TRADE IN CAPITAL GOODS DURING THE GOLDEN AGE, 1953-1973

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FUNDACIÓN DE LAS CAJAS DE AHORROS
DOCUMENTO DE TRABAJO
Nº 361/2008

De conformidad con la base quinta de la convocatoria del Programa de Estímulo a la Investigación, este trabajo ha sido sometido a evaluación externa anónima de especialistas cualificados a fin de contrastar su nivel técnico.

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Abstract

There is an important consensus in considering "technological catch-up" with the United States as one of the main sources in explaining economic growth and convergence in the European countries after the Second World War. A set of special circumstances have to meet for catching-up to occur. Among these circumstances, the development of a new international order more favourable to trade, especially in Western Europe and between Europe and the U.S., allowed the intensification of trade in goods and services. In this paper we highlight the role of trade in capital goods for explaining economic growth and convergence in Europe, as it should be considered an influential factor in the diffusion of new technology. We present annual data on trade in capital goods and estimate a gravity equation for 18 countries during 1953-1973. Following Eaton and Kortum(2001) we add a new variable to the gravity model which reflects differences in technology between the exporter and the importer countries. We conclude that trade in capital goods was widely led by this gap in productivity and that the importance of distance was changing over time as United States was loosing technological advantage over Europe.

JEL Classification: F43; F21; O33; O51; O52

Keywords: bilateral trade, equipment, Golden Age

1 A. Cubel is grateful for financial support from the Spanish Ministry of Education (SEJ 2004-07402) and M.Teresa Sanchis is grateful for financial support from the Spanish Ministry of Education (SEJ 2006-081881/ECON).

1. Introduction

There is an important consensus in considering the European “technological catch-up” with the United States as a main source in explaining economic growth and convergence in Europe after the Second World War. Around 50 % of the output per capita growth during these years can be attributable to TFP growth. This extraordinary contribution of the residual to overall output growth has been associated with the lagged widespread in Europe of the so called “Second Industrial Revolution” technologies.

Recent models of economic growth consider that the pattern of technical change is determined in large part by international technology diffusion. To date, an important portion of the literature has devoted its attention to the extent of technology flows between countries and their diffusion. This literature takes into account two main channels: international trade and foreign direct investment (FDI).

There is evidence that imports of intermediate goods are a significant channel of technology diffusion. The most influential pieces of research testing this hypothesis are based on open economy versions of the endogenous growth models (Grossman and Helpman, 1991; Rivera-Batiz and Romer, 1991; Eaton and Kortum, 2002)). However, some empirical results reveal that the origin of imports has not had a major effect on productivity, casting some doubts on the capacity of imports coming from high R&D rate countries to increase the productivity of the importers. Other works seem to be more optimistic with regards to the capacity of imports to spread out technology. For example, analyses that specifically consider trade of capital goods over global trade indicate that only a handful of the most advanced countries tend to cover most of the world exports of capital goods and that the exporter countries have generally been the most innovative countries in the world (Eaton and Kortum, 2001). Moreover, it is possible to distinguish between countries where technology transfer is primarily occurring through technology embodied in imports, and countries where non-trade channels are much more important (Acharya and Keller, 2007). Of course, international technology diffusion is not limited to the channel of trade, there seems to be a stronger form of diffusion. It has been called the R&D spillovers, which are the result of acquiring technology that is not tied to any particular form. Among the different methods that try to measure international spillovers, the largest set of papers employs international R&D spillover regressions [2].

A common conclusion in both these approaches is that the diffusion of technology is geographically conditioned, in the sense that the productivity effects of R&D or trade decline with the geographic distance between the innovative country and the recipient ones.. However, the effect of distance could change over time as recent empirical results for the last decades have revealed. The economy has become less tied to the negative effect of distance and these can be attributable to globalization (Keller, 2004).

In this paper we suppose that trade in capital goods could have been an important channel for embodying technology into European economies during the most progressive era in its history, the Golden Age. This hypothesis implies to assume that new capital goods will embody new technologies, although we are aware of the difficulties for correctly accounting this fact[3]. With this purpose, in this paper we have

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2 There are two alternatives to this basic approach. One was pioneered by Coe and Helpman (1995), who analyze the relationship between productivity and foreign R&D conditional on imports from the foreign country. The other alternative relates productivity with FDI (Aitken and Harrison (1999)). Keller (2004) offers a suggesting review of the literature on international technology diffusion.

3 There has been an important discussion during the last decade about the capabilities that new capital goods have for reflecting the embodiment of new technologies. Gordon (1990) for example relates the decline in the relative prices of equipment in the United States to productivity growth in the production of this kind of goods. In growth accounting literature has been treated by Jorgenson et al (1987).

analyzed the bilateral flows of capital goods between a set of 14 European countries, USA, Canada and Japan and the determinants of this particular trade. We consider that this analysis could be a first step in order to analyze technology diffusion during the Golden Age and its impact on TFP growth. The relationship between capital goods trade, domestic and international R&D and Total Factor Productivity growth will be undertaken in a future research.

The paper is organized as follows. Section 2 presents data on trade between 14 European countries, the United States, Japan and Canada. Section 3 reviews the most important interpretations about European growth during the Golden Age.. Section 4 lays out basic facts about production, prices and bilateral trade in capital goods, focusing on the characteristics of the main exporters and on the evolution of the imports by country of origin during the whole period. In section 5 we estimate a gravity model of trade which explains trade in terms of the level of income of the two countries that commerce, some geographical variables and the technological level of the countries. We are especially interested in the last variable because it could be interpreted as a main link between Europe and USA for explaining the catching-up hypothesis.

2. The data

To get an overview of the market for capital equipment after the Second World War and analyze its role in the transfer of technology between the United States and Europe, by one hand, and among European countries, by the other, we examine data of trade in capital goods. Direct measures of trade in capital goods are not available, so we approximate them by associating capital equipment with imports of non-electrical equipment, electrical equipment, instruments industries and transport equipment which correspond to the group seven from the 4-digit Standard International Trade Classification.

We focus on data for the period 1953-1973 for fourteen European countries which include Austria, Belgium-Luxembourg, Denmark, West Germany, France, Greece, Ireland, Italy, The Netherlands, Norway, Portugal, Spain, Sweden, United Kingdom and three countries overseas which are the United States, Canada and Japan. We have taken annual bilateral trade data in order to capture where countries bought capital goods. Specifically, we want to know the main origin of imports for each country in order to test the role of the most technologically advanced countries in the diffusion of technology during the Golden Age, and especially the role played by the United States. Japan has also been included in the sample because nowadays it is one of the main exporters of technology around the world and because, during this period, it became one of the most advanced economies in the world[4].

The bilateral trade data are taken from two sources. For the period 1962-1973 data are available from Feenstra et al.(2005) database. The industry dimension of the trade data is based on a concordance from the 4-digit Standard International Trade

4 Eaton and Kortum (2001) consider that the vast majority of equipment import came from just seven large and rich producers as were France, Germany, Italy, Japan, Sweden and United States.

