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Artigos

The regional impact of neo-liberal policies in Brazil

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RESUMO

Este artigo analisa a dimensão regional do tradicional dilema "eqüidade vs. eficiência" no caso brasileiro. A principal questão discutida é se numa economia aberta e dominada pelo mercado há uma maior ou menor concentração regional da renda, e se há um efeito natural de "trickle down" quando as forças do mercado aumentam a concentração regional do crescimento. Na primeira parte do artigo estas perguntas são examinadas de um ponto de vista histórico, e a segunda parte concentra-se no impacto regional das políticas de mercado aberto na década de 90.

Palavras-chave: eqüidade regional, eficiência, renda regional, Nordeste.

ABSTRACT

This article focuses on the regional dimension of the traditional dilemma of "equity vs. efficiency" as exemplified by the case of Brazil. The main question addressed is whether a more market-oriented and open economy leads to an increased or decreased concentration of income, and whether there is a natural regional "trickle down" effect when unfettered market forces increase regional concentration of economic growth. In the first part of the article these questions are examined from an historical perspective, while the second part concentrates on the regional impact of the open market policies of 1990s.

Key words: regional equity, efficiency, regional income, Northeast.

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One of the most important dimensions of change in the context of Brazilian development has been in the external environment. When regional development policies were proposed in the 1960s, the Brazilian economy had a larger number of policy instruments that could be applied to redress problems of spatial inequity. However, by the 1990s, the external environment had changed dramatically; as a member of MERCOSUL and signatory to the WTO, the degree of freedom for policy manipulation were significantly reduced. Accordingly, there has been a change in the type of policies that have been enacted with a greater focus of what Hirschman would refer to as indirect (or infrastructure) investment. With a greater commitment to market forces, as manifested in the neo-liberal policies of the 1990s, the Federal Government is left with fewer options to manipulate the growth and development of the less developed regions of the country.

As neo-liberal market-oriented policies have spread around the developing world and protection has dramatically declined, there has been concern about the impact of these policies on the distribution of income. It seemed that considerations of efficiency outweighed concerns about equity. This was justified on the grounds that greater efficiency would lead to rapid growth which would ultimately benefit the population in the lower income groups. There is a growing literature dealing with various aspects of this question.[1]

In this article we focus on the regional dimension of the traditional dilemma of "equity vs. efficiency" as exemplified by the case of Brazil. The basic question is: does a more market-oriented and open Brazilian economy lead to an increased or decreased regional concentration of income, i.e., what are the relative strengths of centripetal and centrifugal forces? And, is there a natural regional "trickle down" effect when unfettered market forces result increased regional concentration of economic growth? We shall first briefly examine the Brazilian experience in historical perspective and see how the regional distribution of income was determined when the country's economy was relatively open in the years prior to the 1930s, and how regional distribution fared during the period of Import Substitution Industrialization (ISI). We shall then concentrate on the regional impact of the open policies of the 1990s.

1 See, for instance, Baer and Maloney (1997), Altimir (1994), Berry (1997).

1 A brief historical overview

1.1 Regional growth distribution during the primary export cycles

Prior to Import Substitution Industrialization (ISI), when Brazil's economy was relatively open, the dynamic center of the economy was located in those regions which gave the country a comparative advantage in the production of a small number of primary products (minerals or food).

Until the 20th century, Brazil's economic history was characterized by a series of export cycles, each benefiting a specific region. The sugar export cycle of the 16th and early 17th centuries favored the Northeast, while the gold export cycle of the late 17th and 18th centuries shifted the economy's dynamism to the state of Minas Gerais and the regions supplying it in Southeast Brazil. When these cycles came to an end, the respective regions' economies stagnated. The coffee export boom of the 19th century at first favored the interior of Rio de Janeiro and later the state of Sao Paulo. By the 20th century, however, the historic shifting of favored economic regions came to an end. The coffee export economy had lasted much longer than the other cycles and had resulted in huge infrastructure investments and also investments in ancillary activities in the Sao Paulo region. Thus, when the industrialization process began, it was natural that it became located in this part of the country. The problem often was that other regions of the country, which contained a large part of the population and which had not benefited from the long coffee export cycle, would only have a minor share of growth based on industrialization.[2]

1.2 The regional impact of ISI

When Brazil closed its economy to promote ISI, most of the benefits accrued to the Southeast of the country, while the Northeast of the country became increasingly marginalized. While the Southeast accounted for about 42% of the population, its share of the national income hovered around 64% from the 1950s to the 1970s, and its share of the industrial product was close to 80% in the 1960s and 1970s; the Northeast's share of the population has hovered close to 30% in the 1960s and 1970s, while its share of the national income was

2 For more details see Baer (1995), chs. 2 and 12.

about 12% and of industrial product around 7%. Over the period 1960-75, the Northeast's per capita income fluctuated between 38 and 42% of the national per capita income average.[3]

The increased regional concentration of economic activity resulting from ISI is easy to explain. As ISI is already a short-term inefficient process – i.e. high cost industries are promoted behind a protective barrier – it stands to reason that investors in new industries would choose to locate themselves in the most dynamic and cheapest region. Since at the time that ISI was promoted, the Southeast (especially the state of Sao Paulo) had the best available infrastructure in the country, the largest supply of skilled labor, and the largest market, it was not surprising that domestic, multinational and state firms chose this region for their investment location.

Once the industrialization process took off in the Southeast, its dynamism was strong enough to counter any movement of capital or skilled labor to the stagnant region (Northeast) where it was scarce. In fact, the Southeast attracted capital, skilled labor, and the more dynamic part of the unskilled labor force from the Northeast. It also became clear that the backward regions (especially the Northeast) were in fact subsidizing the Southeast's industrialization process. Since these regions continued to export primary goods (e.g. sugar), but were forced to buy many of their consumer durable and capital goods from the Southeast instead of from abroad, their terms of trade declined. That is, these regions had to give up more of their resources to buy industrial goods from the more highly priced Southeast instead of cheaper goods from abroad.[4]

2 Attempts at redressing regional imbalances within the closed economy

Regional equity has not always been a major concern of Brazil's policymakers. It was usually an explicit objective in times of regional calamities (like the periodic droughts in the Northeast) or when it was politically imperative to counterbalance programs that blatantly favored the more advanced regions of the country (the most obvious example being ISI).

After World War II, the formulation of "explicit" regional policies became more frequent, especially from the 1950s on. The objective of these policies was to redistribute income and investment resources from the richer to the poorer regions. Regional equity, however, was

3 For more detailed tables, see Baer (1995, p. 276-77).

4 This is demonstrated in Baer (1995, p. 286-91).

usually just one of a number of objectives of the government. Other goals, such as rapid growth of certain industrial sectors, the control of inflation, or the attempt to combat a balance of payments deficit, were not necessarily in consonance with regional equity. Programs for the attainment of each goal have usually been formulated with little attention to their effects on other goals. This has often led to contradictory policies, especially with regard to regional equity.

The best-known regional policies were developed in the 1960s, after the creation of the SUDENE (Superintendency for the Development of the Northeast).[5] This agency was supposed to direct and coordinate all activities of the Federal Government in the region. Its basic aim was to promote industrial investments in the region through tax incentives, changing the agrariam structure and increasing agricultural productivity and shifting the agricultural frontier, so as to integrate land with higher rainfall. Little was accomplished in modernizing the Northeast agrarian economy in the 1960s and 1970s. The agrarian structure did not undergo significant changes and the promotion of industry through tax incentives resulted in investments located in mainly in two cities, Salvador and Recife, and their activities generated little employment and few linkages within the region. It will be noted in Table 1 that in the 1960s the Northeastern GDP's growth rate was substantially below that of the country even though the share of industry in the Northeastern GDP (Table 2) expanded, although it remained substantially below the national average.

During the 1970s, the Northeast's growth rate was about the same as that of the country as a whole, although the growth of the share of industry from the Northeast in the GDP was smaller than at the national level. The higher growth rate in this decade was the result of the calamitous drought of 1970, which spurred the government on to make renewed efforts towards a more active regional policy. Special resources were used to modernize agriculture and develop the São Francisco River area through irrigation projects. In the second half of the decade, emphasis was placed on "development poles", such as the petrochemical pole in the state of Bahia, a fertilizer pole, a metal and electrical machinery complex, and the strengthening of more traditional industries.[6] As a result of the higher growth rates in the 1970s, the region's share in the country's GDP rose from 12.3% in 1970 to 13.1% in 1980, while the Northeast's per capita income rose from 40.9% of the national average in 1970 to 44.8% in 1980. Also of note is the fact that the Northeast's share in the country's industrial product rose from 7% in 1970 to 12.1% in 1985.[7]

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5 For greater details, see Baer (1995, p. 292-4).

6 Baer (1995, p. 294-5).

7 In a recent empirical study, Azzoni (1997, p. 372) noted a negative association between the rate of regional convergence and the overall GDP growth rate. And thus "*... it is not possible to reject the hypothesis that periods of rapid growth are associated with slower rates of (regional) convergence.*"

It is clear from Table 4 that the central government acted as a re-distributor of resources between regions. Throughout the period 1970 – 1992 the Northeast's share of government expenditure was greater than its share of government revenue. The difference ranged between 1.3 and 5.4 percentage points.

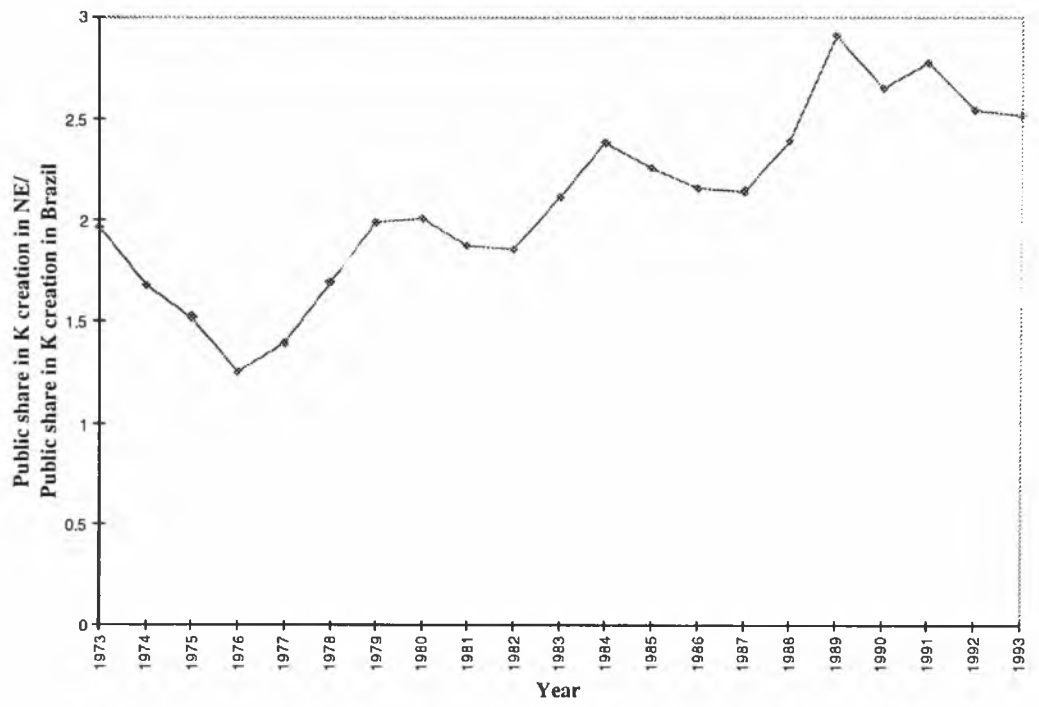
A more complete analysis of interregional flows was made by Rolim *et alii* (1996), using data on the trade balance, government accounts, investment by the public sector and savings. Table 5 presents their results for 1985, which confirm the regional transfer mechanism noted above. Although their analysis covers only one year, they give us a rough idea on how interregional flows took place. It will be noted that the Northeast's interregional trade deficit was partially compensated by its international trade surplus, indicating a transfer of foreign exchange earnings to other regions (mainly the Center-South) of the country. The continual overall interregional trade deficits of the Northeast had to be financed by public and/or private savings, so that the conditions for the macroeconomic balance were met.[8]

The conjecture, taking 1985 as a typical year, is that the transfers of federal resources to the Northeast had to be greater than the trade gaps in order to compensate for the interregional flows of private capital to other regions. Even though the data show a net outflow of private capital from the Center-South, aggregated figures for 1985 show a tendency of net private capital gains to the states of São Paulo and Rio de Janeiro, as well as to the Center-West. The flow of public capital to the Northeast has often been offset by the flight of private capital. Rolim *et alii* (1996) thus argue that this represents an inefficient allocation of government funds from a regional point of view. One might argue, however, that government transfers to the Northeast during the 1970s and 1980s were necessary to build an infrastructure which could in the future strengthen the spread effects from the Center-South. In other words, government transfers to the less developed region creates an infrastructure which will in the future attract private investments from other regions. This hypothesis could be tested by examining the types of investments made in each region. The relation between the share of public investments in the target region to the share of public investments in the country as a whole should show an increasing trend in the 1970s, with an inflection point after the necessary time for infrastructure investments to have matured. From the estimates of the Northeast, however, an increasing share of public investment in the region, compared to the national average, is apparent from 1973 to

8 This condition establishes that income inflows should equal outflows, in equilibrium. Thus, if a region presents a trade deficit with the rest of the country and the rest of the world, in equilitrium, it has to be compensated by net inflows of resources from government expenditures and/or private investments (see Rolim *et alii*, 1996).

1989 (see Figure 1). Even though there seems to be a declining tendency towards the national average in the first years of the 1990s, empirical evidence to support the conjecture on the existence of a change of rhythm is very weak.

Figure 1
Northeast: Ratio of the Public Share in Regional Investment to the Public Share in National Investment for Capital Creation: 1973-1993



Source: SUDENE, Agregados Econômicos Regionais, 1996 and FIBGE, Anuário Estatístico, several years.

3. Regional impact of the 1980s crisis

The various crises of the 1980s (the debt crisis of the early part of the decade and the impact of the runaway inflation and the various failed stabilization plans in the second half the decade) had a much milder effect on the Northeast than on the country as a whole. It will be noted that although the yearly national and regional growth rates fell substantially, they declined less in the Northeast than for the country as a whole (Table 1). The Northeast's growth rate was more than double that of the country. Subdividing this decade, it was noted that in the debt-crisis years 1981-83, while Brazil's GDP was declining at a rate of 2.2% a year, the Northeast's GDP was growing at 2.6% a year. This was mainly the result of government expenditures in the region as a result of a severe drought. When the economy recovered in the mid-1980s and the country's GDP was growing at 7% a year in the years 1984-86, the Northeast's GDP was growing at 10.1% a year.[9]

9 Cavalcanti de Albuquerque and Maia Gomes (1996, p. 156).

After the collapse of the various stabilization plans and the return of economic stagnation, the Northeast once again fell behind the rest of the country. While in the period 1987-93 the national GDP was growing at an annual rate of 0.5%, the Northeast's GDP declined at a yearly rate of 0.5%.[10]

The best explanation of this phenomenon was developed by Maia Gomes (1987) and Cavalcanti de Albuquerque and Maia Gomes (1996). In the former article Maia Gomes concentrated on the importance of the service sector in the Northeast. He noted that in this sector the Northeast's growth was notably greater than that of the country· 8.4% per year in the years 1980-86 versus 3.1% per year for the country as a whole. Furthermore, while in the crisis years 1980-83 employment in the country's formal sector declined, it increased in public administration, and this was most pronounced in the Northeast. This is clearly shown in Table 2, which explains why overall employment growth in that region was positive during the period. Also, in the Northeastern urban sector, only manufacturing and commerce declined in the period: -21% and -0.5% respectively. The negative growth of the former is explained by the fact that the Northeast's industry was established as a tightly integrated unit of the national industrial structure. Thus, a large proportion of Northeastern industrial products were sold outside the region, and the decline of the national market for industrial products therefore had a negative impact on both Northeastern industry and commerce.

The conclusion one reaches is that the Northeast performed better than the rest of the country due to compensatory investments by the government and state enterprises. Maia Gomes found that in 1980-83 public sector investments decreased by 0.7% for the country as a whole, whereas they increased by 21.4% in the Northeast; private investment declined by 29.4% in the country, but by only 9.2% in the Northeast. Thus, although overall investment in the country dropped by 27.8%, it increased by 4.7% in the Northeast. The share of the public sector in total investments in the Northeast was 45.3% in 1980, rising to 52.5% in 1983. The problem with these trends was that increased public employment and investments in the Northeast did little to increase the region's productive capacity and only increased its dependence on transfers from the rest of the country.[11]

The asymmetry of fiscal policies between regions which manifested itself in the early 1980s appeared again in the late 1980s, but this time to the disadvantage of the Northeast. In the late 1980s and early 1990s there was a notable decline of government investment in capital

10 Cavalcanti de Albuquerque and Maia Gomes (1996, p.156).

11 Maia Gomes (1987, p. 40-41).

formation in the Northeast: the yearly growth rate of such capital formation declined from 3.1% in the period 1980-90 to –9.9% in the period 1990-93.[12] Thus, the greater dependence of the Northeastern economy on government expenditures, compared to the rest of the country, has made the region quite vulnerable to downturns in government spending, either for investment or for assistential transfer purposes. Thus, one reaches the conclusion that in the 20th century the Northeast was never able to develop permanent endogenous sources of economic growth.

4 The Northeast in an increasingly open economy

At the beginning of the 1990s, Brazil began to liberalize its economy. The average import tariff declined from 41% in 1989 to 14.2% in 1994. There resulted a dramatic rise of imports from US$ 18.3 billion in 1989 to US$ 33.1 billion in 1994 and US$ 53.3 billion in 1996. At the same time, Brazil loosened its control of the activities of foreign capital in the country and through the privatization process initiated in 1990 allowed foreign investors to participate in sectors from which they had been excluded for a long time, especially public utilities. Direct foreign investment rose from US$ 510 million in 1990 to US$ 1.3 billion in 1992, US$ 2.4 billion in 1994, US$ 4.7 billion in 1995, US$ 9.6 billion in 1996; they were expected to reach over US$ 16 billion in 1997

Much of this direct investment represented investments by multinationals in such key industries as transport equipment. Many which were already located in Brazil expanded their facilities, while other firms set up production facilities in the country for the first time. Besides wanting to participate in a growing and stable Brazilian market, companies wanted to use of Brazil as an export platform for the regional common market, Mercosul, and for the rest of the world. Since the mid-1990s, as Brazil's privatization program began to accelerate and includeed the sale of public utilities, there has been a growing participation of foreign groups in the program. This was also represented in the large influx of foreign investment.

What is the likely impact of these events – the opening of the economy to trade and investments, and the privatization process – on the regional distribution of economic activities? Let us first consider their possible negative and positive impact.

12 SUDENE/DPO/ Contas Regionais.

Negative Regional Impact. Left to market forces, the allocation of resources will probably favor the Southeast and South of Brazil. This is due not only to the higher per capita income of these regions, but also due to the importance of the trade strategy of the country, emphasizing the growing Mercosul region and the adaptation of the country to the process of globalization. By 1996 Mercosul countries' share of Brazil's total exports had reached 15.3%, while the share of the Northeast in these exports was about 7%; and 68% of the Northeast's exports to Mercosul came from the state of Bahia.[13] As a large proportion of exports to Mercosul consisted of manufactured products, and the Northeast's exports consisted mainly of primary and semi-manufactured products based on local raw materials, its future share of this dynamic market looked weak.

Given these trends, there will be a natural tendency for multinationals to locate their investments in the Center-South and South, which are regions closer to the Mercosul markets and which have better infrastructure facilities and skilled labor. This, in turn, will place pressure on the government to increase infrastructure investments in these regions, which, given resource constraints, will make it difficult for less developed regions like the Northeast.

Simulation exercises based on the structure of the Brazilian economy in the mid-1980s reveal that the Northeast will be at a disadvantage in a more open economy. This is shown in Table 10. Assuming a 25% across-the-board tariff reduction, the Northeast will feel a negative impact in both employment and output, *ceteris paribus*. This is revealed in either a decline in the Northeast, with a gain in the Center-South and Brazil as a whole, in such sectors as steel, electrical equipment; or a larger decline in the Northeast than in the Center South (such as chemicals and pharmaceuticals), or a smaller growth in the Northeast than in the Center-South. These calculations assume no counter measures, such as tax incentives.

The 1988 Constitution had a two-fold regional impact. First, it included an automatic transfer of federal tax receipts to the poor regions of the country. That is, 3% of all federal receipts were to be handed over to the states of the Northeast, Center-West and North through their financial institutions in order to strengthen the productive sector. Secondly, the constitution obliged the central government to transfer 21.5% of its tax receipts to the states and 22.5% to municipalities.[14] The degree to which the latter two imply a regional redistribution depends on

13 Data from: SUDENE, *Boletim Conjuntural*, Agosto 1996; and Boletim do Banco Central do Brasil, *Relatorio_1996*.

14 Republica Federative do Brasil, 1988, *Constituição*, Artigo 159.

what basis funds are distributed between states. If it were done according to the proportion of the population in each region, the Northeast would gain much more than if it were distributed according to each region's share in the GDP.

Table 4, which shows the share of each region in the central government's receipts and expenditures, reveals that the budgetary system favors the Northeast, which consistently has had a larger share of government expenditures than receipts. It will be noted, however, that the share differences declined from 1970 to early 1991. By 1992, however, they were larger than ever before, which may possibly be due to the effects of the 1988 Constitution.

Events since the introduction of the Plano Real and the crisis of 1997, which in November of that year resulted in the elimination of many fiscal incentive programs, will diminish this regional redistributive mechanism.

Possible Positive Trends. A combination of circumstances – the opening-up of the economy, the interregional communications network which has been built up since the 1960s, and fiscal decentralization -could possibly result in an flow of investments to the Northeast. The opening of the economy has resulted in a massive inflow of consumer goods (especially textiles and footwear) from Asian countries with substantially lower costs (especially labor costs). There were pressures on the Brazilian government to control these imports (under the justification of alleged dumping practices and/or the "illegality" of paying slave wages in such countries as China).

A more interesting development was the move of a number of firms in the textile and footwear industries to the Northeast, attracted, in part, by the lower wages existing in the region and various types of fiscal incentives. This resembled the movement observed in the United States since the 1950s, when the textile and related industries moved from the Northeast and Midwest to Southern states, where wages were lower (because of the lack of labor unions) and states were willing to offer various types of attractive fiscal incentives.

5 Structural weaknesses of the Northeastern economy

A basic structural weakness of Brazil's Northeast (and other peripheral regions, like the North) is the fact that its internal regional linkages are much weaker than those of the Center-South. This will be noted in Table 11. In the Center-South, the high share of sales to intermediate production within the region suggest a high degree of intra-regional linkages, which might generate potentially high internal multipliers. The lower values for the Northeast suggest a less integrated regional structure. The share of total extra-regional sales (intermediate, capital

creation and household) reflects the degree of interregional dependency of each region, from the point of view of demand from other regions: as can be seen, the values show a much higher degree of dependence for the Northeast (12.4%) than for the Center-South (3.7%).

An interregional dependency pattern also appears in the use of inputs from intra-regional and extra-regional sources. As can be seen in Table 11, 88.6% of total intermediate input used by industries in the Center-South is provided by regional industries and only 3.6% comes from the rest of the country; while in the Northeast slightly less than 80% come of intermediate inputs used by Northeastern industries come from the region and 18.5% come from other regions. Finally, the Center-South purchases a relatively small share of its household consumption and total consumption from outside the region (3.3 and 3.1% respectively), while the Northeast purchases 21.9% and 16.7% respectively from outside the region.

The greater degree of self-sufficiency of the Center-South can also be perceived in Table 12, which shows the direct and indirect effects of a unit change in final demand in each region net of the initial injection, i.e., the output multiplier effect net of the initial change. The entries are shown in percentage terms, providing insights into the degree of dependence of each region on the other regions. The Center-South is by far the most self-sufficient region; the flow-on effects from a unit change in sectoral final demand are in excess of 93%. For the Northeast, there is a lower degree of intra-regional self-sufficiency, and the dominant interregional flows generated by the region usually end up in the Center-South.

The greater degree of self-sufficiency of the Center-South region means that under present structural conditions there will be little impact on the Northeast from increased amounts of economic activities in the Center-South which may result from a more open economy subject to market forces, with a continuously smaller amount of government programs to redress regional inequities. One thus comes to the conclusion that regional equity can only be achieved by going beyond market forces.

6 The market, the state and regional equity

The evidence presented in our analysis leads us to the conclusion that, *ceteris paribus*, the opening of Brazil's economy, the retreat of the state and the full play of market forces favors the more developed region of the country. In other words, the trickle-down effects generated by market forces are still very unlikely to overtake the polarization effects from the Center-South. If regional equity is part of the country's development agenda, an active regional policy by the central government is needed in order to reduce regional economic disparities.

An examination of other countries' experiences lends credence to our interpretation of Brazil's experience. In most advanced industrial countries the unfettered forces of the market have mostly resulted in regional imbalances and it was left to the state, in one form or another, to attempt to achieve some equity in the development of various regions. Let us look at a few examples.

