVC foils is the selection of a suitable adhesive which gives an effective initial bond to the surface without being influenced by the various plasticizer migration effects which may occur. PVC foils captured first the furniture-finishing market in West Germany but has now also been accepted in the UK. There are, however, only two home producers in this field:

Company	Trade name
Storey Bros & Co Ltd, White Cross, Lancaster	Storey-Clad
Commercial Plastics Ltd, London	

The latter firm, furthermore, only makes these products to order.

Table 32. Suppliers of paper surfacing films in the UK, 1971.
Taulukko 32. Ison-Britannian paperipintafilmien toimittajat v. 1971.

Company *Toiminimi*	Trade name *Tuotteen nimi*
Resinfilms Ltd, London	Elgon
Catalin Ltd, Waltham Abbey, Essex	Catafoil
Kurt Herberts (UK) Ltd, Folkestone, Kent	Letron
George Harrison (Agencies) Ltd, Croydon	Decorplast, Paratex

Table 33. Makers of decorative plastic laminates in the UK, 1971.
Taulukko 33. Ison-Britannian koristemuovilaminaattien tuottajat v. 1971.

Company *Toiminimi*	Trade name *Tuotteen nimi*
Arborite, London	Arborite
Armabord Ltd, Foulbridge, Nr. Colne Lancaster	Armabord
Allied Manufacturing Co Ltd, London	Beaumel
Bonded Laminates Ltd, London	Belfort
Berite Ltd, London	Berite Laminate
Consort Laminates Ltd, London	Decamel
Formica Ltd, London	Formica
Mica-Plast Ltd, Brierley Hill, Staffs	Marlica
Rex Bousfield Ltd, London	RBL Textile
Arborite Ltd, London	Superdec
Bakelite Xylonite Ltd, London	Warerite

Seven foreign firms, five of which are West German, are represented through permanent agents and clearly at present control the major market in this field.

The group of products comprising decorative plastic laminates are constructed from sheets of paper impregnated with resins. Usually the major part consists of several layers of kraft paper which has been impregnated with phenolic resin. On top of these is a patterned or coloured paper and finally a sheet of melamine-impregnated paper. The thickness of the final product is normaly 0.8–1.5 mm. Horizontal surfaces are considered to require 1.5 mm, while for vertical surfaces thinner laminates are sufficient.

To obtain special effects, the decorative paper can be replaced by other materials such as real wood veneers, woven fabrics or metal foils. The last of these can make the product considerably more fireproof. Since laminates are resistant to mechanical damage and to most household liquids, and are readily wiped clean, they have won a large market in the kitchen and as table tops. Laminate products can be cut, drilled and planed with ordinary woodworking machines, but the tools wear more quickly because of the products hardness.

The producers of decorative plastic laminates in the UK are shown in Table 33 (cf. HINDBY 1971).

Besides the products of these 11 British firms, some 30 different foreign laminate products are sold through agents. The most prominant are West German, Swedish and Italian products, but Finland also has a corner of the market with Formalitti and Iki boards.

Economic factors relating to the veneer substitutes described here are difficult to analyse in further detail. They depend on the scale of production, type of product, amount of new equipment needed etc. There is also no possibility of direct comparison with the costs of wood veneers. The fact that all three of the processes described are becoming more widely used indicates that no one of them has a clear advantage.

5. PRICE DEVELOPMENTS OF TIMBER AND PLASTICS

51. Raw-material supplies and price movements

It is obvious that the future price level of timber products decisively affects their competiveness. Of equal significance is, of course, the relationship of the price of timber to that of plastics. As has already been indicated, plastics have certain properties which make them usable for special purposes at a higher price than the equivalent products manufactured from timber. However, a major break-through of plastics into the field of forest products can

only take place in the event that the price of plastic raw material reaches the level of that of wood fibre. If this occurs, technical development will make possible final products in the same price class regardless of the raw-material base. As this is clearly a central problem, the question will be examined in more detail.

The resources of timber raw material are sufficiently well documented by various authors that only the following points need to be set out here.

World consumption of paper and paperboard has developed during the last 20 years in the following way:

1950	42 million tons
1960	74 million tons
1970	125 million tons

The latest forecast from FAO, in May 1971, estimated that consumption in 1985 will have reached 285 million tons. A major study of this question has been made in Sweden by SUNDELIN, who concluded that FAO's total forecast was to a large extent correct but that the figures for Western Europe were too high (cf. SUNDELIN 1971 p. 528).

The figures presented by FAO and SUNDELIN for Western Europe are as follows:

	FAO	SUNDELIN
1970	35 mill.tons	34 mill. tons
1975	45 " "	44 " "
1980	59 " "	55 " "
1985	78 " "	68 " "

Regarding different grades, the situation will develop according to SUNDELIN in the following way:

	1970	1975	1980	1985
Newsprint	5.2	6.4	7.7	9.1
Priting and writing paper	8.6	11.4	14.5	17.9
Kraftpaper/board	5.5	7.5	9.6	12.0
Other grades	14.4	18.5	23.5	29.1

Even if SUNDELIN's more conservative figures are used, it is questionable whether it will be possible to increase pulp production sufficiently to meet the growth in consumption. In 1970, the surplus production of pulp in all the OECD countries combined was only about one million tons. The UK had the largest deficit, with 2.7 million tons, and the six EEC countries of that time had a deficit of 4.8 million tons. The fact is that Western Europe's deficit of pulp may reach more than 8 million tons in 1985. Relatively little new construction is planned, as the European countries have largely reached the limit of their resources of raw material. Capital costs, besides, have increased, due among other things to the required installation of anti-pollution equipment. The low profit margins in relation to many other branches of industry further make new planning difficult. Everything seems to point to a continued increase in the price of conventional pulp, which will obviously facilitate the emergence of synthetic pulp. During the period 1962–70, a price increase of more than 32 % took place in the case of certain grades, for example unbleached sulphite (OECD 1971 p. 17).

These price increases are naturally reflected in paper prices. In the UK, the price of paper increased between 1963 and 1970 by between 22.2 and 45.8 %, as the index in Table 34 show (source: BPBMA 1971).

Table 34. Index prices of paper and paper products in the UK, 1970 (1963 = 100).
Taulukko 34. Ison-Britannian paperin ja paperituotteiden hintaindeksi v. 1970, (1963 = 100).

	1970
Paper and board (excl. building board) – *Paperi ja kartonki (paitsi rakennuslevyt)*	128.5
Paper – uncoated – *Paperi – päällystämätön*	126.3
Board – uncoated – *Kartonki – päällystämätön*	140.9
Printings and writings (incl. newsprint) – *Painatus- ja kirjoitus (mukaanl. sanomalehtipaperi)*	129.0
Kraft wrapping paper – *Voimakäärepaperi*	130.4
Food wrapping paper – *Elintarvikekäärepaperi*	122.2
Packaging boards – *Pakkauskartonki*	145.8
Cardboard boxes, cartons and packing cases – *Kartonkilaatikot, rasiat ja pakkauskotelot*	137.6
Paper sacks – *Paperisäkit*	127.6
Paper bags – *Paperipussit*	125.1

Table 35. Index of wholesale prices of chipboard and competing materials, in the UK, 1963–70.
Taulukko 35. Ison-Britannian puulastulevyjen ja kilpailevien tuotteiden tukkuhintaindeksi v. 1963–70.

Year *Vuosi*	Home produced chipboard *Kotim. puulastulevyt*	Imported chipboard *Ulkom. puulastulevyt*	Plywood *Vaneri*	Softwood *Havupuu*	Hardwood *Lehtipuu*
1963	100	100	100	100	100
1964	103	100	104	108	102
1965	103	100	115	113	104
1966	103	95	116	113	106
1967	103	90	112	113	107
1968	110	86	125	126	126
1969	110	106	135	133	133
1970	113	111	138	136	137

When developments in 1971 and 1972 are taken into consideration, the overall price of paper and board will have shown an increase of about 50 % in 10 years. The price rise is actually illusory in view of the falling value of money. The consumer price index in the UK in September 1972 was already 160 (1963 = 100).

Other forest-industry products show a corresponding price rise, as the index in Table 35 shows (source: TTJ 1972, 4.3. p. 36).
Chipboard price increases have been lowest which partially explains its growing popularity.

