Revisiting Import-Substituting Industrialization in Brazil: Productivity Growth and Technological Learning in the Post-War Years

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<u>Draft</u>

Prepared for the Conference on "Latin America, Globalization, and Economic History", 24th and 25th of April 2009, UCLA

March 2009

1. Introduction

Scholars have long been disputing the causes of the post-war story of boom and boost in Brazil and other major Latin American countries, in particular the nature of import-substituting industrialization and its role in the post-1979 slowdown. Early in the 1960s a positive view of the achievements of industrialization in Brazil and Latin America gave way to pessimism and mounting criticism.[1] "Market critics", to use Werner Baer's words, pointed to the distortions caused by high and indiscriminate protection, subsidies and exchange controls in Latin American industrializing countries. According to these critics, the indiscriminate nature of import-substituting industrialization led to the development of deeply inefficient and high-cost industries (Baer, 1972, pp. 101-6).

Market criticism was shared by scholars from different perspectives.[2] In the early 1960s, Santiago Macario from Economic Commission for Latin America (ECLA) provided a thorough and critical analysis of the sort of import-substitution policies pursued in Latin America. Macario pointed out that such policies allowed domestic firms to charge high prices and offered them little incentive to produce efficiently. Moreover, the indiscriminate protectionist policy hampered the development of manufacturing exports and worsened external vulnerability, because of its negative impact upon productivity growth and competitiveness (Macario, 1964, pp. 75-83).[3] This point was similar to what was later argued by – in Stephen Haggard's words – "neoclassical critics", who became highly influential from the early 1970s (Haggard, 1990, pp. 10-13; Wade, 2004, pp. 8-22).[4] But there remained major differences between ECLA and neoclassical views. Macario pointed out that the problem lay not with trade protection itself, but rather with the policy of indiscriminate trade barriers and import substitution at any cost (for example, regarding efficiency considerations) that historically prevailed in Brazil and other Latin American countries (Macario, 1964, pp. 11). For their part, most neoclassical critics viewed government intervention

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[1] Hirschman (1968), pp. 1-4. As plainly stated by a recent assessment, "Latin america's history has been characterized by mediocre growth, rampant protectionism, very high inflation, low productivity growth, and sucessive crisis" (Edwards, Esquivel and Márquez, 2007, p. 1).

[2] As acknowledged by Balassa (1970, pp. 30-1), although not by Krueger (1997).

[3] See also Prebisch (1963); Hirschman (1968), pp. 2-3, note 4.

[4] For influential neoclassical critics, see Little, Scitovsky and Scott (1970); Krueger (1978); Baghwati (1978); Balassa (1982).

in trade, exchange and credit markets, aiming at promoting the industrial sector, as the ultimate source of distortions and chronic problems in Latin American economic development. Although cautious about the available evidence regarding the dynamic effects from export orientation when compared to those from import substitution policies, neoclassical critics saw the sheltered industries and inward-oriented strategies as harmful to innovation and technical progress (Bhagwati, 1978, pp. 193-7; Srinivasan and Bhagwati, 1989, pp. 28-31).

Economic historians have interpreted the long-term record of Latin American industrialization in lines similar to those laid down by market critics. A first group of scholars have argued that Latin America represents a conspicuous example of the failure of state-led, inward-oriented industrialization. Low productivity growth and technological stagnation would be a straightforward and unavoidable outcome of import-substitution policies, in particular of high trade protection. Victor Bulmer-Thomas (1994), in his classic economic history of Latin America, argued that the problem with import-substituting industrialization lay not in its excesses, but rather in its use of distorting policies (mainly trade protection) which generated deep-rooted inefficiency. By suppressing imports, there was no way of keeping "the productive apparatus efficient and technologically up to date". Thus, according to Bulmer-Thomas, "[t]he inward-looking model, particularly in the 1950s, is now seen as an aberration (...) although the excesses were often unnecessary the model – even in a less-distorted form – still cannot be defended"(pp. 281, 283). In a more cautious fashion, Stephen Haber (2006) pointed out that "it is not clear […] that the increase in the *size* of Latin American industry necessarily translated into an increase in the *productivity* of Latin American industry". Then Haber quotes estimates of substandard productivity growth (Total Factor Productivity) in Mexico and Argentina's manufacturing industry and seems to infer that they are a good description of the performance of Latin America in the post-war years. In his overall assessment, Haber argued that "the ultimate outcome of import-substituting industrialization (ISI) is as depicted in the standard literature: highly protected and woefully inefficient industries" (pp. 538, 577-8).

Another group of scholars shares the criticism of the distortions generated by high protection but has raised doubts about the view of an essentially negative record of import-substituting industrialization in Latin America. Rosemary Thorp (1998) argued that Latin America economic history shows "a reality that is complex and contains both good and bad". There were "distortions, inefficiencies and lost opportunities" but there was also "a radical transformation of infrastructure and institutions". Industrial firms gradually acquired new skills and engaged in assimilating, adapting and developing new technologies (Thorp, 1998, p. 197; Cárdenas, Ocampo and Thorp, 2001). This view of a gradual learning process that did not preclude productivity gains and technological growth has some support from case studies on individual industries in Brazil and other large Latin American economies. For example, Werner Baer's well-known estimates of costs and prices of steel products indicated that some Brazilian companies compared favorably to their counterparts in the United States during the 1960s (Baer, 1970, ch. 6). For the same period, Nathaniel Leff (1968, ch. 6) found that Brazilian companies in the heavy-engineering industry were competitive compared to imports. There is likewise evidence of significant productivity growth in other manufacturing industries, particularly in modern branches such as steel, metallurgical and motor vehicle parts. According to Teitel and Thoumi (1986), increasing productivity in manufacturing, along with a reduction of the anti-export bias of trade policies, propelled manufactured exports from the 1960s. The phenomenon of technology exports by Brazil and other developing countries from the 1970s is another piece of evidence that indicates technological upgrading in manufacturing (Lall, 1984; Dahlman and Sercovich, 1984; Teitel and Sercovich, 1984; Sercovich, 1984). Thus, for the case of Brazil, William Tyler (1976) argued that in "those industries where post-war industrial growth and import substitution have been the greatest, e.g. steel, machinery, and transport equipment, by the mid-1970s reasonable international competitiveness has been attained in a large number of lines of production" (p. 867).

At first sight it may be surprising that such contrasting views about efficiency and technological capabilities have been drawn from the same reality of Brazilian industrialization. Yet the experience of economic growth in Brazil was influenced by two factors that complicate analysis and help make an assessment of industrial performance elusive. Firstly, there was a wide range of productivity and technological levels in firms of the same industry (Dahlman and Frischtak, 1993; Tyler, 1976, p. 868). Analyses that stresses low productivity and lack of innovation of the majority of firms will find little more than conservatism and technological stagnation, even though there were noticeable cases of innovative and competitive firms in post-war Brazil. Secondly, manufacturing firms were heavily affected by the collapse of debt-led growth in Brazil in the early 1980s. The macroeconomic environment deteriorated sharply, policies were discontinued, firms cut investments so that industrial conditions before and after the debt crisis changed radically (Dahlman and Frischtak, 1993, pp. 420-5; Fishlow, 1986). A retrospective view that evaluates the period as a whole without taking into account its different macroeconomic conditions, or that regards the debt crisis as an outcome of deep inefficiencies of import-substituting industrialization, will tend to see Brazil's post-war industrialization in a very distinct way from one that allows for the differences in macroeconomic conditions affecting industrial performance. The role of these two factors is even more important given the fact that detailed historical research on the technological development of manufacturing firms and industries is still relatively scant in Brazil.

This article aims at contributing to fill this gap by presenting new data about labor productivity, technological content of exports and selected firms and industries. We will bring these new data together with evidence gathered by other empirical studies in order to draw a general picture of the performance of Brazilian manufacturing industry in the post-war years. We present evidence from both macro and micro levels in the assumption that a one-sided focus on macroeconomic aggregates misses important aspects of industrialization and technological development. On the micro-level of firms and industries, labor skills, working conditions, work effort, organizational structures and engineering capabilities played a key role in shaping Brazilian industrialization. The article views trade policies as only one of the major factors influencing productivity levels and technological learning in manufacturing. We contend that market critics that gave nearly exclusive emphasis on trade protection overlooked other major factors shaping firm and industry performance, in particular those associated to labor markets and the social set-up in which industrialization took place. We build on a diversified body of theoretical and historical literature to argue that labor market institutions, wage-setting arrangements, training systems and education levels are examples of factors that, though often neglected by the standard literature, influenced technological and industrial performance in post-war Brazil.[5]

The article is organized in four sections within a time span which covers the heyday of import substitution policies, starting in 1945 with the end of the Second World War and ending in

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[5] See in particular Leibenstein (1966); Lewchuk (1987); Lazonick (1990); Ashton and Green (1996); Lall (1992); Rosenberg (1976).