Classification to a set of industry codes used by the Bureau of Economic Analysis. For previous years, from 1953 to 1961, bilateral trade data are not available at any international electronic database and thus data have been collected by the authors from the United Nations *Yearbook of International Trade Statistics. Volume I* (several issues).

Data of trade have been matched with data of production in order to relate the productive structure of the countries with its role in the international market of capital goods. Data on production are also necessary to calculate how much equipment each country provides by itself and how much is imported. Data of production for the period 1953-1973 are not available to a suitable disaggregated level at any international database. For example, the United Nations (UNIDO, 1999) assembles data on gross production by 3-digit International Standard Industrial Classification (ISIC) across a wide set of countries, where production of equipment could be obtained as the sum up of ISIC 382, 383 and 385 (machinery, except electrical; machinery, electric; professional and scientific equipment). But the main drawback of this database is that it only provides data from the 1970s on. Data of machinery production can be also obtained for several countries at the level of 56 industries at the Groningen Growth and Development Centre, but the main pitfall is again the beginning year, 1979. Backward data are available since 1947 for a subset of countries also at the Groningen Growth and Development Centre Databases. The countries included are Denmark, France, Italy, Japan, The Netherlands, Sweden, The US, Spain, United Kingdom and Germany, but the maximum level of dissaggregation is ten sectors and "manufacturing" is not broken down into the production of machinery and equipment.

Finally, we have decided to take data on machinery and equipment production from the OECD National Account Statistics although 1971 is the first year with available data. In spite of the fact that this year is at the end of our sample period and, hence, it cannot inform us about the evolution of machinery and equipment industry in any particular country, it offers us an accurate picture of differences in the degree of industry development between countries.

3. Trade in capital goods in the interpretation of post-war growth

World R&D activity and world production of capital equipment used to be highly concentrated in a small number of countries[5]. While only few countries do much R&D, the benefits tend to widespread around the world through exports of capital goods that embody new technology. After the Second World War, the most advanced country was by far the United States and a wide gap in terms of GDP per capita, and hence, in terms of technological development, had opened between this country and the European economies.

In the explanation of the huge growth rates during the post-war period some authors have insisted on the importance for some countries of the reconstruction effort[6]. Those countries more damaged by the war were those that grew faster. But pre-war income levels recovered quickly and around 1950 the reconstruction could be accomplished. In the explanation of the afterward growth, the catching-up hypothesis tends to occupy a central role (Abramovitz, 1986; Dowrich and Nguyen, 1989; and Nelson and Wright, 1992). The catching-up hypothesis implies the widespread in

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5 Eaton and Kortum (2001) demonstrated the high level of concentration of exports of machinery and equipment and its high relationship with R&D spending taking a sample of 35 countries in 1985 as an example.

6 Part of the growth after the war can be explained by the reconstruction of the productive capacities destroyed by the war (Dumke, 1990). An overview of the literature is given in Eichengreen (1995), Crafts and Toniolo (1996) and van Ark and Crafts (1996).

Europe of those technologies that had been born and developed in the U.S since the last decades of the XIXth century. Up to that date those technologies could not have been attained in Europe because they were particularly adapted to the resources endowments and market dimensions of the U.S. After the war the two main pillars of the U.S advantage were eroded[7]. The first one refers to the U.S. advantage in resources endowment (capital and natural resources) and scale-intensive technologies. This U.S. advantage had initiated a series of related technological, organizational and managerial innovations that had raised productivity, wages and hence demand for mass consumption in the U.S. Meanwhile, European countries had less natural resources, markets were smaller and demand was less homogeneous. The second pillar was the so-called "high-tech" industry, the origins of which had been large private and public educational investment during a prolonged period in the U.S.

After the Second World War, the domestic and the international markets grew rapidly for European countries and allowed the development of economies of scale and capital intensive technologies. The increase in trade could be explained by the new attitude of post-war policy-makers and market participants which have learned about the disasters of the interwar years and have determined not to repeat them" (Eichengreen(1996, pp.41). New institutions were drawn after the war to promote the expansion of intra-European trade as well as international trade. The Marshall Aid, the international cooperation within the GATT, the Bretton Woods exchange system and, afterwards, the European economic integration through the EFTA and the EC, made possible the integration of international markets of goods and factors.[8] At the same time,

7 Nelson and Wright (1992).

8 Helliwell(1992) also highlights the role of openness. The new international order has been outlined by Eichengreen (1996). Boltho (1982) stands out the monetary stability under the Bretton Woods system.

social capabilities were improved at the national level through investment in education, the consolidation of more cooperative arrangements between state, firms and interest groups, and the creation of specific governmental institutions to support technological change. It is what Abramovitz(1986) has called the development in Europe of "social capabilities" that made leader technologies more "congruent" with European endowment of resources and market conditions[9].

Some authors consider that the enormous growth in the early reconstruction phase contributed to the development of these new social capabilities because it had created an economic atmosphere with demand increases and high physical and R&D investment which was favourable to growth afterwards[10].

In this climate, trade between European countries and between them and the U.S. increased, and Europe was better prepared to embody and adapt the capital and scale intensive technologies born in the U.S. The demand for new capital goods grew in Europe, which increased the weigh of capital goods in global trade and, what is more important in our main argument, increased also imports coming from the U.S. In figure 1 there has been drawn the evolution of trade of capital goods for every country of the sample expressed in index number, taking as base year 1953. The original series were valued in millions of dollars and all of them have been deflated by the U.S. GDP deflator. In figure 1 we can observed that imports in every country present an increasing upward slope, which seems more pronounced in those countries that will be identified in the next section as the main exporters and the countries with less imports in total absorption (United States and Germany).