The United States. After the Civil War, the U.S. economy experienced many decades of rapid industrialization. Most of the industrial growth was at first located in the Northeast, gradually spreading to the Midwest. The South, however, remained an economically stagnant area, relatively unaffected by the industrialization process. The thrust towards a more equitable distribution of economic activities came through governmental action. The well-known TVA (Tennessee Valley Authority) project was an attempt to stimulate both agricultural and industrial activities through a government-owned investment project – a series of dams designed to regulate the rivers of the region and thus stimulate agriculture, and the provision of cheap electricity to both rural areas and the cities of the region. After World War II, the South gained a large proportion of defense contracts, which was the result of the influence of Southern politicians, who had gained substantial power through perennial re-election. Similarly, the location of the space programs in Alabama and Houston (Texas) was also the result of political lobbying. Also, the combination of the construction of the inter-state highway system, which substantially reduced interregional transportation costs, together with the politically-influenced reduced level of union activities in the South, made the lower-wages of the region attractive to many industries. Finally, the Southern states increasingly used tax incentives to attract domestic and foreign investments. With fewer commitments than Northern and Midwestern states towards educational and other social expenditures, these states were in a more fiscally competitive situation to attract investments.[15]

The combination of these factors resulted in a rapid industrialization of the South. It is important to note that it was the actions of the state (both in terms of direct expenditures and fiscal incentives) which was responsible for decreasing the regional disparities in the U.S.

Germany. The reunification of Germany automatically resulted in a regional problem, the West part being one of the world's richest regions, and the Eastern states (Länder), which formerly

15 There exists a vast literature on the topic. See, for instance: Wright (1986,,p. 257 – 264).

made up the German Democratic Republic, being a second-rate industrial region. It was the state which had to step in to carry out a policy leading to greater regional equity. The government invested huge sums (mostly raised by a special tax in Western Germany) to rebuild the delapidated regional infrastructure. A major economic mistake was made, however, in rapidly allowing wages of the Eastern states to rise to the level of the West without a compensatory rise in Eastern labor productivity. The latter lagged dramatically behind the West. The net result has been a rapid improvement in infrastructure, but with labor costs being totally out of line with productivity, there has been relatively little private investment in the Eastern states, resulting in very high levels of unemployment. Once again, it was the state which had to step in to build up the necessary infrastructure to set the stage for more regional equity. However, it was also the state that established a wage policy, which was incompatible with greater private investment equity.[16]

Italy. Ever since the unification of Italy there has been a geographic duality in its economy, the North industrializing at a rapid pace, while the south has lagged behind. Although market forces resulted in a huge migration from the South to the North, this did very little to establish a greater equality between the two regions. As a result of political pressures, the Cassa Per Il Mezzogiorno was established by the government to try to help redress the imbalance. State companies were made to locate some of their operations in the South. The net results were disappointing, as the state enterprises located in the backward region were inefficient and had little forward or backward linkage impacts within the region.

7 Conclusion

In a 1995 study of the macroeconomic evolution of the Northeast of Brazil, Maia Gomes and Vergolino showed the fundamental importance of the state in maintaining some degree of regional equity between the Northeast and the Southeast. They found that employment in the public sector as a proportion of total formal employment in the late 1980s was about 36% in the Northeast, compared to a little over 21% in the country as a whole; and that the state and its enterprises accounted for about half of investments in the region, and that considering that a large proportion of *private* investment in the region was made with public resources which were lent at subsidized rates by public development banks, it becomes evident that a retreat of the state in the Northeast could have severe negative repercussions on the region's development.[17]

16 For more details, see: Heimsoeth (1996); Holthus (1996); Krüsselberg (1994).

17 Maia Gomes and Vergolino (1995, p. 62-64).

As we have seen, the regional policies of the Federal Government consisted of isolated subsidies and industrial incentives to growth centers. In the context of the fiscal adjustment process of the mid-1990s, the role of the central government directly stimulating productive activities and enhancing social overhead capital in lagging regions is being neglected. In the Real stabilization plan, introduced in mid-1994, there was no explicit concern about the formulation of a regional development policy. The plan was conceived as a stabilization plan, which included economic reforms (privatization, deregulation) and institutional reforms (tax system, social security and administrative), without proposing any strategy for medium and long-term development. However, with the benefits from stabilization and other reforms, a new cycle of private investments emerged. Most of these were concentrated in the South and Southeast, which provided a full range of non-traditional (e.g., technical skills and urban agglomeration) and traditional (e.g. friction of distance – MERCOSUL) locational factors to attract incoming capital. The lack of investment by the Federal Government which would complement the spurt of private investment led regional governments to engage in strong competition for private capital through fiscal mechanisms. In some cases, political pressures by the representatives of the backward regions produced elements of compensatory regional policies, as was the case of the special automotive regime promoted by the Federal Government for the less developed regions, which resulted in plans for transportation equipment investment in the Northeast. However, with the Asian crisis of the second half of 1997, there were doubts that these would be carried out.[18] In fact, the austerity program to deal with the Asian crisis, introduced in late 1997, cut the regional tax incentive program in half. This again revealed that regional equity is frequently sacrificed to resolve general macroeconomic problems.

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Table 1
Average Yearly Real Rate of Growth of GDP

	Northeast	Brazil
1950-60		
1960-70	3.5	6.1
1970-80	8.7	8.6
1980-1990	3.3	1.6
1990-1995	2.6	2.7

Source: SUDENE, *Boletim Conjuntural*. Agosto 1996, p. 384.

Table 2
Sectoral Shares in GDP: Brazil and Northeast
Brazil

	Agriculture	Industry	Services	Total
1960	19.2	32.6	48.2	100.0
1970	11.6	35.8	52.6	100.0
1980	10.2	41.0	48.8	100.0
1990	9.3	34.2	56.5	100.0
1995	12.3	32.0	55.7	100.0

Northeast

	Agriculture	Industry	Services	Total
1960	30.5	22.1	47.4	100.0
1970	21.0	27.4	51.6	100.0
1980	17.3	29.3	53.4	100.0
1990	13.3	28.5	58.2	100.0
1995	12.6	23.8	63.6	100.0

Source: same as Table 1, p. 386-7.

Table 3
a) Share of Northeast in GDP of Brazil and Per Capita Northeast GDP as Percent of National Average

	Share in GDP	Per Capita Northeast GDP as % of National Average
1960	13.2	41.8
1970	12.3	40.9
1980	13.1	44.8
1990	13.6	59.1
1995	13.4	55.2

a) Share of Northeast in Industrial Product

1949	9.4
1959	8.3
1970	7.0
1985	12.1
1994	7.9

Source: Same as Table 1, p. 374-75.

Table 4
a) Regional Shares of Central Government Receipts

	1970	1975	1980	1985	1991	1992
North	1.4	1.5	1.7	2.2	2.3	2.1
Northeast	10.0	8.2	7.2	8.3	9.9	9.3
Southeast	74.8	75.2	74.5	72.0	62.4	58.2
South	11.3	10.3	7.9	9.6	12.7	12.6
Center-West	2.5	4.8	8.7	7.9	12.7	17.8
Total	100.0	100.0	100.0	100.0	100.0	100.0

b) Regional Shares of Central Government Expenditures

	1970	1975	1980	1985	1991	1992
North	3.2	2.5	3.0	3.5	3.6	5.0
Northeast	13.4	10.9	10.3	10.4	11.2	14.7
Southeast	64.6	67.9	66.2	63.9	54.3	63.5
South	10.5	8.8	8.5	9.5	11.2	9.1
Center-West	8.3	9.9	12.0	12.7	19.7	7.7
Total	100.0	100.0	100.0	100.0	100.0	100.0

Source: same as Table 1, p. 397 and 400.

Table 5
Interregional Flows by Regions, 1985*
(in Cr$ 1,000,000,000)

	Northeast	Center-South
1. Interregional trade balance	-13,071	15,088
2. International trade balance	4,383	56,573
3. Government current account balance	13,651	-117,273
4. Government capital account balance	16,874	80,470
5. Allocation of government resources (3+4)	30,525	-36,803
6. Private Capital Flows (1+2+5)	21, 873	34,898

* Since we did not include the Northern region of Brazil, the data presented here do not show the entire balance of interregional flows.

Source: Rolim *et alii* (1996).

Table 6
Total Exports of Brazil and Northeast
(billions of US$)

	Brazil	Northeast	Northeast/Brazil
1980	20.1	2.3	11.4
1985	25.6	2.5	9.8
1990	31.4	3.0	9.5
1995	46.5	4.2	9.0
1996			

Source: same as Table 1, p. 221.

Table 7
a) Brazil: Commodity Composition of Exports

	Basic Products	Semi-Manufactures	Manufactures	Other	Total
1980	42.2	11.4	44,8	1.6	100.0
1985	33.2	10.9	55.1	0.8	100.0
1990	27.7	16.2	54.8	1.3	100.0
1995	23.7	19.6	55.5	1.2	100.0

b) Northeast: Commodity Composition of Exports

	Basic Products	Semi-Manufactures	Manufactures	Other	Total
1980	54.3	21.5	23.7	0.5	100.0
1985	32.8	20.6	46.0	0.6	100.0
1990	24.7	30.0	44.9	0.4	100.0
1995	21.0	35.4	42.9	0.7	100.0

Source: same as Table 1, p. 227-228.

Table 8
a) Brazilian and Northeastern Exports to Mercosul
(millions of US$)

	Brazil	NE	Brazil	NE	Brazil	NE	Brazil	NE
1980	1,091.5	43.7		3.0		6.4		53.1
1985	548.2	64.3		4.7		7.3		76.3
1990	639.0	73.5	379.0	11.3	295.0	11.7	1,313.0	96.5
1995	4,041.0	349.3	1,301.0	41.4	812.0	30.1	6154.0	420.8

Source: same as Table 1, p. 275; Banco Central do Brasil, *Boletim.*

b) Brazilian and Northeastern Imports from Mercosul
(millions of US$)

	Brazil	NE	Brazil	NE	Brazil	NE	Brazil	NE
1980	840.7	58.4		1.2		0.8		60.4
1985	493.2	31.1				1.8		32.9
1990	1,412.0	192.2	330.0	25.0	585.0	29.7	2,327.0	246.9
1995	5,588.0	447.1	515.0	3.5	737.0	27.5	6,840.0	478.1

Source: same as Table 1, p. 280; Banco Central do Brasil, *Boletim.*

Table 9
a) Destinations of Sales of Total Output (1985)
(Percent)
Northeast

Intermediate		Investments		Household		Exports	Government	
Regio-nal	Rest of Brazil	Regio-nal	Rest of Brazil	Regio-nal	Rest of Brazil	Ex-ports	Regio-nal	Federal
37.6	8.2	11.3	0.2	26.4	4.0	4.5	5.4	2.4

Center South

Intermediate		Investments		Household		Exports	Government	
Regio-nal	Rest of Brazil	Regio-nal	Rest of Brazil	Regio-nal	Rest of Brazil	Ex-ports	Regio-nal	Rest of Brazil
49.7	2.0	8.4	1.8	24.5	1.5	6.9	3.2	3.8

b) Source of Firm Purchases
(Percent)
Northeast

Intermediate Goods			Investments		
Regional	Rest of Brazil	Rest of the World	Regional	Rest of Brazil	Rest of the World
79.9	18.5	1.6	93.8	6.0	0.2

Center-South

Intermediate Goods			Investments		
Regional	Rest of Brazil	Rest of the World	Regional	Rest of Brazil	Rest of the World
88.6	3.6	7.8	94.8	1.6	3.6

Table 10
Impact of a 25% Across-the-Board Tariff Reduction (selected sectors)*

Selected Sectors		*Employment*			*Output*		
		NE	*CS*	*Brazil*	*NE*	*CS*	*Brazil*
Steel	SR	0.935	0.709	0.716	0.435	0.360	0.362
	LR	-0.801	0.157	0.125	-0.683	0.293	0.258
Machinery	SR	0.075	0.071	0.071	0.062	0.061	0.061
	LR	-0.600	0.153	0.131	-0.578	0.195	0.171
Electric Equipment	SR	-0.064	0.053	0.055	-0.065	0.045	0.047
	LR	-0.453	0.207	0.194	-0.477	0.243	0.226
Electronic Equipment	SR	-0.142	-0.012	0.014	-0.008	-0.008	0.010
	LR	-0.646	-0.009	0.038	-0.560	0.118	0.163
Transportation Equipment	SR	0.295	0.565	0.560	0.210	0.339	0.336
	LR	-0.240	0.262	0.253	-0.257	0.371	0.361
Wood Products and Furniture	SR	0.042	0.169	0.180	0.035	0.137	0.149
	LR	-0.513	0.284	0.178	-0.497	0.335	0.231
Paper Products and Printing	SR	0.091	0.282	0.282	0.042	0.157	0.157
	LR	-0.772	0.096	0.046	-0.632	0.264	0.211
Chemicals	SR	-0.640	-0.239	-0.284	-0.433	-0.183	-0.214
	LR	-1.207	-0.205	-0.314	-1.054	-0.084	-0.201
Petroleum Refining	SR	0.008	-0.011	-0.008	0.004	-0.006	-0.005
	LR	-1.087	-0.195	-0.318	-0.884	0.024	-0.117
Pharmaceuticals and Veterinary	SR	-0.858	-0.321	-0.342	-0.668	-0.274	-0.292
	LR	-1.571	-0.225	-0.272	-1.426	-0.150	-0.199
Textiles	SR	0.169	0.262	0.248	0.088	0.158	0.147
	LR	-1.052	0.135	0.005	-0.867	0.262	0.123
Clothing	SR	0.077	0.202	0.190	-0.761	0.337	0.123
	LR	-0.846	0.249	0.143	0.319	0.458	0.236
Footwear	SR	0.544	0.632	0.629	0.319	0.458	0.452
	LR	-0.609	0.343	0.305	-0.558	0.394	0.348

Note: NE = Northeast; CS = Center-South (includes South, Southeast, and Center-West, except the State of Mato Grosso); SR = short-run; LR = long-run.

* The results were generated in comparative-static simulations using an interregional CGE model for the Brazilian economy (see Haddad, 1997). The figures refer to the percentage change in employment and output, showing how these variables would be affected, in the short-run and long-run, by the tariff-cut alone.

Table 11
Sales, Cost, and Consumption Structure
(%)
Center-South

Sales	Regional	Rest of Brazil	Rest of World	Regional	Rest of Brazil	Rest of World
Intermed-iate Pds.	49.4	2.0		37.6	8.2	
Capital Creation	8.4	0.2		11.3	0.2	
House-hold	24.5	1.5		26.4	4.0	
Cost Structure: Purchases						
Intermediate	88.6	3.6	7.8	79.9	18.5	1.6
Capital Creation	94.8	1.6	3.6	93.8	6.0	0.2
House-hold Consumption	94.8	3.3	1.9	77.7	21.9	0.4
Total Consumption	91.6	3.1	5.3	82.4	16.7	0.9

Source: Haddad (1997).

Table 12
a) Regional Percentage Distribution of Output Multiplier Effects Net of the Initial Injection: Brazil, 1985

	Northeast	Center-South
Intra-regional Effects	65.7%	93.7%
Interregional Effects	34.3%	6.3%

Note: Calculations from the interregional input-output table developed by Haddad (1997).

Wage gender discrimination and segmentation in the Brazilian labor market

Ana Lúcia Kassouf[§]

RESUMO

Este estudo calcula os retornos à educação e experiência, a discriminação salarial por gênero e a segmentação de mercado, baseado nos coeficientes de equações de rendimentos obtidas de um modelo de correção de seletividade amostral. Uma análise detalhada usando um modelo lógite multinomial é desenvolvida, onde são atribuídos valores 0 à variável dependente, caso os indivíduos não estejam trabalhando, 1 se trabalham no mercado formal e 2 se trabalham no mercado informal. Baseado nos coeficientes estimados desse modelo, a variável lambda (inverso da razão de Mill) é calculada e usada na equação de rendimentos para obter estimativas consistentes. Observa-se que os retornos à educação e experiência diferem quando obtidos de coeficientes de equações de rendimentos com correção e sem correção de seletividade amostral. O retorno à educação dos homens no setor informal, por exemplo, mais do que dobra quando a variável lambda é excluída da equação. Observa-se grande discriminação salarial por gênero quando o rendimento médio estimado das mulheres é obtido por meio da substituição das suas características na equação (estrutura) dos homens. Enquanto o rendimento médio das mulheres é 25% abaixo do dos homens, o rendimento médio estimado das mulheres fica acima do rendimento médio dos homens. Constata-se também que 20% dos diferenciais de rendimento entre os setores formal e informal é atribuído à segmentação de mercado.

Palavras-chave: seletividade amostral, discriminação por gênero, segmentação de mercado

ABSTRACT

This study calculates the returns to education and experience, wage gender discrimination and market segmentation, based on the earnings equations coefficients, obtained by using a sample selectivity bias correction model. To this end, a detailed analysis using a multinomial logit model is developed, where the dependent variable takes value 0 if a person is not working, 1 if he or she is in the formal market place, or 2 if the individual is employed in the informal sector. Based on the coefficients estimated in the polychotomus choice model, a lambda variable (inverse of Mill's ratio) is calculated and used in the wage equation to obtain consistent estimates without sample selectivity bias. Large differences are observed when comparing the returns to education and experience obtained from the coefficients of the earnings equations when both correcting and not correcting for sample selectivity bias. The men's return to education in the informal sector, for example, more than double when excluding lambda. Large gender discrimination was found when the women's average estimated wages is obtained by substituting their characteristics in the men's structure. While the actual average women's earnings is approximately 25% below the men's wage, the estimated average women's earnings surpassed the average men's earnings. Finally, it was observed that 20% of the earnings differentials between formal and informal sectors is attributed to market segmentation.

Key words: selectivity bias, gender discrimination, market segmentation.

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1 Introduction

The number of workers in informal jobs is very high in Brazil. Data from PNAD (National Research Household Samples) show that, in 1993, 38.6% of the workers did not have signed work booklets. Moreover, while the number of formal workers decreased 13% from 1990 to 1993, a 10% increase in the number of informal workers was observed. The PME (Monthly Employment Survey) data, which collects information from six of the main state capitals of Brazil, show a 4.4% decrease in the number of workers with work booklets signed, from 1993 to 1995, and a 4.2% increase in the number of workers without work booklets signed, in the same period.

The increase in informal sectors of the labor force is considered by the IBGE (Brazilian Geographical and Statistical Institute) researchers as a reflection of the economic crisis that the country has been going through. Differences in percentages of formal workers among regions reflect the level of development. While in the Southeast of Brazil there is a high percentage of formal workers, in the Northeast the largest percentage is of informal workers.

Interesting differences are observed between formal and informal workers regarding education, experience, earnings and others, showing the necessity for research in this area. For example, formal workers have higher level of education and salaries compared to informal workers. Barros & Varandas (1987) concluded that informal workers have, in general, inferior work conditions to formal workers.

Returns on education and experience, wage gender discrimination and market segmentation will be analyzed in this study, based on the earnings equation coefficients. However, traditional analyses estimating earnings equations may incur in sample selectivity bias, since wages are observed only for those individuals employed in either formal or informal sectors. To solve this problem, a sample selectivity bias correction method, proposed by Lee (1983), is used.

For this purpose, a detailed analysis using a multinomial logit model is developed, where the dependent variable takes zero value if the person is not working, one if he or she is in the formal market place, or two if the individual is employed in the informal sector. Education, age, number of children, race, region and non-labor income are some of the factors assumed to affect the individual's job market participation. Based on the coefficients estimated in the polychotomus choice model, a lambda variable (inverse of Mill's ratio) is calculated and used in the wage equation to obtain consistent estimates without sample selectivity bias.

There are a number of studies differentiating formal and informal sectors in Brazil (Barros & Varandas, 1987· Sedlaceck, Barros & Varandas, 1990; Cacciamali, 1991, 1993), but a small

number of studies estimating the determinants of labor participation and earnings in these sectors of the economy and, moreover, correcting for sample selectivity bias.(Tiefenthaler, 1994a)

This study, then, intends to caiculate the returns on education and experience for men and women in the formal and informal sectors, based on the earnings equations coefficients, obtained by using a sample selectivity bias correction model. The results will then be compared to those obtained by a traditional method of estimation.

Wage gender discrimination and market segmentation will be analyzed free of sample selectivity bias. Based on the estimated coefficients from the earnings equations, a discrimination analysis is carried out for each sector of the economy, comparing women's actual earnings with their potential earnings. A similar analysis is undertaken to measure market segmentation, comparing earnings from workers with similar characteristics but in distinct market sectors. Barros, Mello and Pero (1993) observed the existence of market segmentation in Brazil, using the fact that equally productive workers were receiving different wages depending on whether they were in the formal or informal sector.

Understanding the determinants of labor participation and earnings as well as the divergence between men and women and the formal and informal sectors is essential to orient policy decisions to decrease discrimination and income inequalities in Brazil.

2 Methodology

2.1 Polychotomus - choice model with selectivity

The description of the Polychotomus-choice models with selectivity bias is based on Lee (1983) and Maddala (1990).

Consider the following polychotomus-choice model with three categories represented by subscript s and N individuals represented by subscript i:

$$w_{si} = x_{si}\beta_s + u_{si} \qquad (s = 0,1,2)$$

$$I_{si}^{*} = z_{si}\gamma_s + \eta_{si} \qquad (i = 1,2,\ldots,N)$$

where x_s and z_s are exogenous variables and $E(u_s \# \# \# x_0, x_1, x_2, z_0, z_1, z_2)=0$ and $E(\eta_s \# \# \# x_0 x_1, x_2, z_0, z_1, z_2)=0$. The 3 categories analyzed in this study are: not working, working in a formal job and working in an informal job. Each category is represented by an equation. The wage w_s is observed only if the sth category is chosen. In practice, I^* is not observed. What we observe is a polychotomus variable I taking values 0, 1 and 2. The sth category is chosen if $I=s$, which happens if and only if,

$$I_s^* > \text{Max } I_j^* \quad (j = 0,1,2, \quad j \neq s)$$

Let

$$\varepsilon_s = \text{Max } I_j^* - \eta_s \quad (j = 0,1,2, \quad j \neq s)$$

It follows that

$$I = s \quad \text{if} \quad \varepsilon_s < z_s \gamma_s$$

Suppose that $\#\#\#_j$ (j=0,1,2) have cumulative distribution function

$$F(\eta_i < c) = \exp[-\exp(-c)]$$

Then, it can be shown that

$$Prob(\varepsilon_s < z_s \gamma_s) = Prob(I = s) = \frac{exp(z_s \gamma_s)}{\sum_j exp(z_j \gamma_j)}$$

Thus, the distribution function of $\#\#\#_s$ is given by

$$F_s = Prob(\varepsilon_s < \varepsilon) = Prob\left[\left(\underset{j=0,1,2 \quad j \neq s}{Max} I_j^* - \eta_s\right) < \varepsilon\right] = \frac{exp(\varepsilon)}{exp(\varepsilon) + \sum_{j=0,1,2 \quad j \neq s} exp(z_j \gamma_j)}$$

Therefore, for each choice s we have the model

$$w_s = x_s \beta_s + u_s$$

where the dependent variable ws is observed if and only if the category s is being chosen, i.e., ###$_s$ < z$_s$###. Consider the following transformation to normality:

$$\varepsilon_s^* = J_s(\varepsilon_s) = \Phi^{-1}[F_s(\varepsilon)]$$

where ###(###) is the distribution function of the standard normal.

The condition ###$_s$ < z$_s$###$_s$ ### ### ###$_s$ < J$_s$(z$_s$###$_s$), and if u is normal distributed we have that,

$$E(w_s \mid w_s \text{ is observed}) = E(w_s \mid I = s) = E(w_s \mid \varepsilon_s < z_s\gamma_s) =$$

$$= E[w_s \mid \varepsilon_s^* < J_s(z_s\gamma_s)] = x_s\beta_s + E[u_s \mid \varepsilon_s^* < J_s(z_s\gamma_s)] = x_s\beta_s + \sigma_s\rho_s \frac{\phi[J_s(z_s\gamma_s)]}{\Phi[\Phi^{-1}[F_s(z_s\gamma_s)]]}$$

where ### is the density function of the standard normal, ###$_s^2$=Var(u$_s$), and ###$_s$ is the correlation coefficient between u$_s$ and ###$_s^*$

The following model can be estimated by the two-stage method. The equation

$$w_s = x_s \beta_s + \sigma_s\rho_s \frac{\phi[J_s(z_s\gamma_s)]}{F_s(z_s\gamma_s)} + v_s$$

can be estimated by ordinary least squares after substituting the estimated values of ###$_s$ from the multinomial logit model where I_s is regressed on z_s by maximum likelihood.

3 Data

The data set used to conduct this study is the 1989 National Health and Nutrition Survey, undertaken by the Brazilian Geographical and Statistical Institute (IBGE), the Institute of Social

Economic Planning (IPEA) and the National Institute of Food and Nutrition (INAN). Approximately 63,000 individuals were interviewed from 17,920 households. It is possible to obtain information from specific regions of Brazil (North, Northeast, Central, South and Southeast) and sectors (rural and urban). However, data from the rural part of the Northern region were not collected.

The data set provides information on monthly earnings (in US dollars) for individuals participating in the labor force a week before the interview, and any sort of payment in-kind received by the individual per month, which was already transformed into dollars. These variables were added to get the monthly earnings. Information on the number of hours worked per week is also available. This variable was multiplied by 4 to obtain the number of hours worked per month. The monthly earnings were divided by the number of hours worked per month to get the hourly earnings.