1979 with the reversal of debt-led growth in Brazil. Section 2 presents an overview of the industrial transformation and estimates of labor productivity growth in the post-war years. The third section provides estimates of the technological content of exports. The fourth section looks into data from selected firms and industries. In the end, we draw conclusions about productivity and technological learning in post-war Brazil industrialization.

2. Industrial change, trade protection and productivity growth

Scholars have long shown that Brazil's economy growth in the post-World War II was largely a result of rapid expansion of industry (Tavares, 1972; Malan et al., 1980; Fishlow, 1980; Maddison, 1992; Baer, 2001). The average growth of industrial output between 1945 and 1979 reached 8.8 per annum. The magnitude of structural change in the post-war years can be seen, firstly, by the share of the industrial sector in the Gross Domestic Product (GDP), which grew from 24.1 percent in 1950 to 40.9 percent in 1980 – whereas agriculture declined from 24.3 percent in 1950 to 10.1 percent in 1980. Secondly, modern industries such as machinery, electrical materials, transport equipment and chemicals performed particularly well. Their share in manufacturing output jumped from 12.6 percent in 1949 to 43.6 percent in 1980. By contrast, traditional manufacturing experienced a sharp relative decline, the most noticeable cases being those of the food and textile industries, which saw a reduction in their share of manufacturing output from 31.9 and 18.6 percent in 1949 to 13.9 and 6.4 percent in 1980, respectively.[6]

Rapid industrial growth and structural change in Brazil were stimulated by a diversified mix of economic policies, which included multiple exchange rates, quantitative import restrictions, direct foreign exchange controls, tariffs, and fiscal and credit subsidies. These tools were often a product of balance-of-payment crises and attempts to achieve external balance. Yet promoting manufacturing activities also became a policy favored by successive governments from the late 1930s (Dean, 1969, ch. 10).[7] Despite the myriad policy tools adopted in Brazil after World War II, the *rationale* behind them was already relatively clear in the 1950s. Protection of

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[6] Data elaborated by the author from Abreu (1990), Appendix; Brasil (1990) pp. 125-7, 386. Figures of industry's share of GDP are measured in current prices. For a detailed analysis of structural change in Brazil, see Baer, Fonseca and Guilhoto (1987).

[7] Others have argued that state policies aiming at promoting industrialisation were adopted since the "Revolution of 1930". See Hilton (1975) and Fonseca (2003).

industry should be kept at a high level, both to redress balance-of-payments imbalances and to foster import substitution of all ranges of goods which could be replaced by those of domestic production (Macario, 1964). Estimates of trade protection corroborate this view, as can be seen in Table 1.

Table 1. Nominal protection in the manufacturing industry, Brazil and European Economic Community, *c*. 1960 (percent)[a]

Industries	Brazil[b]	EEC[c]
Manufacturing industry (97 products)[d]	165	17
Non-metallic minerals (2 products)	33	10
Metallurgy (12 products)	79	7
Machinery (20 products)	73	11
Electrical materials (10 products)	302	17
Transport equipment (10 products)	170	17
Furniture (1 product)	336	18
Paper and products (1 product)	36	6
Rubber (2 products)	106	21
Leather (1 product)	336	19
Chemical and pharmaceutical products (13 products)	109	11
Perfumes and soaps (1 product)	325	19
Textiles (4 products)	248	9
Clothing and footwear (3 products)	345	21
Food products (16 products)	238	37
Beverages (1 product)	346	13

Source: Macario (1964), Annex III. Industries reclassified by the author.
Notes:
[a] *Ad valorem* incidence of duties and charges in Brazil and EEC. Products included are "the most representative of the production and trade of the countries concerned", Macario (1964), p. 74.
[b] Duties and charges in March 1962.
[c] Duties and charges *c*. 1960.
[d] Manufacturing industry averages were weighted by the number of products in each group.

As Table 1 shows, by the early 1960s nominal protection (measured by charges and duties on imports) in Brazil was very high, with an average of 165 percent over import prices in the manufacturing industry, compared to an average of 17 percent in the European Economic Community (EEC). Two features can be stressed regarding specific classes of products. Long-established industries, such as the textile industry, enjoyed particularly high protection rate (248 percent over import prices) and defied the logic of infant industry, which commended only a transitory period of protection for new industries, before being left to compete with imports. This pattern is also evident in other traditional industries: for example, food products, with an average of 238 percent over import prices. Also, modern industries benefited from high trade protection, even though well-established foreign companies had a substantial share in these new branches of the manufacturing industry. A case in point was the production of electrical consumer goods and motor vehicles, in which the incidence of duties and charges on imports was over 300 percent (Macario, 1964, Annex III). The logic of the protection policy was also apparent in the industries with relatively lower levels of nominal protection, such as metallurgy and machinery (79 and 73 percent, respectively), since their duties and charges too were high by international standards (compared to the EEC, for example).[8]

These trends shown by data on nominal protection are confirmed by estimates of effective protection; that is, with value added taken into account, along with final prices, for calculating trade protection. Effective rates of protection were even greater than nominal rates in Brazil's manufacturing industry. Again, the most favored industries were those which were already mature in the 1960s. In 1966, nominal protection was 181 percent and effective protection 379 percent for textiles, and 226 percent and 337 percent for clothing, respectively. In the manufacturing sector nominal and effective rates of protection achieved 96 and 113 percent, respectively. In 1954, the same indicators for the manufacturing sector in Norway, for example, were just 8 percent (Balassa, 1971, p. 54; Bergsman and Malan, 1971, p. 120).

This is the sort of evidence that has been used to support the view that trade policies generated widespread inefficiency and technological stagnation, despite high industrial growth in post-war Brazil. However, what does the evidence about productivity and technological growth in Brazilian manufacturing reveal? We look firstly into new data on labor productivity for the period 1945-1979, constructed by using interpolation and backward extrapolation of available statistics.[9]

Table 2 shows the annual average rates of growth of labor productivity in eighteen industries as well as in Brazil's manufacturing industry as a whole, in different periods of the post-war years. The yearly average rate of labor productivity growth in Brazilian manufacturing industry reached 5.2 percent between 1945 and 1979. The average growth rate was lower in the period 1961-1968 (3.9%) when compared to those from the other two periods in which the series

[8] However Leff argued that tariffs and restrictions were not usually applied to equipment imports at the time (1968, pp. 134-42).

was split in Table 2: annual growth rates of 5.5% in 1945-1961 and 5.6% in 1968-1979. It seems that macroeconomic instability and relatively low economic growth during part of the 1960s negatively affected industrial labor productivity.[10] Overall individual industries followed the same pattern as the manufacturing industry, with the exceptions of non-metallic minerals, textiles, furniture and machinery.

Table 2. Growth of labor productivity by industrial sectors, Brazil, 1945-1979 (percent growth)

Industries	1945-1961	1961-1968	1968-1979	1945-1979
Chemical and pharmaceutical products	6.6	6.2	8.6	7.2
Paper and products	6.4	2.2	8.0	6.7
Tobacco	9.1	4.2	6.8	6.5
Rubber	8.8	0.4	4.7	5.9
Non-metallic minerals	5.1	5.8	6.3	5.6
Textiles	4.9	5.1	8.0	5.6
Metallurgy	5.7	3.0	7.1	5.4
Leather	5.1	1.0	7.7	5.3
Miscellaneous	6.6	3.2	4.8	5.2
Transport equipment	7.3	-1.4	4.7	5.0
Printing and publishing	4.0	3.8	6.6	5.0
Furniture	5.0	6.5	5.3	5.0
Machinery	4.1	6.9	3.9	4.9
Electrical materials	4.8	3.5	5.8	4.7
Food products	5.3	2.9	3.9	4.6
Wood	3.8	3.2	6.9	4.5
Clothing and footwear	4.3	2.0	5.3	4.1
Beverages	2.9	3.1	6.8	4.1
Manufacturing industry	5.5	3.9	5.6	5.2

Sources: see Appendix.

Yearly average rates of labor productivity growth differed appreciably across industries in Brazil. If we take the growth rate of labor productivity in the manufacturing industry (5.2 percent) as a dividing line between high-growth and low-growth industries, we see that among fast-growing branches there were both modern industries, such as chemical and pharmaceutical products (7.1 percent), and traditional ones, such as textiles (5.6 percent). Among the low-

[9] Details about these estimates are described in the Appendix.