The raw-material resources for plastics production remain a subject of controversy. Since plastics are at present almost totally manufactured from oil and natural gas, the future of plastics is linked with the question of the world's oil resources. Assessments of these resources are naturally unsure, but they are estimated at present to amount to 55 000 million tons. On the basis of new finds, the estimate of resources in the year 2000 amounts to 116 000 million tons despite an increase in annual requirements from 2200 to 6500 million tons. According to the latest estimate (BRIDGE 1972 p. 17), the world's final total oil resources amount to 290 000 million tons. Of great interest for the UK are the finds in the North Sea, which are becoming steadly more important. According to the Financial Times (1972, 30.6 p. 28), it is possible that one half of the UK's gas and oil requirements in 1980 will be supplied from these finds (290 000 tons a day). There should not be a shortage of oil, at least during present century. Besides, the manufacture of plastics will almost certainly survive an oil shortage, as another raw-material base would come into use. It is also worth mentioning that scientists have put forward a theory that oil is continually being formed in the Earth's crust (cf. POHJANPALO 1970 p. 111).

The quantity of oil used by the plastics industry constitutes only about 5 % of the total annual oil consumption, in equivalent energy terms, so that the plastics industry has no possibility of influencing prices. The price of crude oil will probably show a continuous rise, especially in view of the political complications which can arise in connection with deliveries from the Middle Eastern countries. It should be noted, however, that the oil-producing countries are as eager to sell their oil as the industrialized countries are to buy it. Also to be emphasized is the fact that crude-oil costs make up a comparatively small part, c. 5–10 %, of the price of base plastics. With further processing, the share of crude oil falls to about 2–3 % of the final product's price in the more sophisticated products, so that the price development of crude oil is not of prime significance. As a comparison, it can be mentioned that the raw-material price in the forest industry varies between 5 % for sophisticated products such as cellophane and rayon, to 30–35 % for particle board and even higher for plywood and sawnwood products.

The most important polymers used for consumer products are PS, LDPE, HDPE, PP and PVC. Of these, PS, LDPE and PVC are "old" products, developed in the 1930s, while PP and HDPE were developed in the 1950s. For PS production ethylene and benzene are needed, PE is polymerized from ethylene and PP from propylene. All of these base products are obtained in Europe from the naphtha crude-oil fraction at petrochemical plants.

If at a later stage, say 1990, an oil shortage appears so imminent that a rationing system must be introduced, the plastics industry will remain in an advantageous position because of the abudent supplies of naphtha, which occur in excess in connection with the manufacture of petrol. At present, the supplies of naphtha are greater than required, with the result that the ethylene capacity has been built out beyond needs. The consumption of plastics is growing relatively evenly, but the production of monomer is growing in large steps, as nowadays only large plants are profitable. The situation has features in common with that of many of the forest industries. Temporary over-capacity is difficult to avoid so long as there is no international agreement regulating expansion. As a result, prices can fall below the level of profitability.

Regardless of the rising price of crude oil, the price of plastics has steadily fallen over a long period, as the graph in Figure 8 shows (source: Department of Trade and industry). Despite this strong decline in prices, profitability in 1970 was better in the chemical industry than in the paper industry. The curve illustrates the development of all plastics prices. It can be seen that the price fell steadily until 1967, when the pound was devalued. If 5-year means are calculated for the price fall, it stands between 1.5 and 3.5 %. After 1967, a price rise of 2.1 % annually can be observed. Table 36 presents the results of a detailed examination of price movements for different grades of plastics (source: EIDEM 1971 p. 65).

When the falling index figures for plastics are compared with the simultaneous rise for cellulose, it is evident that the competitive position of plastics has greatly improved for the 1970s.

The actual price level for plastics material at the end of 1972 in the UK is shown in Table 37 (source: Europlastics Monthly 1972 Aug.)

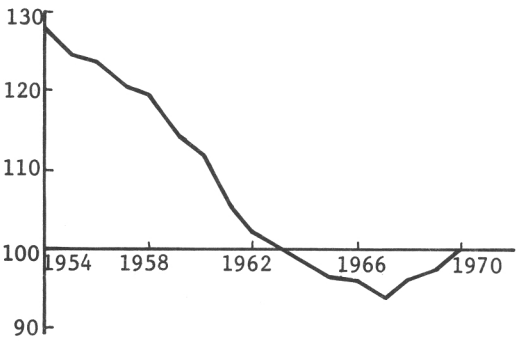

Fig. 8. Wholesale price index (1963 = 100) for plastic materials in the UK, 1954–70.
Kuva 8. Ison-Britannien muoviaineiden tukkuhintaindeksi v. 1954–70 (1963 = 100).

Table 36. Wholesale price index (1960 = 100) for individual plastic materials and pulp in the UK, 1970 and 1975 (estimated).
Taulukko 36. Ison-Britannian eri muoviaineiden ja sellun tukkuhintaindeksi v. 1970 ja 1975 (ennuste), 1960 = 100.

	1970	1975
PVC	66	65
LDPE	41	39
HDPE	45	36
PS general purpose	68	68
PS high impact	67	67
PP homogenous polymer	36	29
PP composite polymer	39	32
Bleached sulphite	133	n.a.
Bleached sulphate	130	n.a.

Table 37. Price of plastic materials in the UK, 1972.
Taulukko 37. Ison-Britannian muoviaineiden hinnat v. 1972.

	Cost £/ton	Density g/cm^3	Cost new pence/cm^2
PVC, general purpose mechanical grade	125	1.40	17.5
PS, general purpose	130	1.07	13.9
LDPE, film grade	154	0.94	14.5
HDPE bottle grade	197	0.97	19.1
PS, high impact	200	1.07	21.4
PP, general purpose	220	0.91	20.0

Prices quoted are local delivered prices for standard material in lots of between 5 and 20 tons depending on grade. Export prices can be 10–20 % cheaper.

If the price development for the main grades is examined, it is evident that newer plastics, HDPE and PP, at present stand at a higher price than the plastics developed in the 1930s. As has previously been shown (RUNEBERG 1971, p. 1; cf. also BRIDGE 1972 p. 18), this relationship is expected to even out during the next few years. On the whole, a similarity in the various polymer prices can be observed. A comparison of the volume base gives primarily the same price picture as weight comparisons. Only PVC is a relatively dear material because of its high density.

The corresponding current prices for forest products are as follows (sources: TTF year book of timber statistics 1971, Paper and Packaging Bulletin 1972 Nov., and Finnish Cellulose Association 1972):

	£/tons	
Sawn softwood (£/m^3 24.75)	35.36	Mean import value CIF in 1971
Plywood (£/m^3 65.96)	101.48	
Particle board	50.68	
Fibreboard	52.34	
Sulphite pulp, bleached ($ 194)	82.55	CIF end of 1972 Finnish deliveries
Sulphate pulp, bleached ($ 201)	85.53	
Semi-chemical fluting	61.50	Delivered price August 1972 Scandinavian
Newsprint in reels	74.25	
Kraft linerboard in reels	80.25	CIF August 1972, Scandinavian
MG kraftpaper, bleached	145.58	

Wood pulp prices, which were down about 10 % at the end of 1971 and during early 1972, have now recovered and passed their previous level which corresponded to an index of 150 (1963 = 100).

52. Price calculations on the basis of empirical material

Several alternative ways exist of estimating the future price development of a product. A common method is to project future values by undertaking a regression analysis on the basis of available empirical material. However, this type of analysis might give impossible values if the empirical material shows a rapid rate of growth (cf. RUNEBERG 1967 p. 88). If, for example, West European polyolefine consumption is estimated according to present trends, a volume of 500 million tons a year is reached for 1995. Earlier experience shows, however, that the development of a new product follows, through time, an S-curve, as illustrated in Figure 9. (cf. BRING 1969 p. 73).

However, as long as the development is still in the stage of rapid growth, and it is not known when the growth rate will begin fall off, there are no concrete values available for inflection and extreme points. Particularly on the plastics side, the growth rate remains so high that the possibility of estimating the present position on the growth curve is small. On the other hand, we know that the saturation must sooner or later make itself felt.