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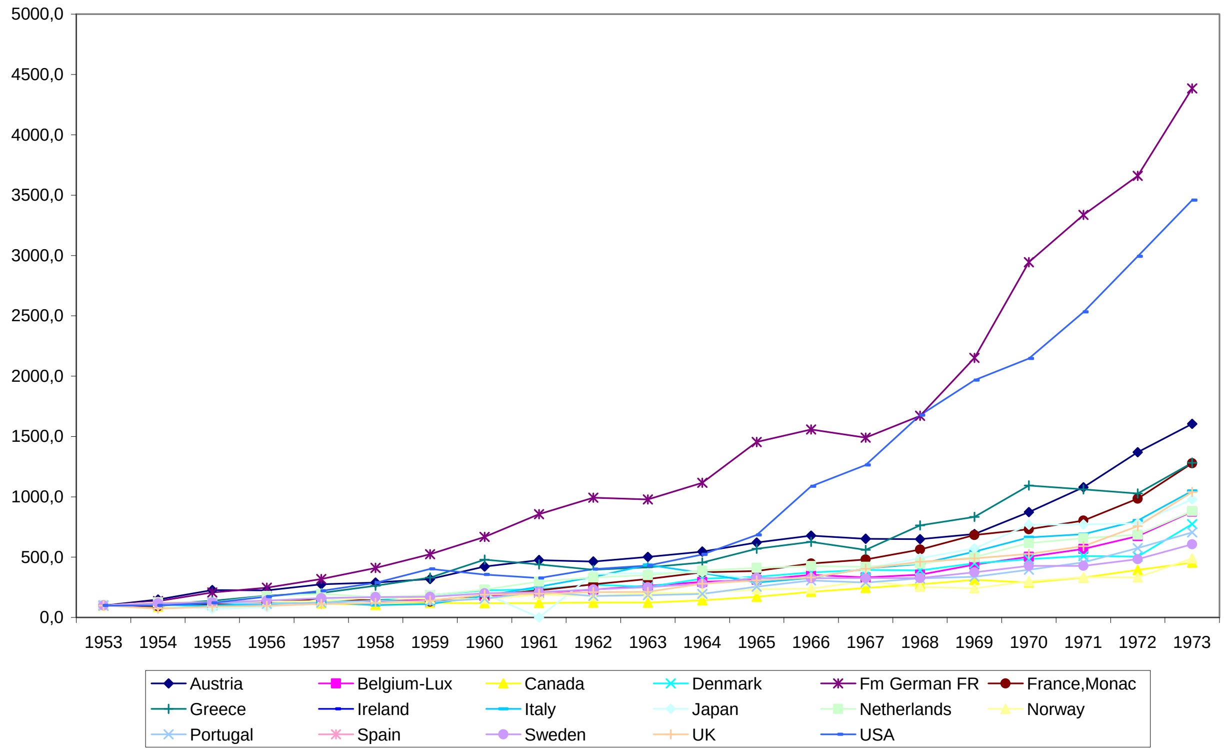
9 Crafts and Toniolo (1996) in the introduction to the book highlight the role of the new institutions.
10 Dumke (1991), Smolny(2000).

Figure 1

Total Imports of Capital Goods by Country, 1953-1973

(Index Number, base 1953=100)



Source: For 1953 and 1960 United Nations *Yearbook of International Trade Statistics* (several issues) and Feenstra et al (2005) for 1973. Data are expressed at constant prices. Imports of every country have been deflated by the U.S. GDP deflactor, base 1990=100.

4. Characteristics of the market of capital goods during the Golden Age

4.1. Who were the main exporters of machinery and equipment?

Table 1 represents in descending order the share of every sample country in the total volume of exports in 1953, 1960 and 1973. The six major exporters were the U.S., German FR, United Kingdom and France during the whole period, although some changes can be observed in the composition of the leader group. For example in 1953 almost half of the total exports came from the United States (40%) and, in 1973, the

U.S. share in total exports was reduced. The declining share of the U.S. was substituted by an increasing share of Germany RF and Japan, followed by a moderate increase in the share of total exports of France, Italy and Belgium-Luxembourg. We should also highlight the incorporation of new countries to the group of exporters, as were Japan (from 0% in 1953 to 9% in 1973) and Austria, Norway and Spain (from 0% to 1%). In this group Japan played the most relevant advance, passing from the last position in 1953 up to the third position in 1973, with a share in total exports of 9 %.

We can find that there is a close relationship between the main exporters of machinery and equipment and the countries that devote more resources to R&D (table 2). The countries more specialized in exporting equipment were also the most R&D intensive as the high correlation between the log of the share of each country in total exports and its rate of R&D spending over GDP shows (0.77). The United States appears as the clear technological leader in terms of R&D spending as late as 1967. In 1967 the United States still doubled the effort made by the first followers. But during the 1970s and 1980s Germany, Sweden and Japan caught him up. The group that lags considerably behind is made up by Spain, Greece, Portugal, Italy and Ireland.

Data of trade have also been matched with data of production in order to relate the productive structure of the countries with its role in the international market of capital goods. Backward data of manufacturing production are available since 1947 for a subset of countries at the Groningen Growth and Development Centre Databases. The countries included are Denmark, France, Italy, Japan, the Netherlands, Sweden, USA, Spain, United Kingdom and Germany (table 3).

Table 1

% Share in Total Exports

1953		1960		1973	
USA	40	USA	29	German FR	23
German FR	17	German FR	22	USA	19
UK	16	UK	14	Japan	9
Canada	5	France,Monac	6	France,Monac	8
Sweden	4	Denmark	4	Canada	7
Belgium-Lux	3	Netherlands	4	UK	7
France,Monac	3	Italy	4	Italy	5
Netherlands	3	Sweden	4	Belgium-Lux	4
Italy	2	Belgium-Lux	3	Netherlands	4
Denmark	1	Canada	2	Sweden	3
Japan	0	Japan	2	Denmark	1
Austria	0	Austria	1	Austria	1
Norway	0	Norway	0	Norway	1
Spain	0	Spain	0	Spain	1
Greece	0	Portugal	0	Ireland	0
Ireland	0	Greece	0	Portugal	0
Portugal	0	Ireland	0	Greece	0

Source: For 1953 and 1960 United Nations *Yearbook of International Trade Statistics* (several issues) and Feenstra et al (2005) for 1973.

Table 2

Business R&D intensities (business R&D expenditures as a fraction of GDP)

	1967	1975	1990
USA	0.021	0.015	0.019
Germany	0.011	0.014	0.020
Switzerland	0.019	0.018	0.021
UK	0.015	0.013	0.015
Sweden	0.010	0.012	0.016
Japan	0.008	0.011	0.022
France	0.011	0.011	0.015
Belgium	0.007	0.008	0.012
Netherlands		0.011	0.011
Norway	0.004	0.006	0.010
Denmark	0.004	0.004	0.008
Italy	0.003	0.004	0.008
Ireland	0.002	0.002	0.006
Spain	0.001	0.002	0.005
Portugal	0.000	0.001	0.002

Source: Verspagen (1996, table 5.1, pp.219).

As the development process advanced in the European countries, machinery and equipment production increased its share in manufacturing. Hence, more countries were increasing their presence in the international trade of capital goods not only as importers but also as exporters. So the loosing weight of the U.S. as a machinery exporter in the international market and, specifically, in the European market, could be explained by the advance of the industrialization process in Europe that came jointly with the increase of income per capita and productivity levels. As the European countries grew and modernized their productive structures, the sources of capital goods exports diversified. More countries, with similar productive structures became exporters and, hence, it is more difficult to find a clear relationship between the share of the manufacturing sector in GDP and the share of each country in global exports of capital goods. In this case, the correlation between the share in total exports and the share of manufacturing in GDP is very low (R^2=0.26) and the correlation between the share in total export and the equipment share in manufacturing is also low (R^2=0.33). These results reveals that the high spending in R&D is the characteristic that better distinguish the exporter countries.