[10] Brazil's industrial output growth between 1961 and 1968 was 5.9%, compared to 9.8% in 1945-1961 and 9.9% in 1968-1979. For Brazil's macroeconomic performance in the 1960s, see Wells (1977).

productivity growth industries there were activities regarded as modern and more skill-intensive, whose role in the industrial transformation in post-war Brazil was significant – machinery (4.9 percent) and electrical materials (4.7 percent). Transport equipment (5.0 percent), another industry which was at the center-stage of post-war industrial change, also showed a below-average rate of labor productivity growth in the period analyzed.[11] On the other hand, annual average rates of labor productivity growth tended to be higher in industries with higher levels of labor productivity.[12]

Interestingly, evidence about the relation between labor productivity growth and trade protection is mixed. Tariff rates were kept at high levels between 1945 and 1966, decreased between 1966 and 1973 and rose again from 1974 to 1980 (Braga and Tyler, 1990, p. 5). In the period 1945-1966, industries with lower import duties exhibited higher labor productivity growth.[13] However, from 1966 to 1973 there was no clear relation between labor productivity growth and tariff duties. The same happened in the years between 1973 and 1980, when import duties rose again after the decline observed in the preceding years.[14]

Overall the results of labor productivity growth presented in Table 2 are very significant when compared to the performance of other developing and even developed countries. International comparisons by Bart van Ark and Marcel Timmer using estimates drawn from national industrial census or surveys, and therefore similar to the data presented here, show that Brazil achieved relatively high productivity levels by the 1960s. Brazil's labor productivity was 54.1 percent of the United States's in 1960 and 56.0 percent in 1973 – compared, for example, to 11.3 and 17.1 percent in Korea; 25.8 and 43.4 percent in Spain and 48.3 and 53.4 percent in the United Kingdom, respectively.[15] At the same time, these figures indicate that the speed of Brazil's catch up was slower than that of other countries between 1960 and 1973. Brazil's catch-

[11] Thus, correlation between modern industries and high labour productivity growth was positive (0.14390) but not statistically significant (p-value = 0.58163).

[12] Correlation between industries with high labour productivity levels (in 1979) and those with fast growing labour productivity was positive (0.65394) and statiscally significant (p-value = 0.00324).

[13] Correlation between average labour productivity growth from 1945 and 1966 and trade protection in 1966 was negative (r = - 0,4451) and statiscally significant at about 5 percent (p-value = 0.05479).

[14] Correlation between average labour productivity growth from 1966 and 1973 and trade protection in 1973: r = 0.20153, with p-value = 0.42259; and for 1973 and 1980: r = -0.10811, with p-value = 0.66937.

[15] van Ark and Timmer's labour productivity data refer to the value added per person employed in manufacturing. Data for Korea and Taiwan refer to 1963 and 1973; see van Ark and Timmer (2001), p. 48, table 2.

up with the levels of US labor productivity was particularly strong during the 1950s, and continued throughout the 1960s up to the mid-1970s, when started to reverse (van Ark, 1993, pp. 92-97; Appendix, table IV.4). Indeed, Brazil's productivity level dropped to only 35.9 percent of the US level in 1998 – whereas Korea (43.1 percent), for example, continued to catch up. As argued by van Ark and Timmer, the economic crisis ignited by the collapse of the debt-led growth in the 1980s severely hit the productivity performance of the Brazilian industry, although it is also clear that labor productivity growth had already lagged behind other emerging economies from the 1970s (van Ark and Timmer, 2001).[16]

It is reasonable to expect that the relatively high productivity growth in Brazilian manufacturing industry stemmed from the reallocation of resources among sectors, in a process of structural change which was investigated by Arthur Lewis and Simon Kuznets (Syrquin, 1988). As we saw earlier, modern industries increased their share in total manufacturing in relation to traditional industries in the post-war years. Such structural change in the industrial sector, when leading to a reallocation of capital and labor from lower to higher productivity growth branches, may become the major cause of the increase in aggregate labor productivity of the manufacturing industry. In this situation, intra-branch growth in labor productivity, explained by more efficient use of resources by firms, turns out to be only a secondary or irrelevant factor in explaining aggregate productivity growth.

We can estimate the impact of both structural change and intra-industry productivity on aggregate productivity growth by using the shift-share analysis, originally proposed by Solomon Fabricant in the 1940s, extended by W. Salter in the 1960s, and applied in recent studies on industrial growth (Fabricant, 1942; Salter, 1960; Fagerberg, 2000; Timmer and Szirmai, 2000; Peneder, 2003). The shift-share analysis decomposes the growth of aggregate labor productivity into three specific effects:

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[16] Astorga, Bergés and Fitzgerald (2003) also argued that "aggregate productivity" (measured by the PPP adjusted GDP divided by the economically active population) collapsed in the 1980s. Likewise, Prados de la Escosura (2007) found that the 1980s marked a major breakthrough in the trend of per capita GDP growth in Latin America (pp. 20-5). Estimates of Total Factor Productivity in Latin America have also shown a sharp fall during the 1980s. See, for example, Elías (1990); Fajnzylber and Lederman (2000); Hofman (2000); Loayza, Fajnzylber and Calderón (2005).

$$\text{Growth}\ (LP_T) = \frac{LP_{T,t} - LP_{T,t-1}}{LP_{T,t-1}}$$

$$= \frac{\overbrace{\sum_{i=1}^{n} S_{i,t-1}(LP_{i,t} - LP_{i,t-1})}^{\text{(I) within-industry effect}} + \overbrace{\sum_{i=1}^{n} LP_{i,t-1}(S_{i,t} - S_{i,t-1})}^{\text{(II) static shift effect}} + \overbrace{\sum_{i=1}^{n} (LP_{i,t} - LP_{i,t-1})(S_{i,t} - S_{i,t-1})}^{\text{(III) dynamic shift}}}{LP_{T,t-1}} \qquad (1)$$

where LP is the labor productivity, i an individual industry, Si the share of industry i in total manufacturing, T the sum over industries i, $t-1$ the initial year and t the final year.

The first component (within-industry effect) measures the contribution of productivity growth within individual industries resulting from factors such as learning by doing, higher capital intensity and shift-effects among firms. The other two terms on the right-hand side of equation (1) refer to structural change. The second term (static effect) shows how much a shift of labor towards industries with a higher level of labor productivity affects aggregate labor productivity. If industries with a higher level of labor productivity increase their share in total employment, this effect will be positive. The third term (dynamic effect) measures the combined effect of changes in labor productivity of individual industries and the shifts of their relative shares in total manufacturing. If industries with higher rates of labor productivity growth also increase their share in total manufacturing employment, then this effect will be positive.

Table 3 shows the results of the shift-share analysis for the Brazilian manufacturing industry.[17] The post-war years are divided into three sub-periods in order to capture possible different patterns in labor productivity growth and structural change. First, the period between 1945 and 1961 comprises the golden age of "developmentalism", when the annual average growth of GDP and industrial product achieved 7.3 percent and 9.8 percent, respectively. Second, economic growth faltered from 1961 to 1968 (GDP, 5.3 percent; industrial product, 5.9 percent). Third, there was another boost in the average growth of GDP (9.0 percent) and industrial product

[17] We follow the presentation by Timmer and Szirmai (2000), p. 377.

(9.9 percent) between 1968 and 1979.[18]

Table 3. Decomposition of labor productivity growth in manufacturing, Brazil, 1945-1979 (percent)

Labor productivity growth		Percentage of labor productivity growth explained by:			
Periods	Annual growth (percent)	Within-industry effect	Static shift effect	Dynamic shift effect	Total effect
1945-1961	5.5	88.6	5.6	5.8	100.0
1961-1968	3.9	86.6	12.1	1.4	100.0
1968-1979	5.6	111.9	-1.4	-10.4	100.0
1945-1979	5.2	98.0	2.2	-0.2	100.0

Sources: see Appendix.

During the golden age of developmentalism (1945-1961), annual growth of labor productivity was 5.5 percent and structural change explained 11.4 percent of the aggregate productivity growth. Both static (5.6 percent) and dynamic-shift (5.8 percent) effects were present. Thus a shift of labor to more productive industries and an increasing share of fast growing industries in total employment had some impact upon productivity in Brazilian manufacturing. Nonetheless, productivity changes within industries were the major causes of manufacturing productivity increases – 88.6 percent of the aggregate productivity growth in the period.

