TECHNOLOGY TRANSFER AND THE POLYMER INDUSTRY IN PORTUGAL – THE CASES OF BAKELITE AND PVC

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ABSTRACT: The establishment of a polymer production industry in Portugal took place under a political regime that considered agriculture as the prime sector for economic development. The first polymer introduced in Portugal was Bakelite, a synthetic plastic, in the mid–1930s. PVC, another plastic, followed it at the beginning of the 1960s. These global industries were established in Portugal by means of foreign technology, imported mainly from the rest of Europe and Japan. This technology was imported because at the time, the technological environment was characterized by a weak technical and scientific infrastructure, unable by itself to bring about technological innovation. In Portuguese industrial history, there are two factors to emphasise in the development of these industries: the beginning of industrialisation and the maturity of the industry itself. This article discusses whether a developing economy in a peripheral country such as Portugal actually assimilates new technology (with the introduction of new technological innovations) or whether it only copies production technologies. In a related manner, given that the time gap between the introduction of these two polymers is about thirty years, we question whether this per se is evidence of technological backwardness relative to the source of these technologies. Additionally, we analyse the importance of this kind of production in pioneer corporations, as well as the contribution of their entrepreneurs to the development and progress of national industry, in the context of the industrial policy of the time (1930–1974).

KEYWORDS: History, technology transfer, polymers, Portugal

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1. The Beginning of the Polymer Industry

Before analysing the status of Portuguese polymer industry it is important to provide a historic view of the origins of the two polymers, Bakelite and PVC.

Despite the fact that from the earliest times man has moulded natural organic polymers, it is generally accepted that the plastics industry began in 1862, when the first synthetic plastic, Parkesine, a nitrate of cellulose, was industrially produced and launched on the market. Semi-synthetic plastics such as vulcanite, Parkesine, celluloid and cellulose acetate, all of them chemical modifications of natural organic polymers, emerged as the outcome of the research carried out in order to obtain easily available and cheaper materials. On the same lines Leo Hendrick Baekeland, a Belgium – born American chemist, in 1907 produced the first totally synthetic plastic, Bakelite, a phenol-formaldehyde resin.[2] Bakelite`s electrical insulating properties, as well as its ease of moulding, led to its use in several fields. The electrical, telecommunications, automobile and radio industries were the main consumers of Bakelite. During the 1914–1918 war, it was a raw material essential for the production of radio boards used in wireless communications in ships.[3] After the war, the radio industry used phenol-formaldehyde resins on a large scale.[4] After the Second World War, phenol-formaldehyde resins were still produced as a raw material for the production of several articles: decorative objects, cigarette boxes, cups, pipes, umbrella handles, etc.[5]

The development of chemical theories to interpret polymerisation, put forward especially by Hermann Staudinger in the 1920s and Wallace Hume Carothers during the 1930s, and progress in high-pressure technologies were of paramount importance for the improvement and development of commercial plastics. They allowed many of the technical problems involving the production of polymers and their conversion into commercially viable materials to be overcome. They also led to great progress in the

[2] Before Baekeland`s discovery, chemists like Sir James Swinburne, Adolf von Baeyer, Werner Kleeberg and Adolf Luft, among others, produced hard and viscous materials by the reaction between phenol and formaldehyde, but never realized the potential of these products. See Mossman and Morris, The Development of Plastic, 26.

[3] Ibid., 33.

[4] Ihde, 'The Development of Modern Chemistry', 712.

[5] Hardie and Pratt, 'A History of the Modern British Chemical Industry', 197.

production of this kind of chemical compounds. Between 1925 and 1945, the majority of commercially important polymers, such as polyvinyl chloride (PVC), polyethylene (PE) and polystyrene (PS), were launched on the market. These entirely new materials are characterised by the combination of useful properties and by their ability to be processed by techniques such as moulding, injection, extrusion, and inflation.[6]

PVC was developed in Germany, in the IG Farben[7] laboratories, just before the Second World War broke out. I. G. Farben, Union Carbide and Du Pont registered major PVC patents between 1927 and 1933.

PVC is produced by the polymerisation[8] of vinyl chloride, a monomer first synthesised in 1835 by the French chemist Victor Regnault, in Justus Liebig`s laboratory. E. Baumann described vinyl chloride polymerisation under the action of light in 1872.[9] In 1912, further studies carried out by the German chemist Fritz Klatte and by the Russian chemist Ivan Ostromislensky led the Russian chemist to a process via which it was possible to plastify a hard and rigid PVC in order to produce substitutes for ebonite, celluloid and gutta percha.[10] Nevertheless, the patent on PVC plastification went to Waldo Lionsbury Semon, of B.F. Goodrich, in 1932.[11]

6 On this subject, see Fournier, 'L`Ère des Matières Plastiques, 1955; Gossot, Les Matières Plastiques, Fabrication Technologie, 1977; Heaton, 'An Introduction to Industrial Chemistry', 1991; Meikle, 'American Plastic: A Cultural History', 1995; Mossman, 'Early Plastics: Perspectives, 1850–1950', 1997; Imperial Chemical Industries Limited, Landmarks of the Plastics Industry, 1962.

7 I.G. Farben, a German chemical association, was created in 1925 and dissolved after the Second World War. It was one of the first big corporations conducting intensive research before 1939. In the first part of the twentieth century, teaching and the basic chemistry research were particularly advanced in Germany, and the theoretical work of Staudinger and his Institute of Macromolecular Chemistry were essential to I.G. Farben`s achievements. Succeeding corporations like BASF, Bayer and Hoechst continued to spend large amounts on research during the fifties. Freeman, 'The Plastic Industry: A Comparative Study of Research and Innovation', 33–34.

8 Polymerisation is a chemical reaction in which monomers, repeated molecular units, are linked by covalent bonds, creating polymers with long molecular chains (macromolecules), with high molecular weight.

9 See New Dictionary of Plastics – Tables – Trends – Technologies, 74–75; Imperial Chemical Industries Limited, Landmarks of the Plastics Industry, Birmingham, 38 and Freeman, The Economics of Industrial Innovation, 96.