Table 3
Production of manufactures and equipment (in %)

	Manufacturing/GDP		Equipment/ Manufacturing
	1953	1971	1971
Germany	28.64	36.40	40.68
UK	27.93	30.70	n.d.
USA	23.38	21.60	41.62
France	18.69	25.60	35.96
Sweden	18.58	24.10	41.17
Denmark	17.26	18.80	36.90
Netherlands	14.00	21.00	31.75
Spain	12.53	20.60	25.70
Japan	12.01	21.70	n.d.
Italy	11.94	17.00	25.96

Source: The Groningen Growth and Development Center Database for manufacturing in GDP and OECD for equipment in manufacturing in 1971.

4.2. Where did countries buy machinery and equipment?

Equipment appears to be a highly traded good and, during the post-war years, the imports of this kind of goods grew at a high rate, although with great differences among countries. Table 4 presents data of the sources of purchases of machinery by country of origin. Absorption of equipment is calculated as the sum of the gross domestic output of equipment producing industries plus imports of capital goods less exports. This information has been calculated with reference to 1971 the first year for which we have available information on equipment production. The share of imports on total absorption and the share of imports coming from the seven big exporters are presented. As we can observe, an important group of countries of the sample generally purchased more than 70% of their machinery and equipment abroad (the Netherlands, Canada, Belgium-Luxembourg, Norway, Denmark, Greece and Sweden). At the other extreme of the distribution were the most developed countries such as the U.S., United Kingdom and Germany or France, which tended to buy domestic products. Other countries, such as Spain and Ireland, maintained a lower weight of imports on absorption despite their economic backwardness. This fact was due to their protectionist policies, which went against the general framework of openness and market integration prevailing in Europe.

We should also notice the high degree of concentration of imports in a selected group of exporters: the big seven. The last column of the table shows that more than 70% of equipment imports came from the seven largest and richest producers. Some of these exporters are the countries that, in the previous section, have been identified as the most industrialized countries with the highest rates of R&D spending. The lower degree of imports concentration corresponded to the two main exporters, the United States and

Germany. These two countries had also the lowest share of imports in absorption. The explanation for this fact could be that the main motivation for the leading technological countries to import capital goods from abroad could not necessarily be a search for technological advantage in the these countries since they were clearly ahead in this respect. Motivation for trading should be explained by other factors. Hence, among the main suppliers of machinery and equipment for Germany we can find its neighbours Belgium-Luxembourg (12.06%) and the Netherlands (9.27%). Something similar occurs with the U.S. having 32% of imports coming from Canada. So, geographical distance seems to be the main determinant in explaining trade of capital goods in the more developed countries.

To better examine the bias that the geographic distance could have in this particular trade we have grouped the countries into two broad regions: the European countries and the non-European (the US, Canada and Japan). For each group we have calculated a weighted average of the share of each country in the global imports. We have taken into account the weight of every country in the total amount of imports and the weight of imports coming from the five main exporters. The resulting series for the period since 1953 up to 1973 are drawn in figures 2 and 3. The geographical effects are striking. Germany dominates the exports of equipment to almost all European destinations while the United States is the main supplier in the other area, and clearly dominates over the whole exporters' group.

Table 4

Sources of equipment purchases in 1971

	Imports/ Absorption	Source of equipment purchases (% of absorption)							
		USA	Japan	Fm German FR	UK	France Monac	Italy	Sweden	Imports from the "Big 7"
Netherlands	99.49								
Canada	94.17	83.73	4.86	2.91	4.38	0.90	0.62	0.97	98.37
Belgium	89.41	6.89	1.64	44.05	6.36	18.02	4.87	2.42	84.25
Norway	84.01	6.66	10.16	20.13	10.34	2.87	3.23	22.59	75.97
Denmark	78.02	12.65	2.71	27.38	13.65	5.43	2.92	20.14	84.88
Greece	76.26	5.53	18.81	27.27	9.56	5.99	10.23	2.16	79.55
Sweden	74.43	12.02	2.83	33.60	15.59	4.67	2.92	0.00	71.64
Austria	62.44	5.24	2.12	53.15	8.73	5.67	6.42	4.05	85.38
Portugal	56.05	5.62	4.90	25.37	19.41	8.87	10.22	3.61	78.00
Italy	52.61	11.23	2.66	39.30	6.60	18.83	0.00	2.29	80.92
France	36.49	14.37	2.00	38.14	8.01	0.00	13.77	2.59	78.87
Spain	35.23	24.86		25.30	10.04	13.71	10.39	3.12	87.42
Germany	28.51	13.28	6.15	0.00	7.07	20.34	12.40	2.55	61.79
USA	13.76	0.00	24.99	15.35	6.36	1.55	2.43	1.78	52.46
Ireland	15.73	1.44	12.79	51.24	2.50	4.75	2.25		74.98
United kingdom		25.03	4.14	19.92	0.00	9.71	6.13	6.09	71.04

Source: For trade data see table 3. Data of production are from OECD. Absorption of equipment is calculated as gross production of equipment producing industries plus imports less exports. Data of imports by country origin for Spain are for 1970.

Although geography seems to dominate an important part of trade in capital goods, it is also interesting to observe how the United States, despite the distance, occupies a dominant place in exports to European countries, especially during the fifties, and how it maintained, together with Germany, a dominant position in the European market also in the sixties. This can be interpreted as an effect derived from the United States' leadership in terms of technology.

During the sixties, U.S. exports were progressively loosing weight in European markets in favour of other suppliers. The new suppliers were other European nations that experienced a rapid growth and modernization such as Germany, France, Italy, and the Netherlands. But also entering this group we find a non-European country, Japan. The catching-up process with the United States during the Golden Age allowed more European nations to improve its technological capacity and to become new exporters of capital goods. The new equipment produced in Europe was adapted to its special conditions in terms of factor endowments and size of European markets. This way, the newly modernized European economies would find its particular comparative advantage in front of the American products in the European market. Another fact that could explain the moderate ascendancy of the European producers is the constitution of the European Economic Community in 1957 that began to work in 1958. This fact would explain how the loosing weight of the U.S. and United Kingdom in European imports of machinery and equipment was fulfilled by Germany and by the ascendancy of France and Italy in this particular trade. A more detailed view of evolution of the share of Germany and the U.S. in total exports by country is shown in the appendix (tables A.1 and A.2).