Labor productivity growth slowed down between 1961 and 1968 (3.9 percent, annual average) and structural change became slightly more important (13.5 percent) for aggregate productivity. In this period, transfers of labor to higher productivity industries (static-shift effect) explained 12.1 percent of aggregate productivity growth, against 1.4 percent from the increasing share of fast growing branches (dynamic-shift effect). Within-industry productivity increases explained 86.6 percent of aggregate productivity growth at the time.

During the high-growth years of 1968-1979, average growth of labor productivity reached 5.6 percent, an outcome explained by within-industry productivity growth (111.9 percent) alone. Both static (-1.4 percent) and dynamic-shift (-10.4 percent) effects were negative. These results mean that transfers of labor to lower productivity growth branches along with a decreasing share of fast growing industries in terms of labor productivity contributed negatively to aggregate

[18] Calculated from Abreu (1990), Appendix.

productivity growth.

For the whole period productivity gains within industries were clearly the major source of aggregate labor productivity growth. Table 3 shows that between 1945 and 1979 the structural change effect in Brazil's manufacturing industry was positive but negligible, accounting for only 2.0 percent of the overall productivity growth. The dynamic-shift effect was negative (-0.2 percent), indicating that fast-growing industries (in terms of labor productivity) saw a reduction in their share of total manufacturing employment – the so-called Baumol hypothesis of a structural burden on aggregate productivity resulting from unbalanced growth (1967). Productivity increases within individual industries explained 98 percent of the aggregate productivity growth.

Overall, the data on productivity growth lend support to a qualified view of the efficiency performance of import-substitution industrialization in post-war Brazil. This country achieved high labor productivity levels in the 1960s, although it lagged behind other industrializing and developed countries in the following years, in particular from the mid-1970s. At the same time, structural change had a minor role in explaining productivity growth; the chief determinant of labor productivity was the more efficient use of resources by firms.

3. Technological content of exports

Another measure of efficiency of import-substituting industrialization in Brazil is provided by estimates of the technological content of exports. The assumption is that the export structure of a country reflects domestic learning and innovative capabilities by firms and industries (Krugman, 1995; Dosi, Pavitt and Soete, 1990; Dalum, 1992; Fagerberg, 2000; Montobbio, 2003). We use a typology elaborated by Sanjaya Lall that is roughly similar to the classification of the United Nations Conference on Trade and Development (Lall 2000; UNCTAD, 2002, ch. 3, annex 1). Exported products are initially aggregated at the three-digit level of the United Nations' Standard Industrial Trade Classification (second revision): SITC Rev. 2 (1976). Then, the products are grouped into five categories, according to the estimated technology required for their domestic production. The first group, *Primary Products*, comprises agricultural and extractive exported goods with no or very little industrial processing. Coffee, cotton, fresh meat, unmilled cereals and copper are some examples in this category. Manufactured products in turn are grouped into four different categories. "Resource Based

Manufactures" are processed natural resources, usually of a simple, labor-intensive and low-skill type, although there were products in this group which could be more intensive in capital and technology, like mineral ores and processed fruits. Examples of resource based manufactures are prepared meat, dairy products, chocolate, processed wood, refined petroleum, rubber tyres, paper, wood manufactures, iron ore, glass and organo-inorganic compounds.

"Low Technology Manufactures" consist of goods with stable and well-diffused technologies, labor intensive and low-skill content. The same caveat as that to the previous group applies: there are products in this category that may be more skill- and technology intensive, such as footwear, garments and steel bars. Some examples of low technology goods are leather and its products, textile yarn, cotton fabrics, pottery, railway materials and manufactures of base metal. "Medium Technology Manufactures" include products intensive in capital, technology and labor skills. Although technology for this category could be available in international markets, its diffusion, adaptation and improvement were complex and required substantial learning capabilities. Products in this category include motor vehicles and parts, synthetic fibers, fertilizers, pig iron, radio receivers, agricultural machinery, textile machinery and machine tools. Finally, "High Technology Manufactures" are characterized by rapid technological progress, high R&D content and sophisticated skills. Requirements including complex infra-structure, high level of labor and management skills, and interaction with research institutions made technology development in this category especially difficult for newly industrializing countries. Typical products are medicinal and pharmaceutical goods, office machines, automatic data processing, telecommunications equipment and aircraft.

Table 4 shows the technology content of manufactured exports. We see clearly that Brazil was largely dependent upon primary exports throughout the period 1945-1979. Shares of primary products in total exports were above 50 percent in most of the post-war years; they were particularly high in late 1940s and early 1950s, when coffee prices experienced a boom in international markets.

Table 4. Manufactured exports classified by technological categories, Brazil, 1945-1979 (percent)

Year	*Primary Products*	*Resource Based Manufactures*	*Low Technology Manufactures*	*Medium Technology Manufactures*	*High Technology Manufactures*	*Total Manufacturing Exports*
1945	64,5	15,7	16,7	2,2	0,9	35,5
1946	75,1	16,4	6,9	1,0	0,6	24,9

Year	Primary Products	Resource Based Manufactures	Low Technology Manufactures	Medium Technology Manufactures	High Technology Manufactures	Total Manufacturing Exports
1947	78,2	13,2	7,2	1,0	0,4	21,8
1948	86,0	10,1	3,0	0,7	0,3	14,0
1949	89,3	9,2	1,1	0,2	0,1	10,7
1950	87,7	9,8	1,9	0,5	0,1	12,3
1951	89,7	10,0	0,1	0,2	0,04	10,3
1952	91,5	8,1	0,1	0,2	0,04	8,5
1953	84,9	14,5	0,2	0,5	0,03	15,1
1954	89,3	9,7	0,2	0,7	0,02	10,7
1955	79,4	19,7	0,2	0,6	0,1	20,6
1956	76,3	22,8	0,4	0,4	0,1	23,7
1957	77,1	22,1	0,3	0,4	0,1	22,9
1958	76,3	22,5	0,6	0,6	0,1	23,7
1959	74,1	23,8	0,3	1,6	0,2	25,9
1960	75,5	22,2	0,4	1,7	0,3	24,5
1961	75,3	22,4	0,4	1,5	0,3	24,7
1962	74,0	21,7	1,3	2,6	0,4	26,0
1963	68,8	24,5	2,9	3,2	0,5	31,2
1964	70,6	23,4	2,8	2,5	0,8	29,4
1965	68,3	23,2	3,3	3,7	1,5	31,7
1966	70,5	23,4	2,8	2,5	0,8	29,5
1967	68,3	23,2	3,3	3,7	1,5	31,7
1968	68,0	25,5	2,4	2,8	1,3	32,0
1969	67,2	25,4	3,0	3,0	1,4	32,8
1970	63,3	26,0	4,6	4,4	1,7	36,7
1971	51,9	37,4	4,4	4,8	1,5	48,1
1972	50,7	35,1	6,8	6,2	1,2	49,3
1973	53,8	30,7	7,7	6,7	1,1	46,2
1974	44,0	38,9	5,3	8,6	3,2	56,0
1975	44,6	35,7	5,7	11,3	2,7	55,4
1976	57,1	26,0	6,8	7,9	2,2	42,9
1977	53,0	25,9	7,7	10,5	2,9	47,0
1978	52,1	24,4	8,4	11,7	3,4	47,9
1979	42,4	23,5	11,0	19,1	4,0	57,6

Source: export data from Brazil, *Anuário Estatístico do Brasil*, various years. Classifications as described in the text.

Resource-based products were the main category of manufactured exports during the post-war years. From 1953 to 1963, the share of resource based products in manufactured exports was more than 90 percent. The high share of low technology manufactures in 1945 (47 percent) owed to the textile products, which had increased their participation in foreign markets after the collapse of traditional suppliers during the war. However, that increase was short-lived and textile exports dropped sharply in the years that followed. By 1953 textile exports were nearly inexistent. If exports are taken as a proxy of technological capabilities, such data clearly suggest that Brazil's industrial sector was dominantly labor intensive, low skill and technologically simple. This seems to be a reasonable generalization of post-war industrialization in Brazil that conforms with other quantitative and qualitative assessments. Nevertheless, other trends also emerged during this time, the most important being that more sophisticated products began to increase their share in manufactured exports (Teitel and Thoumi, 1986; Dahlman and Frischtak, 1993).