10 Cf. New Dictionary of Plastics – Tables – Trends – Technologies, 74–75; Imperial Chemical Industries Limited, Landmarks of the Plastics Industry, Birmingham, 38 and Kaufman, The History of PVC – The chemistry and industrial production of polyvinyl chloride, 28.

11 On this subject see Semon and Stahl, History of Vinyl Chloride Polymers, 199–214;

This discovery as well as developments in stabilizers resulted in the commercial success of this plastic.

The success of this and other plastics owe a lot to Hermann Staudinger, an IG Farben consultant. The concept of the macromolecule was introduced by this German chemist at the beginning of the twenties, as was the first understanding of the polymerisation phenomenon.[12] In a similar way, in the thirties, Wallace Hume Carothers[13] further developed the chemical theory of polymerisation. The knowledge of the molecular characteristics of these materials made better production process control possible and consequently the development and improvement of polymers. So it was possible to produce materials with characteristics that made them suitable for a broad set of applications and resulted in commercial success.

Although the commercial production of PVC started in 1931, its industrial boom took place after Second World War started, almost simultaneously in Germany and in the USA.

The history of PVC is a good example of innovation and research at IG Farben, where solutions for different problems were developed during the twenties and thirties. Its introduction in the German economy was a success and was the result of a long series of experiments, inventions and discoveries that took place over a 30-year period, with delays and disappointment.[14]

2. The Origin of the Polymer Industry in Portugal

The polymer (plastics) industry was launched in Portugal in the 1930s with the production and transformation of bakelite.[15] This industry started using imported technology and emerged as a response to the needs of the electrical industry, but soon began production of other goods for the end-consumer. The corporations involved in this were the *Sociedade Industrial de Produtos Eléctricos* (SIPE) and Nobre & Silva.[16]

Seymour, Pioneers in Polymer Science, 119–122; and Kaufman, The History of PVC – The chemistry and industrial production of polyvinyl chloride, 104, 106.

12 Ihde, The Development of Modern Chemistry, 713.

13 Wallace Hume Carothers started his career with Du Pont in 1929. He worked on condensation polymerisation and invented nylon 66. See Walsh, 'Invention and Innovation in the Chemical Industry: Demand-pull or Discovery-push?', 221.

14 Freeman, Christopher, The Economics of Industrial Innovation, 98.

15 Callapez, Maria Elvira, A Origem da Indústria Transformadora de Plásticos em Portugal, 1998.

16 Nobre & Silva was created in response to the „Barefoot campaign". It started producing rubber and canvas shoes and later diversified its industrial activities. For the „Barefoot

The industrial context was marked, internationally and nationally, by several events, in particular the 1929 Wall Street crash, the implementation of the Regime of Industrial Constraint by the Portuguese Government, the Great Exhibition of Portuguese Industry (1932) and the First Congress of Portuguese Industry (1933).

The impact of the Great Depression on Portuguese economy «(...) took place relatively late (only in 1931 were the effects of the crisis clearly felt), quick (in 1932 most indicators showed signs of recovery), and smooth. The effects of the crisis in the economic and social sectors were far from reaching the levels or the duration, which affected most countries. The consequences of the depression were particularly marked in sectors such as trade, import/export, and agriculture.»[17]

Although the effects of the crisis in Portugal were less severe than in other parts of the world, the country was affected by unemployment, especially in the agricultural sector and exports, and by low prices and inactive capital.[18] In this context, the industrial sector stood up and claimed its importance to the economic development of the country as an economic activity complementary to agriculture. According to Araújo Correia,[19] the crisis also brought some benefits to Portuguese industry, because it led «a certain number of small, inefficient and ill-equipped industrial plants to close down. They pulled down prices with no benefit to the customer. This situation occurred mostly in the textile sector, especially in the wool and cotton industries».[20]

One of the measures taken by the State as a means to overcome the difficulties affecting industry was the establishment of the Regime of Industrial Constraint. As a result of the 1929 crisis, an industrialising

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campaign" see Liga Portuguesa de Profilaxia Social, O Pé Descalço – Uma Vergonha Nacional que Urge Extinguir, 1956.

17 Rosas, O Estado Novo nos Anos 30 (1928–1938), 93–94. See also Sousa, 'Crise industrial: seus factores e soluções', 11 and 'Primeiro Congresso Industrial Português', Indústria Portuguesa, Janeiro 1934, 89.

18 Rosas, O Estado Novo nos Anos 30 (1928–1938), 107.

19 José Dias de Araújo Correia (1894–1978). He was Minister of Transport and Trade in 1928 and a Member of Parliament during the Estado Novo. He also belonged to the board of administrators of Caixa Geral de Depósitos from 1929 to 1964. See Rosas and Brito, Dicionário de História do Estado Novo, 225.

20 'A obra efectuada pela Caixa Nacional de Crédito no Ano – económico de 1930–1931 e a grave crise que assoberba o nosso país e todo o mundo que produz e permuta', Indústria Portuguesa, Julho 1931, 23.

attitude arose, at a time when agriculture was the dominant sector of the Portuguese economy and industry was almost negligible. Thus, in order to tackle the crisis, the development of national industry was advocated.

By that time, Portugal was living under Salazar's dictatorship, a regime known as the „New State".[21] In 1931, the government launched the Regime of Industrial Constraint, informally implemented in 1926, as a means of intervening in and controlling industrial growth.[22] At first this Regime had a temporary character but it soon became permanent and lasted until the end of the „New State" (1974). The Regime of Industrial Constraint prescribed that the establishment of any new industry and its location, the enlargement of industrial premises, the acquisition or replacement of equipment and machinery, and the trade of industrial goods had to be sanctioned by the central government.

During the recovery period following the crisis of 1929, the main voice arguing in favour of industrial development was the Portuguese Industrial Association (AIP). This Association organised the Great Exhibition of Portuguese Industry, in 1932, in Lisbon, to show the potential of Portuguese industry and the importance of industrial development for the country`s welfare. Considered the most important event of that year, it became the stage of Portuguese industrial life and a showcase of industrial achievement, by displaying and advertising the quality and variety of national industrial goods. It was a moment of intense industrialist propaganda intended to neutralise the prevailing ruralist tendencies within the „New State".