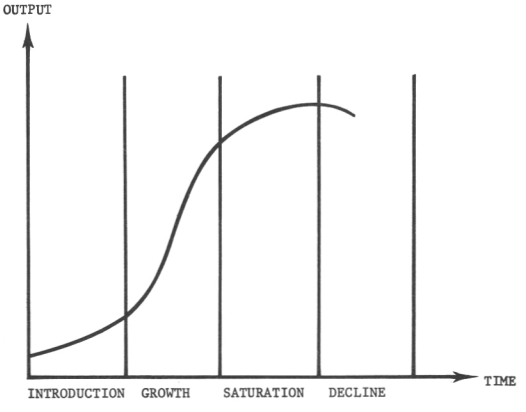

Fig. 9. Sales development of a new product.
Kuva 9. Uusien tuotteiden myynnin kehityskäyrä.

It is a known fact that the price of a product, stands in relation to the quantity produced. The Boston Consulting Group in the USA has on this basis developed the following line of thought.

As an enterprise's accumulated production (i.e. tons in year 1 plus year 2 and so on) grows over the years, the unit costs of production fall. This fall can be considered to occur at a constant percentage rate for every doubling of the accumulated output (i.e. experience). This effect is, in fact, the result of a combination of many separate economic forces, for instance (Moose and Zakon 1971 p. 23):

Productivity improvement due to technological change and/or "learning" effect;
Modifications in the nature of the product;
Economies of sale and of specialization;
Displacement of less efficient factors of production;
Falling costs of employing capital relative to labour;
Capital for labor substitution as wage rates rise;
Shifts in demand and responses in supply.

Since every component of cost is affected in its own way, the total cost actually responds to many interacting influence. The law of large numbers makes conflicting tendencies net one another out, and as a result a clean straightforward pattern emerges. The net effect is a systematic tendency for industrial cost to fall.

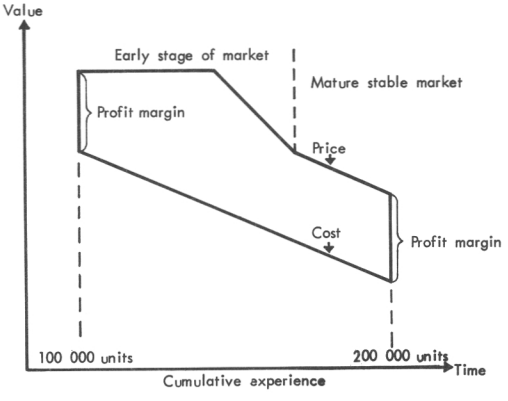

Fig. 10. Price and cost behaviour of a new product.
Kuva 10. Uusien tuotteiden hinta- ja kustannustason käyttäytyminen.

The final price of the manufactured product usually falls proportionally. This assumes, of course, free competition. In the early stages of development of a new product, price movements are uncertain as the method may be secret or protected by patent. Figure 10 illustrates this (cf. Moose and Zakon 1971).

On the plastics front, it can be considered that comparatively long-developed market conditions exist for all important base plastics, since the Italian Montecatini patent for the manufacture of PP has run out.

If this reasoning is applied to some of the main plastic raw materials in the UK, the results shown in Table 38 are obtained (source: archive statistics from ICI).

This empirical material indicates a 21–22 % decline in price per doubling of accumulated production. The equivalent figures obtained for HDPE were 17–18 %, and for high impact PS 22–23 %. The price decline for PP on the other hand is only 10–11 % so far, probably depending on protected market conditions.

Table 38. Accumulated production and selling price of LDPE in the UK, 1956–71.
Taulukko 38. Ison-Britannian kumuloitu LDPE:n tuotos ja myyntihinta v. 1956–71.

Year *Vuosi*	Accumulated production 1000 tons *Kumuloitu tuotos 1000 tonnia*	Selling price in £/tons *Myyntihinta £/tonnia* Current *Käypä*	Deflated (1963 = 100) *Indeksikorjattu*
1956	170	600	697.7
1957	221	450	517.8
1958	290	306	341.9
1959	390	287	318.9
1960	514	243	267.3
1961	641	192	204.3
1962	794	173	176.5
1963	962	174	174.0
1964	1149	161	155.8
1965	1355	149	137.6
1966	1581	145	127.8
1967	1817	141	121.2
1968	2054	131	106.3
1969	2315	129	100.1
1970	2630	132	94.8
1971	2936	136	89.7

Table 39. Accumulated world production and selling price of bleached kraft pulp, 1961–71. *Taulukko 39. Maailman kumuloitu valkaistun sulfaattisellun tuotos ja myyntihinta v. 1961–71.*

Year *Vuosi*	Accumulated production million short tons *Kumuloitu tuotos milj. lyhyttä tonnia*	Selling price in $ per short ton *Myyntihinta $/lyhyttä tonnia* Current *Käypä*	Deflated (1963 = 100) *Indeksikorjattu*
1961	630.2	145	148.6
1962	676.1	140	143.0
1963	726.0	137	137.0
1964	752.0	145	142.7
1965	839.8	150	144.9
1966	902.0	148	139.2
1967	966.1	150	137.0
1968	1038.1	145	128.3
1969	1116.1	148	128.9
1970	1201.1	156	131.6
1971	1302.0	162	131.2

As far as forest products are concerned, the UK maket is not suitable as a basis for comparison because of the small domestic production. If, however, the world market for bleached kraft pulp is examined, the figures in Table 39 can be compiled (cf. Heslop 1971). These figures give a price decline per doubling of production of 17–18 %. It can be assumed that the import price in the UK market will follow this world trend.

If, on the basis of this reasoning, estimates of the trends are made, it is evident that the price of plastics will fall at least twice as quickly as that of cellulose, since at present accumulated production is doubling about every 4th year in the plastics branch but only every 10th year in the cellulose branch. The older an industry becomes, the larger its accumulated production, and hence the rate of doubling of production slows down. If an annual 5 % decline in the value of money is taken into consideration, the actual price of LDPE and PS for example, will show a slow sinking trend (10 x 5 % – 2.5 x 22 %) of about 1/2 % annually while the price of cellulose will rise by 3.2 % a year (10 x 5 % – 18 %).

A comparison of the price development of plastics and cellulose to 1980 on the basis of this method of calculating gives the following undeflated (5 % inflation rate) values in new pence per kg:

Year	Bleached kraft pulp	LDPE	High-impact PS
1970	7.8	14.4	16.5
1975	9.1	14.0	15.9
1980	10.1	13.5	15.4

The price different between sulphate cellulose and LDPE in 1980 should thus have fallen to 30 %. It is possible, furthermore, that the shortage of timber raw material that is likely to appear in Europe during the present decade will eliminate the price decline per doubling of production as far as cellulose is concerned.

Approximately the same results are arrived at through regression analysis of LDPE and kraft-pulp prices (cf. RUNEBERG 1968 p. 6; also LEVLIN et al. 1971 p. 162).

6. FUTURE OUTLOOK

61. The future of the plastics industry

In the future of the plastics industry, the middle of the 1980s has been given as a magic date when world consumption of plastics will pass steel in volume (HOUWINK 1966). This forecast, which was published in 1965, has been complemented by other assessment which suggest that the Compertz function in development has been insufficiently taken into account. In fact, however, the actual development has so far overtaken even Houwink's forecast.

Although later forecasts take a more cautious standpoint, the expected world consumption remains considerable. The Standford Research Institute, for example, estimates consumption

Table 40. Annual mean growth rate of plastics production and consumption in selected countries, 1955–70, in %.
Taulukko 40. Eräiden maiden muovin tuotosten ja kulutuksen keskimääräinen kasvu v. 1955–70, %.

	1955–1960		1960–1965		1965–1970	
	Production *Tuotos*	Consumption *Kulutus*	Production *Tuotos*	Consumption *Kulutus*	Production *Tuotos*	Consumption *Kulutus*
Austria	29.0	30.5	17.3	17.1	10.3	12.2
Benelux	20.5	32.0	25.0	19.6	17.7	14.3
Canada	12.0	9.9	9.0	11.7	8.9	13.9
France	25.0	19.5	17.6	14.9	14.9	14.8
Italy	31.0	28.0	19.7	16.5	17.2	17.2
Japan	39.0	29.0	24.0	18.4	17.4	17.1
Sweden	15.7	14.6	16.0	18.2	10.6	14.6
Switzerland	14.9	24.0	8.0	16.8	11.3	15.4
UK	10.5	12.1	11.7	12.1	9.3	9.0
USA	10.7	9.3	12.5	13.0	9.5	10.8
USSR	13.5	14.9	18.2	17.1	19.9	17.3
West Germany	21.0	30.0	15.5	15.5	15.5	13.4

in 1980 at 77.3 million tons, and UNIDO estimates it at 90 million tons, compared with 105 million tons according to Houwink. While the total volume of forest products will clearly long be above that of plastic products, there is no doubt that mankind is rapidly entering an increasingly marked plastics age.