The emergence of new branches and products can be initially identified in the low technology category and, more importantly, in medium technology category. Exports of low technology products indicate the presence of standardized technologies, which usually required relatively low skills and capital, but that at the same time could develop important incremental improvements in products and processes. That exports in this category fell so sharply after 1945 suggests serious problems of efficiency, which apparently only began to be overcome in the early 1960s. A more consistent performance was that of medium technology exports, whose export shares steadily increased from the end of the 1950s. High technology products, in turn, had the lowest share of total manufactured exports..

These results clearly shows the limited technological capabilities of Brazil's industrial structure; at the same time, the results are also relevant when placed in the context of the highly discriminatory policy against exports prevailing in post-war Brazil. The bias against exports was expressed by tariffs and quotas on inputs which raised the cost (and reduced the value added) of export industries compared to import-substituting industries. Overvalued exchange rates meant that export industries earned less in domestic currency than they could in a hypothetical free-trade situation. There is evidence that discrimination against export industries in Brazil achieved some of the highest levels observed among developing countries in the 1950s and 1960s. In 1966, for example, eight out of 21 manufactured products in Brazil would have had negative value added if they had been exported: textiles, and leather production, for example (Bergsman and Malan, 1971, p. 120; Balassa, 1971; 1979). Export biases like these were a major cause of the slow response by manufactured exports to the otherwise fast industrialization in Brazil. As argued by Teitel and Thoumi, "such was apparently not the case for the major Asian SICs, which from the outset relied more for their industrial growth on attaining substantial exports of labor-intensive products than on the growth of domestic demand" (1986, p. 458). On the other hand, that manufactured exports expanded and diversified in such an adverse context seems to be further evidence of technological learning in Brazilian industry after 1945.

Lower levels of data aggregation add further evidence on the diversification of manufacturing exports in post-war Brazil. Table 5 shows the relative shares of individual classes of products in total exports according to technological categories. The years selected (1945, 1960, 1973) can be used to identify overall trends in exports and technological capabilities during the post-war period. In the case of resource-based manufactures, simply worked wood was among the major exports in the three years selected, although its relative share fell over the same period. In its place, new products such as sugar and iron ore became the chief manufactures sold abroad in the resource-based category. Also, exports of refined petroleum products seem to indicate the development of more sophisticated manufacturing capabilities in the wake of the import-substituting policies implemented during the 1950s.

Table 5. Groups of exported products by technology categories, Brazil, 1945, 1960 and 1973

Year	*Groups of exported products*[a]	*Share (percent)*[b]
	Resource based manufactures	
1945	Wood, simply worked, and railway sleepers of wood (248)	21.4
	Animal and vegetable oils and fats, processed and waxes (431)	15.7
	Meat and edible offal, prepared/preserved, fish extracts (014)	10.9
	Pearls, precious and semi-precious stones, unworked/worked (667)	9.0
	Other fixed vegetable oils, fluid or solid, crude (424)	7.6
	Total	*64.5*
1960	Sugar and honey (061)	20.5
	Iron ores and concentrates (281)	18.9
	Wood, simply worked, and railway sleepers of wood (248)	16.6
	Vegetable textile fibers and waste of such fibers (265)	8.3
	Animal and vegetable oils and fats, processed and waxes (431)	6.8
	Total	*71.1*
1973	Iron ores and concentrates (281)	33.8
	Sugar and honey (061)	26.3
	Wood, simply worked, and railway sleepers of wood (248)	7.8
	Other fixed vegetable oils, fluid or solid, crude (424)	5.7
	Meat and edible offal, prepared/preserved, fish extracts (014)	3.7
	Petroleum products, refined (334)	3.7
	Total	*81.0*
	Low technology manufactures	
1945	Cotton fabrics, woven (652)	72.3
	Leather (611)	8.1
	Textile yarn (651)	7.6
	Clothing accessories of textile fabrics (847)	3.9
	Textile fabrics, woven, other than cotton/man-made fibers (654)	3.0
	Total	*95.0*
	Cotton fabrics, woven (652)	41.2
	Textile yarn (651)	17.6

Year	*Groups of exported products*[a]	*Share (percent)*[b]
1960	Leather (611)	15.7
	Structures and parts of structures, iron, steel and aluminium (691)	10.4
	Iron and steel bars, rods, angles, shapes and sections (673)	8.8
	Total	*93.7*
1973	Footwear (851)	20.2
	n.c. (various)[c]	17.4
	Leather (611)	9.9
	Made-up articles, wholly/chiefly of textile materials (658)	4.7
	Universals, plates and sheets, of iron or steel (674)	3.9
	Total	*56.0*
	Medium technology manufactures	
1945	Alcohols, phenols, phenol-alcohols and their derivatives (512)	53.1
	n.c. (various)[d]	16.6
	Fabrics, woven, of man-made fibers (653)	13.2
	Pig iron, spiegeleisen, sponge iron, iron or steel (671)	9.2
	Tubes, pipes and fitting, of iron and steel (678)	7.7
	Total	*100.0*
1960	Alcohols, phenols, phenol-alcohols and their derivatives (512)	56.1
	n.c. (various)[e]	10.1
	Pig iron, spiegeleisen, sponge iron, iron or steel (671)	9.5
	Textile and leather machinery and parts (784)	5.2
	Food processing machines and parts (727)	4.1
	Total	*84.9*
1973	n.c. (various)[f]	30.2
	Pig iron, spiegeleisen, sponge iron, iron or steel (671)	11.6
	Alcohols, phenols, phenol-alcohols and their derivatives (512)	8.4
	Fabrics, woven, of man-made fibers (653)	7.3
	Parts and accessories of vehicles (784)	5.0
	Total	*62.5*
	High technology manufactures	
1945	Medicinal and pharmaceutical products (541)	100.0
	Total	*100.0*
1960	Medicinal and pharmaceutical products (541)	89.0
	Aircraft and associated equipment and parts (792)	11.0
	Total	*100.0*
1973	Office machines (751)	25.0
	Automatic data processing machines and units thereof (752)	24.6
	Thermionic, cold and photo-cathode valves, tubes, parts (776)	13.8
	Medicinal and pharmaceutical products (541)	12.1
	Rotating electric plant and parts (716)	6.0
	Total	*81.5*

Notes:

(a) Numbers between parentheses correspond to the three-digit SITC classification, Rev.2.

(b) Share of the five most important products in the technological category.

(c) Other synthetic and artificial textiles; Other tapestry, pile, lacework, etc. textiles; Other clothing and accessories; Other footwear, leggings, gaiters and the like; Other cast iron and steel; Other hand and machine tools, cutlery; Other manufactures of metal; Other diverse manufactures.

(d) Machines, apparatus, tools and utensils.
(e) Other machines and vehicles, parts.
(f) Other organic chemicals; Other soap, cleansing, polishing products, lubricants, artificial waxes, etc.; Other diverse chemical products; rubber and plastic manufactures for domestic use; Other boilers, machinery, mechanical apparatus and appliances; Other electrical machinery, apparatus and appliances; Other motor and not-motorized vehicles; Other optical, photograph, medical, meters, counters, measuring and checking appliances.
Sources: same as Table 4.

Two important facts about the low technology manufactured exports can be inferred from Table 5. First, it is possible to see that the puzzle of fast-declining exports in this category between 1945 and 1953 (see Table 4) was mainly related to the textile industry. Textiles achieved 86.8 percent of low technology exports and 40.7 percent of all manufactured exports in 1945 but dropped to virtually no sales abroad in 1953. The reason for such a negative performance was associated to deep technological and organizational deficiencies of Brazilian textile firms at the time. Brazilian textile companies had taken advantage of the collapse of international markets and substantially increased their exports during World War II. When foreign buyers returned to their traditional sources after the war, the Brazilian textile industry was unable to compete in price and quality with international producers such as Japan, for example. Exports of textile yarn and cotton fabrics only started to recover moderately in the second-half of the 1950s, partially at least as a result of sweeping changes in work organization and investments in automatic machinery prompted by the crisis in the immediate post-war years (Stein, 1957, ch. 11; Colistete, 2001, pp. 132-4).

Second, there was a clear diversification of low technology exported manufactures from the end of the 1950s. In 1945 and 1960, five classes of products made up more than 90 percent of all low technology exports, but by 1973 the share of low technology exports had dropped to 56 percent. Another indicator of diversification is the group of non-classified (n.c.) manufactures, with 17.4 percent of the category's exports (Table 5). The type of products comprised in this group gives an idea of the rapid diversification of low technology manufactures: synthetic and artificial textiles, cast iron and steel, hand and machine tools, manufactures of metal and diverse manufactures. New manufactures such as footwear and steel and iron products appeared in external markets around the end of the 1950s.