In 1933, at the end of the Exhibition, the First Congress of Portuguese Industry took place. Underlying the speeches was the rhetoric of industrial progress, in which the principles of the industrialisation of the country were enunciated.

The plastics industry emerged in this context, and the first plastics manufacturers in Portugal were the Industrial Company for the Manufacture of Electrical Material, SIPE (Sociedade Industrial de Produtos Eléctricos) and the firm Nobre & Silva. Both reached important

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[21] Salazar's dictatorship lasted from 1932 to 1968 and was continued by his successor, Marcelo Caetano, until the Revolution of 1974.

[22] This regime was informally implemented in 1926, before the global crisis of 1929–1935. It was legally enforced in 1931. See Decreto no. 19 354, 3 January 1931. See also Brito, A Industrialização Portuguesa no Pós-Guerra (1948–1965) – O Condicionamento Industrial, 112.

positions in the Portuguese plastics industry and deserve to be considered in some detail.

3. The Industrial Company for the Manufacture of Electrical Material (SIPE)

SIPE was the pioneer manufacturer of plastics in Portugal. In fact, it was the first company of its kind ever set up not only in Portugal, but also in the Iberian Peninsula.[23] It was founded by João Cândido Barbosa Corsino, Engineer and Professor at the Technical University in 1935, in Dafundo, near Lisbon,[24] and its creation was a response to the needs of the electrical industry. SIPE`s manufacturing programme consisted of the synthesis of Bakelite and its use in low-voltage electrical devices and in other common goods.[25] Like many similar companies in other countries, SIPE imported various raw materials such as phenolic acid, urea, urotropine, and aniline, especially from Britain[26]. In the context of Portuguese industry of the time, SIPE soon acquired a leading position.

According to Corsino, the government bureaucracy took nine years to give permission for this industry to be introduced in the country[27]. Had it been given on time, the Portuguese plastics industry would be the same age as that in developed countries.

The pioneer of the Portuguese plastic industry endorsed the view that national manufacture should be intensified and imports reduced or even forbidden.

4. The Firm NOBRE & SILVA

José Nobre Marques and José Lúcio da Silva, two bank employees, founded the firm Nobre & Silva, in Leiria, in 1927[28]. At first it manufactured

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[23] 'J. B. Corsino, Lda. – A fábrica montada pelo pioneiro em Portugal da pequena aparelhagem em matéria plástica', Indústria Portuguesa, May 1967, 301.

[24] Henriques, 'Indústria de Matérias Plásticas', 4. See also 'A SIPE e a sua fábrica na vanguarda europeia – Dos Mais Acreditados Produtores da Pequena Aparelhagem Eléctrica', Indústria Portuguesa, May 1967, 312 and Diário do Governo, no. 7, III série, January 1959.

[25] The firm SIPE, joined the firm J.B.Corsino in 1991, becoming LEGRAND ELÉCTRICA, located in Carcavelos and still functioring. It manufactures electrical devices.

[26] 'O fabrico da Baquelite em Portugal', O Jornal do Comércio e das Colónias, 7 January, 1939, 4.

[27] 'O fabrico da Baquelite em Portugal', O Jornal do Comércio e das Colónias, 7 January, 1939, 8.

[28] Information given by the local newspaper O Mensageiro, 11 February, 1928, 2 and the

rubber and canvas shoes and later rubber sandals. This firm appeared as a response to a legal imposition that prohibited people from walking barefoot.

Nobre & Silva started as a modest workshop, where its owners worked in their spare time, but it was soon upgraded with new technology copied from a similar factory operating in Mahon (Spain)[29]. The technology associated with the transformation of natural rubber and the creation of a market for these goods eased the transition to the manufacture of plastics, and in 1936, it began manufacturing plastics. This company, whose first plastic products were Bakelite stoppers, widened its production further to include other plastic commodities designed for the current consumer. Although it had, in 1942, requested permission to manufacture synthetic resins in order to replace materials imported from Spain and the USA, it never came to manufacture them, despite the permission being awarded in 1943. Nobre & Silva became one of the leading Portuguese companies in the transformation of plastics, but it went bankrupt in the 1990´s.

5. Remarks about the Emergence of Portuguese Plastics[30]

As stated above, in Portugal, the plastics industry was launched when internationally this industry was still taking its first steps. Its emergence also coincided with the beginning of the industrialisation of the country.

At that time Portugal was a country without industrial or technological traditions. As a matter of fact, Portuguese industrialists simply copied what was being manufactured in more advanced countries. In Germany, Britain and the USA, new commodities were being invented, but they reached Portugal only after a considerable delay. Thus, from the point of view of industry and technology, Portugal's original contributions were almost negligible. The National industry had neither skilled labourers nor technicians, nor adequate machinery and equipment, which could have supported the improvement or development of manufacturing techniques.

This industry, in general, lacked a technical structure capable of satisfying the essential requirements of quality. Most of the companies were of the

manager of Nobre & Silva between 1960 and 1985. See also Diário da República, no. 135, III série 9 June 1953. The firm Nobre & Silva was moved to Venda Nova – Amadora in the 1940s. One of its founders, José Lúcio da Silva, founded another factory, BIS, also in the 1940s.

[29] 'Alpergatas', Indústria Portuguesa, September 1931, 31.

[30] These concluding remarks were taken from Callapez, A Origem da Indústria Transformadora de Plásticos em Portugal, 1998.

family type in which the leading figure was the manager, administrator, and technician, accompanied by the apprentice, the servant and the mechanic.

In the majority of cases, there was no industrial design. An exception was SIPE, whose leader was an engineer technically and professionally qualified in this area.

In spite of the situation described above, there was an obvious effort to keep pace with the progress made in this sector by foreign industry, whose technologies were then imported by national industrialists.

During the 1930s, 1940s and 1950s the Portuguese industry of polymers merely produced and transformed Bakelite. During the 1950s, the industrial transformation of PVC was introduced and its production started in the beginning of the 1960s by the Companhia Industrial de Resinas Sintéticas, CIRES. This corporation is to this day the only PVC manufacturer in Portugal.