The sample used in this study is made up of 14,661 men and 15,417 women, aged 18 to 65, which includes those who do not participate in the labor market, as well as those participating in the formal or informal sector of the economy. There are a large number of definitions in the literature that try to characterize the informal sector. Some characterize it according to the nature and structure of the productive process, by the legality of economic activities, by labor contracts, etc.. The IBGE considers formal workers as those having their work booklets signed and informal workers as those not having their work booklets signed and self-employed workers. However, in this paper, formal workers are those who pay social security tax.[1] Recent literature has considered workers that do not pay social security taxes as belonging to an underground economy.(Cacciamali, 1991)

The mean, standard deviation and the description of the variables for 6,139 men in the formal, 6,924 men in the informal, 3,192 women in the formal and 3,284 women in the informal sector are presented in Table 3.1. There are 13% and 3% more male and female workers, respectively, in the informal than in the formal sector.

1 The reason for using social security tax as a way to differentiate the formal from the informal sectors is that the information available in the data set on signed work booklets presented an extremely large number of missing values, precluding the analysis. However, for the objectives of this paper, it is an adequate measure to differentiate the market sectors and interesting to be analyzed so that the results could be compared with other studies using different variables.

In each sector, the women's earnings are 20 to 30% lower than the men's earnings. Moreover, the earnings in the informal sector are about 50% of the earnings in the formal sector. One explanation for the lower earnings in the informal sector is that the formal sector requires a higher level of education and training. Note that the average number of years of education in the formal sector is almost twice that observed in the informal sector, for men and women. Moreover, the average age in the formal sector is a little higher than in the informal sector.

The set of data used in this study does not provide information on job training or experience. Therefore, a measure of experience was calculated as age minus years of schooling minus six. Table 3.1 shows that the average experience in the informal sector is greater than in the formal sector, which is a consequence of the method used to calculate experience. As has been discussed, workers in the formal sector have significantly more years of schooling than those in the informal sector, but the age is almost the same in the two sectors of the economy.

Another interesting point to observe is that in the Southeastern and Southern regions as well as in the urban sector there are more workers in the formal than in the informal sector, for both men and women. However, in the Northeast and Central of Brazil there are more informal than formal workers. Pastore (1981) observed that the wealthier the region, the larger the participation in the protected labor market.

Among races, differences are observable for white workers (including Asians) who, as opposed to blacks and mulattos, are more numerous in the formal sector.

4 Results

4.1 Participation in the formal and informal sectors of the economy

The coefficients for the multinomial logit model, estimated by maximum likelihood, are presented in Table 4.1, for men and women from 18 to 65. The dependent variable takes value 0 if the individual is not working, 1 if he or she is working in the formal sector and 2 if he or she is working in the informal sector. Workers in formal jobs, as opposed to those in informal jobs, pay taxes for social security purposes.

Table 3.1
Description of the Variables, Means and Standard Deviations, for Men and Women in the Formal and Informal Sectors

Variables	Description of the Variables	MEN				WOMEN			
		Formal Sector		Informal Sector		Formal Sector		Informal Sector	
		mean	s.d.	mean	s.d.	mean	s.d.	mean	s.d.
WAGE	hourly wage rate	1.89	3.45	0.82	1.90	1.36	2.11	0.67	1.42
LNWAGE	logarithm of the hourly wage rate	0.088	0.58	-0.73	0.42	-0.23	0.49	-0.99	0.37
HOURS	number of hours working per week	46.59	12.85	46.41	12.99	39.83	12.10	34.02	17.45
LAMBDA	inverse of Mill's ratio	0.63	0.36	0.83	0.40	1.02	0.47	1.31	0.22
NORTH	=1 if individual resides in the North of Brazil	0.03	0.16	0.03	0.18	0.03	0.18	0.03	0.17
NORTHEAST	=1 if individual resides in the Northeast of Brazil	0.16	0.34	0.42	0.30	0.19	0.38	0.34	0.33
CENTRAL	=1 if individual resides in the Central of Brazil	0.06	0.24	0.08	0.28	0.07	0.25	0.07	0.25
SEAST	=1 if individual resides in the Southeast Brazil	0.60	0.49	0.34	0.47	0.56	0.50	0.42	0.49
SOUTH	=1 if individual resides in the South of Brazil	0.18	0.38	0.16	0.37	0.18	0.38	0.17	0.38
URBAN	=1 if individual resides in the urban sector	0.90	0.31	0.53	0.50	0.94	0.23	0.73	0.45
WHITE	=1 if individual is white or Asian	0.64	0.48	0.43	0.50	0.66	0.48	0.48	0.50
MULATTO	=1 if individual is mulatto	0.30	0.46	0.51	0.50	0.29	0.45	0.44	0.50
BLACK	=1 if individual is black	0.06	0.19	0.06	0.22	0.05	0.19	0.08	0.22
HEAD	=1 if individual is the head of the household	0.77	0.41	0.69	0.46	0.23	0.42	0.18	0.38
WIFE	=1 if individual is a wife in the household					0.45	0.50	0.60	0.49
SON/DAUGT	=1 if individual is son or daughter in the household	0.19	0.37	0.27	0.44	0.25	0.42	0.15	0.37
EXPERIENCE	individual's experience in years	23.17	13.42	26.36	14.41	19.35	12.80	25.21	14.26
EXPERIENCE2	individual's experience squared	716.5	748.43	902.2	864.3	540.22	630.9	848.76	820.1
EDUCATION	individual's number of years in school	6.67	4.47	3.40	3.27	8.21	4.54	4.65	3.77
EDUCEXP	individual's education times experience	122.6	95.95	64.76	68.15	123.7	94.53	79.86	72.57
NONLINC	nonlabor income (rent, pension, alimony, etc.)	22.99	168.38	12.14	75.44	14.52	70.31	8.01	57.10
AGE	individual's age in years	35.82	11.64	35.32	13.03	33.62	10.66	35.83	12.44

The number of children (sons and daughters) with different age ranges, reflecting childcare costs (Tiefenthaler, 1994b) is included in this analysis, as affecting labor force participation. So, the variable representing the number of children from 0 to 2 years old is called CHILD2, from 3 to 5 years old CHILD3-5, from 6 to 12 CHILD6-12, the number of sons 13 years old or older CHILDM13, and the number of daughters 13 or older CHILDF13. Some of those variables can increase childcare costs (young children) and others decrease childcare costs (teenagers).

While the presence of very young children had practically no effect or a positive effect on men's participation in the labor market, it had a strong negative effect on women's participation. The presence of children in the household increases the father´s participation in the labor market, since it increases the need for household income. On the other hand, as the number of young children increases, the mother´s reservation wage increases, i.e., the amount of extra earnings required by an individual, who is not working, to give up one unit of leisure. So, the participation in the labor force of mothers decreases as the number of young children at home increases. Young children demand lots of care, increasing the value of the mother's time. It is interesting to observe that teenager daughters presented a positive effect on female job market participation. This fact can be explained by considering older daughters as mother substitutes, taking care of very young children, allowing the mothers to work outside the home even in the presence of young children. On the other hand, teenage sons had a negative effect on the mother's labor participation, acting as labor substitutes in the job market.

In the previous analysis, fertility is seen as an exogenous decision. However, it is possible to have an endogenous fertility decision and, then, care has to be taken to interpret the results. If, for example, some mothers enjoy having children and staying at home to take care of them more than others, then the negative correlation between number of children and labor force participation may be indicating that it is not the children that prevent mothers from participating in the job market, but that mothers who enjoy having children and staying home with them also tend to have more children.

Tiefenthaler (1994a) also found that in Brazil the participation of women with children under five is decreased in both sectors. However, she obtained a negative effect of teenager daughters on women's participation, indicating that they were not replacing their mothers as child minders, as we found, but were instead replacing mothers in earning income.

Table 4.1
Participation Equations for Men and Women in the Formal and Informal Sectors

	Men		Women	
Variables	**Formal**	**Informal**	**Formal**	**Informal**
CONSTANT	-1.80	1.18	-5.79	-1.864
	(-6.52)***	(4.25)***	(-22.56)***	(-8.27)***
CHILD2	-0.0866	0.00371	-0.815	-0.536
	(-1.00)	(0.04)	(-12.81)***	(-10.25)***
CHILD3-5	0.252	0.258	-0.192	-0.0449
	(2.72)***	(2.77)***	(-3.57)***	(-0.99)
CHILD6-12	0.122	0.163	-0.158	0.0827
	(2.64)***	(3.52)***	(-5.04)***	(3.28)***
CHILDM13	-0.0126	0.00359	-0.203	-0.0285
	(-0.29)	(0.08)	(-5.45)***	(-1.00)
CHILDF13	0.201	-0.00586	0.0529	0.0719
	(3.83)***	(-0.11)	(1.26)	(2.09)**
HEAD	0.940	0.837	0.847	0.561
	(6.58)***	(5.67)***	(6.10)***	(4.21)***
WIFE			-0.359	-0.252
			(-2.68)***	(-1.99)**
SON/DAUGT	-0.683	-0.203	0.176	-0.0408
	(-5.00)***	(-1.44)	(1.30)	(-0.30)
OTHERS	0.803	1.169	2.108	2.138
	(1.90)*	(2.79)***	(9.29)***	(9.84)***
WHITE	0.0735	-0.0942	-0.244	-0.569
	(0.59)	(-0.74)	(-2.36)**	(-6.40)***
MULATTO	-0.088	-0.0383	-0.189	-0.406
	(-0.69)	(-0.30)	(-1.76)*	(-4.49)***
NONLINC	-0.00181	-0.00123	-0.00233	-0.00233
	(-9.28)***	(-5.09)***	(-5.79)***	(-5.79)***
NORTH	0.384	0.479	0.424	0.0162
	(2.28)**	(2.92)***	(3.13)***	(0.13)
CENTRAL	0.668	0.415	0.249	-0.0563
	(5.17)***	(3.29)***	(2.45)***	(-0.63)
SEAST	1.001	0.0492	0.561	-0.0101
	(12.82)***	(0.64)	(8.40)***	(-0.18)
SOUTH	0.914	0.201	0.777	0.0561
	(8.78)***	(1.94)*	(9.28)***	(0.74)
URBAN	0.303	-1.09	0.981	0.317
	(3.66)***	(-14.34)***	(11.82)***	(5.58)***
EDUCATION	0.198	0.00335	0.406	0.137
	(11.28)***	(0.18)	(26.48)***	(9.14)***
EXPERIENCE	0.139	0.0762	0.256	0.106
	(9.99)***	(5.41)***	(20.19)***	(9.37)***
EXPERIENCE2	-0.00262	-0.00165	-0.00401	-0.00174
	(-13.80)***	(-8.61)***	(-21.46)***	(-10.79)***
EDUCEXP	-0.00464	-0.00344	-0.00955	-0.00477
	(-7.08)***	(-4.86)***	(-15.65)***	(-8.16)***
EXPERIENCEH			-0.00174	-0.000667
			(-1.18)	(-0.48)
EDUCATIONH			-0.0363	-0.0327
			(-5.53)***	(-4.70)***
Likelihood Ratio	5054.7 ***	5054.7 ***	4416.3 ***	4416.3 ***

The t-statistics are given in parentheses below the coefficients.

* denotes significance at the 10% level; ** denotes significance at the 5% level and; *** denotes significance at the 1% level.

Hill (1989), using a sample from Japan, concluded that young children reduce women's propensity to work as employees or family workers.

Tiefenthaler (1994b), studying Philippine women working in formal and informal piece-work sectors, observed that the number of children younger than 6 decreases the probability of participation in both formal and piece-work sectors and is insignificant in determining informal-sector participation. Moreover, she concluded that the presence of daughters older than 13 increased the probability of the mothers working in all of the three sectors, as they can reduce childcare costs or help their mothers with informal-sector work.

Variables representing the position of the individuals in the family (HEAD, WIFE, SON/DAUGT, OTHERS) showed that the head participates more in the job market than the son and also the female head works more outside the house than the wives, as we would expect. Women that are heads of families are usually divorced, widows or single and need to work to survive. On the other hand, wives may depend on their husbands as is very common in Brazilian society.

The coefficients of the race variables (WHITE, MULATTO, black is omitted) were negative, when significant. This reflects the fact that blacks participate more in the job market than whites or mulattos. The data show that while 10% of white male workers are not on the job market (49% work in formal jobs and 41% in informal jobs) and 12% of mulattos do not work (35% work in formal jobs and 53% in informal jobs) only 9% of blacks do not participate in the labor market (36% work in formal jobs and 55% in informal jobs).

The non-labor income variable (NONLINC) represents all sort of income that does not come from salaries. Income from rent, pensions, alimony, etc., was added up to obtain the value of the family non-labor income per month. According to the results, the higher the income from non-labor sources, the less likely the person is to be employed, in both formal and informal sectors.

The results also showed a positive relation between the North, Central, Southeastern and Southern regions of Brazil and job participation in the formal sector (the Northeast variable was omitted to avoid perfect collinearity). Job opportunities in the formal sector may increase as development and wealth in the regions increase. However, the results for participation in the informal sector were different. There was almost no statistical significance in the regions' coefficients. Table 3.1 shows that there are more informal workers in the Northeastern region than in any other region. The lack of formal jobs in poor regions induce individuals to participate in informal types of jobs.

Different results were also found between male workers in the formal and informal sectors living in the urban areas. While a significant positive coefficient was obtained in the formal sector, a negative one appeared in the informal sector. In the rural sector most the farmers do not pay social security tax.[2]

Tiefenthaler (1994b) considered the urban dummy variable as a proxy for transportation costs and obtained results similar to the present one.

The variable EDUCATION is the highest degree of education in years. It has the expected positive coefficient, indicating that more years of schooling increases the possibility of being employed. Only the result for men in informal jobs is not significant.

Tiefenthaler (1994) found that education has stronger effects on increasing the participation of women in the formal sector than in the informal sector. In fact, her results show that additional education decreases the probability of women's participation in the informal sector, which contradicts our findings.

The stock of on-the-job training human capital (EXPERIENCE) is hardly measured in survey questionnaires. Due to this fact, job experience is commonly estimated as the individual's age minus years of schooling minus 6. In doing this we are assuming that all workers begin elementary school at six and that no time is spent outside the labor force or school.(Berndt, 1991) Work experience and together with schooling are forms through which human capital can be accumulated. However, human capital can also depreciate, following a parabolic curve. The results indicate that as a person gets more experience, more job opportunities appear until a point is reached after which participation in the labor force starts decreasing, reflecting the fact that as the people age, their ability is reduced. This is shown in Table 4.1 by the positive coefficient for EXPERIENCE and the negative coefficient for EXPERIENCE2, respectively.[3]

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2 In the rural sector the concept of informal jobs does not apply very well. Based on this, the whole analysis was repeated considering only urban workers, but the results were practically the same.

3 Heckman (1980) analyzed a possible endogeneity of labor market experience in the participation decision. According to the author, experience records previous work history and is highly correlated with unmeasured determinants of the current labor force.

It is good to point out that developed regions, urban sector, education and experience variables also have also a positive effect on the earnings equations (Table 4.2). Therefore, there is not only an isolated direct effect on participation but also an indirect effect through earnings. So, a positive coefficient for education, for example, in the participation equation, may be capturing two effects: the direct one shows that higher education increases job participation and the indirect effect shows that higher education increases earnings and hence job participation.

An interaction term EDUCEXP represents years of education times years of experience. The negative sign shows that the effect of education (experience) decreases as the amount of experience (education) increases, i.e., the importance of a person's level of education (experience) to get a job is not so significant if he or she has a very large experience (education) in a specific area.

Variables representing the education of the head of the household (EDUCATIONH) and his or her work experience (EXPERIECEH) are included in the women's equations. The idea is that the wage of the head affects the women's participation in the labor force. However, the wage rate is an endogenous variable, and a better way to account for the head's influence over women's participation in the labor force is to use the head's experience and education as exogenous variables. The result shows that the higher the head's education, the lower the women's participation in work. A highly educated man has great chance to have a good job and a high salary, sparing the woman from working.

4.2 Earnings functions in the formal and informal sectors of the economy

4.2.1 Sample selectivity correction

Table 4.2 shows the earnings equations estimated by least squares, weighted by the sample expansion factors, for men and women in the formal and informal sectors. The dependent variable is the logarithm of the hourly earnings. Table 4.3 also shows the earnings equation, though it differs from Table 4.2 in the fact that in Table 4.2 there is a correction for sample selectivity bias (includes lambda) and in Table 4.3 no correction for sample selectivity bias is made (excluding lambda).

Table 4.2
Earnings Functions for Men and Women in the Formal and Informal Sectors, Including Variable Lambda

Variables	Men		Women	
	Formal	Informal	Formal	Informal
CONSTANT	-3.32	-2.49	-4.33	-3.98
	(-18.17)***	(-31.56)***	(-22.76)***	(-25.96)***
LAMBDA	0.191	1.09	0.396	0.573
	(2.73)***	(8.94)***	(7.97)***	(6.59)***
NORTH	0.230	0.587	0.509	0.557
	(3.68)***	(10.27)***	(6.83)***	(6.48)***
CENTRAL	0.321	0.384	0.405	0.392
	(6.91)***	(10.37)***	(7.00)***	(6.39)***
SEAST	0.320	-0.0686	0.485	0.339
	(8.29)***	(-1.79)*	(11.95)***	(8.60)***
SOUTH	0.224	0.0640	0.422	0.263
	(5.34)***	(1.73)*	(8.54)***	(4.94)***
URBAN	0.360	-0.235	0.490	0.199
	(7.62)***	(-3.79)***	(8.14)***	(4.90)***
WHITE	0.352	0.142	0.312	0.190
	(8.45)***	(3.37)***	(5.47)***	(3.11)***
MULATTO	0.102	0.103	0.181	0.00348
	(2.34)**	(2.48)**	(2.98)***	(0.06)
EXPERIENCE	0.101	0.0506	0.0812	0.0866
	(17.84)***	(11.93)***	(11.50)***	(13.15)***
EXPERIENCE2	-0.00133	-0.000752	-0.00105	-0.00120
	(-15.92)***	(-12.51)***	(-9.73)***	(-12.58)***
EDUCATION	0.191	0.0629	0.219	0.145
	(25.72)***	(6.55)***	(23.45)***	(15.06)***
EDUCEXP	-0.00171	-0.000470	-0.00175	-0.00112
	(-6.96)***	(-1.77)*	(-5.02)***	(-2.90)***
R^2	0,44	0.29	0.48	0.34
F test	395.74***	233.31***	245.60***	139.27***
OBS	6139	6924	3192	3284

The t-statistics are given in parentheses below coefficients.

* denotes significance at the 10% level; ** denotes significance at the 5% level; *** denotes significance at the 1% level.

Table 4.3
Earnings Functions for Men and Women in the Formal and Informal Sectors Excluding Variable Lambda

	Men		Women	
Variables	**Formal**	**Informal**	**Formal**	**Informal**
CONSTANT	-3.32	-2.49	-4.33	-3.98
	(-18.17)***	(-31.56)***	(-22.76)***	(-25.96)***
LAMBDA	0.191	1.09	0.396	0.573
	(2.73)***	(8.94)***	(7.97)***	(6.59)***
NORTH	0.230	0.587	0.509	0.557
	(3.68)***	(10.27)***	(6.83)***	(6.48)***
CENTRAL	0.321	0.384	0.405	0.392
	(6.91)***	(10.37)***	(7.00)***	(6.39)***
SEAST	0.320	-0.0686	0.485	0.339
	(8.29)***	(-1.79)*	(11.95)***	(8.60)***
SOUTH	0.224	0.0640	0.422	0.263
	(5.34)***	(1.73)*	(8.54)***	(4.94)***
URBAN	0.360	-0.235	0.490	0.199
	(7.62)***	(-3.79)***	(8.14)***	(4.90)***
WHITE	0.352	0.142	0.312	0.190
	(8.45)***	(3.37)***	(5.47)***	(3.11)***
MULATTO	0.102	0.103	0.181	0.00348
	(2.34)**	(2.48)**	(2.98)***	(0.06)
EXPERIENCE	0.101	0.0506	0.0812	0.0866
	(17.84)***	(11.93)***	(11.50)***	(13.15)***
EXPERIENCE2	-0.00133	-0.000752	-0.00105	-0.00120
	(-15.92)***	(-12.51)***	(-9.73)***	(-12.58)***
EDUCATION	0.191	0.0629	0.219	0.145
	(25.72)***	(6.55)***	(23.45)***	(15.06)***
EDUCEXP	-0.00171	-0.000470	-0.00175	-0.00112
	(-6.96)***	(-1.77)*	(-5.02)***	(-2.90)***
R^2	0,44	0.29	0.48	0.34
F test	395.74***	233.31***	245.60***	139.27***
OBS	6139	6924	3192	3284

The t-statistics are given in parentheses below coefficients.

* denotes significance at the 10% level; ** denotes significance at the 5% level; *** denotes significance at the 1% level.

The correction variable LAMBDA, included as exogenous variable to avoid selectivity bias, presented a highly significant coefficient, indicating that its inclusion was necessary in the model. Its positive sign indicates that unmeasured factors which increase the probability of participation increase earnings.

Observe that the coefficients of variables EXPERIENCE, EXPERIENCE2, EDUCATION and EDUCEXP,[4] shown in Table 4.3, are all smaller in absolute value than those presented in

4 Only these variables are analyzed in detail because they will be used to obtain the returns on education and experience. However, the behavior of the others is very similar.

Table 4.2 for men and women in the formal sector. Therefore, the use of traditional methods (excluding lambda) of estimating the logarithm of hourly earnings, using only a sample of working individuals, gives, in absolute value, a downward bias estimate of the true effect. In the informal sector, the results are not so clear. There is an upward bias estimate of the true effect, in absolute value, for men, if the traditional method is used, and a downward bias estimate of the true effect, for women, except for education which, as opposed to the other coefficients, increased in the traditional method.

4.2.2 Discussion of the results

The following analysis will be based on the earnings equations corrected for sample selectivity bias.

Men and women receive lower earnings in the Northeastern region (omitted variable) than in the North, Central Southeast and South of Brazil. The same phenomenon happens for workers in the urban areas, who receive higher earnings than those in the rural areas. For men in the informal sector, however, the relatively more developed Southeastern region as well as the rural areas pay lower salaries to the workers than in the Northeastern region and urban areas, as we can see by the negative coefficient in the second column of Table 4.2. A considerable number of the workers in the Northeast and rural areas of Brazil are classified as informal workers because they work in agriculture or as craftsmen, where it is not mandatory to pay social security taxes. So, the earnings of those individuals in poor regions or in the rural areas are better than informal workers in developed regions or in the urban areas. This characterizes job conditions as precarious and chosen only as a way to survive in the absence of anything better. The results for women in the informal sector (fourth column of Table 4.2), on the other hand, follow those of the formal sector, indicating that women in the informal sector in developed regions and urban areas might not have such precarious work conditions as men do. The reason is that some women have jobs that are related to crafts or hobbies.

Savedoff (1990), based on household survey data (PNAD) from 1976 to 1986. analyzed the influence of local and national factors on wages. He concluded that regions in Brazil account for a significant part of the wage difference. However, he points out that the wages have also strong national components and it would be wrong to treat wage determination as either a purely national or an isolated regional process.

The results from the race variables show that blacks (variable omitted) receive lower salaries than whites and mulattos, reflecting discrimination against blacks.

Observe that the EXPERIENCE coefficient is positive and EXPERIENCE2 is negative as suggested by the human capital theory, which states that earnings follow a parabolic curve, peaking somewhere in mid-life, due to a depreciation of the workers' human capital in the form of taking more time to perform tasks, for example, as they age.

Education is highly significant. The higher the number of years of schooling, the higher the salaries for men and women in the formal and informal sectors. Observe that the coefficient values and the tests are higher in the formal than informal sector. As also observed by Barros, Mello and Pero (1993), the degree of informality tends to be larger among less-educated workers.

4.3 Returns on the job training and education

4.3.1 Returns and the correction for sample selectivity bias

Consider the following equation

$$ln\, w = \alpha + \beta_1 exp + \beta_2 exp^2 + \beta_3 educ + \beta_4 exp \times educ + \varepsilon$$

where w is hourly earnings, *exp* is experience and *educ* is education.

As suggested by the human capital theory, the earnings function is considered concave in experience, i.e., it is expected a positive coefficient for ###$_1$ and negative for ###$_2$. Besides this, it is assumed that earnings are linear in education and that the effects of experience on earnings do not depend only on experience but also on education. To capture this effect, an interaction term is added (see Berndt, 1991 and Willis, 1986).

To obtain the effect of experience on log earnings, we compute the partial derivative,

$$\frac{\partial \ln w}{\partial\ exp} = \beta_1 + 2\beta_2 exp + \beta_4 educ$$

and for the effect of education on log earnings,

$$\frac{\partial \ln w}{\partial\ educ} = \beta_3 + \beta_4 exp$$

As an example, consider the earnings equation for men in the formal sector given in column 1 of Table 4.2. The effect of experience on log earnings is,

$$\frac{\partial \ \ln w}{\partial \ exp} = 0.1013 - 2 \times 0.00133 \times exp - 0.00171 \times educ \qquad (4.1)$$

which is, considering 8 years of education, 7.70% at 4 years of experience, 6.63% at 8 years of experience and 5.57% at 12 years.

Table 4.4 shows the percentage of returns on experience for men and women in the formal and informal sectors of the economy, based on the results of Tables 4.2 and 4.3, i.e., correcting and not correcting for selectivity bias, respectively.