It is obvious that a direct trend analysis on the basis of existing material from the plastics branch leads to astronomical values after about 20 years. Clearly the saturation must be taken into consideration, at least when the forecast covers several decade. On the other hand, it should be possible to base short-term forecasts, up to 10 years, on regression analyses of empirical material if there is no particular sign of a change in development. Table 40 presents the average growth rate of plastic products and consumption in the main countries during the 1950s and 1960s (source: Standford Research Institute).

Nine of eleven countries showed a slowing down in the rate of both production and consumption increase during the 1960s. It can be seen that the UK's rate of growth lagged behind that of the other countries. An indirect increase in consumption is expected in the UK during the present decade through the decline in the growth of other important countries, as the figures in Table 41 show (MÜLLER 1970 p. 316).

Even with these growth rates, the plastics industry is still one of the fastest growing industries in the world.

Announced plans for the expansion of production until 1980 are shown in Table 42 (MÜLLER 1970 p. 317).

Table 41. Forecasted annual mean growth rate of world plastics production, 1970–80, in %.
Taulukko 41. Maailman muovin tuotannon ennustettu kasvu v. 1970–80, %.

	1970–1975	1975–1980
Benelux	13.5	10
Canada	9.0	8
France	12.0	9
Italy	12.0	10
Japan	13.0	10
UK	10.0	9
USA	8.5	7
USSR	15.0	12
West Germany	10.0	8
Other countries	17.5	16

Table 42. Planned world production of plastics, 1975 and 1980, in 1000 tons.
Taulukko 42. Maailman muovin arvioitu tuotanto v. 1975 ja 1980, 1000 tonnia.

Country/Market block *Maa/Markkinointialue*	1970	1975	1980
USA	8200	12800	18000
Canada	360	600	900
North America, total	8560	13400	18900
West Germany	4200	6600	10000
France	1300	2300	3800
Italy	1900	3800	5800
Benelux	800	1700	2600
EEC, total [1]	8200	14400	22200
UK	1500	2500	3800
Other EFTA countries	600	1200	1700
EFTA, total	2100	3700	5500
Japan	4600	7000	12000
USSR	1900	4100	7400
Other Comecon countries	1400	2900	4000
Other countries	1200	2700	6500
World, total [2]	27960	48200	76500

It appears that production and consumption on a global scale will develop fairly evenly during the present decade.

It should be observed that the retardation in the rate of growth predicted for plastics production during this decade does not take into account the stimulation of possible entirely new markets, such as plastic paper, for example. Neither are completely new polymer groups of commercial significance expected to be discovered this decade. However, as STERN (1969 p. 20) states, "major developments of sudden and shattering impact on the conventional have sometimes been utterly unpredictable."

Growth is expected to be concentrated in the thermoplastics group, in which world production is predicted to develop as follows (cf. MÜLLER 1970 p. 317):

	1970	1975	1980
	Million tons		
Polyolefines	7.60	14.70	23.00
PVC	5.90	10.25	15.10
PS	2.25	3.55	5.90

1) EEC and EFTA according to position in 1972.
2) Excluding People's Republic of China.

At the present stage, the polyolefine group has the best chance of supplying the raw material for future plastic pulp and plastic paper. In the UK, the forecast for the polyolefine group is as follows:

1970	390 000 tons
1975	560 000 "
1980	1 100 000 "

These figures still do not allow scope for a considerable production of plastic paper, considering that the construction and packaging branch alone in 1980 will use some 750 000 tons (cf. Europlastics Monthly 1972, Aug. p. 8).

62. Diverse future trends (social structure, silviculture and environmental conservation)

To assess developments in the UK, it is useful to examine conditions in the USA, which is in the process of passing over to a post-industrial society where the standard of living is concentrated to an increasing degree around various forms of services. It is estimated that information and planning work will employ 50 % of all professional workers in 1980, compared with 1/3 now. A continued expansion of social services can also be reckoned with. A high living standard entails the use of more highly processed materials, with the consequence that value increases more than weight. On the other hand, there is a good correlation between paper and panel consumption and national income per capita. The increased need for information, progressing bureaucratization and strong concentration on throw-away packaging are all factors increasing paper requirements in the post-industrial society. Developments in the UK can be expected by the end of this decade to manifest post-industrial tendencies, with consequent high paper consumption.

A post-industrial society has its industrial strength in capital-intensive mass production and fields where special techniques are required. This easily stimulates the import of simple ready-made goods.

With regard to the rate of diffusion of plastic-paper production, it is of interest to observe that the UK is considered the leading country in Europe in respect of the introduc-

tion of new techniques (source: Industriens Utredningsinstitut, Sweden). On the other hand, a long time passes before the innovation spreads throught its particular branch. Both Sweden and West Germany lie ahead of the UK in this respect.

There is clearly no possibility of the UK increasing its home timber raw-material base to any large extent. Certainly extensive planting was initiated after the Second World War, and considerable areas are still being planted annually. A significant increase in timber removals is awaited in two or three decades when these new plantations begin to yield. However, the total removals of industrial wood are between 3 and 4 million m^3 annually, whereas requirements reach 40 million m^3 WRME. Obviously, silvicultural measures cannot have any decisive influence on the situation. The increasing demands on forests for multiple-use purposes such as recreation and nature conservation will clearly restrict intensive production of industrial wood. In addition, continued population growth is nibbling at the available forest land.

The future of the forest and plastics industries in the UK, as elsewhere in the world, is obviously closely coupled with questions of environmental conservation, especially air and water pollution. It can be mentioned that Denmark was the first country in the world to found a Ministry for Environmental Conservation and is in the process of developing effective legislation in the field. Without doubt, a firmer grip on these questions will also be taken in the UK. An official report (Refuse Disposal) was published in 1971 presenting the results of a conference on "Plastic Waste and Environment" held the same year. Later, a working group was set up on the theme "Designing for Disposability". No less than four government ministries are represented in the group, including the recently formed Department of the Environment.

Environmentally, large parts of the forest industry create as many problems as the plastics industry. Thus between 1965 and 1970 the paper industry spent c. £ 7 million on investment for pullution control. No country-wide estimate of the full costs of cleaning up air and water pollution has been made in the UK as yet, but the situation can be illustrated by the following estimated cost in the USA (Newsweek 1972 June 12):

	Capital invested	Annual cost (1971)	Added cost to customers
Pulp and paper	$ 3 300 million	$ 5.5–12.5/ton	3.5–10 %
Oil refineries	$ 634–1000 million	$ 21 million	$ 0.55 per ton

In addition, about 100 paper factories and 12 oil refineries would have to close. It is apparent that the costs are considerable in both industries. These renewals should, on the other hand, mean that factories will be forced to do away with old plants and find better methods. The plastics industry has a clear advantage in paper manufacturing in that the water requirements are considerably smaller than for conventional paper. In Japan, it has been calculated that to produce 2.4 million tons of plastic paper requires 52 million m^3 of water, whereas the equivalent quantity of conventional paper needs 310 million m^3. The plastics industry also requires less space than the forest industry, as the storage area needed by the former, for raw material is small. The final products, too, often take up less space, as for example plastic paper compared with conventional paper (a difference of at least 25 %).

Closely related to environmental conservation is the question of recycling waste paper and plastic waste. The recycling of waste paper in the UK, as has been seen, is no less than 30 %. The possibility of further raising this percentage presupposes a considerable rise in the price of paper, as the margin of profitability in this field is small. For instance in Japan the waste-paper percentage is showing a downward trend due to increasing labour costs and worsening traffic conditions.

A long-standing argument against plastics is their chemical durability and inability to decompose in nature. On the other hand, plastic waste has not yet become a sufficiently large part of the total amount of refuse for economic recovery to be possible. On average in Europe, plastic waste amounts to about 2 % of all domestic waste. At a later stage, when this share has grown to 10 %, for example, then certainly utilization of plastic waste will become economically worthwile (cf. BP 1972, Jan. p. 7). The variety of plastic grades will, however, further complicate the procedure. As a

detail, it can be mentioned that shrink-wrap packs are considered in the retail trade as less bother and easier to dispose of than corrugated cases. An interesting possibility is also plastic paper developed on a urea base (containing nitrogen), which could be used as soil fertilizer after use.