6. The PVC Industry – CIRES

The PVC production industry was introduced in Portugal at the beginning of the sixties by means of international technology transfer. Companhia Industrial de Resinas Sintéticas, CIRES, S.A.R.L., was the pioneer corporation, a joint-venture set up by the Portuguese Bank, Portuguese and Japanese corporations, and was based in Estarreja (Aveiro, Central Portugal).[31] The following companies participated (Table I):

Table I - Founders of CIRES

Fundadores da CIRES	Participações (%)
1 - Banco Pinto & Sotto Mayor, S.A.R.L. (BPSM);	15
2 - Banco Português do Atlântico, S.A.R.L. (BPA);	20
3 - Empresa Industrial do Freixo, S.A.R.L. (UEP/EIF)[32];	-
4 - MITSUI Bussan Kaisha, Limited (MITSUI);	25
5 - SHIN-ETSU Chemical Industry C°., Limited, (SHIN-ETSU);	25
6 - Sociedade Comercial Luís Alvim, Limitada, (SOCOLAL);	2.5
7 - União Eléctrica Portuguesa, S.A.R.L. (UEP)	12.5

Source: «Fundamental Agreement» de 11 Junho de 1960 (CIRES Archive); CIRES Statutes, 1960; *Diário do Governo*, N.º 291, III Series 16 December 1960; *Diário do Governo*, No. 291, III Series, 16 December 1960 and the legal document of the foundation of CIRES, 1º Cartório Notarial, Oporto, 23/11/1960; Serra, CIRES 35 Anos de Progresso na Indústria Portuguesa (1960–1995), 9–13.

[31] On 23 November 1960, with an initial investment of 20 million PTE. It began manufacturing in 1963.

In the 1960s, Portugal was a country with a very low scientific, technological and cultural level. This can be seen as a natural result of a weak educational system and from the lack of commitment from the political system to change this situation.

As shown in Table II, in the 1960s nearly half of the Portuguese population was illiterate and the majority of the remainder were merely able to read and write.[32]

Table II - Level of Education of the Population Residing in Portugal (%)

	1960	1970
Unable to read or write	40.3	33.6
Able to read and write but with no school qualification	21.1	4.5
Basic primary education	22.5	49.6
Secondary education	0.3	0.1
Higher education	0.6	1.5

Source – Barreto, A Situação Social em Portugal, 1960–1995, 89.

In view of the lack of technological and scientific infrastructure and to further the country's industrialisation, there was a constant need to import technology from abroad by means of agreements (licences) as well as capital goods.[33] In Portugal, the main channels[34] for technology transfer in the 1980s were foreign investment and the importation of intermediate goods and machinery.[35] However, the importation of equipment was the

32 Barreto, A Situação Social em Portugal, 1960–1995, 89.

33 A study of 152 corporations, carried out by the Finance Ministry, revealed that, in 1972, the payments for agreements totalled 211 903 000 escudos, of which 129 635 000 escudos were associated with technical production and processes. 42 061 000 escudos were spent on patent registers and 42 207 000 escudos on research and/or experimental work. The amounts from Banco de Portugal for patents, brand names, models, drawings, inventions and copyright for the same year totalled 293 000 000 escudos. 1976 statistic, concerning payments made through the bank system, show a growth to 500 000 000 escudos. On this subject see Ferreira, 'Problems Relating to the Transfer of Technology in Portugal' 78–79.

34 It is usual to confuse technology importation with technology transfer. Importation refers to ordinary international commercialisation, while transfer also implies the assimilation, adoption and diffusion of technological knowledge in order to drive the importer's own technology creation. See Rosa, 'A Ciência e a Tecnologia na Luta do Povo Português contra a Dependência e o Subdesenvolvimento', 11.

35 Ibid., 10.

main channel for technology acquisition because of the low production of investment goods.[36]

Most licences were not consecutively renewed, which may mean that these technologies were not absorbed.[37] So these technologies would not have had the desired impact, as the appropriate use of foreign technology by a national corporation is closely connected with its ability to absorb this technology and with the degree of technological independence it can achieve during the agreement period.[38]

Economic factors and the lack of scientific research in Portugal, during this period (1960–1970) led in most cases to the importation of technology. The establishment of the polymer industry is a case in point. As this is a very demanding sector with regard to technology and science, and as there was no efficient supporting structure in these fields, it was hardly to be expected that technological innovation in the polymer industry would be found in Portugal.

Indeed, in the Portuguese universities there was no polymer chemistry teaching, as there was in Germany and in the USA. This situation was reflected in the plastic materials sector, particularly for transformation, which did not have a team of technicians and equipment able to carry out the tests and research required for the development and improvement of production techniques.

We can conclude that in the 1960s, Portugal was a country with a small – scale social and economic structure scale, with scarce resources and an economy dependent on the exterior.[39] Given its science and technology system, Portugal was inevitably dependent on the exterior with

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36 Ibid., 11.

37 Ibid., 77.

38 Ibid.

39 Control over technology importation and scientific and technological capacity have been described as major factors that could overcome Portuguese social and economic backwardness. On this subject there are some works that discuss and list the historic causes for Portugal`s scientific, technological, economic, political and social backwardness. Others have studied the science versus technology relationship in Portugal and the factors in its development or lack of development. See, for instance, Reis, O Atraso Económico Português em Perspectiva Histórica: Estudos sobre a Economia Portuguesa na Segunda Metade do Século XIX, 1850–1930, 1993; Gago, Ciência em Portugal 'Sínteses da Cultura Portuguesa Europália 91 – Portugal' 199; Caraça, Do Saber ao Fazer: Porquê Organizar a Ciência, 1993; Rosa, 'A Ciência e a Tecnologia na Luta do Povo Português contra a Dependência e o Subdesenvolvimento', 11.

regard to technology and equipment. For this reason CIRES had to import PVC technology from Japan, more specifically from the Japanese company SHIN-ETSU.