Figure 2
Main origin of imports for European Countries

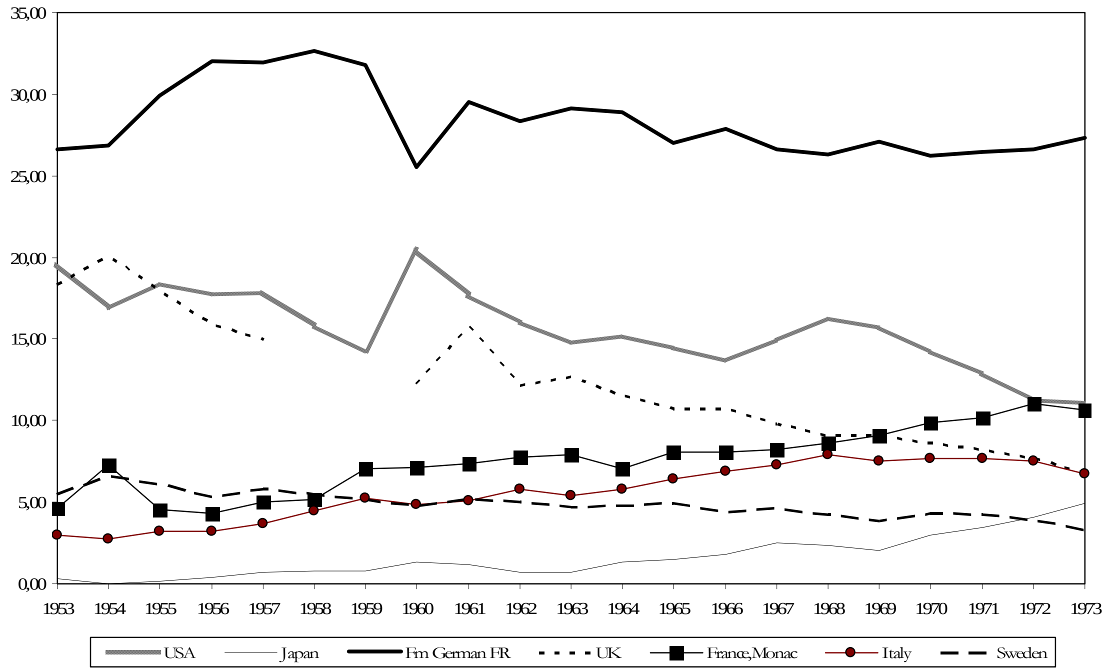
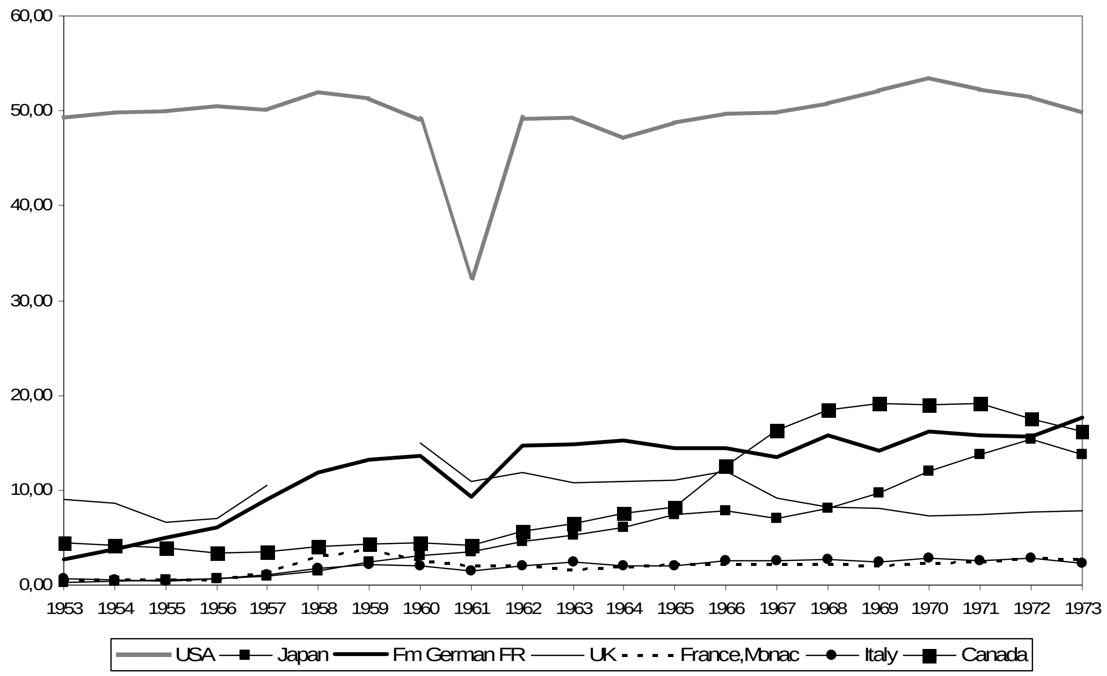


Figure 3
Main origin of imports for non-European Countries:
USA, Japan and Canada



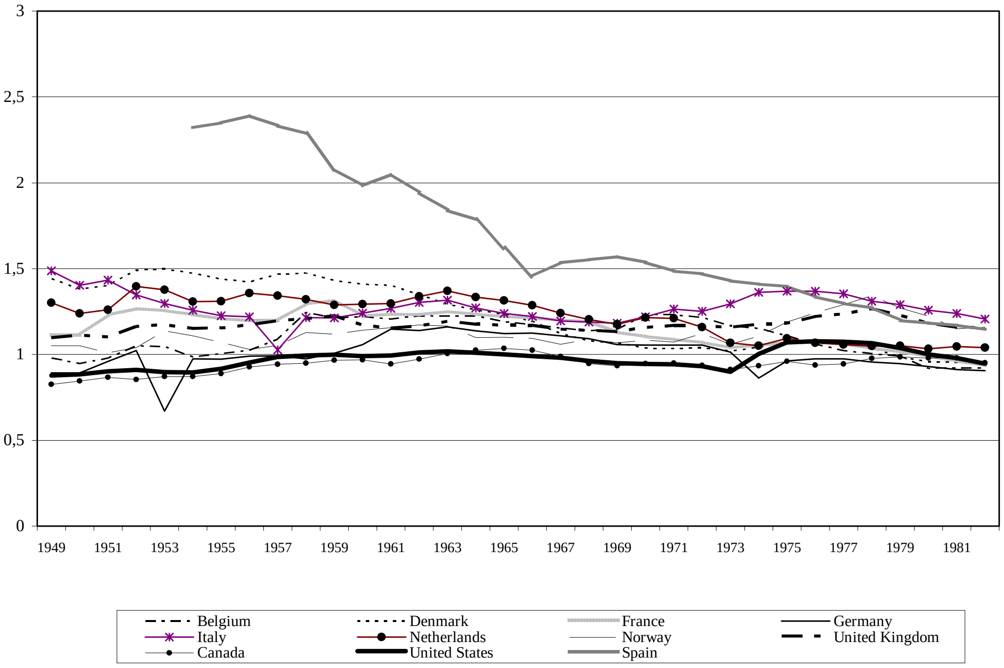
In the non-European area, the United States dominated exports during the whole period with Germany following by quite a distance. The unique noticeable change was the ascendancy of Canada and Japan in the sixties as a consequence of their rapid growth that improved their capacity to penetrate in the North-American market.