It can further be pointed out that self-destructive plastics are being developed in different parts of the world. It was recently announced in the UK (Financial Times 1972 4.7.) that 3 major European manufacturers of plastics have signed agreements with SCOTT (University of Aston, Birmingham) to use his process for making photo-degredable plastics (cf. also Europlastics Monthly 1972, Oct. p. 78). The chemicals added to the plastic do not affect the manufacturing process and raise the product's price by only a few percent. The breakdown of the plastic occurs by exposure to ultra-violet light and can be controlled so that bottles and suchlike do not decompose too early. Principally, this should mean that such plastic waste would disappear significantly faster than, for example, waste paper. Whether the disappearance in this way of valuable raw materials will be desirable in the future remains to be seen.

When the difficulties of destroying plastic are discussed, the possibility of burning plastic waste in the normal way is often disregarded. Of the three principal plastics, PVC, PE and PS, the last two can be burnt without difficulty. The final products consists only of water vapour and carbon oxides, the same as when timber is burnt. PVC can also be burned, but yields hydrochloric acid gas which is a potential health hazard.

It is evident from this short survey that there is no reason to suppose that, in relation to the question of environmental conservation, the plastics industry and plastic products in the future will be in a worse position than the forest industry and forest products.

63. The United Kingdom's future import requirements of forest-industry products

It is well-known that the consumption of forest products is to a high degree dependent on the general economic development of a country. In this respect, the UK has fought against particularly considerable difficulties during the whole of the 1960s. The task of consolidating the UK's trade balance after the devaluation in 1967 has been unrewarding and resulted in slow economic growth and high unemployment. The average growth of GDP between 1960 and 1971 was thus only 2.5 % a year. A consequence has been that the level of investment in many industries has lain below that of other industrialized countries.

The outlook for the present decade suggests a definite turning-point for the better. Membership in the EEC should promote larger investments in the modernization of the sectors of British industry that have fallen behind technically. A large part of the unnecessary ballast weighting down business life has been thrown overboard with monetary reform and conversion to the metric system, and the country has adjusted to a more self-subsistent economy in place of the earlier imperial economy. The world economic upswing should help recovery in the approaching years. Of course, there are also negative signs that can be pointed to, but it seems realistic to reckon with a somewhat faster growth of GDP during the coming decade. The economic studies that have been undertaken indicate that the growth will be 3–4 % annually. The future consumption of forest-industry products will consequently be judged on this basis.

With regard to the widening of the EEC and possible related free-trade groupings, negotiations are still going on in various quarters. Regardless of this, however, it is reasonable to expect that by the end of the 1970s the whole of Western Europe will constitute a free-trade area for industrial products. The customs barriers that are being temporarily erected against the EFTA countries remaining outside the EEC will scarcely affect to a major extent the earlier pattern of imports to the UK. With British Membership in the Common Market from the beginning of 1973, the other EEC countries will eventually gain free access to the British paper and timber market. However, all the EEC countries are major importers of these goods, so that there is no question of considerable exports to the UK. Of course, there will be more intensified competition for the British market in certain products, for instance better-quality and fine papers, but the total imports from the Scandinavian countries can be expected to continue to grow.

Table 43. Consumption of paper, plywood, particle board and sawn softwood compared with consumption of plastics in selected fields in the UK, 1971, in 1000 tons.
Taulukko 43. Ison-Britannian paperin, vanerin, lastulevyn ja havusahatavaran kulutus verrattuna muovin kulutukseen eräillä aloilla v. 1971, 1000 tonnia.

	Paper-board *Kartonki*	Plywood *Vaneri*	Particle board *Lastulevy*	Sawn softwood *Havusahatavara*	Total woodfibre *Puukuitu yht.*	Plastics *Muovi*	Plastics compared to woodfibre % *Muovia verrattuna puukuituun %*
General construction *Yleinen rakennustyö*	.. [1]	208	197	4155	4560	166	3.6
Joinery – *Puusepäntyö*	..	64	11	709	784	..	..
Furniture – *Huonekalut*	..	106	224	170	500	47	9.4
Shopfitting – *Myymälä-sisustukset*	..	24	22	–	46	..	..
Packaging – *Pakkaus*	1400	45	5	454	1904	312	16.4
Vehicles – *Kulkuneuvot*	..	57	11	45	113	69	61.1
Ship & boat building *Laiva- ja veneenrakennus*	..	14	2	28	44	17	38.6
Toys – *Leikkikalut*	..	5	–	113	185	35	18.9
Do-it-yourself – *Tee-se-itse tuotteet*	..	38	29			–	

[1] not available

The transfer to the value-added tax (VAT), which is a pre-requisite of British entry into the EEC, is likely to have some interesting consequences in the construction and building industry. The industry, in contrast to other end-use industries, has received the right to deduct VAT costs from its raw-material supplies. This will probably stimulate the trend towards inbuilt products such as furniture, cupboards and shelving in the construction phase. A new houseowner will pay 10 % less for these items than if they are bought in a furniture shop.

It was earlier stated that a significant expansion of domestic timber as a raw-material base is out of the question in the UK. Since on the other hand the need for forest products can in many cases be expected to rise in relation to national income, it is evident that the import of these products will, as far as supplies admit, remain at a high level. The only thing that can be expected to change this picture is the continued growth of plastics as a raw-material base for similar products. In this case, the UK has the possibility of expanding home production on the basis of oil raw materials, which to a considerable extent can be obtained in the near vicinity from the North Sea. Before an assessment is made of how quickly and how far plastic infiltration may take place, a summary of the present situation is presented in Table 43.

The figures for plywood, particle board and sawn softwood have been calculated from the consumption figures for 1971, presupposing the same end-use as in 1968.

A comparison based on weight units, as has been seen, contains many uncertainties, but nonetheless gives a clear picture of the great preponderance of sawnwood at the present stage. The following guide lines and forecasts can be given for future developments for the most important products.

631. Paper and paperboard products

Trade in paper products in the UK has been estimated for the next few years as follows (Hoare & Co. 1971):

	1973 1000 tons	% change	1974 1000 tons	% change	1975 1000 tons	% change
Consumption	8 031	+4.0	9 192	+ 2.0	9 192	–
–Imports	3 333	+6.7	3 486	+ 4.6	3 611	+ 3.6
+ Exports	235	+16.9	270	+14.9	305	+13.0
Production	4 933	+3.3	4 976	+ 0.9	4 886	–1.8

Imports and exports are expected to rise, while domestic production will show little chance in the near future and is even expected to show a small reduction at the end of the trade cycle in 1975. The development of consumption during the 1970s can as a whole be expected to rise on average by 3.5 % annually, which for 1980 gives a demand of more than 10 million tons of paper and paperboard. The packaging grades can be estimated to grow by more than 5 % and printing and writing grades by about 4 % annually. The demand for coated papers on the printing and writing side will grow especially quickly (8–9 % annually) and will constitute in 1980 nearly 50 % of this market. The growth of consumption as a whole will depend on a corresponding increase in imports, as the domestic industry will scarcely be capable of holding its earlier position.

Of primary interests is the part of paper consumption which can be expected to fall within the packaging sector and how this will develop in relation to shrink film. In Table 44, an attempt has been made to calculate the development until 1976 (cf. Paper and Packaging Bulletin no. 70 p. 17) on the assumption that the rate of growth of consumption will be 5.1 % per annum compound for the total casing demand and 16.8 % for shrink film.

The total growth of the demand for packaging is based on empirical material and presupposes that GDP grows at a rate of 3 % annually. It is estimated that the rate of growth of the demand for shrink film will fall off in the mid-1970s, when the market's possibilities will first become saturated. It is further estimated that about 70 % of the total usage of film will compete with cardboard cases. By this method of estimation, the use of film in 1976 will be equivalent to about 10 % of the total supply of cardboard cases. This agrees well with the forecast made by BEAD (1971 p. 1) that the UK's demand for corrugated cases in 1980 will reach 1.9 million tons, i.e. an annual growth of 4.5 %, and that 10–15 % of the market will be lost for cardboard. It is obvious that the rapid rate of expansion of the 1960s can hardly be maintained. This development depended to a large extent on the introduction of cartoning systems which offered more or less automatic production handling.