Despite the fact that CIRES emerged under Salazar's dictatorship, when agriculture dominated the Portuguese economy, the political, social and economic situation of the 1960s favoured the creation of such an enterprise. CIRES was also favoured by the admission of Portugal to EFTA[40] (European Free Trade Association) and GATT[41] (General Agreement on Tariffs and Trade) in the 1960s, which led to the liberalisation of external trade. CIRES exported to South Africa, Sweden, the United Kingdom and the USA, although the amounts exported were not significant.[42] Paradoxically CIRES began exporting to leading industrialised countries such as the USA and the United Kingdom.[43]

CIRES also benefited from the plans launched by the state, known as the Development Plans, the guidelines of which were compulsory for the public sector and recommended the private sector. Developing countries in various continents designed this kind of plan, often inspired by the programmes of economic aid implemented especially by the World Bank and the USA.[44] In this context external pressure was oriented towards the idea that Portugal should implement a development policy that would keep pace with other Western European countries.[45] Development Plans were launched from the 1950s until the end of the dictatorship in 1974. Various industries resulted from these policies and the target of economic development then became part of the rhetoric of political discourse.[46]

The 1st Encouragement Plan (1953–1958) was a strategy of investment for the promotion of agriculture, industry, transport and technical education.[47] The 2nd Encouragement Plan (1959–1964) had a general economic purpose. The aims were to accelerate the increase rate of the gross domestic product, the improvement of living standards, the reduction

40 Portugal became a member of EFTA in 1960.
41 The agreement was signed in 1962.
42 Serra, CIRES 35 Anos de Progresso na Indústria Portuguesa (1960–1995), 24.
43 Serra, Durval, interview on 9 May 1999.
44 Lopes, A Economia Portuguesa desde 1960, 284.
45 Guerra, Evolução da Economia Portuguesa, (1963–1966) e Outros Estudos, 21.
46 Ibid.
47 Rosas and Brito, Dicionário de História do Estado Novo, 740.

of unemployment and the improvement of the balance of trade.[48] The Interpolate Encouragement Plan (1965–1967) focused on social targets: housing, health and education which, however, were dealt together with the productive sectors and infrastructures. The 3d Encouragement Plan (1968–1973) emphasised the resolution of problems associated with regional imbalances.

Technical education and research were for the first time included in the 2nd Encouragement Plan under the headline *Research and Technical Teaching*, and was endowed with a sum amounting 630 million PTE.[49] This sum was especially allocated to applied research and various economic sectors such as agriculture, forestry, mining, industry and civil engineering works. In the Interpolate Plan (1965/67) *Education and Research* was endowed with a sum around 1 billion PTE, but fundamental research was neglected and only 119 million PTE were allocated to applied research. [50]

The sums allocated to R&D were, however, modest. By comparing the percentage of the gross domestic product (GDP) ascribed to R&D, with that of industrially developed countries, Portugal like Greece and Spain, was below current standards. Figure 1, shows sums allocated to R&D (% of Gross Domestic Product) (1963/65).

The Encouragement Plans launched between 1953 and 1973 were aimed at stimulating Portuguese economy and were an important instrument for its development. However, their impact on Portuguese society was reduced:

20 years of planning were not enough to eradicate poverty and reach acceptable standards of living; to reduce asymmetries, ensure employment and social welfare (...). Planning as practised in Portugal was unable to solve the great problems of a model of development oriented to improving living standards and minimise inequality. [51]

As shown in the table II, when CIRES was established half of the Portuguese population was illiterate and the majority of the remaining population was merely able to read and write.[52]

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48 Ibid.

49 Dores, O Desenvolvimento da Economia Portuguesa e o Plano para 1959–1964, 49.

50 Agudo, 'As Universidades Portuguesas e a Investigação Científica e Técnica', 139–140, (offprint).

51 Silva, O Planeamento Económico em Portugal – Lições da Experiência, 26.

52 Barreto, A Situação Social em Portugal, 1960–1995, 89.

So we can say that CIRES benefited from the conjunction of a large number of favourable factors, which made it a technology transfer success. The creation of CIRES and the associated technology transfer process coincided with a period of the Portuguese economy during which the industrialization started, supported by the government.

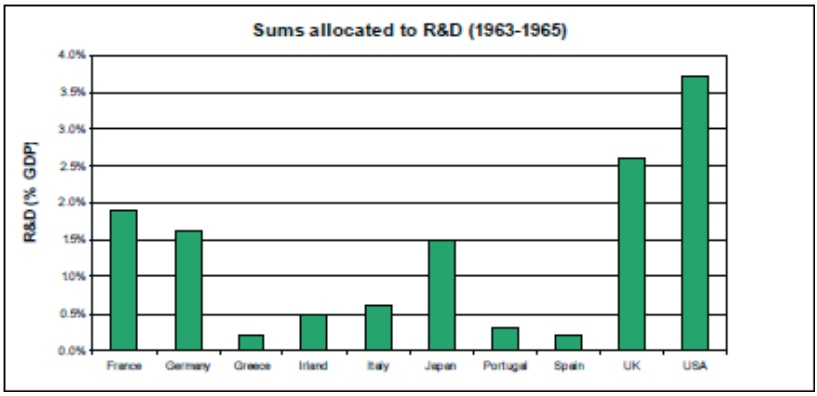

Figure 1 – Sums Allocated to R&D (% of Gross Domestic Product). Source: Agudo, As Universidades Portuguesas e a Investigação Científica e Técnica, *Análise Social*, 6, (1968): 133 (offprint); Ferreira, Portugal 45–95 nas Artes nas Letras e nas Ideias, 234–235.

PVC Manufacturing at CIRES. CIRES signed up a first contract with Shin-Etsu[53] in December 1960. According to the contract, this Japanese company had to supply engineering projects for the construction of the Portuguese PVC plant. It also had to collaborate in its actual construction and in the manufacture of the monomer VC (vinyl chloride), PVC as well as providing technical advice. The technology was that applied by Shin-Etsu in its factory located at Naoetsu, in Japan[54].

The monomer VC was manufactured from the beginning at the Estarreja plant, through the *carbo- chemical* process,[55] as well as PVC of the *suspension* type (PVC-S). The raw materials, calcium carbide and

53 The Japanese Shin-Etsu Chemical Industry, Company, Lda., was based in Tokyo. It began manufacturing PVC in 1957. See Shin-Etsu Chemical Industry, Cº, Lda, Polyvinyl Chloride, 1959, 15.