Table 4.4
The Effect of Experience on Log-earnings, in Percentage, Correcting for Selectivity Bias (including lambda) and not Correcting for Selectivity Bias (excluding lambda)

	Including lambda					Excluding lambda			
	Formal Sector		Informal Sector			Formal Sector		Informal Sector	
Exper.	Men	Women	Men	Women		Men	Women	Men	Women
					Educ=4				
4	8.38	6.57	4.27	7.25		7.63	5.06	5.03	6.87
8	7.32	5.73	3.67	6.28		6.68	4.49	4.41	6.01
12	6.25	4.89	3.07	5.32		5.73	3.92	3.79	5.15
					Educ=8				
4	7.70	5.87	4.08	6.80		7.03	4.69	4.97	6.50
8	6.63	5.03	3.48	5.83		6.08	4.12	4.35	5.64
12	5.57	4.19	2.88	4.87		5.13	3.55	3.73	4.78
					Educ=12				
4	7.02	5.17	3.89	6.35		6.43	4.32	4.91	6.13
8	5.95	4.33	3.29	5.38		5.48	3.75	4.29	5.27
12	4.89	3.49	2.69	4.42		4.54	3.18	3.67	4.41

The effect of schooling on log-earnings, also based on Tables 4.2 and 4.3, is presented in Table 4.5.

Table 4.5
The Effect of Education on Log-earnings, in Percentage, Correcting for Selectivity Bias (including lambda) and not Correcting for Selectivity Bias (excluding lambda)

	Including lambda				Excluding lambda			
	Formal Sector		Informal Sector		Formal Sector		Informal Sector	
Experience	Men	Women	Men	Women	Men	Women	Men	Women
4	18.37	21.17	6.10	14.02	17.13	17.10	12.33	15.31
8	17.69	20.47	5.91	13.57	16.53	16.72	12.27	14.94
12	17.01	19.77	5.73	13.12	15.94	16.36	12.21	14.57

It is interesting to observe the difference in returns on experience and education when correcting for selectivity bias and not correcting. The returns on education for men in the informal sector, for example, was 6.10, when including lambda and 12.33, when excluding lambda, showing, therefore, an increase of more than 100%. The returns on experience for men in the informal sector when excluding lambda increased 25% on average. However, in the formal sector, the results showed decreases in returns when excluding lambda.

Table 4.6 summarizes the results from Tables 4.4 and 4.5. It is observed in the formal sector an average decrease, ranging from 7% to 18%, in the returns on experience and education, when not correcting for selectivity bias compared to correcting. In the informal sector, on the other hand, an increase of 108% in men's returns on education, 10% increase in women's returns on education and 25% increase in men's returns on experience are observed. The only different result in the informal sector is for women's returns on experience, which decrease 3% when excluding lambda.

Table 4.6
The Average Difference in the Returns on Experience and Education when Correcting for Sample Selectivity Bias Compared to Non-correcting

	Formal Sector		Informal Sector	
	Men	Women	Men	Women
Difference in the returns on experience	8% (-)	18% (-)	25% (+)	3% (-)
Difference in the returns on education	7% (-)	18% (-)	108% (+)	10% (+)

4.3.2 Discussion of the results

The subsequent analyses will be made using as a base the model with selectivity correction, as it is intended to be econometrically more correct, as it avoids a possible sample selectivity bias that may appear when the earnings equations are estimated only for those who are employed.

Observe that the returns on experience in Table 4.4 are positive and decline with increases in years of training and schooling. The values range from 2.69% for men in the informal sector to 8.38% for men in the formal sector and from 3.49% for women in the formal sector to 7.25% for women in the informal sector. While the returns on experience for formal male workers are higher than for informal male workers, the opposite is observed for female workers, who have higher returns in the informal sector. Moreover, looking at the formal sector, the returns are higher for men than for women, but the opposite is observed in the informal sector, where the returns on experience are greater for women than for men.

The returns on education presented in Table 4.5 range from 5.73% for men in the informal sector to 18.37% for men in the formal sector and from 13.12% for women in the informal sector to 21.17% for women in the formal sector. These returns are positive and decline with increases in years of experience. Observe that the returns on education are much higher than the returns on experience. Moreover, the returns on education are three times bigger for men and one and a half time bigger for women in formal jobs than informal jobs. Also, women have greater returns on education than men in both formal and informal sectors.

Lam and Levison (1990), using Brazilian household data (PNAD) from 1985, observed that the returns on education increased with age. They reached the same conclusion analyzing data from the United States. Moreover, they observed that the returns were higher in Brazil than in the United States. They found returns on education around 15%, which is close to the values observed in this present study.

Barros and Ramos (1992), analyzing the household surveys (PNAD) from 1976 to 1989, also obtained returns on education of around 15%, when controlling for age and region, and even higher than 15% without control of variables. Psacharopoulos (1985) found a 14% return on education in Latin America, 11% in Asia, 8% in the Intermediate region (Cyprus, Greece, Iran, Portugal), and 9% in the Advanced region (Australia, Canada, France, Germany, Japan, Sweden, UK, USA).

Berndt (1991) presented results found by Psacharopoulos (1981) in the United States, who observed rates of returns on secondary education close to 12% from 1939 to 1976 and rates of returns on college education near 11% from 1939 to 1969, falling to a value close to 5% in 1976. Berndt also reported the returns on experience found by Mincer (1974), who used 1959 data on white, nonfarm, nonstudent, American males up to 65 years-old. Similar to our findings, the returns on experience decreased with an increase in educational attainment and in years of experience. The rates obtained ranged from 11% to 5%.

4.4 The earnings peak

To obtain the number of years of experience at which workers'earnings peak, equation (4.1) is set equal to zero, and solved for experience at different years of schooling. To find the workers' age where earnings peak, the number of years of schooling plus six is added to the number of years of experience. Thus, with 4, 8 and 12 years of education, men in formal jobs maximize earnings at 35.5, 32.9 and 30.4 years of experience, corresponding to ages 45.5, 46.9 and 48.4. These results are presented in Table 4.7 for men and women in the formal and informal sector. As years of education increase, the age at which earnings are maximized increases, but not much. The largest difference occurs for men in the informal sector, where age went from 42 to 48 years. Observe that this age for women in formal jobs almost did not vary with education.

Barros, Mello and Pero (1993) observed that wages reach a peak at 45-55 age group for men with formal contracts, which is very similar to our findings.

Table 4.7
Number of Years of Experience and Age at Which Earnings Peak

	Formal				Informal			
	Men		Women		Men		Women	
Education	Experience	Age	Experience	Age	Experience	Age	Experience	Age
4	35.5	45.5	35.2	45.2	32.4	42.4	34.1	44.1
8	32.9	46.9	31.9	45.9	31.1	45.1	32.2	46.2
12	30.4	48.4	28.6	46.6	29.9	47.9	30.3	48.3

Since the age at which earnings peak does not vary much with respect to different levels of education, it is possible to infer that those spending more time in school and, therefore, starting to work later, reach their earnings peak earlier than those who are less educated, which might be that the age-earnings profile is steeper for the more educated workers. Algebraically,

substituting the variable experience by age minus education (the constant 6 will not alter the results), in Table 4.2 column 1, and taking the derivative of log-earnings with respect to age, instead of experience, as was done in equation (4.1), yields:

$$\frac{\partial \ln w}{\partial age} = 0.101 - 2 \times 0.00133(age - educ) - 0.00171\, educ$$

$$= 0.101 - 0.00266\, age + 0.00266\, educ - 0.00171\, educ$$

$$= 0.101 - 0.00266\, age + 0.00095\, educ$$

Observe that the education coefficient in the above equation is positive, showing that the age-earnings profile is steeper for the more educated worker, as was stated.

4.5 Discrimination and market segmentation

To measure the male-female earnings differential, a hypothetical average hourly wage for women is obtained by using their own characteristics (means) and the men's structure (coefficients). After the adjustment, the increase in the women's wages is attributable to discrimination, and the wage differential remaining between men and women is due to differences in characteristics. This approach was used by Brown, Moon and Zoloth (1980) and Barros *et alii* (1995). The bases for these studies, however, go back to Blinder (1973) and Oaxaca (1973), who argued that the coefficients (intercept and slopes) of the earnings regressions estimated separately for men and women, based on a set of personal characteristics, contain information about discrimination.

Table 4.8 displays the specific mean of log earnings for men and women in the formal and informal sectors and the average wage for women that would result if they faced the same wage structure as men. In the formal sector, the actual men's and women's average earnings are 0.088 and -0.23 respectively, i.e., women receive 27% less than men[5] However, the women's log wage estimated by substituting the women's characteristics in the men's earnings equation is 0.32, which shows that women were supposed to receive 26% more than men, given their characteristics, and not suffering discrimination. In the informal sector, men's and women's average earnings are -0.73 and -0.99 respectively, i.e., women receive 23% less than men. In this case, the women's estimated wage is -0.22 or 67% more than the men's wage.

5 To obtain the 27 percentage 1-exp(-0.23-0.088) was calculated.

Based on this analysis, it is possible to conclude that gender discrimination occurs in large proportions in both formal and informal sectors of the economy, being higher in the informal sector compared to the formal sector.

Barros, Machado and Mendonça (1997) observed that one third of the male-female wage differential for workers with the same age and education is attributable to occupational attainment. They showed that female occupations are not only different than men's occupations but also worse, which can be also a form of discrimination.

Table 4.8
Actual Log Earnings for Men and Women in the Formal and Informal Sectors, and Estimated Log Earnings for Women

	Average Men's Earnings	Average Women's Earnings	Estimated women's Earnings
Formal sector	**0.088**	**-0.23**	**0.32**
Informal sector	**-0.73**	**-0.99**	**-0.22**

The same analysis just performed is repeated as a way of measuring the existence of market segmentation, i.e., that equally productive workers receive different wages depending on whether they are in the formal or informal sector. In order to do this, the wages that would result if their characteristics (means) in the informal market were used in the formal sector structure (coefficients) were separately estimated for men and women.

Table 4.9 displays the specific means of log earnings received in the formal and informal sectors, for men and women, and the average wage estimated in the informal sector if the wage structure was the same as in the formal sector. The actual mean log earnings in the formal and informal sectors for men are 0.088 and -0.73 respectively, while the estimated wage in the informal sector, given the structure of the formal sector, is -0.57. Therefore, 80% of the earnings differential is due to differences in characteristics and 20% to market segmentation.[6] For women, while the averages in the formal and informal sectors are -0.23 and -0.99 respectively, the estimated earnings in the informal sector, given the structure of the formal sector, is -0.83, which yields that 79% of the earnings differential is due to difference in characteristics and 21% is due to market segmentation.

6 To obtain 80% (0.088-(-0.57))/(0.088-(-0.73)) is calculated.

These results lead to the conclusion that for both men and women, market segmentation exists and is 20% of the earnings differential observed between formal and informal sectors, the remaining part being attributable to differences in the workers' endowments.

Barros, Mello and Pero (1993),[7] using household surveys (PNAD) from 1981 to 1989, observed that workers with formal contracts earn twice the wages of workers without formal contracts and showed that "*one half of this wage gap is explained by differences between workers with and without formal labor contracts with respect to education, age and region of residence.*" So, they found segmentation in the market, claiming that "*if workers with same age and education who reside in the same metropolitan area were on average equally productive, then the metropolitan labor market of Brazil would be segmented with a randomly drawn worker in a job without formal labor contract experiencing a 50% wage increase if he/she could find a job with a formal contract.*"

Table 4.9
Actual Log Earnings for Men and Women in the Formal and Informal Sectors, and Estimated Log Earnings in the Informal Sector

	Average Formal Earnings	Average Informal Earnings	Estimated Informal Earnings
Men	**0.088**	**-0.73**	**-0.57**
Women	**-0.23**	**-0.99**	**-0.83**

5 Conclusions

The labor force participation for men and women in the formal and informal sectors of the Brazilian economy was estimated by maximum likelihood using a multinomial logit model. The results show that number of children, education, experience, among other variables, affect the decision of men and women to participate in the formal and informal markets. Some differences are present, though. While young children have a negative impact on women's participation, they have a positive impact on men's participation. Moreover, teenager daughters increase the mother's participation in the job market, as they can act as substitutes from the mother's care towards very young children. Connected to this fact is the result that the head of the household

7 This study includes only male employees in the urban segment of nine metropolitan areas in the private sector with and without formal labor contracts.

participates more in the labor force than the wife. Education also has a very strong effect on participation for both men and women in the formal sector. However, in the informal sector, the effect is much smaller for women and even insignificant for men. The level of education required in informal jobs is lower than in formal jobs.

The earnings functions were estimated by weighted least squares, correcting for selectivity bias and the results compared to a traditional method of estimation, showing large differences between coefficients. Race, region, education and experience are variables affecting earnings.

The variable lambda captures the unobservable effect of the variables, which affects both the selection of the workers into the sector and their earnings. It is recommended that further research be conducted to find out which these unobservable variables are and the real necessity to control them for the purpose of the analysis proposed in this study.

Large differences are observed when comparing the returns on education and experience obtained from the coefficients of the earnings equations when both correcting and not correcting for sample selectivity bias. Men's returns on education in the informal sector, for example, more than doubles when excluding lambda. Returns on education ranged from 5,73% for men in the informal sector to 21,17% for women in the formal sector, being much higher in the formal than informal sector. Returns on experience were lower than on education, ranging from 3,18% for women in the formal sector to 8,38% for men in the formal sector.

The number of years of experience and the age at which earnings peak were calculated. The age range was not wide, from 42 to 48 years, which indicates that more highly educated workers reach their peak earlier than less educated ones.

Considerable gender discrimination was found when comparing women's wages estimated by substituting their characteristics in the men's structure. While the actual average women's earnings are approximately 25% below men's wages, the estimated average women's earnings surpassed the average men's earnings.

Finally, it was observed that 20% of the earnings differentials between formal and informal sectors is attributed to market segmentation.

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Aplicação de redes neurais à economia: demanda por moeda no Brasil

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RESUMO

Os modelos de redes neurais vêm sendo utilizados na área de economia basicamente com o objetivo de se obter previsões mais acuradas. Desse modo, dada a ampla generalidade desta classe de modelos, está se desperdiçando a possibilidade de exploração do grande poder analítico na estimação de relações não-lineares. O objetivo deste trabalho é apresentar as principais características, elementos envolvidos, vantagens, dificuldades e limitações para a utilização de modelos econômicos estimados a partir de redes neurais. Para tal, utilizar-se-á como primeira abordagem a estimação de uma função demanda por moeda para o Brasil. Os principais resultados indicam que as profundas transformações ocorridas desde a implantação do Plano Cruzado provocaram fortes impactos sobre a função demanda por moeda, refletindo-se em oscilações acentuadas nas magnitudes das elasticidade-juros, renda e preços da referida função.

Palavras-chave: redes neurais, modelos não-lineares, demanda por moeda.

ABSTRACT

Neural network models have been used in the economics basically aiming at obtaining more accurate forecasting. Thus, given the wide generality of this category of models, the possibility of exploring the great analytic power in the estimation of non-linear relations is being wasted. This paper is intended to introduce the main characteristics, involving elements, advantages, difficulties, and restrictions on the use of economic models estimated from neural networks. For such a purpose, the estimation of a money-demand function for Brazil will be used as the first approach. Main results indicate that the deep changes occurred since Cruzado Plan implementation have had strong impacts on the money-demand function, which is shown by marked oscillations in the magnitudes of interest elasticity, income elasticity, and price elasticity of that function.

Key words: neural networks, non-linear models, money demand.

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1 Introdução

A ampla capacidade de modelagem apresentada pelas redes neurais vem instigando recentemente vários pesquisadores, principalmente na área de finanças. Os estudos indicam, de forma consistente, uma superioridade desta classe de modelos essencialmente não-lineares sobre os lineares, nos casos em que estes últimos apresentam falhas sistemáticas.

Especificamente no caso das redes neurais, deve-se frisar que apresentam uma grande vantagem em relação a outros modelos não-lineares. Assim, quando estão sendo tratados problemas extremamente complexos, os métodos convencionais de modelagem demandariam um esforço enorme e muito freqüentemente não se conseguiria construir o modelo. A utilização de redes neurais parte apenas da definição de premissas básicas de modelagem na topologia da rede e na forma de treinamento; assim, o trabalho de procura do modelo será computacional e não humano.

Na área de estudo de problemas econômicos, a maioria dos trabalhos com aplicações de redes neurais tem procurado apenas construir modelos cujo objetivo principal é a produção de previsões *(forecasts)* de séries financeiras[1] ou mesmo macroeconômicas.[2]

Ocorre, entretanto, que o potencial analítico desta classe de modelos não está sendo explorado neste tipo de aplicação. Na verdade, este comportamento reproduz tradição vigente nas áreas tecnológicas, onde a técnica de construção de redes se desenvolveu. Na maioria das aplicações, controle de processos, robótica, reconhecimento de padrões, processamento de imagens, por exemplo, exige-se dos modelos o maior poder preditivo possível. Não se busca uma razoabilidade em termos de magnitudes ou sinais dos parâmetros obtidos, qualidade tida como essencial na análise de modelos econométricos.

Desse modo, torna-se compreensível que as dificuldades de associação entre os parâmetros estimados pelo modelo e os parâmetros do modelo econômico correspondente ainda sejam inúmeras, considerando-se, principalmente, o fato de que as redes são construídas de forma a permitir a existência de alto grau de não-linearidades e cruzamento de efeitos das variáveis "explicativas" sobre a "explicada".[3]

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1 Maiores detalhes podem ser encontrados em White e Swanson (1995) e Azoff (1994).

2 Ver Swanson e White (1995).

3 Na linguagem das redes, as conhecidas variáveis explicativas denominam-se *inputs* ou entradas e a variável explicada corresponde ao *output* ou saída.

Sendo assim, pretende-se neste trabalho apresentar as principais características, elementos envolvidos, vantagens, dificuldades e limitações para a utilização de modelos econômicos construídos a partir de redes neurais. Para tal, pretende-se utilizar como primeira abordagem a estimação de uma função demanda por moeda para o Brasil.

Deve-se destacar, deste modo, que os resultados obtidos têm como objetivo apresentar uma alternativa metodológica que pode colaborar para o aprofundamento das pesquisas teóricas no sentido de permitir a especificação de modelos mais abrangentes, por meio da utilização de redes neurais.

2 Potencial das redes neurais

Conforme bem coloca Skapura (1995, p. 3 e 4), existem vários tipos de problemas que vêm se mostrando não passíveis de tratamento dentro da arquitetura computacional existente. Entre eles pode-se citar: a previsão de tempo, reconhecimento e interpretação de voz, imagens, escrita manual, entre outros.

Por outro lado, é preciso considerar que o ser humano realiza algumas dessas tarefas sem ao menos notar a complexidade envolvida, apesar de a capacidade de processamento dos neurônios humanos ser da ordem de 1000 sinais por segundo e a do computador ser bilhões de sinais por segundo. A diferença básica reside na distinção da arquitetura analítica entre a mente humana e o computador. Enquanto a primeira processa as informações de forma paralela (simultânea), o segundo trabalha de modo seqüencial. O exemplo mais simples é o de reconhecimento de imagens. A maioria dos algoritmos computacionais procura correlacionar cada ponto com os que estão à sua volta, na tentativa de encontrar um padrão semelhante aos previamente definidos. Já a mente humana recebe a imagem completa, ativando para tal uma grande quantidade de neurônios simultaneamente.

Dessa forma, verifica-se que a existência deste paralelismo gera um enfoque analítico completamente distinto, que aliado à possibilidade de tratamento de não-linearidades vem permitindo a aplicação desta metodologia a uma vasta gama de novas situações.

2.1 Conceitos básicos

O elemento básico de uma rede é normalmente conhecido como neurônio, nódulo, ou unidade capaz de receber sinais de diferentes magnitudes ("grandes" e "pequenos") e

polaridades ("excitatório" e "inibitório", por exemplo, +1 e -1, respectivamente) e agregá-los de forma a produzir uma saída única.

Assim, pode-se sinteticamente expressar o estímulo que um neurônio recebe de n entradas da seguinte forma:

$$estímulo = \sum_{j=1}^{n} w_j entrada_j$$

onde w_j representa a ponderação associada à entrada j.

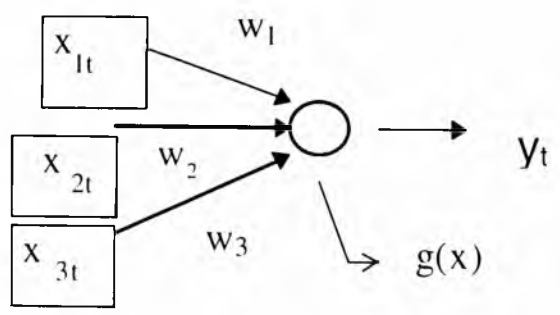
Após a chegada deste estímulo conjunto, o neurônio pela aplicação de uma **função de ativação do neurônio** produz o sinal correspondente à saída única referida acima. Tem-se, então:

$$y = g(\sum_{j=1}^{n} w_j x_j),$$

onde y corresponde à "saída" e x à "entrada" do neurônio.

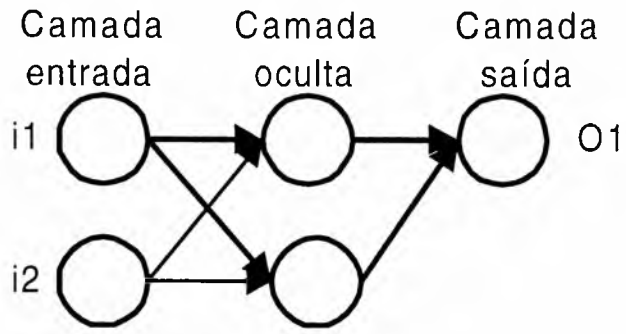
A partir das considerações acima é possível ampliar a estrutura de análise por meio da construção de uma rede de neurônios dispostos em camadas. A mais simples dessas redes recebe o nome de perceptron e pode ser vista na Figura 1.

Figura 1
Perceptron



Na estrutura acima verifica-se que na entrada também existem neurônios, que normalmente são modelados de tal forma que a função de ativação apenas reproduza o estímulo original sem produzir nenhuma alteração. Esses neurônios que recebem as entradas da rede denominam-se **camada de entrada** enquanto que a camada composta dos neurônios que geram a saída final da rede recebe o nome de **camada de saída**. As camadas intermediárias são denominadas de **camadas ocultas**. Essa rede que apresenta camadas múltiplas é ilustrada na Figura 2.

Figura 2
Rede Multicamada[4]



Conforme se verifica facilmente, a camada de entrada apresenta dois neurônios, correspondentes a duas "variáveis explicativas"; a camada oculta também possui dois neurônios e a de saída apenas um neurônio, referente à "variável explicada"

Em relação à função de ativação merecem menção as mais utilizadas:

- Função Linear - $y = \sum_{j=1}^{n} w_j x_j$

- Função Step - $y = \begin{cases} 1, para \sum_{j=1}^{n} w_j x_j > \theta \\ 0, para \sum_{j=1}^{n} w_j x_j \leq \theta \end{cases}$ onde θ corresponde a um ponto que delimita dois grupos ou estados.

4 Esta estrutura representa uma rede mais conhecida como *Multilayer Perceptron (MLP)*. Existem outras estruturas mais complexas como a Elman e a Jordan com retroalimentação, a primeira, a partir das camadas ocultas e a segunda a partir da camada de saída, mas que não serão alvo deste estudo.

- Função Sigmóide ou Logística - $y = (1 + e^{-2\beta \sum_{j=1}^{n} w_j x_j})^{-1}$, onde β corresponde a parâmetro de ajustamento do grau de inclinação da função de ativação.

- Função Gaussiana - $y = exp(((\sum_{j=1}^{n} w_j x_j) - 1)/\sigma^2)$ onde σ corresponde a um parâmetro de alisamento.

Algumas observações se fazem necessárias. A primeira delas refere-se ao fato de as funções acima aplicarem-se também aos neurônios da(s) camada(s) oculta(s). Neste caso, a entrada x_j corresponde, na verdade, aos valores de saída dos neurônios da camada anterior e não às entradas originais da rede. Esta menção é de extrema relevância, pois em arquiteturas bem mais complexas pode ser introduzido um mecanismo de retroalimentação de neurônios, ou seja, saídas da(s) camada(s) oculta(s) ou de saída podem retornar à rede alimentando um grupo de neurônios da camada de entrada.

Deve-se mencionar, também, que cada uma das funções de ativação apresentam determinadas características que favorecem grupos específicos de aplicações. Assim, por exemplo, a função Linear é usualmente utilizada em neurônios da camada de entrada de redes com a estrutura apresentada na Figura 2.

A função de ativação Step é muito útil, como, por exemplo, na tarefa de distinção entre dois estados - ativo e inativo. Neste caso, θ seria zero. Para valores negativos do estímulo, a saída seria zero. Para valores positivos do estímulo, a saída seria 1.