Exports of medium technology products showed a similar trend towards diversification and more complex products. Alcohols, phenols, phenol-alcohols and their derivatives were the major exported manufactures during the 1940s and 1950s, but at the same time other products witnessed substantial growth in their relative shares. Along with pig iron, man-made fabrics and other manufactures from iron and steel, new products such as machinery and parts began to play a relatively important role in exports. This result can be seen initially through the high relative shares of non-classified products (n.c.) in the three years selected, since the n.c. group consisted largely of machines, tools and parts (see Table 5).

It is also possible to identify the performance of individual machinery, tools and parts exports. Brazil's export data already recorded exports of textile, leather, food processing and printing machinery and their parts, as well as mechanical handling equipment (lifts and elevators), during the 1950s. Among the exported products in the early 1960s were steam boilers, internal combustion piston engines, non-electric engines and motors, agricultural machinery, paper and pulp machinery, machine-tools, equipment for distributing electricity, passenger motor cars, motor vehicles for transport of goods and materials, and parts and accessories of motor vehicles in general. In all these cases, production processes were sophisticated and required high levels of engineering and designing capabilities, a skilled labor force and an ability to assimilate, adapt and improve existing technologies.

Finally, exports of high technology manufactures also witnessed diversification despite their low shares in total exports throughout the post-war years. Medicinal and pharmaceutical products were the only high technology goods exported from 1945 onwards. It seems to reflect earlier technological capabilities developed in the production of alkaloids, medicaments, vaccines and the like in Brazil. Apart from such products, only exports of small aircraft were recorded during the 1950s. However, new high technology products came to the fore in the mid-1960s. The most important were office and automatic data processing machines, thermionic, cold and photo-cathode valves, tubes and parts, and rotating electric plants and parts (Table 5). In addition to these products, there were also exports of telecommunications equipment and parts, electrical power machinery and electrical machinery and apparatus.

The technological content of exports therefore reveal a mixed scenario. Brazil's industrial sector was predominantly labor intensive, low skill and technologically simple; but diversification of the exports structure towards more sophisticated products, although slow and limited, indicates a process of gradual technological learning and increasing productivity that took place during the post-war years.

4. Technological learning in individual firms and industries

Evidence about industries and firms suggest that there were significant cases of companies that developed technological capabilities and achieved high levels of productivity during the classic period of import substitution in Brazil. As we will see, although such firms are sometimes seen as basically represented by foreign companies, there was substantial domestic learning by local producers. Qualitative and quantitative evidence also indicate, however, that there was a wide range of productivity and technological standards within individual industries in Brazil. This variation in productivity and capabilities in general has been found in both modern and traditional, high and low-skills industries. Yet rather than a peculiar feature of the Brazilian manufacturing industry, uneven and unbalanced productivity growth may well represent a common pattern of industrial growth in general, although specific institutional and social conditions of Brazilian economic history may have accentuated such features.[19] In this session, we summarize evidence on technological learning, productivity and uneven development among firms and industrial sectors in order to formulate tentative hypotheses about how market and institutional conditions played a role in shaping Brazilian industrialization in the post-war period.

A case of technological learning in Brazil during the post-war years took place in the motor vehicle parts industry. This industry witnessed a boom from the late 1940s, stimulated, first, by successive external crises and import restrictions; second, by growing demand for replacement parts; and, third, by incentives, subsidies and trade protection provided by a government engaged in setting up a motor vehicle industry since the early 1950s. The estimated number of firms jumped from 30 in 1946 to 1,300 in 1960 (Gattás, 1981; Addis, 1993; Colistete, 2001; Shapiro, 1994; Lessa, 1982). A strategy favored by local companies was to establish partnerships with foreign companies to import, assimilate and adapt technologies.[20] Metal Leve, for example, was set up in 1950 and started to produce pistons and piston pins with the technical assistance of the German firm Mahle. Cofap, established in 1951, made agreements in the

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[19] Sharp differences in sectoral productivity led Harberger (1998) to describe industrial growth as a "mushroom-like" instead of an even, "yeast-like" process. On the other hand, William Baumol (1967) depicted economic growth as a unbalanced process, combining "stagnant" and "progressive" sectors in terms of productivity growth. See also Baumol, Blackman and Wolff (1985).

[20] Other major ways of absorbing foreign technology by Brazilian firms were reverse engineering, licensing and technical assistance: see Erber, Guimarães and Araújo Jr. (1974); Braga and Matesco (1989); Biato and Guimarães (1973); Leff (1968).

following years with American (Perfect Circle, Monroe, Thompson) and German (Boge and Mahle) companies to produce piston rings, cylinder parts and dampers. These and other domestic firms adopted a strategy of forging links with foreign companies to enter the marketplace, and then developed their own expertise in engineering, designing, product quality, and distribution. Metal Leve and Cofap sought to recruit a qualified labor force, established links with research centers and provided above-average conditions and welfare. Both companies engaged in active learning that allowed them to raise productivity, produce high-quality products and to be competitive on both domestic and foreign markets in the following decades.[21]

Another example of developing technological capabilities was in the machine-tools industry. This sector grew out of simple repair and maintenance shops that diversified into machinery production stimulated by import restrictions and increasing domestic demand for capital goods (Lago, Almeida and Lima, 1979; Leff, 1968). In 1961, there were approximately 114 establishments employing about 5,000 workers in Brazil, turning out a wide range of products such as lathes, shapers, presses, machines for sheets and drilling machines. Machine tools production grew at annual average rate of 21.1 percent between 1955 and 1961. Local producers engaged in a process of learning in an industry which was known for its highly demanding standards of skills, mechanical precision and product quality (ECLA, 1969; Leff, 1968, ch. 3-4).

An illustration of innovative firms producing machine tools is Romi, a former agricultural machinery producer in the 1930s which turned to the production of lathes during the 1940s in the city of Santa Bárbara d'Oeste, state of São Paulo.[22] The company grew rapidly during World War II and later, jumping from 120 employees in 1938 to nearly 1,000 in 1944, 1,726 in 1957 and 4,163 in 1980. Production of lathes increased at a relatively steady pace, as shown in Table 6, column 1.[23]

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[21] "Cofap"; Doretto (2006); *História da Indústria de Auto-peças*. A similar strategy was pursued by firms in other branches, such as steel: Dahlman (1984); Dahlman and Fonseca (1987).

[22] Romi and Metal Leve were picked up as noticeable examples of innovative firms in Latin America by a wide-ranging inquiry in the 1980s, as reported by Katz (1984), pp. 130-2.

[23] Romi Archives. Santa Bárbara d'Oeste, São Paulo. I thank Pollyana Carvalho for collecting the data.

Table 6. Production of lathes by Romi, 1941-1979

Year	Total output (units) (1)	Domestic output (units) (2)	Exports (units) (3)	Exports share (3)/(1) (4)
1941	46	46	0	0,0
1942	193	193	0	0,0
1943	770	770	0	0,0
1944	899	891	8	0,9
1945	1.098	994	104	9,5
1946	1.660	1.145	245	14,8
1947	1.110	610	500	45,0
1948	731	440	291	39,8
1949	798	630	168	21,1
1950	857	857	0	0,0
1951	1.379	1.379	0	0,0
1952	942	938	4	0,4
1953	880	876	4	0,5
1954	1.306	1.306	0	0,0
1955	1.492	1.492	0	0,0
1956	1.629	1.596	33	2,0
1957	1.449	1.446	3	0,2
1958	1.779	1.776	3	0,2
1959	1.237	1.233	4	0,3
1960	1.659	1.646	13	0,8
1961	1.756	1.719	37	2,1
1962	1.979	1.865	114	5,8
1963	1.679	1.367	312	18,6
1964	1.784	1.391	393	22,0
1965	1.535	1.112	423	27,6
1966	2.011	1.569	442	22,0
1967	1.875	1.453	422	22,5
1968	2.219	1.788	431	19,4
1969	1.905	1.357	548	28,8
1970	1.690	1.226	464	27,5
1971	2.009	1.469	540	26,9
1972	2.346	1.778	568	24,2
1973	2.814	2.227	587	20,9
1974	3.009	2.621	388	12,9
1975	4.317	3.599	718	16,6
1976	4.843	4.567	276	5,7
1977	4.872	4.555	317	6,5
1978	5.762	4.867	895	15,5
1979	6.740	4.569	2.171	32,2

Source: Romi Archives.