Table 44. Forecasted consumption of packaging for shrink film and cardboard in the UK to 1976, in 1000 tons.
Taulukko 44. Ison-Britannian kutistefilmin ja kartongin ennustettu käyttö pakkaustarkoituksiin vuoteen 1976, 1000 tonnia.

	Total casing demand *Pakkausten kysyntä yhteensä*	Total shrink-film consumption *Kutistefilmin kulutus yhteensä*	Displacement of cases by shrink film (in terms of casing demand) *Laatikoiden korvaaminen kutistefilmillä (laatikkoina)*	Cardboard cases *Kartonki-laatikot*
1970	1 465	6.5	76.4	1 388
1971	1 517	8.5	99.8	1 417
1972	1 604	9.9	113.9	1 490
1973	1 690	12.0	137.3	1 553
1974	1 786	13.6	151.3	1 634
1975	1 881	15.0	166.9	1 714
1976	1 976	16.5	181.0	1 795

Of considerable interest for paper consumption is also the future development of the market for sacks and bags, where it has been earlier observed that the UK is lagging behind as far as infiltration by plastics is concerned. A comparison with Swedish conditions, where development has gone further, can assist in assessing the situation in the UK. It can be noted that between 1960 and 1970 paper increased its share of total packaging material used in Sweden from 40 % to 45 %, despite strong competition from plastics. It is estimated, however, that the share of paper will sink again to 42 % in 1975, while the share of plastics will rise from 15 % to 21 %. Paper appears to have reached its culmination in the mid-1960s. The following percentages show the annual rate of growth expected for the next few years (source: Swedish Packaging Federation 1971):

	Paper	Plastics	All packaging materials
1965–70	7 %	18 %	8.0 %
1970–75	4 "	12 "	4.7 "

Thus it is predicted that the rate of growth will gradually ease off. The demand for consumer packaging is, however, expected to grow somewhat faster than the total packaging market, at least in value.

In 1970, the percentage value of different groups of material within consumer packaging in Sweden was the following:

Paper and paperboard	40 %
Metals	24 "
Plastics	24 "
Glass	12 "
	100 "

In the UK, the value of plastic packaging in 1971 was about £ 100 million, which is equivalent to 9 % of the UK's total expenditure on packaging materials. Empirical material on the consumption of plastics in packaging during the last 10 years is presented in Table 45.

It can be seen that growth has remained around 20 % or more on average. On the basis of what has been said previously, consumption can probably be expected to reach 1 million tons a year before 1980. One should keep in mind, however, that the packaging industry at this juncture will still be using about 3 million tons of paper and other wood products.

Table 45. Consumption of plastics in packaging in the UK, 1962–71, in tons.
Taulukko 45. Ison-Britannian muovin kulutus pakkauksiin v. 1962–71, tonnia.

Year *Vuosi*	Tons *Tonnia*	Growth % *Kasvu %*
1962	60000	
1963	90000	50.0
1964	110000	22.2
1965	130000	18.2
1966	158000	21.5
1967	195000	23.4
1968	241000	23.6
1969	300000	24.5
1970	356000	18.7
1971	312000	–12.4

Regarding the future market for plastic paper, WOLPERT (1972 p. 361) writes that the question is no longer whether plastic paper will penetrate the conventional paper market but:

1) "the rate at which these new products will achieve a major penetration,
2) who will become the leading large-scale manufacturer of these new types of products, and
3) what type of production and converting equipment will be available".

The situation for the most important paper groups is expected to develop in the following way.

Newsprint is unlikely to experience competition from plastic paper in the UK before the 1980s. (In Japan, however, other views have been put forward).

With regard to printing and writing paper, competition from plastics has so far concentrated on speciality types, but as pointed out in Chapter 4 it is expected that within a few years plastic-film paper will account for 4 % of the coated-paper market. In the long view, a major break-through can be expected as the rigidity properties which have so far hindered its usability are improved. FAO (1971 p. 5) writes concerning this: "it is, however, in the field of paper for printing and writing where lies the greatest remaining latent potential for replacement of paper by plastics."

Concerning wrapping and packaging paper, continued penetration by plastics can be

expected in the next years. For industrial papers, a transfer to PP film for capacitor tissues is particularly expected.

A summary of the infiltration of plastics on the paper and paperboard side is given in Table 46 (cf. BPBMA report in 1971).

Table 46. Areas of partial or total replacement of paper and paperboard products by plastic products in the UK, 1972.
Taulukko 46. Tuotealoja, joilla muovit osittain tai kokonaan ovat syrjäyttäneet paperi- ja kartonkituotteet Isossa-Britanniassa v. 1972.

Applicational area	Individual application	Conventional material	Plastics replacement or substitute
Communications media	Drafting paper	Treated paper	Treated polyester film
	Cartography, advertising display & general-use paper	Art paper	Coated plastics & filled plastics films (generally based on PS, PP, PVC, HPDE or LDPE) fibre reinforced paper
	Carbon paper	Coated paper	Polyester or LDPE film
	Special-purpose books (childrens & workshop manuals)	Heavily coated paper	PVC and filled LDPE film
Flexible packaging	Milk	Glass bottles or coated board	HDPE film sachets and bottles
	Shopping bags	Kraft paper	HDPE film bags, woven nylon bags
	General-purpose paper bags	Sulphite and Kraft paper	LDPE and HDPE film bags
	Refuse sacks	Metal bins or paper sacks	HDPE sacks
	Heavy-duty sacks	Multiple paper sacks	HDPE film sacks and woven LDPE & PP tape sacks
	Display wrapping	Tissue paper, window bags, glassine	HDPE film overwrap and LDPE tissue
	Greaseproof	Greaseproof and waxed papers	HDPE and LDPE films
Rigid packaging	Corrugated and paperboard cases	Corrugated board & paperboard	Profiled LDPE or PP extrusions. Expanded PS & Kraft paper laminates
	Package collation	Corrugated board & paperboard	HDPE or PVC shrink-wrap
	Tray inserts (platforms)	Formed paper pouches	Thermoformed PVC and PS trays
	Yoghurt, cream & some cheese	Glass bottles or waxed paper cartons	Injection-moulded or thermoformed PS or PP containers
	Milk	Glass bottles or coated paper	PR bottles
	Vending cups	Waxed paper	Thermoformed PS or moulded expanded-PS

	Toilet cleaners scouring powders	Tins or spirally wound paper containers	LDPE blow-moulded containers
	Vending trays	Hartman trays (pulp)	Expanded-PS or thermoformed PS trays
	Egg boxes	Loose-packed in paper bags or pulp boxes	Expanded-PS or thermoformed PS boxes
	Soft-fruit interleave trays	Pulp trays	Formed expanded-PS trays
Cushioning packaging	Cushioning	Paper in various forms, fluted paper	Expanded-PS moulding, Expanded-PS sheet waste LDPE tissue paper Air pockets trapped between layers of film
Wall covering	Wallpaper	Paper	PVC/paper laminate
		Hessian	Woven PP & LDPE tape fabric
Disposable goods	Fabrics & dresses	Paper	Paper with the addition of fibrous thermoplastics to increase wet strength
	Table ware (cloths, placemats)	Paper	Expanded-PS sheet
	Plates	Paperboard	Thermoformed or injection-moulded PS or PP & paper extrusion coated with HDPE or PP
Electrical insulation	Cable & capacitor production	Impregnated paper	Direct extrusion of HDPE & LDPE insulation & sheating Polyester, oriented PP & nylon spunbonded fibre wrap

As has been stated earlier, the market for plastic paper in the UK for 1975–76 is estimated at 1 % of total paper requirements. Continued development from this point, however, is completely dependent on how rapidly plastic pulp will begin to be produced in the UK or sold on the world market. It is quite possible that a conventional division into plastic and wood-fibre paper at this point will lose all significance because of extensive mixing of plastic, wood fibre and other subsidiary material in the production process. The share of plastics in consumption of paper products in the UK after the turn of this decade may easily reach 1 million tons yearly, i.e. about 10 % of total consumption.

In future, paper will need to be supplied with a declaration of raw-material content in the same way as many other goods. Superficially it would seem apparent that the UK will seek to construct its own plastic-pulp industry, thinking not least of the future difficulties of finding suppliers of conventional cellulose. Against this is the tendency in a post-industrial society not to attempt especially to construct industries for cheap bulk goods. Since the UK's own cellulose industry, as has been seen, is insignificant in relation to total needs, the creation of a plastic-pulp industry would mean construction from the foundations, with large capital investments. In view of the fact that in the present cellulose-exporting countries such a bulk industry is already developed, it is not impossible that the development of plastic pulp will concentrate in these countries, especially if combinations of plastic pulp and wood fibre become popular in the future. Undoubtedly, it would be significant for future Finnish export trade to the UK if Finland could offer these new products in time.