A função Sigmóide opera de forma semelhante à Step, apenas com a distinção de que esta última é uma função contínua e diferenciável. A maior utilização desta função está nos problemas de classificação, de forma análoga à da função Step. A restrição desta função reside justamente neste ponto. Por ser contínua, é possível encontrar valores de saída distintos de 0 e 1, por exemplo, 0.7. Neste caso, fica a dúvida no referente a que categoria enquadrar o referido *input*. Vale lembrar que neste caso os valores de saída, y, podem ser considerados como probabilidade de estar na categoria definida como y=1.[5]

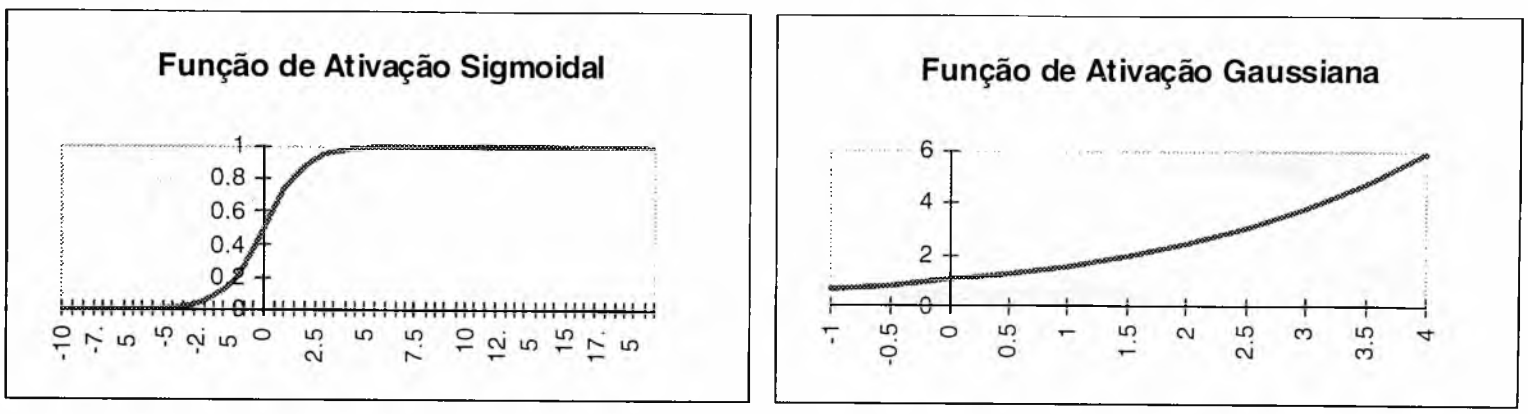
---

5 Sargent (1993) fornece um exemplo muito ilustrativo: "*(...) let there be two classes of people, American football players (y=1) and economists (y=0). Let x_t be a vector of characteristics, say weight and salary, of individual t. When we present the perceptron with x_t for economist t, we want the perceptron to eject y_t=0, and when we input the characteristics of a football player, we want the perceptron to say y_t=1. With the Heaviside step function as the squasher, the neuron 'fires' (y_t=1) if and only if $w'x_t \geq 0$. With one of the other squasher functions, the value of y_t could be interpreted as the probability that an individual is a football player.*"(p. 55 e 56)

Finalmente, a função Gaussiana é freqüentemente utilizada quando se pretende obter uma classificação em que existem mais do que duas categorias. Deve-se notar que este tipo de função de ativação, distintamente do que se verifica nas categorias apresentadas anteriormente, não implica a existência de um valor máximo para a saída y, obtida a partir da rede.

Na Figura 3 é possível verificar a forma das funções sigmóide e gaussiana.

Figura 3
Formas das Funções de Ativação Sigmóide e Gaussiana



Dada a estrutura apresentada acima, fica a questão de como definir os pesos w da "melhor" forma possível. Este processo de estimação é mais conhecido como processo de aprendizagem ou treinamento da rede, no sentido de que a rede estaria aprendendo ou sendo treinada a reproduzir as transformações desejadas.

O algoritmo mais conhecido e utilizado neste processo é o método da retropropagação do erro,[6] que é análogo ao velho conhecido dos economistas, o método dos mínimos quadrados. Consiste, basicamente, em encontrar o vetor de parâmetros w* que minimize a soma de quadrados do erro, entendido como a diferença entre o valor de y dado pela rede e o real. Sendo assim, por meio de um processo iterativo[7] os parâmetros vão sendo corrigidos da seguinte forma:

$$w_{jk} = w_{jk-1} + \eta \sum_{t=1}^{T} (y_t - y_t^*) \frac{dg(x)}{dx} x_t$$

6 Por este motivo a rede multicamadas - *Multilayer Perceptron (MLP)* - é também chamada de *Backpropagation Network (BPN)*.

7 Greene (1997, p. 202 e seguintes) apresenta de forma mais detalhada o funcionamento do referido método.

Deve-se mencionar, ainda, que as redes MLP treinadas por *Backpropagation* realmente se assemelham muito ao método de mínimos quadrados não-lineares uma vez que o método de treinamento, a cada fase, minimiza o erro entre a saída da rede e a saída correta. Contudo, se forem utilizados outros paradigmas neurais tais como redes auto-organizadas, *counter-propagation*, ressonante etc. as diferenças entre o método de mínimos quadrados e o treinamento das redes tornam-se marcantes.[8]

A partir da estrutura apresentada acima, verifica-se, facilmente, a existência de um paralelismo na incorporação dos efeitos das entradas sobre a(s) camada(s) oculta(s), bem como a possibilidade de inclusão de não-linearidades a partir da seleção de uma função de ativação adequada.

Conforme antes destacado, na maioria das situações convencionalmente modeladas por redes neurais a função linear é utilizada apenas na camada de entrada, estando mais comumente associadas aos neurônios da camada oculta bem como da camada de saída as funções sigmóide e/ou gaussiana. Obviamente, a combinação destas funções introduz uma enorme dificuldade na especificação completa da forma funcional da rede, ou seja, aquela com a qual os economistas estão tradicionalmente acostumados.

A seguir será apresentada uma aplicação simples à estimação da demanda por moeda no Brasil.

3 Modelo de demanda por moeda no Brasil

Inúmeras foram as tentativas de encontrar uma especificação para a demanda por moeda no Brasil. A maioria dos trabalhos realizados acaba por limitar-se a abordar uma ou algumas particularidades da forma funcional, chegando, invariavelmente, à conclusão de que os choques pelos quais passou a economia durante a segunda metade da década de 80 até a primeira metade dos anos 90 acabou por introduzir elementos que dificilmente são passíveis de tratamento pelos métodos convencionalmente utilizados na estimação da maioria das relações econômicas. Na verdade, em muitos dos trabalhos encontram-se entre as sugestões de aprimoramento a busca de alguma estrutura não-linear capaz, por exemplo, de incorporar os

8 Maiores detalhes acerca destas arquiteturas distintas podem ser encontrados em Skapura (1995).

efeitos dos referidos choques.[9] Esta situação, entretanto, não parece ser exclusivamente brasileira, pois as mesmas observações foram apresentadas por Bucacos (1997) para o Uruguai.

Conforme bem destaca a autora, as inovações financeiras bem como a convivência prolongada com altas taxas de inflação certamente provocaram efeitos sobre a demanda por moeda e não existe qualquer razão para se supor que tais influências possam ser incorporadas de forma linear. Pelo contrário, as indicações são de que estes efeitos são efetivamente não-lineares.

Pretende-se, desse modo, nesta primeira abordagem, enfocar algumas peculiaridades dos resultados obtidos a partir da estimação de um modelo baseado na estrutura de uma rede neural para a demanda por moeda para o Brasil. Para tal, considerar-se-á o seguinte modelo:

$$M = f(Y, R, P).$$

onde:
M representa Meios de Pagamento (M1), deflacionado pelo IGP-DI;
Y representa Nível de Renda, também deflacionada pelo IGP-DI;
R corresponde à Taxa de Juros - *Overnight*, e
P representa a variação do IGP-DI.

As informações têm periodicidade trimestral e foram analisadas 90 observações trimestrais compreendidas entre o primeiro trimestre de 1975 e o segundo trimestre de 1997 Todos os dados foram obtidos na Macrométrica.

Antes de passar diretamente à estimação do modelo, não se pode deixar de frisar que a existência de simples indicações acerca da presença de não-linearidades certamente não é condição suficiente para garantir que a simples estimação de um modelo não-linear, qualquer que seja sua especificação, deva apresentar resultados mais adequados do que os obtidos por meio de um modelo linear. Na verdade, o procedimento mais adequado consiste sempre na aplicação preliminar de um teste sobre os dados, com o intuito de verificar se a hipótese de linearidade pode ser rejeitada no caso sob foco de análise.

9 Para maiores detalhes, ver Triches (1992).

A literatura sobre esta categoria de testes tem se desenvolvido nos últimos anos, especialmente na direção de incorporar conceitos da teoria de redes neurais. A este respeito vale citar Lee, White e Granger (1992) e Teräsvirta, Lin e Granger (1993). Este último, em particular, apresenta um teste do tipo Multiplicador de Lagrange, que corresponde a uma alternativa superior ao proposto por Lee, White e Granger. A conclusão acerca desta superioridade foi baseada em resultados obtidos a partir de experimentos de Monte Carlo.

Por este motivo, optou-se por aplicar aqui o teste proposto por Teräsvirta, Lin e Granger (1993). Essencialmente, o teste consiste em três etapas básicas, ou seja, estimar uma regressão base entre o vetor da variável explicada, neste caso, *M* e a matriz de explicativas, estimar a regressão auxiliar entre o vetor dos resíduos gerados na regressão base e a matriz de explicativas acrescida de j regressores auxiliares, que representam, neste caso, as combinações de termos não-lineares e, finalmente, calcular a estatística do teste, a partir da soma de quadrados de resíduos obtida tanto na regressão base como na auxiliar.

É preciso mencionar que o teste proposto no artigo foi derivado a partir de uma definição de modelo univariado. Sendo assim, na matriz de explicativas constava apenas a variável dependente, neste caso M_t com vários níveis de defasagens, ou seja, M_{t-1}, M_{t-2}, M_{t-3}, e assim sucessivamente.

Este teste foi realizado inicialmente, conforme sugerem os autores, a partir desta especificação, considerando o pressuposto de que a alternativa não-linear ainda não estava precisamente especificada. Em seguida procedeu-se a uma adaptação do teste, considerando que a variável dependente defasada não será incorporada entre as explicativas, substituindo-se os termos correspondentes pelas combinações geradas a partir das variáveis Y, R e P. No Quadro 1, a seguir, encontra-se um resumo acerca dos regressores auxiliares incorporados, tanto para o teste originalmente proposto como para adaptação realizada, e na Tabela 1 encontram-se os resultados do teste.

Quadro 1
Regressores Auxiliares incorporados nos Testes da Presença de Não-Linearidades

Teste	Regressores auxiliares
Original V23	M_{t-1}^{2} $M_{t-1}M_{t-2}$ M_{t-2}^{2} M_{t-1}^{3} $M_{t-1}^{2}M_{t-2}$ $M_{t-1}M_{t-2}^{2}$ M_{t-2}^{3}
Adaptado	Y^2 YP YR P^2 PR R^2 Y^3 Y^2P Y^2R YP^2 YPR YR^2 P^3 P^2R PR^2 R^3

Tabela 1
Resultados dos Testes da Presença de Linearidade

Cálculo da Estatística do Teste		**Teste Adaptado**	**Teste Artigo - V23**
Soma dos quadrados dos Resíduos	base	21428.88	14442.1
Soma dos quadrados dos Resíduos	Limitada	10612.38	9410.878
Regressores - j		16	7
Total de elementos		90	88
Número de Explicativas		3	2
Graus de liberdade do numerador		16	7
Graus de liberdade do denominador		70	78
Estatística do teste F		4.459149361	5.957168715
Hipótese nula: coeficientes quadráticos e cúbicos = 0 ⇒ existência de linearidade			
Probabilidade de cometer erro tipo 1	nível de significância	0.00057%	0.00143%

Verifica-se que em ambas as alternativas não se pode aceitar a hipótese nula de presença de linearidade, considerando, inclusive, níveis de significância inferiores a 1%. Está, desse modo, justificada a estimação de um modelo não-linear, e conforme já destacado anteriormente, dadas as vantagens da teoria de redes neurais, será este o modelo a ser estimado a seguir.

Cabe destacar, a princípio, que uma primeira versão deste trabalho foi realizada a partir da utilização de uma versão *shareware* de um *software* disponível na Internet. Ocorre, entretanto, que a elaboração e estimação de uma rede neural, dada a relativa precocidade do método, ainda segue um padrão "artesanal" Isto implica que cada aplicação apresenta característica específicas, principalmente em relação à normalização prévia à estimação, o que dificulta a utilização de um *software* padronizado. No caso deste trabalho, tornou-se de extrema relevância a realização de simulações sobre o comportamento da série estimada diante da imposição de pequenos choques nas variáveis de entrada, uma vez que isto permite dar uma noção geral acerca das respectivas elasticidades da demanda por moeda. Por este motivo, foi crucial o desenvolvimento de um *software* específico que possibilitou a obtenção deste tipo de resultado. Na verdade, esta é a prática comum nas áreas em que esta metodologia vem sendo aplicada mais comumente.[10]

Foram estimadas várias versões da Rede Multicamada apresentada acima. Essencialmente, a distinção entre elas estava no número de camadas, no número de neurônios da(s) camada(s) oculta(s) bem como nos valores do parâmetro β da função sigmóide. Esta foi a função de ativação considerada mais adequada para o modelo analisado em função do melhor ajustamento dos resultados obtidos.[11]

Deve-se mencionar que, dado o caráter de exploração metodológica da utilização de redes neurais aplicadas a modelos econômicos, optou-se pela utilização do modelo relativamente simples, que é MLP. Porém o modelo MLP com *backpropagation* também incorpora, de forma implícita, as relações dinâmicas entre as variáveis, uma vez que durante a fase de treinamento os pesos sinápticos são alterados sucessivamente à medida que são introduzidas temporalmente as séries de entrada. Existem, entretanto, outros modelos neurais mais complexos, tais como a TDN (*Time delay network*) que incorporam explicitamente na

10 Este *software* foi desenhado para ambiente WINDOWS 95 e poderá ser obtido gratuitamente por e-mail nos seguintes endereços: madmdiaz@usp.br ou ljsimoes@uol.com.br

11 Deve-se mencionar que em todas as especificações o valor inicial dos pesos sinápticos foi gerado aleatoriamente, usando um distribuição uniforme [0,1].

camada de entrada as mesmas séries de entrada com defasagens, cuja aplicação está sendo programada para desdobramentos futuros. Com a TDN, por exemplo, a rede recebe simultaneamente as entradas nos instantes t,t-1,...t-d. Desse modo, a rede acaba armazenando mais explicitamente as relações temporais existentes entre as variáveis.

Outro ponto que merece destaque refere-se ao fato de terem sido utilizadas todas as observações no processo de treinamento da rede. Na verdade, convencionalmente, treina-se a rede apenas com parte das observações da amostra. O restante das informações é utilizado para verificação acerca da adequação da rede para a previsão de dados futuros. Ocorre, neste caso, que o objetivo é encontrar os pesos que permitam um melhor ajustamento das observações compreendidas no período de análise, não se pretendendo, portanto, utilizar o modelo para realização de previsões sobre valores futuros da variável de saída.

Foi utilizado como critério para a seleção do modelo mais adequado a minimização de uma função erro, expressa por:

$$erf = \sum_{i=1}^{T} (y_i^* - y_i)^2 ,$$

onde y_i representa o valor observado da variável explicada e y^*_i corresponde ao valor gerado pela rede. Calculou-se também a seguinte função de Erro Médio:

$$Erro\ Médio = \left[\sum_{t=1}^{T} \left(\frac{\left| (y_t^* - y_t) \right|}{y_t} \right) \right] / T ,$$

onde T é o número total de observações.

Esta medida pode ser interpretada como um erro porcentual médio existente no conjunto da rede.

De acordo com os critérios acima, o modelo mais adequado possuía 3 camadas, sendo que a de entrada apresenta três neurônios (i1,i2 e i3) correspondentes às três variáveis explicativas - Renda, Inflação e Juros, respectivamente. A camada oculta possui cinco

neurônios e a de saída um neurônio (o1). A função de ativação adotada foi a sigmóide, com $\beta = 0{,}4$. O Erro Médio deste modelo foi de aproximadamente 13%. A forma funcional da rede pode ser expressa da seguinte forma:

Sejam x^1_t, x^2_t, x^3_t, x^4_t as entradas no instante t da rede ($x^4_t = 1 \ \forall \ t$)

Seja ne = 4: número de entradas + 1 (bias)

Seja $m^i = \max\{ x^i_t \ \forall \ t \}$ i=1,2,3 (supondo $m^i > 0$)

Sejam $X^i_t = x^i_t / m^i$ para i=1,2,3 e $X^4_t = -1$ para qualquer t: {X^i_t entrada normalizada pelo máximo}[12]

Seja $$f(h) = \frac{1}{1 + e^{-2\beta h}}$$

onde $\beta = 0.4$

Sejam w_{ij} os pesos sinápticos entre a entrada i e o neurônio interno j, com ($1 \leq i \leq ne$ e $1 \leq j \leq J$)

Seja J o número de neurônios internos + 1 (bias)

Sejam W_j os pesos sinápticos entre o neurônio interno j e o neurônio de saída.

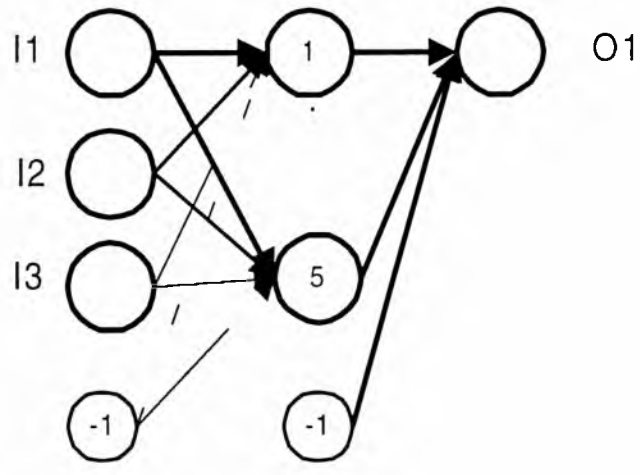
A Rede Neural no instante t é igual a:

$$RN(t) = f\left\langle -W_1 + \sum_{j=1}^{J-1} W_j \, f\left(\sum_{i=1}^{ne} w_{ij} X^i_t \right) \right\rangle$$

Sendo assim, a estrutura da rede estimada pode ser vista na figura a seguir:

12 Algum tipo de normalização é inevitável quando as entradas apresentam ordens de grandeza discrepantes. Se não houvesse normalização, os efeitos numéricos gerados pelos valores maiores iriam polarizar a rede, "apagando" totalmente os valores pequenos. Dentre as várias formas de normalização que não eliminam a variação relativa do instante t para o instante t+1 da série tem-se a normalização pelo máximo (em módulo) da série dada.

Figura 4
Esquema da Rede Estimada para a Demanda por Moeda



Pode-se verificar a presença de um neurônio adicional na camada de entrada alimentando a camada oculta e outra na camada oculta alimentando a camada de saída. Estes neurônios representam a existência de um *bias*. Na verdade, o mecanismo completo de ativação do neurônio exige que o estímulo supere um certo "limiar",[13] ou seja, o neurônio somente se "ativará"[14] se o valor do estímulo atingir ou superar este limiar. Pode-se representar, entretanto, como fazem Hertz, Krogh e Palmer (1991), este "limiar" como um neurônio adicional, conforme representado na figura. A entrada a ele associada será sempre -1 e os pesos serão estimados. Assim, na verdade, o valor deste "limiar" será também estimado ao invés de ser previamente determinado.[15] Cabe ainda mencionar que em termos computacionais estes neurônios também são de grande utilidade, pois durante o processo de convergência mantêm o fluxo de entrada para todos os neurônios, evitando que algum deles se torne inativo como decorrência de uma combinação específica dos pesos estabelecidos.

Deve-se notar que cada linha que conecta pares de neurônios implica a existência de um peso w correspondente. Sendo assim, este modelo gerou a estimação de 30 pesos, que se encontram na Tabela 2.

13 Tradução para *threshold*.

14 Tradução para *fire*.

15 Maiores detalhes podem ser encontrados em Skapura (1995) e Hertz, Krogh e Palmer (1991).

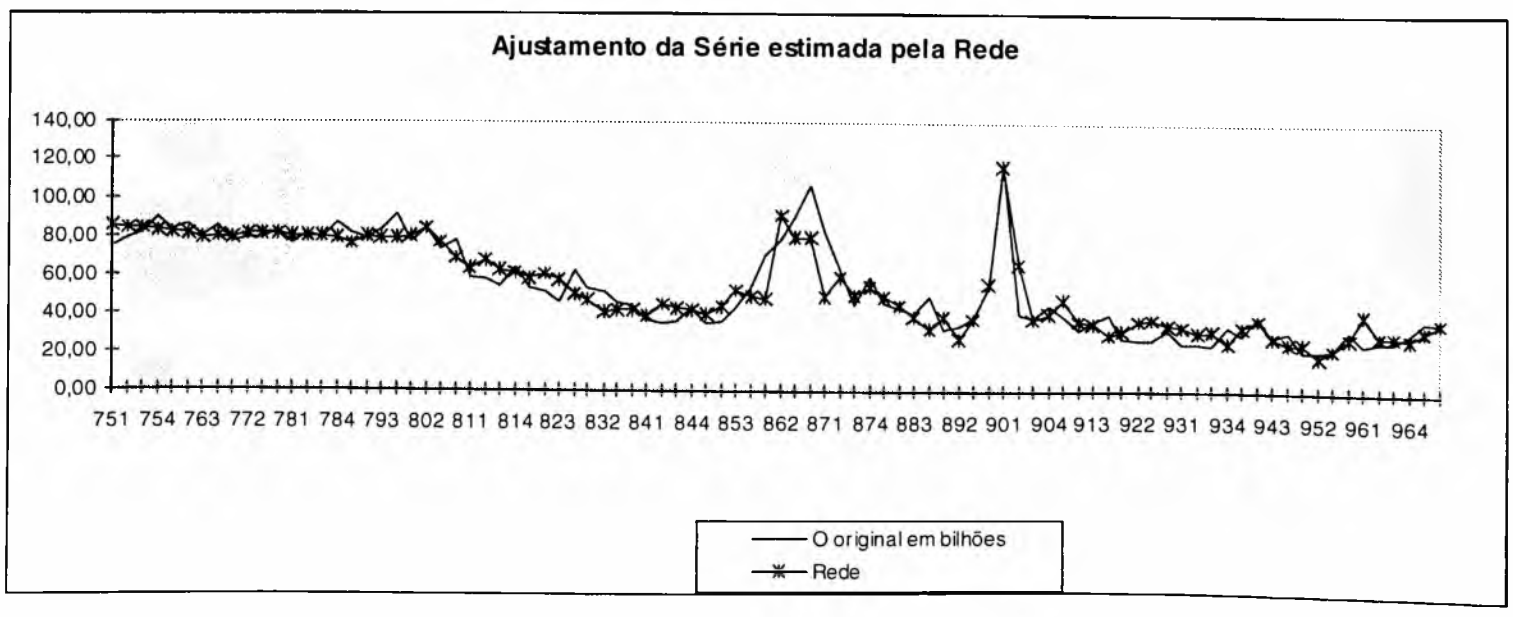
Tabela 2
Matriz de Pesos

Renda	Inflação	Juros	*Bias*	
da camada de entrada *input* para a camada oculta				
-3.201866	-4.290433	-7.994329	-6.84649	(da camada de *input* para o neur. 1 da camada 2
37.598601	-8.530865	-0.363789	31.54668	(da camada de *input* para o neur. 2 da camada 2
14.782775	8.617191	-8.978976	12.66386	da camada de *input* para o neur. 3 da camada 2
-2.298129	-5.373911	-6.681378	-10.8061	da camada de *input* para o neur. 4 da camada 2
-5.826484	-26.163934	-43.315264	-6.65530	da camada de *input* para o neur. 5 da camada 2
18.895733	6.708914	38.872601	-39.1304	da camada de *input* para o neur. 6 da camada 2

da camada oculta para a camada de saída – *output*						
1.912275	-6.046809	5.952796	-8.50546	2.425573	-5.485888	da camada oculta para o neurônio único da camada de saída

Na Figura 5 é possível verificar o bom ajustamento da rede treinada à série normalizada de M1.