Romi started exports by the end of the World War II, achieving high export shares in total production of lathes in 1947 (45.0 percent) and 1948 (39.8 percent), likely as a result of the disruption of traditional suppliers in international markets by the global conflict. Indeed, lathe exports practically disappeared from Romi's records when international trade was restored in the following years. Only from the early 1960s the company resumed its sales in foreign markets, possibly helped by exchange rate incentives implemented from the end of the 1950s and by accumulated experience and learning in domestic markets. The average share of exports increased from 0.4 percent in the 1950s to 16.9 percent in the 1960s and 18.9 percent in the 1970s (Table 7, columns 3 and 4).

More detailed export data are available for 1962-1967, when Romi exported on average 19.7 percent of its lathe production, totaling 2.106 units (Table 7, columns 3 and 4). Importers were distributed among South and Central America (49.9 percent), North America (33.3 percent), Western Europe (12.4 percent), Africa (1.8 percent), Eastern Europe (1.7 percent), Middle East (1,0 percent), Oceania (0.6 percent) and Asia (0.3 percent). Seventy percent of all foreign sales in the period were concentrated in five countries: Chile (24.3 percent), Mexico (21.7 percent), the United States (8.6 percent), Netherlands (8.3) and Peru (7.1 percent).[24]

Available data of patenting suggest that Romi actively engaged in incremental innovation. Romi's first patent dates from 1942, and by 1967 there are records of 120 patents registered by the company in Brazil (68.3 percent), Argentina (8.3 percent), Germany (8.3 percent), Great Britain (5.8 percent), Italy (4.2 percent) and the United States (3.3 percent). These patents were for product improvements such as speed control devices, as well as new models of lathes.[25]

Given the successful cases of firms like Cofap, Metal Leve and Romi, how can we explain the faltering achievements (from the 1970s onwards) shown by the data on industrial productivity growth as well as the uneven and limited outcomes of the technological content of exports? Were there deep-rooted factors in Brazilian institutions and conditions that affected technological development in manufacturing as a whole, aside from the high trade protection highlighted by market critics of import-substituting industrialization? In the following we rely upon both empirical and theoretical studies to formulate hypotheses about the major causes of the unequal and apparently contradictory outcomes of Brazilian industrialization in the post-war

[24] Annual Reports, 1962-1967. Romi Archives.

[25] *Ibid*. These percentages likely include double counting, since one invention could be patented in more than one

years. Apart from high trade protection, it will be suggested that specific conditions of the labor markets and the social set-up in Brazil help explain salient features of post-war Brazilian industrialization that are hardly reconciled in the standard literature.

Machine tools and parts vehicle industries can be taken as representative of what happened to the manufacturing industry in Brazil. A highly heterogeneous structure in terms of productivity, quality and technological capabilities seems to have been developed in the post-war years. Romi was clearly a successful example of innovative company, but it was just part of a small group of firms in the emerging capital goods industry in Brazil. A study carried out by ECLA in 1961 found out that only eight out of ninety machine-tools firms surveyed in Brazil achieved international standards of productivity and technological development. True, the leading group employed 55.4 percent of the total employees and owned 63.6 percent of installed capacity in the sample. According to the ECLA study, this group held "complete, efficient and up-to-date production equipment, and at the same time the technical knowledge required for the proper use of the machines"; its manufacturing processes kept pace "with the constant technological advances of the sector". These firms reached "international standards comparable with those registered in the more highly industrialized countries". However, the remaining firms used antiquated equipment, lacked technical expertise and turned out low-quality products. Thus, along with the development of high standards, the Brazilian machine-tools industry was also noteworthy by the heterogeneous conditions of its firms in terms of productivity, quality and technological development (ECLA, 1969, pp. 73, 78-79).[26] Caren Addis has also shown that, despite the successful cases such as Cofap and Metal Leve, most of the national firms in the parts vehicle industry lagged far behind and concentrated in replacement markets and low-quality production (Addis, 1993).

Strong heterogeneity in productivity and quality production was also a feature of traditional industries in post-war Brazil. A detailed study of cotton textile producers in Latin America in the early 1950s by ECLA estimated that 91 percent of the spindles and 95 percent of the looms in Brazil were old. Yet mills from São Paulo state differentiated themselves from those

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country simultaneously.

[26] High heterogeneity in the capital goods sector was also reported by another survey: Erber, Guimarães and Araújo Jr. (1974), pp. 16-17.

in other states by their higher share of new equipment (about 15 percent) and productivity. Referring to a sample of modern firms in the spinning industry, the ECLA inquiry pointed out that "good productivity conditions" prevailed in São Paulo and that "[a]ll the mills manufactur[ed] a limited number of yarns and [were] outstanding for the high quality of their management". Quality control of intermediate and final products was common and "most of the mills [were] equipped with laboratories and well-trained technicians" (United Nations, 1951, p. 23). For their part, old mills suffered more acutely from equipment obsolescence, poor layout, lack of quality control, defective raw materials, untrained and superfluous labour force.

Interestingly, the ECLA inquiry also found that not only old firms, but also modern mills operated well below their productivity potential. There was room for significant increases in labour productivity by modern mills – 54 percent in spinning and 98 percent in weaving compared to 280 percent and 694 percent, respectively, in the old sector. In modern spinning mills, neither size nor degree of modernity was the main factor explaining productivity levels. According to the study, the key reason for substandard labour productivity was the use and quality of the labour force. Few machines assigned to tenders, excess of workers in all sections, small work loads, untrained labour force and high turnover were the deficiencies singled out as the major causes of relatively low productivity even in modern textile firms.[27]

The ECLA study interpreted poor quality and defective use of labour force, along with technological obsolescence in the old sector, as a result of the fact that firms' incentives to modernise were weak or absent. Two major reasons were highlighted. Firstly, the pressure to modernise was "extremely weak, principally owing to the relative unimportance of the average wage level in industry, as compared with the average price of textile goods". Compared to the price of a popular fabric in local markets (= 100), the estimated cost per person-hour of work in Brazil was 60, while in the United States it was 355. Secondly, "the lack of proportion in the measures adopted to protect industry ... [had] also limited any incentive ... to reduce costs and to improve the quality of the products". Low wage levels and high trade protection, therefore, undermined incentives to modernise and search for productivity and quality production (United Nations, 1951, pp. 10-1).

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[27] See also Clark (1987) for international comparisons (including Brazil) of productivity in the textile industry which

More than ten years later, another inquiry by ECLA highlighted wage levels and foreign competition as central causes of low productivity levels. The 1963 study found that there was little difference between the productivity conditions of Brazilian textile industries in the early 1950s and early 1960s – rather, possibly the situation had even deteriorated. Firms failed to replace obsolete machinery at a significant rate and, particularly, to improve the quality of raw materials, maintenance, and use of labour. Average productivity levels remained well below international standards. In cotton weaving, for example, Brazilian mills achieved only 10.3 percent of the US productivity levels in 1963 – Japan, for example, reached 38.9 percent. Again, in both cotton spinning and weaving industries, the role of machinery obsolescence and size was small, whereas conditions of the labour force were the most important factor in explaining productivity levels (ECLA, 1963, pp. 54; 65, table 87).[28] It seems, therefore, that the relatively high average productivity growth observed in the textile industry between 1945 and 1961 (4.9 percent; Table 2) was not sufficient to reduce the gap between local and international levels of productivity.

The situation in the textile industry described by ECLA seems to have been typical in other branches of manufacturing industry in post-war Brazil. Low average wage levels and weak foreign competition helped create an environment which was in general little conducive to raise productivity, quality production and technological levels. A relatively small group of firms that supplied more demanding consumers in local markets, as in the case of the leading group of machine tools producers, had the incentives and pressure to modernise, innovate and increase efficiency. Likewise, competition in domestic markets also created pressure on firms to raise productivity, as in the case of São Paulo cotton spinning firms. These were firms noticeable for their high manufacturing standards and high productivity. Nevertheless, incentives to modernise and achieve productivity gains were not strong enough to reach the firms across the board. There was little pressure from labour markets and foreign competition to scrap obsolete equipment, improve organisational structures and use the labour force and other resources more efficiently,

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emphasise the conditions of labour.

[28] In a regression analysis, the ECLA study found that obsolescence and size explained 14 percent of productivity levels in cotton spinning and 24 percent in cotton weaving (1963, pp. 78-79). It is worth noticing that, although also highlighting the conditions of the labour force as a key factor to explain low productivity in underdeveloped countries, Clark sharply differed from ECLA's view in his emphasis on workers' cultural attitudes. See Clark (1987); (2007).

so that even highly inefficient methods of production and firms were able to survive. The outcome was a highly heterogeneous industrial structure in terms of productivity, quality and technological capabilities.[29]

Besides the pressures from labour markets and foreign competition, the ability of firms to innovate was also affected by the social set-up of post-war Brazil, in particular by those factors that influenced conditions, incentives and attitudes of the labour force. Both theoretical and historical works have pointed out that educational levels of the population, industrial training systems, working conditions, and labour relations affect the quality of the labour force, engagement in the production process and innovation in the workplace.[30] ECLA's observations about small work loads, excess of workers, lack of industrial training and high turnover may have been a direct reflection of the way that Brazil's social set-up affected the labour force and the production process.