54 Technology contract signed up with Shin-Etsu in 2 December 1960.

55 Its manufacture continued until mid–1986.

hydrochloric acid, were supplied by Empresa Industrial do Freixo, S.A.R.L. (EIF)[56] and União Industrial Têxtil e Química, S.A.R.L. – UNITECA[57].

In the 1960s, the founders of CIRES decided to manufacture VC from acetylene, that is, from raw materials produced by electrochemically based industries – the manufacture of calcium carbide and hydrochloric acid – despite the fact that VC was already profitably obtained from petrochemical processes. Underlying this option was not only the low cost of electrical power in Portugal[58] but also the impositions of the Regime of Industrial Constraint. Figure 2 shows the evolution in the manufacture of carbo-chemical VC as well as the importation of petrochemical VC, from 1963 to 1973.

The manufacture of carbo-chemical VC increased regularly until the 1970s. From that time on there was a temporary decrease because the company began the importation of petrochemical VC. From 1972 onwards there was an increase in the production of carbo-chemical VC due to an expanding market. This period coincided with the enlargement of the premises concerned with production.

In the context of the developing Portuguese plastics industry CIRES had no difficulties in expanding. As the major manufacturer of PVC in the country, it supplied the main areas of the transforming industry, in particular that of plastics, electric cables, shoes, packaging etc. Figure 3 depicts the evolution of the production of PVC resins (PVC-suspension) and shows the growing manufacturing capacity of CIRES. It began with 3 thousand tons and 10 years later it reached 22 thousand tons.

The reason is that PVC industry was dominant in Portugal and it was economically more profitable to market this material internally. In addition, the production of the company had been hit by the scarcity of raw materials and consequently the company did not work in accordance with its full manufacturing capabilities.[59] The peak, which occurred in 1964, was due to a contract in which CIRES supplied an American company, which was being set up with Shin-Etsu technology.[60]

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56 See Boletim da Direcção Geral dos Serviços Industriais, 19/10/1960, 535.

57 See See Boletim da Direcção dos Serviços Industriais, 22/6/1960, 310.

58 Serra, Durval, interview on 9 May 1999.

59 'Relatório e Balanço da Companhia Industrial de Resinas Sintéticas, CIRES', Exercício de 1970.

60 Serra, Durval, interview on 16 July 1999.

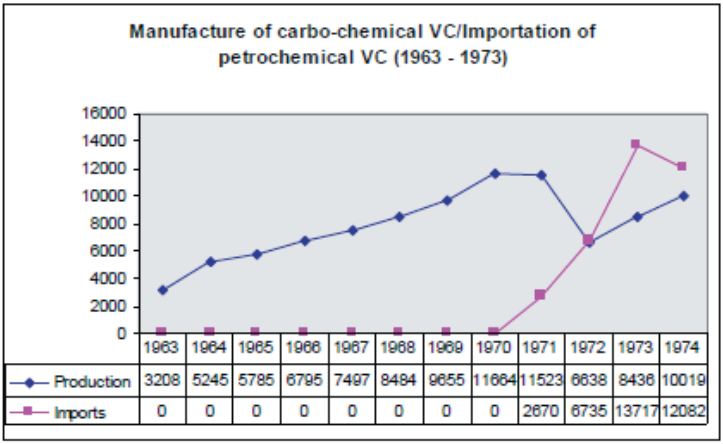

Figure 2 – Evolution in the manufacture of carbo-chemical VC and importation of petrochemical VC, from 1963 to 1973 (tons/year). Source: CIRES (Reports) and Serra, CIRES 35 Anos de Progresso na Indústria Portuguesa (1960–1995), 137

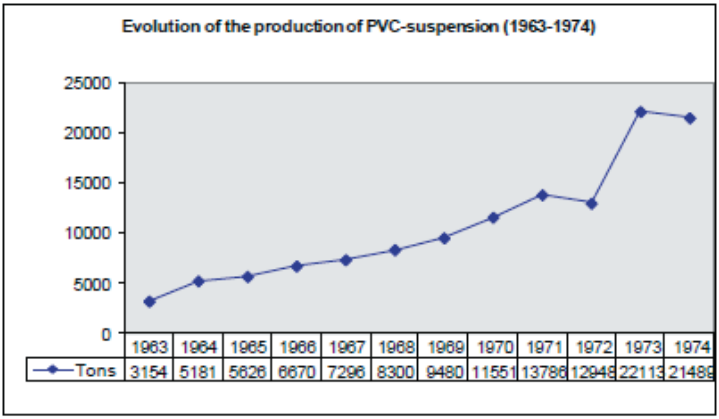

Figure 3 – Evolution of the Production of PVC Resins (PVC-suspension) at CIRES (1963–1974). Source – Serra, CIRES 35 Anos de Progresso na Indústria Portuguesa (1960–1995), 138.

Regarding exports there were almost no variations between 1967–72, as shown in Figure 4.

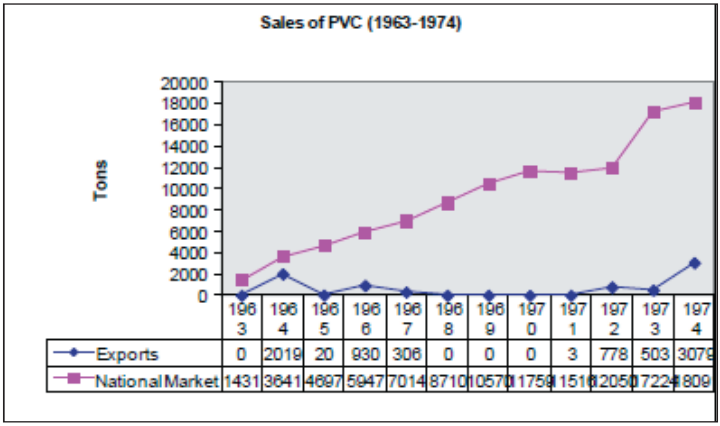

Figure 4 – PVC for the National Market and Exports of CIRES (1963–1974). Source: CIRES (Reports) and Serra, CIRES 35 Anos de Progresso na Indústria Portuguesa (1960–1995), 149

The Entrepreneurs and CIRES Technical Team

Portugal's scientific and technological backwardness could have jeopardised the introduction of a high-tech industry. Nevertheless, the entrepreneurs who co-founded CIRES, Mamede Mendes de Sousa Fialho and Luis Villas Boas Alvim, both engineers with an unusual degree of entrepreneurship and vision for the country at that time, knew how to evaluate the potential of the new product and its introduction in the Portuguese market as well as how to take advantage of all available grants. The product had in fact already been commercialised in Portugal by Villas Boas Alvim, which gave him a good knowledge of the market.