Figura 5

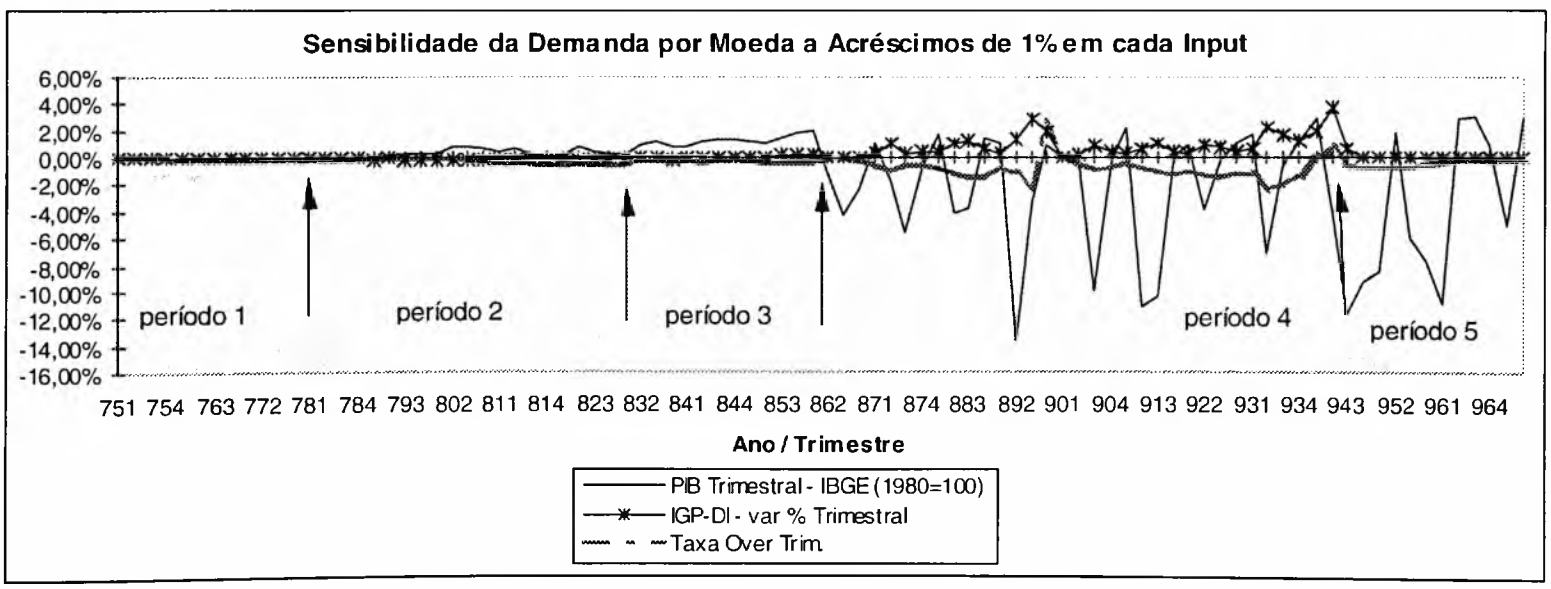


De acordo com o exposto anteriormente, os pesos somente podem ser interpretados como estímulos e não como qualquer conceito relacionado a derivadas parciais da variável explicada em relação às explicativas. Para que tal análise pudesse ser feita seria preciso reconstruir a função que relaciona as variáveis explicativas e a explicada. Ocorre que, dada a complexidade do modelo, isto se torna muito difícil. Porém, pode-se realizar uma análise de sensibilidade, que implica verificar o efeito sobre os resultados da saída da rede decorrentes de variações de 1% em cada uma das variáveis de entrada.

Vale mencionar que os resultados[16] indicam que a influência de alterações no nível de Renda sobre a demanda por moeda é maior do que a influência das variáveis Preço e Taxa de Juros. É interessante notar que Bucacos (1997) também enfatizou este resultado, porém de forma indireta e inadequada, ou seja, analisando os valores absolutos dos pesos da camada de entrada para a camada intermediária. Se este fosse o critério aqui adotado, a conclusão seria de que a variável Juros é a mais importante, pois a soma dos valores absolutos dos pesos do neurônio associado a esta variável é 106.2063 enquanto para a variável Renda tal soma atinge apenas 82.60359.

A Figura 6, a seguir, permite que se tenha uma visão bem clara acerca da magnitude dos referidos impactos.

Figura 6



16 Anexo, encontram-se os valores para cada uma das variáveis para todo o período de análise.

Para facilitar a exposição dos resultados proceder-se-á a uma divisão do período analisado em cinco subperíodos: do 1° trimestre de 1975 ao 1° trimestre de 1978, do 2° trimestre de 1978 ao 1° trimestre de 1983, do 2° trimestre de 1983 ao 1° trimestre de 1986, do 2° trimestre de 1986 ao 2° trimestre de 1994 e, finalmente, do 3 ° trimestre de 1994 até o 2° trimestre de 1997

O primeiro subperíodo é marcado por uma demanda por moeda que apresenta resposta negativa, porém praticamente insignificante em relação a mudanças em qualquer das variáveis consideradas. Isto parece indicar a existência de um certo "primitivismo" em relação à política monetária e até mesmo em relação à própria concepção sobre o papel da moeda.

No segundo subperíodo verifica-se uma mudança qualitativa relevante, pois a demanda por moeda passa a apresentar respostas positivas a incrementos no nível de Renda. Na verdade, esses impactos também tornam-se relevantes porque chegam a atingir o patamar de 0,76% em 1982. Em relação às variáveis Preço e Juros, os impactos mantêm-se negativos, porém apresentam um significativo incremento em termos de magnitude. É interessante notar que no segundo trimestre de 1977 foram adotadas várias medidas restritivas em relação à política monetária e creditícia, inclusive pela fixação de juros reais positivos, introduzindo uma maior complexidade no sistema. Merece destacada menção o fato de que somente neste período verificam-se as respostas tradicionalmente esperadas, de acordo com os modelos teóricos referentes à demanda por moeda.

Ao longo do terceiro subperíodo mantém-se a tendência ascendente da magnitude do impacto de mudanças na variável Renda sobre a demanda por moeda. Assim, ao final do período o incremento de 1% na Renda já gerava uma resposta de aproximadamente 2% na demanda por moeda.

Por outro lado, a variável Preços passa a apresentar um resultado positivo, ou seja, o impacto sobre a demanda por moeda decorrente de pequenos acréscimos na inflação passa a ser positivo. Pode-se cogitar que a política econômica adotada - essencialmente uma combinação de elevadas taxas de juros e política cambial ativa -, que objetivava promover o ajuste externo, e que teve como conseqüência a aceleração inflacionária, talvez tenha introduzido uma mudança estrutural que irá permanecer até praticamente o final do período, ou seja, até o 2° trimestre de 1996, quando os impactos negativos voltam a ser observados, porém com pequena magnitude.

Neste ponto, cabe uma comparação com os resultados obtidos por Triches (1992), que estimou inúmeros modelos na forma log-log para o período compreendido entre o primeiro

trimestre de 1973 e o quarto trimestre de 1985. As elasticidades[17] de curto prazo em relação à renda, por ele estimadas, variaram entre 0,276 e 0,465, dependendo da taxa de juros utilizada.[18] No caso dos juros, as elasticidades de curto prazo variaram entre -0,230 e -0,078 e as elasticidades de curto prazo em relação à taxa de inflação situaram-se no intervalo entre -0,155 e -0,104.

A título de comparação, pode ser feita uma média simples das respostas obtidas a partir da rede neural estimada, considerando o período equivalente ao analisado por Triches (1992). Assim, a elasticidade-renda "média" é de 0.453, a elasticidade-juros "média" é de -0.265 e, finalmente, a elasticidade em relação à taxa de inflação é -0.041. Verifica-se que a magnitude das elasticidades obtidas é próxima dos resultados apresentados por Triches (1992). Deve-se entretanto frisar que, conforme já observado, dentro do período analisado por Triches (1992) existem três subperíodos marcadamente distintos. Desse modo, a utilização dos coeficientes obtidos a partir dos modelos convencionalmente utilizados, como, por exemplo, os modelos log-log, certamente encobre aspectos de extrema relevância para este tipo de análise.

O quarto subperíodo inicia-se com o Plano Cruzado e encerra-se com o Plano Real. Constata-se, facilmente, que este é certamente o período mais conturbado da série, coincidindo com a alternância de planos econômicos fracassados com a retomada do processo inflacionário. De maneira geral, percebe-se que a demanda por moeda passa a ser extremamente sensível a pequenas variações em qualquer das três variáveis de entrada. Em relação à variável Juros, merece destaque o fato de que em todo o período analisado a magnitude da resposta da demanda por moeda é geralmente inferior a 1%, indicando relativa inelasticidade da demanda por moeda em relação à variável Juros, à exceção de dois intervalos contidos neste quarto subperíodo: 2º trimestre de 1987 a 4º trimestre de 1989 e 1º trimestre de 1991 a 4º trimestre de 1993. Esses períodos foram marcados por tentativas de manutenção de uma política de taxa de juros reais elevada, principalmente após o lançamento de cada um dos planos de estabilização.[19] Assim, torna-se interessante notar como estas mudanças de política parecem afetar de maneira estrutural a função demanda por moeda.

17 Somente serão considerados os resultados obtidos a partir da definição de moeda equivalente à aplicada neste trabalho, ou seja, M1.

18 Triches (1992), na análise da demanda por moeda de curto prazo, trabalhou com três definições de taxa de juros: a de operações de mercado aberto, a taxa de rendimento da poupança e a taxa de juros de letras de câmbio.

19 Maiores detalhes acerca do contexto e do conjunto da política econômica vigente nesses períodos podem ser encontrados em Latif (1995).

Por outro lado, nota-se que em relação às variáveis Renda e Preços os sinais apresentados pelos impactos são contrários aos esperados, pois incrementos na Renda geram respostas negativas na demanda por moeda enquanto que incrementos na taxa de inflação geram um resultado positivo na demanda por moeda.

Em relação à variável Preços, vale observar que Triches (1992) obteve resultado semelhante ao tentar incorporar os anos de 1986 e 1987, ou seja, incluindo apenas os efeitos do Plano Cruzado. Segundo ele, "*tendo em vista os maus resultados obtidos com a inclusão na amostra dos dois últimos anos, tudo leva a crer que os dados observados, principalmente em 1986, não devam ser incluídos no presente modelo.*"(Triches, 1992, p. 43)

Nakane (1994), por outro lado, analisando a demanda por moeda para o período entre o primeiro trimestre de 1974 e ao terceiro trimestre de 1988, obteve um resultado qualitativamente[20] semelhante para a variável Renda. Conforme o autor, "*Outro ponto surpreendente é o sinal negativo para* Δy_{t-1}. *A influência negativa de variações do nível de renda real sobre os encaixes reais também foi obtida por Ericsson e Pereira (1989) em um modelo de mecanismo de correção de erros com dados trimestrais para o período 1966(1)/1979(4).*"(Nakane, 1994, p. 101)

Em relação aos resultados obtidos para o período que vai até o último trimestre de 1979, verificou-se, anteriormente, quando da análise do primeiro subperíodo, que isto realmente ocorria. Porém a magnitude destes impactos era tão pequena que podia ser considerada como praticamente nula.

Sendo assim, parece haver uma forte indicação, obtida a partir de evidências empíricas geradas por metodologias distintas, que a influência tanto dos programas de estabilização como das inúmeras inovações introduzidas no mercado financeiro, como decorrência da convivência prolongada com altas taxas de inflação sobre a função demanda por moeda, foi tão profunda que introduziu elementos ainda não incorporados pelos modelos teóricos existentes.

Obviamente, não se pode deixar de mencionar que, na verdade, estão sendo estimados pontos de equilíbrio entre a demanda e a oferta monetária. A estimação da forma como está sendo feita pressupõe que esta função seja estável. Desse modo, considera-se que os pontos

20 É importante notar que o modelo de Nakane foi estimado a partir das primeiras diferenças, por isso, a comparação não pode ser feita diretamente, mas visa apenas evidenciar a presença deste resultado analogamente inesperado em dois outros trabalhos.

observados representem o equilíbrio entre uma oferta monetária que oscila sobre uma dada curva de demanda por moeda. A este respeito é interessante verificar os resultados obtidos por Pastore (1997) acerca da passividade da política monetária verificada no período 1990 a 1994, corroborando, de certa forma, esta hipótese. Nakane (1994), por outro lado, ao realizar vários testes de exogeneidade[21] não conseguiu obter evidências inequívocas em relação à exogeneidade das variáveis taxas de inflação e taxa nominal de juros para os parâmetros da equação da demanda por moeda, o que colocaria certas restrições à hipótese adotada neste trabalho. Assim sendo, pode-se considerar que alguns dos resultados obtidos decorrem da violação da hipótese de estabilidade da função demanda, o que implicaria a necessidade de estimação de uma rede neural correspondente a um modelo de equações simultâneas não-lineares, o que foge ao escopo deste trabalho.

Finalmente, a análise do último subperíodo indica uma redução da magnitude dos impactos das variáveis Juros e Preços, sendo que no caso desta última voltam a aparecer impactos negativos. No caso da variável Renda, ainda persistem os fortes efeitos negativos sobre a demanda por moeda, porém ao final do período já se observa um certo arrefecimento e o aparecimento de efeitos positivos de magnitude considerável. É necessário, entretanto, o acompanhamento futuro para comprovar a hipótese de que esteja efetivamente ocorrendo uma reversão na tendência dos efeitos dessa variável sobre a demanda por moeda.

4 Conclusões

Este trabalho representa uma primeira aproximação da estimação de modelos econômicos utilizando a arquitetura das redes neurais. A grande vantagem desta categoria de modelos é a de permitir a estimação de parâmetros de modelos sem a imposição de qualquer tipo de restrição acerca da linearidade ou da normalidade de distribuição de probabilidades dos parâmetros. Por outro lado, a contrapartida a esta vantagem é a inexistência de critérios estatísticos para avaliação da qualidade dos resultados bem como para nortear a seleção de modelos. As pesquisas recentes em redes neurais estão justamente concentradas nessa área.

Os resultados indicaram que ao longo do período compreendido entre o primeiro trimestre de 1975 e o segundo trimestre de 1997 muitas foram as transformações sobre a demanda por moeda, e o bom ajustamento da rede estimada permite concluir que a presença de inovações

21 Na verdade, o conceito de exogeneidade relevante para este trabalho é o de superexogeneidade, e é sobre esse conceito que está baseada a afirmação acima. Maiores detalhes acerca dos referidos conceitos bem como da sua correta aplicação podem ser encontrados em Nakane (1994).

financeiras e a convivência prolongada com altas taxas de inflação certamente provocaram efeitos sobre a demanda por moeda, não existindo qualquer razão para se supor que tais influências possam ser incorporadas de forma linear. Pelo contrário, as indicações são de que estes efeitos são efetivamente não-lineares, conforme se verifica pelas grandes oscilações nas elasticidade-juro, renda e preço da demanda por moeda ao longo do período analisado.

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Anexo

Impacto do Acréscimo de 1% em cada Variável Explicativa

Trimestre	Renda	Inflação	Juros.
751	-0.04%	-0.01%	-0.02%
752	-0.01%	-0.01%	-0.03%
753	-0.03%	-0.02%	-0.03%
754	-0.05%	-0.02%	-0.05%
761	-0.08%	-0.04%	-0.06%
762	-0.05%	-0.04%	-0.09%
763	-0.07%	-0.06%	-0.12%
764	-0.07%	-0.03%	-0.11%
771	-0.12%	-0.05%	-0.12%
772	0.01%	-0.04%	-0.09%
773	-0.02%	-0.02%	-0.11%
774	-0.01%	-0.03%	-0.09%
781	-0.08%	-0.04%	-0.10%
782	0.03%	-0.05%	-0.11%
783	0.07%	-0.04%	-0.14%
784	0.03%	-0.04%	-0.16%
791	-0.07%	-0.09%	-0.19%
792	0.18%	-0.05%	-0.14%
793	0.33%	-0.10%	-0.14%
794	0.34%	-0.10%	-0.14%
801	0.32%	-0.08%	-0.15%
802	0.73%	-0.08%	-0.12%
803	0.70%	-0.11%	-0.22%
804	0.62%	-0.16%	-0.34%
811	0.39%	-0.19%	-0.41%
812	0.55%	-0.12%	-0.41%
813	0.25%	-0.14%	-0.49%
814	-0.05%	-0.14%	-0.54%

Impacto do Acréscimo de 1% em cada Variável Explicativa

Trimestre	Renda	Inflação	Juros.
821	0.10%	-0.20%	-0.51%
822	0.76%	-0.13%	-0.50%
823	0.49%	-0.11%	-0.57%
824	0.25%	-0.13%	-0.62%
831	0.16%	-0.20%	-0.55%
832	0.97%	0.01%	-0.36%
833	1.19%	0.03%	-0.33%
834	0.70%	-0.07%	-0.41%
841	0.70%	-0.01%	-0.31%
842	1.26%	0.01%	-0.42%
843	1.36%	0.07%	-0.35%
844	1.30%	0.07%	-0.33%
851	1.15%	0.07%	-0.30%
852	1.01%	0.08%	-0.42%
853	1.46%	0.18%	-0.43%
854	1.74%	0.23%	-0.42%
861	1.96%	0.17%	-0.37%
862	-1.21%	0.00%	-0.05%
863	-4.32%	0.01%	-0.18%
864	-2.34%	0.00%	-0.25%
871	1.05%	0.36%	-0.54%
872	-1.85%	1.11%	-1.01%
873	-5.70%	0.28%	-0.59%
874	-0.57%	0.49%	-0.55%
881	1.65%	0.47%	-0.68%
882	-4.24%	1.07%	-1.17%
883	-3.74%	1.18%	-1.54%

Impacto do Acréscimo de 1% em cada Variável Explicativa

Trimestre	Renda	Inflação	Juros.
884	1.47%	0.60%	-1.45%
891	1.01%	0.26%	-0.69%
892	-13.70%	1.30%	-1.20%
893	-3.24%	2.87%	-2.36%
894	0.88%	1.97%	2.75%
901	0.06%	0.06%	-0.02%
902	-0.01%	0.14%	-0.39%
903	-10.02%	0.89%	-0.84%
904	-0.10%	0.42%	-0.79%
911	2.23%	0.26%	-0.38%
912	-11.23%	0.56%	-0.71%
913	-10.37%	1.10%	-1.03%
914	0.12%	0.46%	-1.35%
921	0.98%	0.28%	-1.09%
922	-3.90%	0.95%	-1.38%
923	-0.23%	0.82%	-1.47%
924	1.00%	0.50%	-1.24%
931	1.64%	0.55%	-1.37%
932	-7.21%	2.25%	-2.41%
933	-0.59%	1.71%	-2.08%
934	1.22%	1.26%	-1.27%
941	2.79%	2.02%	-0.10%
942	-4.30%	3.71%	0.83%
943	-11.59%	0.56%	-0.58%
944	-9.20%	0.04%	-0.74%
951	-8.45%	0.03%	-0.70%
952	1.85%	0.00%	-0.80%

Impacto do Acréscimo de 1% em cada Variável Explicativa

Trimestre	Renda	Inflação	Juros.
953	-5.94%	0.01%	-0.75%
954	-7.75%	0.01%	-0.55%
961	-10.94%	0.02%	-0.37%
962	2.83%	-0.02%	-0.35%
963	2.99%	-0.01%	-0.33%
964	0.89%	0.00%	-0.32%
971	-5.04%	0.02%	-0.29%
972	2.82%	-0.01%	-0.24%

Pobreza e desnutrição de crianças no Brasil: diferenças regionais e entre áreas urbanas e rurais

Rodolfo Hoffmann[§]

RESUMO

Dados da Pesquisa Nacional sobre Saúde e Nutrição (PNSN), coletados em 1989, são utilizados para analisar a relação entre renda familiar *per capita* e o escore Z de altura para idade de crianças com menos de 5 anos. A análise dos dados individuais mostra que mesmo depois de descontado o efeito da renda há importantes diferenças entre as regiões e entre as áreas urbanas e rurais do Brasil. Em seguida é analisada a relação entre a proporção de crianças com aquele escore Z abaixo de -2 e as medidas de pobreza absoluta em 33 áreas do País. Verifica-se que as medidas de pobreza calculadas utilizando uma única linha de pobreza explicam as diferenças entre áreas urbanas e rurais na prevalência de desnutrição crônica de crianças. Conclui-se que o uso de uma mesma linha de pobreza para áreas urbanas e rurais não leva a superestimar a pobreza rural. Mesmo depois de descontado o efeito da pobreza, as regiões Norte e Nordeste apresentam prevalência de desnutrição crônica entre crianças maior do que nas demais regiões do País.

Palavras-chave: pobreza, desnutrição crônica de crianças, diferenças regionais, contraste urbano-rural.

ABSTRACT

Data from the 1989 Brazilian National Health and Nutrition Survey are used to analyze the relation between *per capita* family income and the height for age Z-score (HAZ) for less than 5 years old children. Using individual data it is shown that even after considering the effect of income, there are important differences among regions and between rural and urban areas. Absolute poverty measures and the proportion of children with HAZ below -2 are computed for each of 33 areas of Brazil. A regression analysis shows that poverty measures computed using a constant poverty line explain the differences between rural and urban areas in the prevalence of children malnutrition. This result indicates that the use of the same poverty line for urban and rural areas does not determine an overestimation of rural poverty. Even after considering the effect of poverty, the prevalence of malnutrition among children in the North and Northeast regions is greater than in the other Brazilian regions.

Key words: poverty, children malnutrition, regional differences in Brazil, the urban-rural contrast.

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1 Introdução

Há várias maneiras de medir o grau de pobreza com base em dados sobre a renda das pessoas ou famílias. Estabelecida uma linha de pobreza, podemos utilizar a proporção de pobres (*H*), que é uma medida da extensão da pobreza, e também podemos calcular várias medidas que levam em consideração tanto a extensão como a intensidade da pobreza, cabendo destacar o índice de Sen (1976) e o índice de Foster, Greer e Thorbecke (1984), que serão indicados por P e φ, respectivamente. Também é possível medir a pobreza por meio de suas manifestações ou conseqüências, como as condições inadequadas de habitação, a mortalidade infantil, a desnutrição etc. O crescimento de uma criança, especialmente nos primeiros anos de vida, é muito sensível aos efeitos da desnutrição causada por alimentação inadequada e/ou problemas de saúde, geralmente associados à pobreza.

Dada a estatura de uma criança, podemos calcular o valor da correspondente variável reduzida (Z), com base na distribuição padrão para crianças do mesmo sexo e com a mesma idade. O padrão mais utilizado e recomendado pela Organização Mundial da Saúde é o NCHS (National Center for Health Statistics, dos EUA). Uma criança com Z de estatura para idade abaixo de -2 é, obviamente, uma criança com estatura muito baixa. Mas isso não significa, necessariamente, que ela seja desnutrida, pois ela pode ser pequena por razões genéticas. Entretanto, sabe-se que, em uma população com boas condições de saúde e alimentação, a probabilidade de observar $Z < -2$ é, aproximadamente, 2,3%.[1] Assim, se em determinado grupo de crianças for constatado que a proporção de crianças com Z de altura para idade inferior a -2 é substancialmente superior a 2,3%, isso é um indicador de que as condições de saúde e alimentação são inadequadas, o que está quase sempre associado à pobreza da população analisada. Como exemplo cabe mencionar um censo antropométrico das crianças dos Centro Educacionais e Creches da Prefeitura Municipal de Piracicaba, realizado em 1994, em que foram examinadas 2099 crianças com até 7 anos. Esses Centros Educacionais e Creches atendem a uma população relativamente pobre da cidade de Piracicaba. Verificou-se que 5,1% das crianças tinham Z de altura para idade inferior a -2, com essa proporção superando 10% nas creches dos bairros mais pobres.(Silva e Sturion, 1995)

Neste trabalho vamos utilizar os dados da Pesquisa Nacional sobre Saúde e Nutrição (PNSN), realizada de junho a setembro de 1989 pelo INAN, IPEA e IBGE. O objetivo é relacionar a desnutrição infantil com a renda e, particularmente, com medidas de pobreza

1 Que é probabilidade de uma variável normal assumir valor menor que dois desvios padrões abaixo da média. Sobre o uso de medidas antropométricas para avaliar desnutrição em crianças, ver WHO (1995) e Dean *et alii* (1990).

baseadas nos dados sobre renda, discutindo as diferenças regionais e setoriais (urbano/rural). Cabe ressaltar que a distribuição da estatura das crianças brasileiras de domicílios com rendimento *per capita* acima do terceiro quartil (os 25% mais ricos) é muito semelhante ao padrão do NCHS.(Monteiro *et alii*, 1992)[2]

Um problema fundamental do cálculo das medidas de pobreza baseadas em dados sobre renda é a determinação da linha de pobreza. Rocha (1993) enfatiza que, no Brasil, o custo associado à satisfação de necessidades básicas (a linha de pobreza) varia muito entre regiões e entre as áreas rurais, urbanas e metropolitanas; assinala que a linha de pobreza é mais elevada nas áreas metropolitanas e mais baixa nas áreas rurais, concluindo que a utilização de uma linha de pobreza única leva a "*subestimar o número de pobres urbanos em relação aos rurais, assim como os metropolitanos em relação aos urbanos.*"(Rocha, 1993, p. 100)

Ao determinar a linha de pobreza é usual considerar, essencialmente, o custo monetário de uma cesta de alimentos básicos. Esse custo certamente é mais baixo nas áreas rurais do que nas urbanas, mas não é tão óbvio que a utilização de uma linha de pobreza única leve a subestimar a pobreza urbana em relação à rural, pois há outros aspectos desfavoráveis ao rural em comparação com o urbano.

O alimento comprado é mais caro na área urbana do que na área rural, mas certamente é mais fácil, na área urbana, obter alimentos de serviços de assistência social ou de caridade. Os serviços de saúde para os pobres da cidade são ruins, mas em muitas áreas rurais eles simplesmente não existem. O acesso a uma escola pública (onde a criança pode inclusive receber a merenda) também é mais difícil para a criança na área rural.

Um dos objetivos desse trabalho é testar a hipótese de que o uso de uma linha de pobreza única leva a superestimar a pobreza rural em comparação com a urbana. O método utilizado foi inspirado no trabalho de Monteiro (1992), no qual ele analisa a prevalência de retardo de crescimento na infância (porcentagem de crianças de menos de 5 anos com Z de altura para idade inferior a -2) em diferentes estados brasileiros, com base na PNSN, e conclui que "*o emprego da renda familiar como mensurador preditivo da pobreza absoluta tende a subestimar as reais diferenças regionais existentes no Brasil quanto ao atendimento das necessidades da população.*"(Monteiro, 1992, p. 6. Ver, também, Monteiro, 1995a e 1995b)

2 Comparações internacionais mostram que as diferenças de estatura associadas com as condições de vida são muito maiores do que aquelas que podem ser atribuídas a fatores étnicos (ver Habicht *et alii*, 1974).