4.3. A look to the International Comparative Price Level of Equipment

In order to analyze the impact of market integration we will try to connect equipment trade with the evolution of relative prices of capital goods during the Golden Age. Although the relative price of equipment is what matters for converting the savings rate into a real investment rate, it is the price of investment itself that is relevant for deciding where to buy equipment. In the Eaton and Kortum's model trade gives access to foreign goods or implicitly to foreign technologies. By specializing in their respective comparative advantage goods, countries can gain from trade in the sense that given a country's resources, the efficient level of output with trade is higher than without trade. In Eaton and Kortum model lower income level countries will buy equipment in the most developed countries where prices are lower in relative terms because they are more efficient in the production of most technological advanced goods. So low income countries will specialize in consumption goods and will buy equipment goods from the most advanced countries. They also assume that unit transport costs are increasing in geographic distance. So the model predicts that relative prices of capital goods will tend to convergence to the lower relative price level of the exporter countries, although differences will continue to persist across countries due to geographic distance or other political barriers to trade[11].

Figure 4

Relative Prices of Machinery and Equipment



Source: Elaborated from OECD Historical Statistics, UN International Comparisons Programme.

We have constructed annual series of international comparative levels of the relative prices of equipment for the sample countries from 1950 up to 1973. First, we have used the benchmark data from the International Comparisons Programme of the

11 As Keller (2004) stands out the conclusions of the general equilibrium model developed by Eaton and Kortum(2001, 2002) are not clear and do not provide strong support for imports as a major channel of technology diffusion. This is because the equipment goods prices predicted by their model are inversely related to those reported in Summers and Heston's International Comparison Program of Price Data (CIC 2003). In Summers and Heston data base prices levels are positively related with income levels. Meanwhile in Eaton and Kortum model lower income level countries will buy equipment in the most developed countries where prices are supposed to be lower. However, when these results are interpreted in relative terms, the price of capital goods relative to the price of consumption goods, the Eaton and Kortum conclusions could be sustainable. It is like measuring equipment goods in efficiency units. That is to say, the relative prices of equipment goods are lower in the most developed countries and so backward countries will import equipment goods from these countries.

United Nations for 1980 to build a comparable estimate of the relative prices of capital goods across countries. We tried to establish the benchmark year as near as possible to the initial year of the period in order to reduce the bias derived from the problem of the index numbers. However, we finally decided to use 1980 as the benchmark year because the previous benchmarks (1970 and 1975) included a small number of countries. Second, we have constructed annual series of relative prices of capital goods and its components by backward discounting the annual variation rates of the implicit price indexes for investment and consumption. The annual implicit prices indexes have been extracted from the OECD National Accounts. Capital goods prices have been expressed in relation to those of consumption, and not with respect to overall GDP because investment is a component of this one.

As can be observed in Figure 4 relative prices of machinery and equipment were dominated by a downward trend throughout the 1960s and ended up converging with the lowest level, maintained by the U.S. Relative machinery prices declined more sharply in those countries that had the highest initial level, as it is the case with Spain, Norway, the Netherlands or France. Convergence in machinery prices could be considered a positive consequence of the vigorous openness to foreign trade and market integration that developed in Europe after World War II, and especially, since the creation of the European Economic Community. International trade can transmit the benefits of technological advances across borders and this implies that progress towards full capital goods market integration would lead to convergence in relative prices of capital goods[12].

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12 In the interwar period there was an upsurge of trade barriers that must have affected trade in capital goods. These barriers should raise the cost of buying and using imported equipment and could discourage the adoption of foreign technology (Collins and Williamson (2001)).

5.- Empirical results

In order to evaluate the empirical factors that determined the trade in capital goods and the influence of the technological difference between countries in this trade an augmented gravity model is used.

The gravity model emerged in the 1960s as an empirical specification with soft theoretical underpinnings. Leamer and Stern (1970) provided some foundations: nations produce their goods and throw them all into a pot; then each nation draws its consumption out of the pot in proportion to its income. In this way, bilateral trade is proportional to the product of the GDP shares.

Anderson (1979) was the first to provide clear microfoundations that rely on the assumption of product differentiation: each nation produces a unique good that is only imperfectly substitutable with other nations' goods. Bergstrand (1985) developed a general equilibrium model of world trade from which a gravity equation is derived from the assumption of perfect international product substitutability.

More recently, Evenet and Keller (2002) have shown that the gravity equation is compatible with different trade theories that assume product specialization: Ricardian models; Hecksher Ohlin models and increasing returns to scale models. A country imports goods because its production and demand are not equal in quantity and/or quality. Due to many different factors and reasons, an economy has some advantage in producing a given commodity and this originates specialization and trade. The product specialization can be obtained because countries have different factor endowment from H-O models or because firms enjoy increasing returns to scale in production or because of technology differences in Ricardian models.

As Feenstra, Markusen and Rose (2001) sum up “The simple gravity equation explains a great deal about the data on bilateral trade flows and is consistent with several theoretical models of trade”.

The basic specification of the gravity model could be expressed as

$$F_{ij} = G\frac{M_i^{\alpha} M_j^{\beta}}{D_{ij}^{\theta}} \tag{1}$$

where F_{ij} is the flow from origin i to destination j; M_i and M_j are the relevant economic size of the two locations; D_{ij} is the distance between locations; and G is a constant . We can take natural logs to obtain a linear relationship

$$\ln F_{ij} = \alpha \ln M_i + \beta \ln M_j - \theta \ln D_{ij} + \rho \ln G + \varepsilon_{ij} \tag{2}$$

The economic size of the exporting and importing countries, M_i and $M_{j,}$ are usually measured with gross domestic product. In empirical estimates we would expect a positive sign of economic size terms in terms of GDP. The use of GDP can raise a problem of simultaneity, since exports are part of GDP. Some studies have tried to deal with this simultaneity by using population instead of GDP. Sometimes both measures GDP and population have been used together. In that case, a negative population coefficient of the exporting country indicates that good exports tend to be relatively capital intensive while a negative impact of the average importer's population support the view that goods trade is mainly in luxuries. On the other hand, a large domestic market promotes the division of labour and thus creates opportunities for a wide variety of goods, which suggest a positive impact of population on bilateral trade. Additionally, if we consider GDP per capita a good measure of the demand for imports and the supply of exports, we would expect a negative impact of population on bilateral trade.

Distance is an important determinant of trade in most of the empirical works. The role of distance is to represent different costs, mainly transport cost, but also synchronization costs, communication costs, transaction costs or cultural distance. Other variables included in empirical studies are income per capita. The idea behind this appears to be that higher income countries generally trade more. One cause might be superior infrastructure. A countervailing effect is that high income countries tend to be more service-oriented, leading to lower trade in merchandise for a given level of GDP.