So, the founders of CIRES set out to link up with someone who was able to provide the technology to produce PVC and who simultaneously had the financial stability to join and finance this project.[61] As it was necessary to acquire technology in order to produce PVC, selection of the supplier was particularly important. SHIN-ETSU Chemical Industry Company Ltd., a Japanese corporation, was finally selected. This preference was based particularly on the following factors: the quality of SHIN-ETSU PVC resin, the terms for the technology transfer, and existing contacts with this corporation.[62]

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61 Companhia Industrial de Resinas Sintéticas (CIRES) SARL, Fábrica de Cloreto de Polivinilo, 14 May 1962, 2 (CIRES Archive).

62 Serra, Durval speaking to Maria Elvira Callapez on 24 October 1998.

Besides SHIN-ETSU, the founders of CIRES linked another Japanese partner to their project, MITSUI-BUSSAN KAISHA,[63] an international finance and commercial group. This corporation was already present in Portugal, through the sale of SHIN-ETSU resins. MITSUI would be responsible for PVC sales in Portugal or abroad.

The founders of CIRES put great emphasis on having a strong technical team, with a sufficiently highly qualified background to manage the development of this technology transfer process.

At the beginning of its work, although most of the workers had only up to 6 years schooling (63.7%), CIRES had a high percentage of workers with higher education, much higher than the industry average. During construction of the plant, the Portuguese technicians were constantly assisted on-site by SHIN-ETSU engineers. The contract also stipulated that SHIN-ETSU was to train the Portuguese technicians in its plant in Naoetsu, Japan, providing them with the skills to produce PVC autonomously in Portugal.[64]

Immediately after CIRES had been legally established, its Portuguese technicians (Table III) were trained in Japan.

The initial technical staff of CIRES was composed of two engineers, two assistant engineers and two technicians possessing a technical secondary education. All possessed professional experience prior to admission in CIRES.[65]

In 1961, a team led by Durval Serra[66] was sent to Japan[67] for four months to receive technical training at Shin-Etsu. There they became

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63 Founded by Takatoshi (1633–1706). See Companhia Industrial de Resinas Sintéticas (CIRES) SARL, Fábrica de Cloreto de Polivinilo, 14 May 1962, 2 (CIRES Archive).

64 All costs (wages, travel, extra costs, etc.) were to be supported by CIRES. 'Memorando Adicional', 11 June 1960, 2 (CIRES Archive).

65 The technical team was composed of an electrical engineer, two assistant engineers – one chemical and other mechanical and electrical- two workers possessing secondary technical education.

66 Durval Serra, completed his degree on Chemical engineering in 1944. He served the chemical industry for 51 years. He began his career as Chief engineer of synthetic dyestuffs at the Indústria Nacional de Produtos Químicos, and worked as a researcher at the Instituto Nacional de Investigação (1959–1960). He was trained at the Department of Scientific and Industrial Research (UK) and in 1960 he was admitted to CIRES where he worked until 1997. He assisted the Japanese engineer responsible for the construction of CIRES plant, Industrial Director, Director General and Consultant of the administration.

67 When they arrived in Japan, for 10 days they received lessons from Durval Serra who had been there for a month. Durval Serra met the members of team for the first time in Japan. See Serra, CIRES 35 Anos de Progresso na Indústria Portuguesa (1960–1995), 16

proficient not only in the processes involved in the manufacture of PVC, but also in aspects pertaining to the operation and maintenance of instruments and equipment as well as in questions of safety. At the beginning of the training period some elements of the team attended elementary lessons on physics and chemistry delivered in Portuguese in order to become acquainted with the practical and theoretical foundations of PVC manufacturing. Various engineers and other technicians of Shin-Etsu helped in the establishment of the factory at Estarreja, launched and standardised manufacturing procedures, and trained personnel. Following this 2 years stage, CIRES began the regular manufacture of PVC in 1963.[68]

As a general policy of the company, Shift Managers were encouraged to attend a course especially designed for them.[69] This course encompassed theoretical and practical aspects involved in PVC manufacturing and related machinery, and was taught by Portuguese and Japanese assistant engineers.

Table III – First Portuguese technical team involved in the launch of CIRES (1962)

Name	Qualification
Carlos Alberto Barosa de Oliveira	Electrical Engineer
Durval Serra	Chemical Engineer
Edmundo Barros Sousa	Assistant Electromechanical Engineer
Fernando de Castro Neves	Electrical Engineer
Guilherme Alvares Ribeiro	Chemical Engineer
João do Espírito Santo Rodrigues Sarmento	Chemical Engineer
José Baptista Garcia	Assistant Electromechanical Engineer
Rogério Ferreira de Oliveira	Assistant Chemical Engineer

Source – Serra, CIRES 35 Anos de Progresso na Indústria Portuguesa (1960–1995), 165.

They returned to Portugal in the company of SHIN-ETSU engineers and other technicians. These cooperated in the construction and start-up of the Estarreja plant, in the standardization of the PVC production, and trained all the Portuguese team (Table IV).

and interview carried out on 24 October 1998.

68 Serra, Durval, interview on 24 November 1998.

69 Serra, Relatório N. 71/62 e Anexo – Curso de Treino para Chefes de Turno, 30/4/1962.

Table IV *– Engineers and technicians from SHIN-ETSU collaborating in the construction and start-up of the Estarreja plant (1962)*

SHIN-ETSU Personnel	Positions
Keizo Kimura (engineer)	Administrator
Hydeia Matsushita (engineer)	Expert on PVC manufacturing
Imekazu Ikeda	Factory Technician
Naoji Yamakawa	Factory Technician
Sadahiro Tanaka (engineer)	Responsible for the construction site
Sadayoshi Yanaguida (engineer)	Instrumentation Expert
Shigenobu Tajima (engineer)	Collaborated in the launch
Shigetaka Takeuchi	Factory Technician
Toshio Miyaji (engineer)	Expert on Vinyl chloride (VC) manufacture
Toshio Takegoshi (engineer)	Assistant to Sadahiro Tanaka
Gilberto Guterres	Marketing Expert and Customer Assistance

Source – Serra, Serra, CIRES 35 Anos de Progresso na Indústria Portuguesa (1960–1995), 166; Report No. 1/DF/964, *Breve Relatório do Primeiro Ano de Funcionamento da Fábrica de Estarreja*, 12 (CIRES Archive).