2 Análise dos dados individuais

A partir da fita de dados da PNSN foi criado um arquivo com o valor do Z de altura para idade, a renda domiciliar *per capita*, a situação do domicílio (urbana ou rural) e a unidade da Federação onde se localiza, para 7077 crianças com menos de 5 anos de idade. Na fita da PNSN a renda domiciliar *per capita* é dada em dólares, informando-se que esse valor foi obtido a partir dos questionários considerando a taxa de câmbio do dia da entrevista. Para cada criança é fornecido, também, um **fator de expansão**, que indica o número de crianças da população correspondente a cada criança da amostra da PNSN. Assim, verifica-se que aquelas 7077 crianças da amostra correspondem a 15.450.830 crianças na população. Cabe lembrar que a PNSN não abrangeu a área rural da região Norte.

Para captar as diferenças regionais na desnutrição das crianças serão utilizadas 4 variáveis binárias: X_h, com h = 1, 2, 3 e 4 para as regiões Norte, Nordeste, Sul e Centro-Oeste, respectivamente, definindo-se $X_h = 1$ para a h-ésima região e $X_h = 0$ para as demais regiões; note-se que a região Sudeste fica como base das comparações. Para captar o efeito da situação do domicílio define-se a variável binária S, com $S = 0$ para domicílios urbanos e $S = 1$ para domicílios rurais. Definindo Y como o logaritmo do rendimento domiciliar *per capita*, o modelo de regressão fica

$$Z = \alpha + \beta Y + \sum_{h=1}^{4} \gamma_h X_h + \delta S + \sum_{h=2}^{4} \theta_h X_h S + u$$

onde u representa um erro aleatório com as propriedades usuais. Note-se que o modelo inclui a interação entre efeitos regionais e a situação do domicílio; há apenas 3 parâmetros referentes à interação porque na região Norte há observações apenas para a área urbana.[3] Os parâmetros foram estimados com base nas 7077 observações da amostra, pelo método dos mínimos quadrados, com ponderação pelo fator de expansão fornecido na fita da PNSN.

Graças ao grande número de observações, embora o coeficiente de determinação da regressão ajustada seja apenas 16,30%, o respectivo teste F é igual a 152,96, indicando que há efeitos muito significativos das variáveis explanatórias consideradas.

A equação ajustada (teste t entre parênteses, abaixo do coeficiente) é:

3 Os trabalhos de Kassouf (1993 e 1994) analisam a influência de várias outras variáveis sobre a estatura das crianças, como a escolaridade da mãe e do pai, existência de água encanada e eletricidade na residência, período de amamentação da criança etc.

$$Z = -1,38082 + \underset{(20,70^*)}{0,30873\,Y} - \underset{(-8,87^*)}{0,73775\,X_1} - \underset{(-10,87^*)}{0,51579\,X_2} - \underset{(-3,02^*)}{0,17134\,X_3}$$

$$\underset{(-0,64)}{-0,04522\,X_4} - \underset{(-3,40^*)}{0,22905\,S} \underset{(-0,23)}{-0,01959\,X_2S} + \underset{(3,01^*)}{0,31982\,X_3S} + \underset{(1,19)}{0,17356\,X_4S}$$

Os valores de *t* significativos ao nível de 1% são assinalados com um asterisco. Como era esperado, verifica-se que há uma relação positiva e estatisticamente significativa entre a estatura das crianças e a renda domiciliar *per capita*. Os coeficientes negativos e estatisticamente significativos de X_1 e X_2 mostram que, mesmo depois de descontado o efeito da renda, a estatura das crianças tende a ser menor nas regiões Norte e Nordeste urbanas do que no Sudeste urbano. Isso está certamente associado ao fato de as regiões Norte e Nordeste serem mais deficientes em serviços públicos como abastecimento de água, saneamento, escola pública e assistência à saúde.(Monteiro, 1992, e Monteiro *et alii*, 1992) O coeficiente de X_3 (a binária para a região Sul), embora tenha valor absoluto substancialmente menor do que os coeficientes de X_1 e X_2, também é negativo e estatisticamente significativo, indicando que, depois de descontado o efeito da renda, a estatura das crianças tende a ser menor no Sul urbano do que no Sudeste urbano.

O coeficiente negativo e estatisticamente significativo de *S* mostra que, na região Sudeste, já descontado o efeito da renda, a estatura das crianças é menor na área rural do que na área urbana.

Como o coeficiente da interação entre X_2 e *S* também é negativo, a desvantagem da área rural é ainda maior no Nordeste. A estimativa de $\delta + \theta_2$ é -0,24864 e o respectivo valor de *t* é -4,63*

Para a região Sul o coeficiente da interação é positivo e supera, em valor absoluto, o coeficiente de *S*. A estimativa de $\delta + \theta_3$ é 0,09077, com $t = 1,08$, indicando que nessa região a estatura das crianças tende a ser maior na área rural do que na urbana, embora a diferença não seja estatisticamente significativa. O coeficiente da interação entre X_3 e *S* positivo e significativo está, provavelmente, associado à grande importância da produção familiar na agricultura do Sul, que deve contribuir para um melhor estado nutricional das crianças. Mas é importante ressaltar que a renda da família do pequeno produtor rural certamente está subestimada, por não incluir o valor da produção para autoconsumo, e isso faz com que aquele coeficiente de interação seja superestimado.

A estimativa de $\delta + \theta_4$ é 0,05549, com $t = -0,42$, indicando que na região Centro-Oeste praticamente não há diferença entre áreas rurais e urbanas no que se refere à estatura das crianças, depois de descontado o efeito da renda.

Vejamos, finalmente, as diferenças entre as áreas rurais das regiões Sudeste, Nordeste, Sul e Centro-Oeste. A estimativa de $\gamma_2 + \theta_2$ é 0,53538 e o respectivo valor de *t* é -7.44*

mostrando a grande desvantagem do Nordeste rural em comparação com o Sudeste rural, mesmo depois de descontado o efeito da renda *per capita*

A estimativa de $\gamma_3 + \theta_3$ é 0,14848, com $t = 1,65$, significativo ao nível de 10%, indicando que a estatura das crianças no Sul rural é maior do que no Sudeste rural. É importante lembrar, aqui, os comentários já feitos sobre a estimativa de θ_3.

A estimativa de $\gamma_4 + \theta_4$ é 0,12834, com $t = 1,00$, indicando que não há diferença significativa na estatura das crianças do Centro-Oeste rural e do Sudeste rural, depois de descontado o efeito das diferenças de renda *per capita*.

3 Desnutrição infantil e medidas de pobreza

Nesta seção vamos relacionar a proporção de crianças com Z de altura para idade inferior a -2 com medidas de pobreza obtidas a partir dos dados sobre renda, distinguindo a situação do domicílio e as unidades da Federação. Para obter as medidas de pobreza foram utilizados todos os domicílios da amostra da PNSN com informações sobre o rendimento domiciliar *per capita*: amostra de 14026 domicílios, que corresponde a uma população de 141,55 milhões de pessoas. Para calcular as medidas de pobreza as pessoas são ordenadas de acordo com seu rendimento domiciliar *per capita*. Considerou-se uma linha de pobreza única, igual a 25 dólares *per capita*. A escolha desse valor é bastante arbitrária, cabendo assinalar que a estabilidade dos resultados foi verificada refazendo os cálculos para uma linha de pobreza substancialmente mais baixa, como se verá adiante.

Algumas unidades da Federação foram agrupadas, tendo em vista evitar uma unidade de análise com número muito pequeno de observações.[4] Mesmo assim, a Tabela 1 mostra que há 3 das 33 unidades de análise onde o número de domicílios na amostra é inferior a 100. O tamanho da amostra é ainda mais reduzido quando se trata de calcular a proporção de crianças cuja estatura está mais de dois desvios padrões abaixo do valor esperado. A Tabela 2 mostra que para a área rural do Rio de Janeiro e Espírito Santo a amostra da PNSN inclui apenas 26 crianças com menos de 5 anos. Isso não chega a ser uma limitação séria para este trabalho porque não será feita nenhuma análise estatística separada para cada unidade. Serão feitas análises de regressão considerando sempre o conjunto das 33 observações (área urbana de 18 unidades geográficas e área rural de 15 unidades geográficas).

A Tabela 1 mostra o número de pessoas em cada uma das 33 unidades de análise, o seu rendimento mediano e três medidas de pobreza, sempre levando em consideração o **fator de expansão** associado a cada domicílio. As medidas de pobreza consideradas são: a proporção de pobres (H), o índice de pobreza de Sen (P) e o índice de Foster, Greer e Thorbecke (φ), todas calculadas adotando-se uma linha de pobreza de 25 dólares *per capita*.

4 Agregação semelhante foi feita por Monteiro (1992).

Tabela 1
Número de Domicílios na Amostra, Número de Pessoas na População, Rendimento Mediano Per Capita e Medidas de Pobreza, por Unidade da Federação e Setor, de Acordo com a PNSN

Unidade da Fed. e situação do domicílio[1]		Número de domicílios[2]	Nº de pessoas (1000)[3]	Rendimento mediano[4]	Medidas de Pobreza[5]		
					H	*P*	φ
AM+RO+AC	U	833	2041	81,47	0,0976	0,0462	0,0167
PA+AP	U	826	2730	35,85	0,3198	0,1520	0,0544
MA+PI	U	82	1667	15,94	0,6298	0,4702	0,2695
	R	247	2715	11,63	0,8369	0,5820	0,3117
CE	U	122	2052	24,00	0,5394	0,3219	0,1444
	R	315	3684	12,36	0,8300	0,5953	0,3258
RN+PB	U	317	4034	33,38	0,4051	0,2373	0,1045
	R	138	1594	10,13	0,9242	0,6546	0,3644
PE	U	405	5321	30,00	0,4350	0,2584	0,1158
	R	92	1087	15,73	0,7634	0,4985	0,2454
AL+SE	U	222	3026	33,95	0,3457	0,2101	0,0959
	R	190	2122	14,79	0,7968	0,4923	0,2315
BA	U	494	6943	28,07	0,4482	0,2468	0,1025
	R	525	5806	16,46	0,7054	0,4620	0,2283
MG	U	337	13439	61,56	0,1760	0,1037	0,0463
	R	978	5399	25,96	0,4836	0,2657	0,1097
ES+RJ	U	559	18363	59,62	0,1559	0,0757	0,0284
	R	88	542	30,57	0,4564	0,2408	0,0961
SP	U	739	24028	87,49	0,0503	0,0273	0,0112
	R	492	2896	35,69	0,3001	0,1537	0,0597
PR	U	534	5079	63,52	0,1348	0,0689	0,0266
	R	624	3247	24,77	0,5091	0,2872	0,1218
SC	U	263	2537	82,69	0,1354	0,0662	0,0250
	R	332	1558	35,69	0,2961	0,1423	0,0523
RS	U	842	7542	71,88	0,1100	0,0510	0,0183
	R	558	2492	37,64	0,3450	0,1843	0,0742
MS	U	248	1159	64,67	0,1238	0,0492	0,0149
	R	306	464	33,68	0,3337	0,1483	0,0505
MT	U	141	658	95,57	0,0997	0,0565	0,0244
	R	261	449	29,68	0,4023	0,2357	0,1041
GO	U	799	3819	44,97	0,2355	0,1132	0,0417
	R	721	1277	28,14	0,4437	0,2489	0,1051
DF	U	396	1783	85,87	0,0950	0,0527	0,0223

(1) Situação do domicílio: urbana (U) ou rural (R).

(2) Número de domicílios na amostra da PNSN.

(3) Número de pessoas na população (expansão da amostra).

(4) Rendimento mediano, em dólares *per capita*.

(5) Proporção de pessoas pobres (*H*), índice de pobreza de Sen (*P*) e índice de Foster, Greer e Thorbecke (φ), adotando uma linha de pobreza de 25 dólares *per capita*.

Para o Brasil como um todo (excluindo a área rural da região Norte) trata-se de uma amostra de 14026 domicílios com informação sobre o rendimento *per capita*, correspondendo a uma população de 141555 mil pessoas, com $H = 0{,}2962$, $P = 0{,}1778$ e $\varphi = 0{,}0801$.

A Tabela 2 mostra, para as mesmas unidades de análise, o número e a porcentagem de crianças com menos de 5 anos cuja estatura está mais de dois desvios padrões abaixo do valor esperado no padrão do NCHS. São utilizadas informações sobre 7314 crianças da amostra da PNSN para as quais se dispõe do valor de Z de altura para idade, correspondendo a 15948 mil crianças na população.[5]

Seja D a proporção de crianças com Z de altura para idade inferior a -2 entre as crianças com menos de 5 anos de idade em cada uma das 33 unidades de análise. Essa variável é um indicador da prevalência de desnutrição crônica entre crianças. A rigor o valor de D não deve ser usado diretamente como variável dependente em uma análise de regressão, pois se trata de uma proporção, com variação limitada ao intervalo de zero a um.[6] Foi, então, utilizado o respectivo lógite:

$$g(D) = ln\frac{D}{1-D}$$

Note-se que $g(D)$ varia de $-\infty$ a $+\infty$, com $g(D) = 0$ quando $D = 0{,}5$. Como as medidas de pobreza absoluta (H, P ou φ) também variam entre zero e um, parece razoável utilizar a mesma transformação. Assim, em lugar de H, por exemplo, utiliza-se:

$$g(H) = ln\frac{H}{1-H}$$

Ao ajustar os modelos de lógite, procurando explicar as variações na prevalência de desnutrição entre crianças (D) em função da pobreza, foram obtidos resultados substancialmente melhores quando se utilizou, como variável explanatória, o lógite da medida de pobreza, e não a própria medida de pobreza.

Os modelos de lógite foram ajustados pelo método da máxima verossimilhança, ponderando cada uma das 33 observações pela respectiva população de crianças com menos de 5 anos de idade.

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5 O número de crianças é menor na seção 2 porque lá foi necessário excluir aquelas sem declaração de renda domiciliar *per capita* ou com valor dessa variável igual a zero.

6 Regressões lineares múltiplas com D como variável dependente foram utilizadas na versão anterior deste trabalho.(Hoffmann, 1995b) É interessante notar que não houve nenhuma mudança qualitativamente importante nos resultados com o uso do modelo de lógite.

Tabela 2
Número de Crianças de Menos de 5 Anos na Amostra, Número de Crianças na População e Porcentagem de Crianças com Estatura Muito Baixa , por Unidade da Federação e Setor, de Acordo com a PNSN

Unidade da Fed. e situação do domicílio[2]		Número na amostra[3]	Crianças na população	Crianças com estatura Muito baixa	
				Número	Proporção
AM+RO+AC	U	430	223885	29823	0,1332
PA+AP	U	574	380427	110817	0,2913
MA+PI	U	55	218216	79535	0,3645
	R	237	502200	173926	0,3463
CE	U	79	307541	71728	0,2332
	R	252	603927	187251	0,3101
RN+PB	U	146	449715	114827	0,2553
	R	104	245373	52122	0,2124
PE	U	184	620421	169597	0,2734
	R	72	175656	67075	0,3819
AL+SE	U	110	362711	90275	0,2489
	R	170	350816	141164	0,4024
BA	U	268	832655	147194	0,1768
	R	399	902643	243071	0,2693
MG	U	136	1290303	91072	0,0706
	R	522	658472	103193	0,1567
ES+RJ	U	200	1827448	179138	0,0980
	R	26	36888	2556	0,0693
SP	U	247	2086335	109513	0,0525
	R	257	354814	31346	0,0883
PR	U	202	480159	41212	0,0858
	R	346	388900	58192	0,1496
SC	U	114	259838	9433	0,0363
	R	162	170759	13084	0,0766
RS	U	301	746348	55339	0,0741
	R	253	275417	28509	0,1035
MS	U	118	138982	7844	0,0564
	R	157	66673	6021	0,0903
MT	U	92	119865	10543	0,0880
	R	147	62440	8073	0,1293
GO	U	347	400367	38339	0,0958
	R	396	181436	17792	0,0981
DF	U	211	226438	9735	0,0430

(1) Crianças com menos de 5 anos cuja estatura está mais de dois desvios padrões abaixo da média esperada para sua idade (Z de altura para idade abaixo de -2).

(2) Situação do domicílio: urbana (U) ou rural (R).

(3) Excluindo crianças sem informação para o valor de Z de altura para idade.

Foram ajustados modelos onde as variáveis explanatórias incluíam o lógite de uma medida de pobreza (H, P ou φ) e variáveis binárias para captar as diferenças entre as 5 grandes regiões do País, entre rural e urbano e também as interações, como no modelo utilizado na seção anterior. Verificou-se que: (a) nenhum dos coeficientes para interação entre região e situação do domicílio era estatisticamente diferente de zero; (b) também não eram significativos os coeficientes das variáveis binárias destinadas a captar diferenças entre Sul ou Centro-Oeste e Sudeste; (c) os coeficientes das variáveis binárias destinadas a captar os efeitos das regiões Norte e Nordeste em comparação com o Sudeste eram positivos e estatisticamente significativos em pelo menos uma das equações ajustadas; (d) o coeficiente da variável binária destinada a captar diferenças devidas à situação do domicílio (rural ou urbano) nunca se mostrou estatisticamente diferente de zero.

Tendo em vista esses resultados, passamos a considerar modelos de lógite mais simples, onde as variáveis explanatórias são:

a) o lógite de uma medida de pobreza (H, P ou φ);

b) uma variável binária N que assume valor 1 para as unidades da Região Norte e valor zero para as demais unidades;

c) uma variável binária E que assume valor 1 para os estados do Nordeste e valor zero para as demais unidades; e

d) uma variável binária S para distinguir a situação do domicílio ($S = 1$ para domicílios rurais de $S = 0$ para domícilios urbanos).

Apesar de o respectivo coeficiente não ter se revelado significativo nas equações ajustadas inicialmente, a variável S é mantida porque um dos objetivos centrais deste trabalho é discutir as diferenças entre rural e urbano no que se refere ao grau de pobreza e à prevalência de desnutrição infantil.

Os resultados obtidos são apresentados na Tabela 3. O coeficiente de S não é estatisticamente diferente de zero em nenhuma das três equações ajustadas. Note-se que

a estimativa do desvio padrão é sempre maior do que o coeficiente dessa variável binária. Esses resultados indicam que, depois de descontado o efeito de uma medida de pobreza calculada com base em uma linha de pobreza única, não há diferença entre rural e urbano no que se refere à prevalência de desnutrição crônica entre crianças. Se a utilização de uma linha de pobreza única levasse a superestimar substancialmente a pobreza rural teríamos, no ajustamento do modelo, um efeito "excessivo" da medida de pobreza nas áreas rurais, que levaria a um coeficiente estatisticamente negativo para *S*. Como nos modelos ajustados o coeficiente de S não é estatisticamente diferente de zero, conclui-se que, na determinação do estado nutricional das crianças, as possíveis vantagens das áreas rurais associadas com o menor custo dos alimentos são anuladas pelas desvantagens mencionadas na introdução.

A análise desenvolvida nesta seção foi repetida adotando-se uma linha de pobreza de 14 dólares *per capita*. É óbvio que as medidas de pobreza, nesse caso, são substancialmente mais baixas, obtendo-se, para o Brasil, $H = 0{,}1556$, $P = 0{,}0831$ e $\varphi = 0{,}0336$. Mas os resultados do ajustamento do modelo de lógite foram muito semelhantes. Em nenhuma das equações estimadas houve indicação no sentido de que o uso de uma linha de pobreza única levasse a superestimar a pobreza rural.

Ainda foi feita uma outra experiência para verificar se é apropriado utilizar para a área urbana linhas de pobreza substancialmente mais altas do que para a área rural:[7] os modelos de lógite também foram ajustados considerando medidas de pobreza (H, P ou φ) calculadas com uma linha de pobreza de 14 dólares *per capita* para a área rural e 25 dólares *per capita* para a área urbana. Agora o coeficiente de *S* é sempre positivo e estatisticamente significativo, indicando que, depois de descontado o efeito da pobreza assim medida, a desnutrição infantil crônica é mais alta nas áreas rurais.

7 Rocha (1995) utilizou linhas de pobreza distintas para áreas metropolitanas, áreas urbanas e áreas rurais de cada região do País. Verifica-se que, dentro de cada região, as médias das linhas de pobreza metropolitanas e urbanas são cerca de duas vezes maiores do que a linha de pobreza para a área rural.

Tabela 3

Resultados do Ajustamento do Modelo de Lógite da Proporção de Crianças com Menos de 5 Anos de Idade que têm Altura Muito Baixa (Escore Z de Altura para Idade Abaixo de -2) em 33 Áreas do Brasil, em 1989, Conforme Dados da PNSN

Variável explanatória ou estatística	Coeficiente[1] (desvio padrão) e estatísticas para o modelo		
	I	II	III
Intercepto	–1,701*	–1,165*	–0,634
	(0,148)	(0,225)	(0,315)
$g(H)$ [2]	0,427*	-	
	(0,070)		
$g(P)$ [2]		0,516*	
		(0,083)	
$g(\varphi)$ [2]	-		0,523*
			(0,086)
S	–0,114	–0,123	–0,087
	(0,135)	(0,133)	(0,130)
N	1,019*	1,059*	1,125*
	(0,125)	(0,121)	(0,117)
E	0,409*	0,360	0,366*
	(0,133)	(0,137)	(0,138)
Logaritmo da Verossimilhança	–3207	–3206	–3207
Qui-quadrado[3]	37,8	35,7	37,8

(1) São assinaladas com um asterisco as estimativas estatisticamente diferentes de zero ao nível de significância de 1%.

(2) Lógite de medida de pobreza calculada adotando uma linha de pobreza de 25 dólares *per capita*.

(3) Qui-quadrado de Pearson para a aderência do modelo, com 28 graus de liberdade.

A Tabela 4 mostra que, dividindo tanto a população rural como a urbana em 5 estratos de renda *per capita*, a proporção de crianças muito baixas na área rural é muito semelhante à proporção de crianças muito baixas na área urbana, quando a comparação é feita dentro de cada um dos quatro primeiros estratos. Não cabe dar muita importância à diferença observada

no estrato mais rico porque nesse caso a amostra para a área rural é pequena. Para os dois estratos mais pobres (25 dólares *per capita* ou menos) a proporção é até mesmo um pouco mais alta na área rural, confirmando que, para os pobres, as vantagens da área rural associadas com o menor custo dos alimentos são anuladas por diversas desvantagens, incluindo a maior dificuldade de acesso a serviços de saúde.[8] Cabe lembrar, ainda, que o rendimento na área rural está subestimado, pois os dados não levam em consideração o valor da produção para autoconsumo, o que é especialmente importante nas regiões onde é comum a pequena produção familiar.

Tabela 4
Distribuição das Crianças com Menos de 5 Anos de Idade em 5 Estratos de Renda Domiciliar Per Capita, e Porcentagem dessas Crianças com Estatura Muito Baixa (Z de Altura para Idade Inferior a -2) Conforme Dados da PNSN. Brasil, 1989

Estratos de renda *per capita*, em dólares	Número de crianças na amostra		Nº de crianças na pop. (1000)		% de crianças com $Z < -2$	
	Urbano	Rural	Urbano	Rural	Urbano	Rural
14 ou menos	625	1460	1902	2481	29,6	30,3
Mais de 14 a 25	552	903	1572	1203	22,5	23,7
Mais de 25 a 50	981	723	2696	865	9,6	9,1
Mais de 50 a 100	829	285	2523	293	4,8	4,9
Mais de 100	827	129	2279	134	3,0	1,2
Total	3814	3500	10972	4976	12,4	22,8

Considerando os valores de H, P e φ para uma linha de pobreza de 25 dólares *per capita* e eliminando a variável S, o ajustamento do modelo de lógite produziu os resultados apresentados na Tabela 5.

8 Cabe assinalar, entretanto, que Wood e Carvalho (1994, p. 113-117) comparam a expectativa de vida ao nascer nas áreas rurais e urbanas de várias regiões do País, para 4 estratos de renda familiar, em 1970, e observam que para o estrato mais pobre a expectativa de vida na área rural é sistematicamente maior do que na área urbana.

Tabela 5

Resultados do Ajustamento do Modelo de Lógite da Proporção de Crianças com Menos de 5 Anos de Idade que têm Altura Muito Baixa (Escore Z de Altura para Idade Abaixo de) em 33 Áreas do Brasil, Excluindo a Variável Binária para Situação do Domicílio (S)

Variável explanatória ou estatística	Coeficiente[1] (desvio padrão) e estatísticas para o modelo		
	I	II	III
Intercepto	−1,812*	−1,351*	−0,819*
	(0,067)	(0,101)	(0,148)
$g(H)$[2]	0,377*		
	(0,037)		
$g(P)$[2]		0,451*	
		(0,043)	
$g(\varphi)$[2]	-		0,475*
			(0,046)
N	1,075*	1,114*	1,159*
	(0,106)	(0,106)	(0,106)
E*	0,484*	0,446	0,428*
	(0,100)	(0,101)	(0,102)
Logaritmo da Verossimilhança	−3208	−3206	−3207
Qui-quadrado[3]	38,7	36,6	38,3

Ver notas da Tabela 3.