The augmented gravity model used in this paper can be specified as:

$$\ln X_{ij} = \alpha_0 + \alpha_1 \ln Y_i + \alpha_2 \ln Y_j + \alpha_3 \ln Dist_{ij} + \alpha_4 TechDist_{ij} + u_{ij} \qquad (3)$$

X_{ij} denotes the value of machinery and equipment exports from country i to j, Y_i are income in the exporter market, Y_j are income in the destination market, $\ln Dist_{ij}$ is the geographical distance between the capital cities of country i and j, and $TechDist_{ij}$ is an indicator of the technological distance between the exporter and the importer countries.

As indicator of technological distance we have used two variables: the difference in labour productivity per person or per hour between the exporter and the importer. We think of it as a synthetic measure of the technological difference between countries. Filipini and Molini (2003) present other measures. They calculate the technological distance as a simple average of three different dimensions: the creation of technology (proxied by the Balassa's Relative Comparative Advantage Index in Medium and High Tech sectors), the diffusion of technology (measured as a simple average of electricity consumption, telephone penetration and Internet users) and the development of human skills (measured as a simple average of secondary and tertiary enrollment ratio plus the literacy rate). Martinez-Zarzoso and Márquez-Ramos (2005) substitute the Balassa Index for the number of patents granted to residents and the receipts of royalties and fees from abroad.

We have preferred the difference in productivity as a measure of technological distance because it reflects the real distance between countries instead of the potential of technological development that reflects others measures. Obviously, differences in productivity can also reflect a wide number of factors (factor endowments, technical election, institutional arrangement,...) but most of them are related to the technological level of the trading countries. To measure the technological distance, we have used the logarithm of the ratio of the productivity per hour between the exporter and the importer countries and the logarithm of the ratio of the productivity per person employed between the exporter and the importer countries.

The model is estimated taking into account 17 countries over a period of 21 years (from 1953 to 1973). We get 272 bilateral flows of trade in machinery and equipment goods. We have augmented the equation with some dummy variables in order to capture the effect of belonging to a trade agreement: DEEC if the two countries are members of the EEC, and DEFTA if the two countries are member of the EFTA.

Trade flows data come from NBER-UN database derived from United Nations trade data by Robert Feenstra and Robert Lipsey. This database offer data from 1962 to 2000. For the previous years we have used the UN data from the Commodity Trade. We selected 17 countries: Austria, Belgium, Canada, Denmark, France, Germany, Greece, Italy, Ireland, Japan, Netherlands, Norway, Portugal, Spain, Sweden, United Kingdom and the USA.

Population, GDP data and productivity data comes from the Total Economy Database, Groningen Growth and Development Centre and the Conference Board. The geographic distance is calculated on the basis of the great circle approach. The dataset is unbalanced due to missing bilateral trade flow in the UN data for the first years of the sample, and for the lack of data on productivity for some countries during the 1950s.

All the economic variables are presented in constant dollars. We deflate the exports of machinery and equipment by the US deflator for durables goods from the Bureau of Economic Analysis. As the deflator for durables is highly influenced by the prices of computer and electronic products, with a different behaviour in relation to other durables, we have used also the deflator of the Gross Domestic Product. The results are not influenced by the use of durables or GDP deflator.

We estimate the gravity equation using a fixed effect model, assuming that heterogeneity is correlated with the regressors. We test this hypothesis using the Hausman test; the result of the test allows us to eliminate the random effect hypothesis. From a theoretical point of view it means that some time-invariant idiosyncratic element exists for each bilateral trade flow affecting its size. We test the heterogeneity with the F-test: the null hypothesis that heterogeneity elements are all zero is rejected. Accordingly, we chose a fixed effect model instead of a pooled OLS model. We have including time dummies in each estimation to take account of any shocks that may affect all the countries in the sample (exchange rate crisis, business cycles,...)

Table 5 shows the fixed effects estimation results of equation (3) for the 17 countries as exporters of machinery and equipment goods. Model 1 presents the basic specification. The results are consistent with economic theory and with our expectations. The signs of the GDP's are positive and highly significant, showing that countries with a high income trade more machinery and equipment. According to the usual derivation of the gravity equation, the estimated coefficients should be close to the value of one. However, we have to bear in mind that our dependent variable is not total trade but a subset of total trade.

We have tried other specifications of the model, including population and/or GDP per capita as additional regressors. We have found a high correlation between GDP and these variables and no gain in the efficiency of the model estimated. Thus, we have preferred including only GDP. We find an interesting result in the different level of the coefficients of exporter and importer GDP. The elasticity of the trade in capital goods is higher for the exporting country than for the importing one. This is a consistent result in every specification we present. An increase in the GDP causes a proportional higher rise in exports of machinery. However, an increase in the GDP causes a rise lower? than proportional in imports of machinery. We can interpret this result as a different behaviour of exporting and importing countries in front of the machinery trade. Economic growth is related to an increase in the share of machinery and equipment production over total production --a well-known fact. This higher share restrains the growth in imports. At the same time, the increase in production of capital goods promotes exports, which increase at a higher rate than production. A similar result was shown in the previous section.

Table 5

Estimation results

	(1)	(2)	(3)	(4)
Constant	- 50.927***	-36.381***	-36.288***	-36.568***
Y_I	4.587***	3.468**	2.816***	3.4718***
Y_j	0.612***	0.448***	1.017***	0.4572***
$Distance_{ij}$[1]	-1.927***	-1.576***	-1.560***	-1.582***
Technological $distance_{ij}$				
Tour productivity		0.6526***		0.658***
Person employed			1.1084***	
CEE				-0.114
EFTA				0.199
R^2	0.7008	0.6047	0.6059	0.6048
Nº observations	5054	3887	3858	3887
Groups	272	272	272	272

***, **, * denote statistical significance of 1%, 5% and 10% respectively. [1] This variable has? been regressed on the residuals of the main regression.

Bilateral trade flows are negatively correlated with geographical distance. To estimate the effect of distance over trade we have regressed the residuals of the main equation over the logarithm of distance, due to the impossibility of include time-invariant variables in the fixed effect model.

Our two measures of technological distance have been included in model specifications (2) and (3). In both cases, the signs are positive and highly significant, showing that the difference in productivity is an incentive to trade in machinery. This is the result we expected: trade in capital goods during the 1950's and 1960's was driven by the difference in the level of development between the European countries and the USA due to the technological advance that the USA acquired during the first half of the twentieth century[13].

In model specification (4) we included two dummies to account for the two regional agreements that were signed in Europe during this period: EEC and EFTA. In both cases the trade agreement dummies are not significant.

6. Conclusions

This paper is an attempt to analyse the trade in capital goods during the 1950's and 1960's among the European countries and the transatlantic trading partners. The gravity equation, a widely used model, has been modified to take into account what we consider a specific characteristic of this kind of trade, the technological superiority. With the inclusion of this variable we want to verify the hypothesis according to which European countries during the period after the Second World War benefited from the high technological level of the USA, importing machinery and equipment coming from this country. We suppose that the new capital goods embodied the new technology and in this way technology transfers between the most advanced country and Europe and other advanced countries in the world occurred. The analysis of this particular trade renders several conclusions.