Overall social conditions were not favorable for achieving quality production, innovation and high productivity of the labour force. For example, statistics on the average years of education for Brazil in 1950 and 1973 show low standards: 2.1 years and 3.8 years, compared to 9.1 years and 10.7 years in Western Europe, 9.1 years and 12.1 years in Japan, and 3.4 years and 6.8 years in Korea, respectively (Maddison, 1995, p. 77, table 3-12). The number of workers who completed some type of apprenticeship or other program organized by the National Service of Industry (*Serviço Nacional da Indústria* or SENAI) between 1946 and 1960, for example, never exceeded two percent of the total industrial workforce in the state of São Paulo, by far the main industrial center in Brazil (Colistete, 2001, pp. 40-41).[31] As late as in 1980, 73 percent of the Brazilian labor force had no formal education or had not completed primary school (Dahlman and Frischtak, 1992, p. 439). Innovative firms like Romi and Metal Leve dealt with such deficiencies by establishing close links with SENAI and public research centers, as well as offering efficiency wages, above-average working conditions and social welfare, in order to recruit and maintain qualified and committed workers. But the dominant feature of industrial

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[29] Evidence on highly heterogeneous levels of productivity and technology in Brazilian manufacturing industry is found in Dahlman and Frischtak (1993); Tyler (1976), p. 868; Erber, Guimarães and Araújo Jr. (1974), pp. 16-7; Braga and Matesco (1989), pp. 8-11.

[30] See references in note 6.

[31] See other comparisons in Lall (1992) and Dahlman and Frischtak (1993).

companies in general was one of low wages, poor conditions and low qualification, providing few incentives for workers to cooperate and engage in the search for incremental innovation and productivity on the shop floor (Colistete, 2001).

Finally, labor relations in post-war Brazil were highly confrontational and antagonistic, both on the shop floor and in society at large. Employers held an anti-labor policy which rejected compromise with the leftist labor militancy which had taken over official trade unions and helped mobilize at grassroots levels since 1945, demanding real wage increases and social rights. International cold war politics just made more difficult a social compact that could help promoting both rapid economic growth and social reforms. Labor productivity grew more rapidly than wages so that the gap between industrial wages and profits widened in the post-war years. Thus a confrontational pattern of labor relations added to an environment which was already little conducive to raise overall manufacturing standards (Colistete, 2007).

5. Conclusions

Market critics of import-substituting industrialization in Latin America have long pointed to the accumulated distortions and inefficiencies resulting from exceptionally high protection and import substitution at any cost that prevailed in most countries of the region. An influential view has argued that new industrial countries such as Brazil paid a very high price for their short-term success in economic growth and industrial diversification. Interventionist state policies, in particular high trade protection, led to massive distortions that caused widespread economic inefficiency and a lack of technical progress. Import-substituting industrialization would then be a failure precisely in that country which until the 1970s had been the most successful late industrializer in Latin America. A different view was taken by scholars who stressed the heterogeneous outcomes of import-substituting industrialization, despite also emphasizing distortions and inefficiencies. A still sparse body of empirical work on individual industries and firms have gathered evidence about technological learning and productivity in Brazil, suggesting that the legacy of import-substituting industrialization was one of mixed and uneven results.

The data presented in this article have not confirmed the view of pervasive technological stagnation and low productivity. A number of firms engaged in assimilating, adapting and improving products and processes, and achieved high productivity during the classic period of import-substituting industrialization in Brazil. This result is still more relevant given the policy of indiscriminate trade barriers and import substitution at any cost that reduced the competitive pressure on firms to produce efficiently and, in addition, gave rise to a high bias against exports in manufacturing industries in the post-war period. It seems that expanding markets, quality demands, externalities and learning effects stemming from increasing local production acted as an incentive to setting up new and more technologically sophisticated industrial activities. In the early 1980s the collapse of the debt-led growth strategy which had been initiated from the mid-1960s checked the expansion of local companies. Data on the productivity catch-up with the United States and OECD indicate that Brazilian industrial firms were severely hit by the effects of the economic crisis, in the form of cuts in private and public spending, increasing unemployment, soaring prices and external imbalances.

At the same time, data on labor productivity, manufactured exports and specific firms and industries show that, even before the debt crisis, the drive for technical progress and efficiency was limited and highly heterogeneous in post-war Brazil. Heterogeneity of firm behavior, uneven productivity increase and unbalanced sectoral growth seem to be common features of industrial growth in general, but sectoral empirical studies have for some time indicated that productivity and technological capabilities were highly heterogeneous in Brazilian industrialization. There is still a need to further comparative research in order to test these findings, but ECLA's empirical studies in the 1950s and 1960s pointed out that a key reason for the wide range of productivity and technological levels among Brazilian firms was the conditions of labor markets and foreign competition. Firms that supplied to increasingly demanding consumers and that faced higher competition in domestic markets came under pressure to modernize, improve methods of production, and search for high productivity. Otherwise, incentives to modernize and search for productivity gains were weak or absent in most firms, given the low real wages and high trade protection that prevailed in Brazil. Such conditions ensured that even very inefficient firms could survive by using obsolete equipment, turning out low-quality production, achieving low productivity and paying low wages. Besides, firms' ability to raise productivity and quality production was hampered by a low-paid and low-skilled labor force, which overall lacked incentives to cooperate in the shop floor. This was the burden of a social set-up marked by a highly unequal income distribution, deficient supply of education and low living standards of the working classes.

From the evidence presented here, it seems that the negative effects of exceptionally high trade barriers stressed by market critics were important, but hardly the only factor that explained the performance of firms and industries. More likely, trade protection joined with labor markets and social conditions to shape the way industrialization took place in post-war Brazil. The resulting heterogeneous structure became an important feature of import-substituting industrialization, as only a group of leading firms gained a competitive edge in the manufacturing sector.

Plausible as perhaps this story is, we still need much more detailed, empirically sound historical studies on industrialization, in particular at the micro-level of firms and industries. This story nonetheless fits better with the available evidence than the stagnationist hypothesis of import-substituting industrialization in Brazil. Rather than suffer pervasive technological stagnation, several firms engaged in searching for new production structures and products. And rather than failure, there were successful cases and mixed results.

Appendix

Sources for labor productivity data (tables 2 and 3):

Labor productivity estimates were obtained by dividing the *valor da transformação industrial* (a measure similar to the industrial value added: see Brazil, 1990, p. 370) by the monthly average number of production workers. The *valor da transformação industrial* was deflated by a proxy of the producer prices, the *Índice de Preços ao Atacado – Disponibilidade Interna* (IPA-DI).

Data on wages/number of production workers, valor da transformação industrial and producer prices were obtained as follows:

1945-1948: wages and production workers extrapolated from the level of average manufacturing wages and number of workers in 1949 (*Censo Industrial*, 1950) by using the rates of growth of the industrial wages and workers compiled by the *Instituto de Aposentadoria e Pensões dos Industriários* (IAPI). *Valor da transformação industrial* was obtained by interpolating data provided by the industrial census: *Censo Industrial*, 1940 (base year:1939) and 1950 (base year: 1949) (Brazil, 1990).

1949 e 1959: Brazil, *Censo Industrial*, 1950 e 1960, manufacturing industry (Brazil, 1990).
1952-1958, 1962: Brazil, *Registro Industrial*, manufacturing industry (Brazil, *Anuários Estatísticos do Brasil*, 1955, 1956, 1957, 1958, 1959, 1960 and 1965).

1963-1969: Brazil, *Pesquisa Industrial*, manufacturing industry (Brazil, *Anuários Estatísticos do Brasil*, 1966, 1967, 1970 and 1971).

1970, 1972-1978: Brazil, *Pesquisa Industrial Anual*, manufacturing industry (Brazil, 1990).

1950, 1951, 1960, 1961, 1971: estimated by linear interpolation.

Índice de Preços ao Atacado – Disponibilidade Interna (IPA-DI), Fundação Getúlio Vargas: yearly averages, 1945-1979 (Brazil, 1990, table 5.12).

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