632. Panel products and sawnwood

A fairly good correlation between the per capita consumption of panel products and of sawnwood is evident with the ECE area. With the rapid growth in the utilization of panel products, the development in relation to sawnwood has progressed as follows:

In 1960 the ratio was	1 : 12.0
1965	1 : 7.8
1969	1 : 6.0

i.e. for every m^3 of panel products used in 1969, 6 m^3 of sawnwood were consumed. If the trend is extrapolated, the ratio for 1980 will be 1 : 4–4.5. In fact, the ratio in the UK already reached 1 : 4.5 in 1970.

Among the most important factors influencing the per capita consumption of these products, FAO (ECE/FAO 1971 a, p. 12) mentions the following:

a) level of living
b) tradition
c) domestic availability
d) climate
e) building regulations
f) level of construction activity
g) competitive strength of the wood-products industries.

In the UK, it can be assumed that tradition will continue to be of great importance for the use of timber and act as a brake to infiltration by plastics. The domestic availability is poor, but on the other hand the import trade is organized particularly effectively. An especially competitive domestic wood-products industry can scarcely be considered to exist. It is hard to demonstrate the relative significance of the various factors, but there is an abvious correlation with standard of living.

So far, the following fields can be regarded as partly lost for timber products in the UK:

Pit-props
Railway sleepers (now made of concrete)
Boats (taken over by plastics)
Furniture (rapidly being taken over by plastics)
Packaging (largely lost to the paper and plastics industries)
Window frames and doors (in danger of being taken over by aluminium and plastics).

The reduced demand for wooden pit-props and railway sleepers works indirectly to the advantage of the forest industry, since timber raw material is released for other purposes.

In the following contexts, on the other hand, timber products have defended and expanded their position. Within the packaging branch, the manufacture of loading palettes has made extensive use of low-grade sawnwood. The annual production in the UK is more than 10 million palettes, of which about 75 % are of wood. For the manufacture of freight containers, plastic-treated plywood has shown itself to be competitive. In the building industry, glued supporting beams of timber have successfully conquered markets from concrete and steel. The main use has been for the construction of halls, but the whole field of glued timber is in a state of rapid development. In Norway, a method has been developed of using timber for non-supporting outer walls, even for blocks of flats, and now no less than 4/5 of flats construction makes use of this method, which is clearly the cheapest. It is, however, hard to believe that this building method will gain a wide distribution in the UK.

On the basis of material collected and facts pointed to in this study, the forecast shown in Table 47 can be made of panel consumption in the UK for the present decade.

With regard to the different grades, the following can be stated. Plywood imports reached their peak during the 1960s, and any further increase in imports is likely to be

Table 47. Future consumption of panel products in the UK to 1980, in 1000 tons.
Taulukko 47. Ison-Britannian paneelituotteiden ennustettu kulutus vuoteen 1980, 1000 tonnia.

	1960	1970	1975	1980
Plywood (including blockboard) – *Vaneri (sisältää rimalevyn)*	440	730	820	850
Particle board – *Lastulevy*	68	419	900	1500
Fibreboard – *Kuitulevy*	284	322	370	400
Total – *Yhteensä*	792	1471	2090	2750

relatively small. The end-uses where an increase in plywood consumption can be expected in the 1970s are the following:

Shuttering
Freight containers
Caravans
Prefabricated buildings
Do-it-yourself products

A clear distinction between untreated plywood and blockboard on one side and surface-treated products on the other side can be predicted, as the following import figures show (in 1000 m^3):

Annual average	Plywood	Blockboard	Surface-treated	Total
1964–67	685.9	184.0	4.1	874.0
1968–71	801.5	203.9	18.9	1024.3
% change	+16.9	+10.8	+363.2	+17.2

The growth rate of surface-treated plywood is so significant that a forecast based on regression analysis of imports during the 1960s (cf. p. 21) leads to unrealistic figures already at the end of the 1970s. A stagnation of plywood products has been falsely predicated previously, and it is possible that surface-treated plywood is capable of considerably influencing growth figures for the whole group. The Finnish share of deliveries within this group was 1970 m^3 in 1971, which does not seem satisfactory against the background of the rate of expansion. A decline in the import figures for 1971 indicates that ordinary plywood is more sensitive to competition than blockboard. An expansion of home production of plywood in the UK is not to be expected.

The difficulties experienced by plywood in conquering new markets are connected to a large extent with the success of particle board. In 1960, particle board made up less than 10 % of the total market for panel products in the UK. During the whole of the 1960s, the market share grew by between 2.1 and 2.7 % (based on 3-year moving averages) and by 1970 had reached 31 %. In view of the probable improved growth of GDP in the UK during the 1970s and of comparable material from other European countries, there is a reason to expect a continued growth of c. 2.5 % yearly. This will result in particle board's share of the market reaching c. 55 % in 1980. In fact, the import figures for particle board in 1971 rose by no less than 56 % over the previous year, so that it is possible that the development will be even faster. The great importance of the market for Finland was indicated by the figures on page 24.

Primarily, the consumption of particle board will increase in the following end-uses:

Shuttering	Vehicles
Built-in furniture	Prefabricated buildings
Partitions	Doors

The growth will be almost entirely in the form of chipboard, while it is estimated that the share of flaxboard in the market will shrink to c. 5 % in 1980.

The domestic production of chipboard in the UK is estimated to rise by c. 200 000 tons in 1973 on account of two planned mills, one to be constructed in Scotland and one in North Wales. Further expansion can scarcely be in question in view of the raw-material situation.

On the marketing side for fibreboard, no major change is to be expected regarding insulation board and hardboard. The fall in consumption in the last few years can be ascribed primarily to the decline in home production due to the closure of Bowater's factory at Kemsley. When the customers were forced to find new suppliers, transfers to other materials became current.

Since considerable fluctuations occurred in earlier consumption, it is not easy to judge developments on the basis of empirical material, but the general economic activity speaks for a certain increase in consumption. When it is kept in mind that particle board will take a growing share of the panel market, plywood and fibreboard will be competing for a decreasing share. Fibreboard has the advantage of being a lighter raw-material resource. Furthermore, fewer of the end products can be replaced by particle board. The best end-use markets for fibreboard can be expected to consists as at present of roofs, partitions and ceilings.

Domestic production in the UK is not likely to rise in the next few years.

As has been shown, plastic can be expected to play an increasing role as the use of surface-treated panel products grows. The total consumption of plastics for surface-treatment will, however, remain small so long as price considerations favour the thinnest possible

plastic coat. At the end of the 1970s, the use of pure plastic boards can be expected to grow rapidly, with an overlapping of end-uses in products such as partitions, doors, furniture, prefabricated buildings etc.

The future of sawmilling is of less interest for this investigation than the other forest products, as so far the infiltration of plastics in this field is insignificant.

The need for sawnwood in general construction and joinery will continue to be considerable, at least during the present decade, despite the general trend towards reduced consumption per unit. For sawngoods to retain their position on the market in the long run, however, a rationalization of the product selection is needed. As the building industry in the UK is in the process of going metric there should be very good opportunities for such efforts (cf. SUNBY 1971 p. 3). At present, a Scandinavian export sawmill produces no less than 5000 products (2 species – pine and spruce –, 3 qualities, 66 dimensions and 13 lengths), which puts them in a weak position against competing industries with similar but more homogeneous building materials. The sawmilling industry cannot in the long term manage with rising labour costs and the capital costs of huge stocks. Standardization and end-use adaption are clearly vital necessities. A development in this direction which has already broken though to a large extent is packed lots of sawnwood where different combinations of paper and plastic coverage play a significant role.

7. SUMMARY

In the introduction, it was stated that the investigation was to throw light on the future of forest-industry products against the background of the growing timber deficit in Western Europe. The United Kingdom was chosen as a case study, not least because of the great importance of the British market for Finland. Special attention is paid to the infiltration by plastics into the field of forest products, with the consequent integrations and adjustments within the machinery of production.

Terminology, which particularly on the plastic-paper side is not yet stabilized, is discussed in Chapter 12. On page 15 is a list of the abbreviations used for various plastic grades.