7. Concluding Remarks – Analysis of the Technology Transfer Process at CIRES

CIRES is a successful case of transfer of international technology resulting from a range of favourable factors. When CIRES was founded the country lived a period of industrial euphoria from which some new industries originated. As a consequence of the Development Plans and of the incentives to the industrialisation of the country, Portuguese banks were willing to join in viable projects. At the time, SHIN-ETSU was among the Japanese petrochemical corporations was interested in selling PVC technology. The founders of CIRES took advantage of all these opportunities. By demonstrating that there was a growing demand for PVC in the Portuguese market, by showing the potential of this product and by profiting from the interest of SHIN-ETSU in participating in this venture, they sought to capture the interest of Portuguese Banks. In fact, the prospects of reaching considerable market shares were good. In this way they gathered support from the banks BPA and BPSM, which became cofounders and main investors: «they will support or act in the way to make possible for CIRES to get the required loans and funds». The Japanese contributed mainly technical and commercial know-how. MITSUI was responsible for the acquisition of equipment from countries other than Portugal, and according to CIRES sales programme it would be also the exclusive

export agent, the only one Portuguese representative abroad. The technology associated with PVC manufacturing was entirely provided by SHIN-ETSU. In Portugal CIRES would have the exclusivity regarding the use of SHIN-ETSU know -how and the right to use its patents, but under the supervision of the Japanese company.

As CIRES did not have the required know-how to carry out the project, it had to import technology. Due to its weak technological and scientific infrastructure Portugal had no industrial tradition or ability to absorb new technologies. However the technology was successfully adopted by CIRES. To achieve its goal, CIRES used several transfer channels, notably Foreign Direct Investment, importation of equipment, and contacts with the exterior, particularly visits, congresses and exhibitions. When it was established in Estarreja as a joint venture[70] by a group of Portuguese and Japanese corporations and banks, CIRES actually acquired a „technological package". The technology provider, had to provide besides some capital investment, technical information and patent licences and provide technical assistance. In developing countries technology transfer usually works in this way.

The technology CIRES imported was produced and developed in a Japanese environment quite different from the Portuguese one. This *joint venture* project would require close contacts between entrepreneurs and technicians from countries with very different economic, social and cultural characteristics. So the social and cultural filter always present in technology transfer mechanisms was to be crucial to the success of this process.[71] The CIRES founders's vision, very unusual in Portugal at that time, led them to recruit a group of technicians with a superior spirit, technical and scientific background, and initiative, which proved to be very useful in overcoming problems.

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[70] On 14 April 1961, CIRES top management approved the Shin-Etsu contract concerning the project and plant engineering, all equipment and installation specifications, and the cooperation of their technicians in the construction of the plant and in the production start-up. At the same time they also approved the payment to Shin-Etsu of US $75 000 of a total of US $300 000, in accordance with the Acordo Fundamental. See, Serra, CIRES 35 Anos de Progresso na Indústria Portuguesa (1960–1995), 21.

[71] According to Timo Myllyntaus, the social and cultural filter affects the selection of technology as well as the channel through which it flows. At the same time, the selection can affect the pattern of adoption and the success of the technology. See Myllyntaus, 'The Transfer of Electrical Technology to Finland, 1870–1930', 295.

As Portugal was a country with a little developed industry CIRES faced the risk of not receiving latest technologies. Under these circumstances perhaps an ordinary technical team would have been selected to carry through the project. However, CIRES committed itself to choosing partners from a long-term perspective. It received state of the art technology, benefited from the assistance of foreign technicians locally, and built a team of skilled Portuguese technicians with the scientific skills and knowledge to understand, exploit and master this new technology. The concern with training was extended to all the workers in order to facilitate their integration into their working environment. Aware of the importance of technical progress, management did all they could to make CIRES a technology transfer success.

In this technology transfer process the role of their technical team was crucial, its skills and ability to use the technology and gain the relevant knowledge for understanding all the technical production details. CIRES also used one of the most efficient channels to deploy information, the mobility of its personnel.[72] When it sent a team to learn new PVC production technologies, equipment handling and management, CIRES was helping to rapidly assimilate and sustain new technologies. Visits, along with the other fundamental channels mentioned above, were efficiently used by CIRES. In this way, the social and technical barriers arising from the lack of scientific and technological background in the polymer domain were overcome as the team gained industrial experience, know-how and skills.

This analysis of the technology transfer process shows that there was a continuous relationship between technology provider and receiver. This relationship started with personal contacts that were maintained and led to good communication and strong personal links. This made it possible to overcome economic, legal, cultural, behavioural and communication barriers that could have obstructed efficient technology transfer. The language barriers between partners did not cause problems and was overcome by a common language, English. The cultural clash between these two very different civilizations, the Portuguese and the Japanese, could have been an obstacle to the success of this process. However it did not affect working relationships or communication. Importation of the „technological

[72] Visits were done to Japan, Europe, the USA and Central America.

package" neither hampered CIRES` technological development nor gave rise to social differences, as the new technology was successfully adopted.

Although it adopted the new technology and it had a technical team with a good scientific level, CIRES carried out no technological innovation. Actually it did not go beyond a technical imitation phase, although in a competent and proactive way. The industrialisation of PVC began in Germany by IG Farben, in the early 1930s, but it took over 30 years to be commercialised in Portugal. This delay, in a developing country can be explained by the fact that the speed of imitation is always linked to the global development of a country.

Despite their small impact on the Portuguese industrial fabric, the strategies implemented by CIRES had some influence especially in sectors of the transforming industry to which CIRES provided technical assistance.

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