- First, the origin of capital goods exports was concentrated in the most advanced countries. The seven most advanced countries of the group (USA, Canada, Japan, United Kingdom, Germany and France) supplied around 70 % or more of

13 Field (2003).

total imports of machinery and equipment to the other countries.

- Second, the main exporters were the countries which devoted more resources to R&D investment.
- Third, distance affects negatively this kind of trade. This result is line with the literature on international technology transfers.
- Despite this fact, in this work we have highlighted that the United States occupied a prominent role as the main exporter of machinery around the world, accounting for around 50% of total imports for the group of non-European countries and around 35 % of total imports for the European countries. The high presence of the U.S. in the European markets confirms that the technological distance between the countries encouraged trade in capital goods despite distance.
- Another important contribution of this work is to show that as the technological distance between the U.S. and its competitors (measured by means of differences in productivity) decreased, the tendency to import north-american machinery and equipment also dwindled. And hence, the weight of the U.S. products in the European imports began to decline during the sixties, in favour of imports coming from other European nations (Germany, France or Italy) and Japan. So the relationship between machinery and equipment imports and the geographical distance seems to have changed over time. With GDP post-war catch-up, the USA lost importance as a sender country in favour of other European sellers.
- Finally, we would like to underline that our paper has the primacy of showing the evolution of bilateral trade of capital goods during the Golden Age, including the 1950's decade. The data presented highlight the prominent role of the U.S. in this particular trade and the noticeable changes operated in the origin of the European imports of capital goods during this period. This work must be understood as a preliminary approach to the more interesting analysis of the process of technology transfers in Europe during the Golden Age and its effect on TFP growth. We will undertake these relationships in a future research.

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Table A.1

Share of the U.S. in Total Machinery and Equipment Imports by country, 1953-1973

(in %)

	Exports coming from the U.S.										
Importer country	1953	1955	1957	1959	1961	1963	1965	1967	1969	1971	1973
Canada	88.1	90.4	86.7	80.0	79.1	84.7	84.6	86.5	86.3	83.7	84.6
Japan	69.6	67.4	65.4	67.0	n.d.	57.0	54.7	55.2	59.5	59.0	54.0
France.Monac	31.7	31.0	30.7	23.9	24.7	20.9	19.8	18.2	14.8	14.4	15.0
UK	30.5	33.5	29.8	23.4	30.9	29.1	32.5	32.4	39.1	25.0	18.6
Italy	25.0	23.5	22.0	16.2	23.1	20.4	17.8	18.3	20.2	14.8	11.2
Belgium-Lux	18.3	19.6	16.2	11.5	12.5	11.5	9.7	9.8	9.0	6.9	6.7
Sweden	17.6	16.2	14.2	13.9	16.0	13.0	13.3	13.4	12.1	12.0	8.4
Greece	16.2	14.5	10.1	10.6	12.5	11.5	9.3	8.6	12.8	5.5	12.0
Fm German FR	15.4	23.3	26.0	20.3	24.6	20.9	20.0	19.4	16.6	14.5	13.3
Netherlands	14.0	13.0	12.7	9.1	12.6	8.5	7.6	9.8	10.1	11.3	8.6
Austria	10.6	3.6	5.0	4.6	6.4	4.0	3.9	3.2	2.8	5.2	3.3
Portugal	10.5	13.6	6.9	6.7	6.2	8.6	9.0	10.2	6.0	5.6	5.8
Norway	6.7	4.2	6.3	4.3	5.1	5.6	5.6	5.3	9.8	6.7	6.9
Denmark	5.2	7.4	9.1	6.9	8.4	7.7	8.3	9.8	9.9	12.6	8.4
Ireland	n.d.	3.7	3.1	n.d.	10.4	2.9	6.7	8.3	14.2	15.7	8.5
Spain	n.d.	n.d.	n.d.	n.d.	n.d.	17.1	18.9	20.9	23.5	17.5	19.3

Source: For 1953 and 1960 United Nations *Yearbook of International Trade Statistics* (several issues) and Feenstra et al (2005) for 1973. Data are expressed at constant prices. Imports of every country have been deflated by the U.S. GDP deflactor. Countries have been ordered in a descending order according to the share of the U.S. in their total imports of machinery and equipment with reference to 1953.

Table A.2

Share of Germany F.R. in Total Machinery and Equipment Imports by country, 1953-1973

(in %)

	Exports coming from Germany F.R.										
Importer country	1953	1955	1957	1959	1961	1963	1965	1967	1969	1971	1973
Austria	55,0	67,8	66,6	65,3	63,7	61,5	61,4	57,1	56,5	53,2	53,8
Netherlands	34,6	35,9	36,3	37,6	35,0	37,2	32,7	33,1	34,4	33,7	37,1
Italy	33,1	36,5	36,0	40,1	34,4	37,3	36,7	39,1	37,5	40,1	39,3
Denmark	33,0	35,1	34,1	37,9	37,6	36,2	35,3	27,9	27,4	27,4	31,7
Sweden	30,3	42,5	40,6	44,9	41,2	40,0	39,4	34,3	34,6	33,6	33,5
Belgium-Lux	29,3	32,8	33,5	32,7	33,4	35,3	37,5	40,1	43,9	44,0	44,2
Norway	27,8	18,6	23,3	30,9	30,1	26,4	23,3	18,0	23,9	20,1	18,8
Greece	24,1	34,7	36,3	27,8	25,0	29,4	28,1	31,5	27,8	27,3	31,2
France,Monac	21,9	25,3	33,8	35,8	32,5	35,1	37,0	38,1	39,2	38,1	38,1
Portugal	19,4	28,0	32,3	34,2	26,3	28,0	29,5	25,2	26,2	25,4	22,2
UK	16,0	22,0	27,7	22,9	24,3	21,6	20,2	19,7	17,3	19,9	21,2
USA	12,2	23,6	28,9	27,1	29,8	28,5	23,6	18,1	15,2	15,4	17,6
Japan	9,7	11,7	12,4	12,2	n.d.	15,2	15,3	13,8	14,8	14,7	16,3
Canada	0,6	1,1	2,3	3,2	3,2	3,2	3,1	2,5	2,6	2,9	2,8
Ireland	n.d.	12,1	10,1		11,3	12,9	11,1	12,1	13,6	12,8	14,1
Spain	n.d.	n.d.	n.d.	n.d.	n.d.	27,9	24,7	23,9	24,8	25,6	25,7

Source: For 1953 and 1960 United Nations *Yearbook of International Trade Statistics* (several issues) and Feenstra et al (2005) for 1973. Data are expressed at constant prices. Imports of every country have been deflated by the U.S. GDP deflactor. Countries have been ordered in a descending order according to the share of the U.S. in their total imports of machinery and equipment with reference to 1953.

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