Domestic production and imports of forest products is dealt with in Chapter 2. British paper production is comparable in size with that of Sweden and Finland, but as a result of lack of new investments during the last decade profitability has seriously deteriorated. The share of imports has greatly increased, reaching 39.2 % of the total consumption in 1971. Finland is the leading supplier, delivering 773 000 tons in 1971. Plastic-coated paper in the UK is manufactured by 5 paper mills and 8 converting packaging firms, which have a total of 20 extruder installations at their disposal. The considerable domestic paper production presupposes a large import of pulp, the purchase of which is become gradually more difficult. The distribution of imports is presented in Figure 4 on p. 19, in which it can be seen that the Scandinavian countries have an important position.

The production and import of panel products is shown in Table 4 on p. 20. Only wood particle board is manufactured in significant quantities in Britain, and even here imports have outweighed home production in recent years. On the plywood side, annual imports passed 1 million m^3 in 1970, but the growth rate of imports appears to have slowed up considerably during the 1060s. Only the statistics for surface-treated grades show a strong growth. The end-uses of plywood are presented in Tables 5 and 6 on p. 21–22. As can be expected, the construction and furniture fields are the most important.

The use of particle board in the UK during the 1960s lay significantly below the average for Western Europe, but the import figures for the most recent years indicate a levelling out of

the difference (Table 7 p. 23). The main end uses of particle board are also for construction and furniture.

Regarding imports of both plywood and particle wood, Finland is the largest supplier. The market for fibreboard in the UK appears to have stagnated during the last 5 years.

The considerable import of sawnwood is shown in Table 11 on p. 27 and the end-use distribution in Table 12 on p. 27. Experiments with wood-plastic composite products have gone on at least since 1967, but the marketing of these products is fairly insignificant.

The plastics industry in the UK is well developed, and with an annual production of 1.6 million tons it holds seventh place in world statistics. The distribution of production among different types of plastic and end-uses is shown in Tables 14–19 on pp. 32–34. The most important fields are packaging and building.

In Chapter 4, the development of production is analysed primarily in the light of competing and co-operative tendencies from the plastics side. For paper products, the packaging field has long been the most important area where a considerable overlapping of interest with plastics cannot be avoided. In the bag and sack markets, the development towards plastic has been slower than in many other European countries, but in 1971 consumption was estimated to have risen to 300 million plastic sacks. The market is dominated by British Visqueen with 35 % of the production. The position on the bag side is shown in Table 22 on p. 38.

The effect of shrink-film in the use of cardboard cases is illustrated in Table 24 on p. 39. The use of 9500 tons of shrink film in 1971 implies the setting aside of c. 130 000 tons of paper products. Considerable co-operation between plastics and paper also occurs. The most important products and producers are mentioned on page 41. As the development of plastic paper is obviously a central question for the future of forest products, this is dealt with in a separate chapter (423). It is shown here that the development so far has concentrated on plastic-film paper, which is produced by means of extruder machines. It is not possible to produce very great quantities by this method, however. Everything indicates that a suitable plastic fibre must be developed to enable the production of plastic paper on conventional paper machines. Intensive research is going on in this field, and the Crown Zellerbach Corporation, among others, is already selling a product of this type. The significance of plastic pulp for the paper industry is not least the possibilities through combination with woodpulp of raising output both quantitatively and qualitatively.

In the British market, the paper producers have shown little interest in developing plastic paper. As can be seen from Table 26 on p. 44, some ten plastics firms have on the other hand entered into this new field of production. On the non-woven side, too, at least 10 factories are operating.

As far as building and carpentry products are concerned, developments are clearly leading to further competition, not only with plastics but also between different timber products. Endeavours to find light materials and the introduction of ready-made elements on the building side undoubtedly give plastics a good advantage point, but the good properties of timber are also considerable. The development of plastics consumption in the construction industry in the UK is presented in Table 27 on p. 47. Plastics have rapidly pushed their way into the furniture industry. No less than 25 plastic firms work with various production methods in this field. It is likely that the furniture branch will be largely lost for the wood industry during the present decade. On the other hand, surface treated and composite panel products are attracting increasing interest, and a large area of co-operation is developing. The main firms and products in the field are shown in Table 31 on p. 51. It can be mentioned, for example, that the flooring material "Purldeck" consists of plywood, urethane foam and PE coated kraftliner, which are thus for the first time combined in a single product.

The respective price developments of plastic and timber products is obviously of decisive importance for future consumption. The development during the 1960s has been largely disadvantageous for the forest industry, as can be seen in Tables 34 and 35 on p. 54–55. Only the price of particle board has avoided a large increase. In view of the increasingly difficult raw-material situation, a change in the rising trend cannot be expected during the coming decade. As far as plastics are concerned, the raw-material situation seems to be secure at

least for the present century. Furthermore, the raw material's share in the final product price is small. The world trend in the price of plastics generally fell during the 1960s.

Future price development can be investigated on the basis of regression analysis of empirical material. Since plastic products, however, are in a state of rapid development, the operation of the Gompertz' function is difficult to estimate. The price development has instead been examined on the basis of the theory that the price falls at a constant percentage rate every time the accumulated production (i.e. experience) doubles. Some of the more important base plastics on the British market which have been examined by this method indicate a price fall of between 17 and 23 % (p. 58). Accumulated world production for sulphate cellulose shows a price fall of 17–18 %. Since, however, the accumulated production of plastics doubles every forth year and that of cellulose every tenth year, the price of plastics is falling more rapidly. These estimates assume comparisons made in deflated money values. Actual prices in the future must naturally take into account inflation rates. A comparison of the prices of sulphate cellulose and LDPE indicates that the difference by about 1980 will be less than 30 %.

In Chapter 61, the future of plastics is further discussed on the basis of growth rates up to now and know expansion plans. The demand for plastic paper has only been taken into consideration by Japan, which has estimated its production in 1980 to be 2.2 million tons.

There are no possibilities of the UK increasing significantly its own cuttings of timber. With regard to problems of environmental pollution, the forest and plastics industries are in the same boat. It is obvious that the recycling of plastic waste is difficult to arrange economically becuase of the variety of grades of plastics.

The UK's future import requirements of forest-industry products are discussed in Chapter 63. Despite the great economic difficulties which have beset the country in recent years, an improvement is expected in the 1970s, which will be reflected in the demand for timber products. The final EEC grouping is still not yet clear, but regardless of this it seems probable that the whole of Western Europe will constitute a common free-trade area in industrial goods by the end of the 1970s. Membership of the EEC will make little difference to the UK's imports, since all the original EEC countries suffer from a shortage of timber.

Table 43 on p. 64 summarizes the situation in 1971 regarding certain important end-uses. The predominance of timber raw material is evident.

Only through a considerable expansion of the plastic raw material base for products earlier based on wood can a change be expected in the present pattern of growing import requirements for wood products. If this occurs, the UK has its own raw-material resources next door in the North Sea.

The market for plastic paper in the UK for 1975–76 has at present been estimated at only 1 % of total requirements. However, the picture can rapidly change as plastic pulps begins to be sold on the world market. It seems unlikely that the UK will develop a plastic-pulp industry of its own. This, however, assumes that existing suppliers abroad will be in a position to deliver this new product in good time.

The future consumption of panel products is noted in Table 47 on p. 69. The main growth looks as if it will concentrate on particle board, the consumption of which will treble during the 1970s. On the other hand, the use of plywood will probably grow considerably more slowly, except for surface-treated boards. As far as domestic production is concerned, only particle board is likely to expand.

The future of sawnwood imports is not discussed in detail in this investigation, but it is evident that a substantial standardization and reduction of the product selection must be rapidly undertaken.

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ABREVIATIONS

BP = British Plastics
BPBMA = British Paper and Board Makers' Association
ECE = Economic Commission for Europe
EVAF = European Association for Industrial Research
FIRA = Furniture Industry Research Association
GATT = General Agreement on Tariff and Trade
MP = Modern Plastics
OECD = Organisation for Economic Co-operation and Development.
SITRA = Suomen Itsenäisyyden Juhlavuoden 1967 Rahasto
TTF = Timber Trade Federation of the United Kingdom
TTJ = Timber Trade Journal
UCNW = University College of North Wales
UNIDO = United Nations Industrial Development Organisation
WRME = Wood raw-material equivalent

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