O fato de os coeficientes de N e E serem positivos e estatisticamente significativos nas três equações mostra que, mesmo depois de considerado o efeito de uma medida de pobreza (H, **P** ou φ), a desnutrição das crianças é maior nas regiões Norte e Nordeste. Uma das causas desse fenômeno é, certamente, o fato de essas regiões serem mais deficientes em serviços públicos como abastecimento de água, saneamento, escolas e assistência à saúde.(Monteiro, 1992, e Monteiro *et alii*, 1992) Será que se justifica, então, utilizar uma linha de pobreza mais baixa no Nordeste, tendo em vista o custo de uma cesta de alimentos, sem levar em

consideração outros fatores que são agravantes das condições de vida da população pobre dessa região?[9]

Seria interessante repetir a análise feita nesse trabalho considerando outros indicadores (ou manifestações) de pobreza como, por exemplo, a mortalidade infantil.

É claro que este trabalho não resolve o problema da determinação da linha de pobreza apenas ressaltando as limitações associadas à sua determinação com base apenas no custo de uma cesta de alimentos. Os resultados obtidos sugerem que esse procedimento leva a subestimar a pobreza rural em comparação com a urbana. Uma comparação mais rigorosa entre pobreza nas áreas urbanas e nas áreas rurais teria que levar em consideração, ainda, o valor da produção para autoconsumo.

4 Conclusão

Sabe-se que, devido à relativa fragilidade das crianças, o seu crescimento é um bom indicador da existência ou não de condições satisfatórias de saúde e nutrição em determinada população. A pobreza corresponde a situações impróprias de saúde e nutrição que, por sua vez, fazem com que grande proporção das crianças sejam muito baixas para sua idade. Métodos já consagrados em estudos de saúde pública permitem transformar a altura de uma criança em uma variável normal reduzida, o escore Z de altura para idade.

Utilizando dados da PNSN (1989), foi ajustada uma equação de regressão mostrando como a relação entre o escore Z de altura para idade das crianças e a renda domiciliar *per capita* é afetada por diferenças regionais e entre áreas urbanas e rurais. Verifica-se que, mesmo depois de descontado o efeito da renda, a estatura das crianças tende a ser menor no Norte e no Nordeste (tanto urbano como rural). Uma das razões para isso é certamente a maior deficiência de serviços públicos nessas regiões. No Sudeste e no Nordeste, mesmo

9 Fishlow (1972), ao analisar os dados do Censo Demográfico de 1960, adota, para as áreas urbanas, duas linhas de pobreza: uma para o Nordeste e outra, 15% mais elevada, para todas as outras regiões. Rocha (1988 e 1991) utiliza linhas de pobreza diferentes para cada uma das 9 regiões metropolitanas analisadas, com base no custo de cestas de alimentos; verifica-se que não há diferenças sistemáticas entre as grandes regiões, sendo que em 1989, considerando valores *per capita*, as duas linhas de pobreza mais baixas são as de Fortaleza e Curitiba, e as duas mais altas são as de São Paulo e Belém.(Rocha, 1991, p. 452) Cabe ressaltar que, além de determinar a proporção de pobres, Rocha também analisa várias características das condições de vida da população pobre, incluindo o acesso a diversos serviços públicos, constatando a desvantagem das metrópoles do Norte e do Nordeste sob esse aspecto. Ver, também, as linhas de pobreza para 1990 em Rocha (1995, p. 27).

depois de descontado o efeito da renda, verifica-se que as crianças das áreas rurais são estatisticamente mais baixas que as das áreas urbanas. Isso não é verdade para as regiões Sul e Centro-Oeste, onde não há diferença significativa de estatura entre crianças de áreas urbanas e áreas rurais, depois de considerado o efeito da renda domiciliar *per capita*.

A análise da relação entre proporção de crianças muito baixas (com escore *Z* de altura para idade menor do que -2) e diversas medidas de pobreza absoluta mostra que a utilização de uma mesma linha de pobreza não leva a superestimar a pobreza rural, se admitirmos que a proporção de crianças muito baixas reflete apropriadamente o grau de pobreza. Verifica-se que a proporção de crianças muito baixas é bastante semelhante em áreas urbanas e rurais quando a comparação é feita dentro dos mesmos estratos de rendimento domiciliar *per capita*.

No que se refere às diferenças regionais, verifica-se que a proporção de crianças com escore *Z* de altura para idade menor do que -2 tende a ser maior nas regiões Norte e Nordeste, mesmo depois de considerado o efeito de medidas de pobreza calculadas considerando uma mesma linha de pobreza para todo o território nacional.

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Total factor productivity growth in Brazilian agriculture and the role of agricultural research

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RESUMO

Este trabalho apresenta estimativas da eficácia do Sistema Nacional de Pesquisa em Agricultura (SNPA) e empresas de extensão rural (EMATERs) no Brasil. O estudo está baseado em análise das variações na Produtividade Total dos Fatores (PTF) entre os anos censitários de 1970, 1975, 1980 e 1985, com estimativas individuais para agricultura e pecuária. Foram incorporados "spillovers" regionais (por exemplo, a região dos Cerrados) e geográficos de dois tipos: (1) de pesquisas do setor industrial privado sobre a agricultura e (2) da região onde ocorreu a pesquisa para outras regiões. Um exercício de contabilidade do crescimento indicou que as principais contribuições ao crescimento tiveram origem nas pesquisas da EMBRAPA, respondendo em média por 9% do crescimento; P&D industriais apresentam contribuição similar; pesquisas desenvolvidas em instituições estaduais contribuíram com 5% do crescimento.

Palavras-chave: produtividade de fatores, agricultura brasileira, pesquisa & desenvolvimento.

ABSTRACT

This paper reports statistical estimates of the effectiveness of the National System for agricultural research (SNPA) and rural extension enterprises (EMATERs) in Brazil. The study is based on an analysis of Total Factor Productivity (TFP) changes over the agricultural census years 1970, 1975, 1980 and 1985, with separate estimates for both crop and livestock sectors. In the analysis of the effectiveness of the research and extension programs, regional (e. g. the cerrados region) and geographic spillovers of two types are incorporated: (1) spillovers from private sector industrial research to agriculture and (2) spillovers from the region of research conduct to other regions. A growth accounting exercise indicates that the leading contribution to growth comes from EMBRAPA research programs, with 9% of growth in the aggregate; the industry R&D sector presents a similar contribution; state research institutions contributed 5% to growth.

Key words: Factor productivity, Brazilian agriculture, research & development.

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1 Introduction

Public sector programs are in continuous need of scrutiny for effectiveness. In the case of programs such as the research and extension programs designed to develop and diffuse improved technology to farmers, effectiveness can be measured in terms of increased farm productivity. In this paper we report statistical estimates of the effectiveness of the National System for Agricultural Research (SNPA) and rural extension enterprises (EMATERs). The SNPA encompasses both the Federal Empresa Brasilera de Pesquisa Agropecuária (EMBRAPA) system and state research units.

The EMBRAPA system has enjoyed good financial support and intellectual leadership since its establishment in the early 1970s. Early studies of the program have shown it to be effective.(Avila *et alii,* 1985; Barbosa *et alii,* 1988; Cruz *et alii,* 1982; Evenson, 1982; Evenson and Cruz, 1989a; Silva, 1984) In the late 1980s and early 1990s, heightened economic problems in Brazil have resulted in criticism of publicly funded programs.(Borges-Andrade and Horton, 1992) It is important that evaluations of these programs be made. Avila and Evenson (1996) completed a recent statistical evaluation of grain productivity in Brazil. The present study is based on an analysis of total factor productivity (TFP) changes over the agricultural census years 1970, 1975, 1980, and 1985 (the 1990 census was not undertaken). It covers both crop and livestock sectors and reports separate estimates for these sectors.

The study keeps estimates of the effectiveness of research and extension programs to guide investment decisions and to guide general policy toward the location and design of research and extension units. Trigo and Kamovitz (1992) have assessed agricultural research programs in Latin America generally and called for reform and redesign of these programs. Regional (e.g., the cerrados region) and geographic spillover issues are important to policy (see Vosti, 1991, Avila and Ayres, 1987: Cruz, 1987; and Evenson and Cruz, 1989a). This paper incorporates spillovers of two types in the analysis: (1) spillovers from private sector industrial research to agriculture and (2) spillovers from the region in which the research was conducted to other regions.

Part 2 of the paper discusses institutional features of the SNPA in Brazil. Part 3 reports indicators of change in Brazilian agriculture. Part 4 develops and reports total factor productivity change indexes for census micro-regions in Brazil. Part 5 outlines the TFP decomposition specification associating research and extension investments with TFP change. Part 6 summarizes variables and the statistical models utilized. Part 7 reports statistical estimates of investment-productivity linkages. Part 8 reports economic calculations based on these estimates.

2 Brazilian agricultural research systems

The Brazilian SNPA encompasses an intricate network of thirty-nine EMBRAPA research centers, located in different country agro-environments, developing technologies of a regional or national scope, and a large set of experimental stations and research centers in almost all of the Brazilian states. The state research institutions are designed to generate agricultural technologies adapted to the local needs (within state). The complete listing of the EMBRAPA research centers and principal state research institutions is presented in Appendix B.

Table 1 provides summary data for investment in EMBRAPA's national and regional centers. The growth in the number of researchers and their academic qualifications indicates the general strengthening of the system. Prior to the development of the EMBRAPA system, Brazil relied on the state research centers. Several of these state programs were strong (notably São Paulo and Rio Grande de Sul), but most were not. The EMBRAPA system provided Brazil with a truly national system.

Table 1
EMBRAPA: Agricultural Research Expenditures and Researchers by Academic Level, 1974-92

Year	Expenditures (US $1,000)	Number of Researchers by Academic Level			
		Bsc	Msc	PhD	Total
1974	70,197	446	385	41	872
1976	195,311	807	464	57	1,328
1978	247,921	542	702	91	1,336
1980	317,369	509	882	162	1,553
1982	402,428	403	968	226	1,597
1984	218,879	320	1,001	298	1,619
1986	283,070	274	1,046	404	1,724
1988	259,965	324	1,088	499	1,911
1990	290,528	435	1,150	561	2,146
1992	241,317	315	1,128	645	2,078

Source: EMBRAPA.

3 The Brazilian agricultural sector: some indicators

In spite of Brazil's socio-economic problems, the agricultural sector has achieved a good performance in the last two decades. Some highlights of this performance can be seen by examining the evolution of some indicators for the period 1970-85, presented in Tables 2 and 3.

Table 2
Land Utilization and Brazilian Agricultural Indicators

Specification	Agricultural Censuses Year				Five Year Rates (%)		
	1970	1975	1980	1985	1970-75	1975-80	1980-85
Area of settlements (millions ha)	294.2	323.9	364.8	376.8	1.95	2.41	0.64
Area Utilized (1,000,000 ha)	89.8	208.5	228.6	239.0	1.90	1.86	0.89
Permanent crops	8.0	8.4	10.5	9.9	0.99	4.54	-1.21
Temporary crops	26.0	31 6	38.6	42.4	3.99	4.09	1.89
Natural pastures	124.4	125.9	113.9	105.5	0.25	-1.99	-1.53
Planted pastures	29.7	39.7	60.6	74.5	5.95	8.83	4.22
Planted forests	1.7	2.9	5.0	6.7	11.55	11.86	5.93
Total of settlements (1,000)	4,924.0	4,993.3	5,159.9	5,832.6	0.28	0.66	2.48
Settlements using fertilizers (1,000)	915.8	1,111.8	1,657.8	1,751.1	3.96	8.32	1.10
Rural laborers (1,000,000)	17.6	20.3	21.2	23.5	2.96	0.79	2.15
Tractors (no.)	165.9	323.1	545.2	666.3	1.14	11.03	4.09
Cattle herd (1,000,000)	78.6	101.7	118.1	128.2	5.29	3.04	1.65

Source: IBGE, *Agricultural Censuses, Brazil* (1992).

Table 3
Evolution and Regional Profile of Brazilian Agricultural Indicators

Specification	Agricultural Censuses Year				Regionalization, 1985				
	1970	1975	1980	1985	North	North-east	South-east	South	Center-west
Land territory used (%)	34.8	38.3	43.1	44.6	17.6	60.1	80.3	85.6	53.0
Used/total area (%)	64.4	64.5	62.6	63.4	38.3	54.5	80.4	79.0	67.4
Pastures/total area (%)	81.2	79.4	76.3	75.3	87.4	70.3	72.0	56.5	88.4
Support capacity	0.51	0.61	0.68	0.71	0.43	0.63	0.84	1.16	0.61
Gini coefficient	0.838	0.850	0.853	0.854	0.79	0.86	0.76	0.74	0.83
Fertilizer used (%)	18.60	22.27	32.13	30.02	3.29	11.77	58.36	60.39	34.72
Workers= productivity	1.93	1.97	2.32	2.22	1.08	1.37	2.85	3.23	5.61
Workers/tractors ratio	106.0	62.97	38.82	35.33	207.2	249.5	19.97	15.68	14.52
Mechanization degree	204.88	123.80	90.06	78.46	223.8	342.3	56.86	50.64	81.47

Source: IBGE, *Agricultural Censuses, Brazil* (1992).

The land data items shown in Table 2 are influenced by the expansion of agricultural land area resulting from the continual advance of the agricultural frontier, mainly to the "cerrados", in the center-west region of the country, and from the introduction of more capital-intensive production techniques, especially in São Paulo and states of the south region. Table 3 presents further indicators showing the wide regional disparities in the Brazilian agricultural sector.

The use of tractors and of fertilizers are examples of the marked imbalance in the modernization process of Brazilian agriculture. In 1985, 43.2 percent of the tractors used in Brazil were concentrated in the south region, with 50.64 hectares per tractor, while in the north and northeast regions this ratio was 223.85 and 342.31 hectares per tractor, respectively. In the case of fertilizer use, the data show the same kind of regional imbalance. Fertilizers were used on only 3.29 percent of the farms of the north region, while this figure was 60.39 percent in the south region.

With regard to fertilizers, the 1980 census data show that their use then was also regionally imbalanced. In the northeast, sugarcane occupied only 6.2 percent of the cultivated area, but consumed 85 percent of the fertilizers used. In the southeast and center-west regions, coffee, sugarcane, soybeans and cotton consumed 75 percent of the fertilizer used, while occupying only 27.2 percent of the cultivated area. In the south, soybeans and wheat were employing 90 percent of the fertilizer used in the region.

4 Total factor productivity in Brazilian agriculture

TFP decomposition is perhaps the most frequently used method for estimating the impacts of agricultural research, extension, schooling and policy actions on agricultural production. Two steps are entailed in TFP decomposition. In the first, TFP indexes are computed in such a way as to isolate the "residual" containing the contributions of the programs and policies being analyzed. In the second, TFP indexes are subjected to a statistical decomposition analysis where timing and geographic spillover weights are incorporated into the specification.

In this section we briefly review the TFP methodology and summarize TFP indexes computed for census micro-regions for four census periods. The TFP residual is readily derived from a simple accounting relationship (or alternatively, from a production or transformation). Two issues for the subsequent decomposition analysis required attention. The first is the curvature or substitution issue. The second is the degree of adjustment for input quality change.

The simplest and least restrictive definition of TFP is derived from a cost accounting framework, which allows one to define a change in TFP from period "t-1" to period "t" Changes from period to period can then be summed up to create TFP measures when we have more than two periods. If no extraordinary profits exist and returns to all factors are properly measured, the values of all outputs (Y_i) will equal the value of all inputs (X_i)

$$\sum_i P_i Y_i = \sum_j R_j X_j \qquad (1)$$

Expression (1) does not impose strict efficiency by all farmers. It is based on an accounting condition that holds in a competitive sector.

Differentiating (1) totally with respect to time, we obtain the following expression:

$$\sum_i P_i \frac{\partial Y_i}{\partial t} dt + \sum_i Y_i \frac{\partial P_i}{\partial t} dt = \sum_j R_j \frac{\partial X_j}{\partial t} dt + \sum_i X_i \frac{\partial R_j}{\partial t} dt \qquad (2)$$

For small changes, (2) expresses the relationship between changes in output and input quantities and output and input prices. Now divide (2) by $P_i Y_i$ and multiply the four terms by Y_i / Y_j, P_i / P_j, X_i / X_j and R_i / R_j, respectively. Define the following:

$$P_i Y_i / \sum P_i Y_i = S_i, \quad R_j X_j / \sum P_i Y_i = C_i, \quad (1/Y_i)(dY_i/dt)dt = \hat{Y}_i$$

and similarly for P_j, X_j *and* R_j

Using these definitions, expression (2) can be written as:

$$\sum S_i P_i + \sum S_i Y_i = \sum C_j R_j + \sum C_j X_j, \qquad (3)$$

$$\hat{P} + \hat{Y} = \hat{R} + \hat{X}, \quad where \ \hat{P} = \hat{S}_i \hat{P}_i, \quad etc. \qquad (4)$$

Expression (4) can be written in Total Factor Productivity form as:

$$\hat{Y} - \hat{X} = \hat{R} \quad \hat{P} = \hat{T} \tag{5}$$

Note that (5) is exact for infinitesimal changes. In this case, we are treating this as a valid approximation only for annual changes from year "*t*" to year "*t*+1"

The "Tornqvist-Theil" TFP index for multiple periods in logarithmic form is:

$$\lambda v(TFP_t / TFP_{t-1}) = \tfrac{1}{2}\sum_i (S_{it} + S_{it-1})\,\lambda v(Y_{it} + Y_{it-1}) - \tfrac{1}{2}\sum_j (C_{jt} + C_{jt-1})\,\lambda v(X_{jt} + X_{jt-1}) \tag{6}$$

The "Tornqvist-Theil" TFP index is a type of "Divisia" index that is consistent with very general production structures and accommodates the substitutability of one input for another.

Many analysts of TFP have attempted to make adjustments to the "raw" TFP measures constructed from data as conventionally measured in censuses or in other measurement systems. Typically these take the form of input "quality" corrections. The most important of these are corrections to the labor input measure to account for changes in age, sex and educational status. We do not deny the usefulness of these adjustments. The failure to deal with quality change in inputs can seriously bias interpretations of TFP measures. In this study we argue that the "raw" uncorrected measure of TFP are appropriate for a decomposition analysis if appropriate "right-hand-side" (independent) variables are developed to deal with input quality (see the next section).

We construct TFP indexes for each census micro-region based on data from the 1970, 1975, 1980, and 1985 Censuses of Agriculture for Brazil. For each micro-region the Tornqvist-Theil index (7) is computed for the three-period changes 1975/1970, 1980/1975, and 1985/1980. These are normalized to an index = 100 for the 1970-75 averages period.

Output index

The output index was constructed including the following products: a) temporary crops - wheat, rice, beans, maize, soybeans, cotton, manioc, onion and tomato; b) permanent crops - cocoa, coffee, sugarcane, banana. citrus and grapes; and c) livestock - beef cattle, milk, swine and eggs. (See Appendix C.)

Input index

The input index was constructed using the following agricultural production factors: a) crops - cultivated area, labor force (permanent, family and temporary), tractors, animal power, fertilizer and chemicals; and b) livestock - natural and artificial pastures, labor force (permanent, family and temporary), tractors, fertilizers, chemicals, feed and animal medicines. In both cases, the prices used were collected from each one of the agricultural census years or from secondary sources.

Table 4 reports changes in the TFP indexes by period, macro-regions and sectors. We note different patterns in crop and livestock TFP. For livestock, large gains were realized in the 1970-75 period and for a few there are no gains since 1975. For crops, TFP gains have been realized most prominently in the 1980-85 period.

Table 4
TFP Index and Rates of Growth: Region and São Paulo State, Brazil, 1970-85 Period

Region	Sector	1970	1975	1980	1985	Annual growth 1970-85 (%)
North	Crops	100.72	99.28	108.06	125.49	1.37
	Livestock	95.52	104.48	109.75	104.55	0.53
	Aggregate	100.20	99.80	111.96	123.75	1.31
Northeast	Crops	92.69	107.31	104.73	125.96	1.99
	Livestock	88.04	111.96	108.09	106.80	1.18
	Aggregate	91.96	108.04	104.74	118.50	1.60
Southeast	Crops	108.00	91.99	105.32	146.96	2.00
	Livestock	72.89	127.11	124.91	120.72	3.65
	Aggregate	90.34	109.66	116.10	140.13	3.06
South	Crops	89.46	110.54	110.17	127.89	2.39
	Livestock	84.59	115.41	96.64	84.23	-0.02
	Aggregate	88.79	11.21	105.13	112.19	1.46
Center-West	Crops	102.97	97.03	115.13	149.50	2.51
	Livestock	77.78	122.22	124.62	137.33	4.25
	Aggregate	87.24	112.76	124.30	146.99	3.80
São Paulo	Crops	97.73	104.27	109.04	128.02	1.87
	Livestock	72.62	127.38	106.09	108.26	2.73
	Aggregate	87.31	112.69	110.41	127.55	2.56

Table 5 summarizes TFP changes for the agricultural sector for twenty-two of the ninety-two Brazilian agro-ecological zones, the more important zones in the context of the agricultural sector. They are responsible for more than 80 percent of the grain, fruit, and animal production.

Table 5
Aggregate TFP Index and Rates of Growth for Selected Brazilian Agro-ecological Zones, 1970-85 Period

Selected Zones	1970 TFP index	1985 TFP index	TFP growth rate (%)
01 Atlantic Coast B RS/SP	94.94	124.55	1.73
15 - Pantanal - MS/MT	86.26	99.08	0.93
17 - Semi-aris (Sertão)	81.45	130.35	3.16
31 - Pará - Northeast Zone	104.44	121.42	1.02
43 - Semi-arid (Agreste)	101.96	85.72	-1.14
54 - RS Campanha	94.70	109.49	0.78
55 - Cerrados Bahia	112.20	116.78	2.66
58 - Tocantins & Goiás	98.64	121.14	1.38
59 - Cerrados North	83.75	138.53	3.41
61 - Cerrados Center-south	83.30	148.67	3.92
67 - RS, SC & PR Forest	90.26	111.93	1 41
70 - RS, SC & PR Fields	91.27	106.15	1.02
71 - West Patos Lagoon	97.33	105.22	0.47
72 - São Paulo Capital Reg.	91.74	135.90	2.64
74 - Minas Gerais	96.20	150.15	3.02
75 - Paraná	82.32	126.89	2.93
78 Northeast Zona Mata	94.21	144.21	2.88
86 Bahia - Cacao Region	86.14	91.64	0.43
87 Center RS & Front. SC	101.01	101.67	0.04
90 São Paulo West	82.78	121.42	2.59
91 Cerrados Center	91.73	130.06	2.36
92 São Paulo Center	82.16	134.73	3.34

It is of interest to note that zones 61 and 59, located in the cerrados region, achieved exceptionally high TFP growth rates. The following zones have achieved high rates of TFP· 17, 74, 75, 78, and 92. By contrast, the following zones have achieved low rates of TFP change: 15, 43, 54, 70, 71, 86, and 87

5 TFP decomposition methods

The TFP measure is by nature a "residual" The economic logic underlying the residual is that the conditions under which input-predicted growth (see (4)) is equal to actual growth do not hold. Specifically this means that one or more of the following production environments has changed:

a) new technology may have become available;

b) new infrastructure may have become available;

c) average farm efficiency may have improved relative to "frontier" or "best"-practice efficiency;

d) markets may have become more (less efficient).

Unfortunately we do not have *direct* evidence as to the contributions of each of these changes, except in some cases where adjustments can be made for changes in the quality of inputs (for example, education adjustment for labor force quality can be made). TFP decomposition is a method for indirectly estimating the contributions of these factors. This method entails a statistical regression of TFP indexes on carefully constructed variables indexing changes in technology, infrastructure, farmer efficiency and market efficiency.

Technology infrastructure and efficiency are not "free" They are produced by investments in capital stocks and by specialized labor services. Technology is produced in research organization (public and private) by skilled scientists using scientific equipment, laboratories, and fields. Farmer efficiency is produced by farmer experiments and information enhanced by schooling and skills. Extension specialists also produce efficiency. Market efficiency is produced by institutional change and is enhanced by infrastructure investments.

Thus, in TFP decomposition we must rely on investment or input data to create relevant variables. And this reliance on input data means that we must address issues associated with the production of these outcomes. Three such issues are particularly critical. The first is the timing relationship between investment and TFP input. The second is the spatial relationship

between the location of research or invention and the realization of TFP growth. The third issue is the deflation issue.

5.1 The timing dimension

There is a time lag between the conduct of research activities and the development of improved technology. Experiments require time and evaluation and sequences of experiments and tests must be designed before new technology is developed. Then the technology must be diffused to farmers. Some of this diffusion requires embodiment in farm inputs (seeds) and some is diffused as information (improved practices). Farmers must experiment and evaluate as they adopt technology and modify it for their farm conditions.

The "time-shape" of these lags is thus similar to the classic technology diffusion lag (Griliches, 1967) with a period of little TFP impact after investment, rising to a peak some years later. However, a second factor, depreciation, plays a role in the time-shape also. It is important to distinguish between depreciation and obsolescence in this regard. Technological obsolescence occurs when new technology (say a new variety of rice) is superior to an existing technology and displaces it. If the new technology was developed as an extension of existing technology (i.e., it was an "add-on" to an existing technology) then the investments associated with the development of the existing technology did not depreciate even though the technology becomes obsolete.

Depreciation occurs when (a) there is incomplete additivity in technology development and (b) when there are "exposure" effects to reduce the value of technology after it has been exposed to use. Host plant gemetoc resistance to plant insects and diseases is often reduced by use exposure, and this is an example of depreciation. Changes in prices can reduce (or enhance) the value of technology, and this is a source of depreciation as well (e.g., a rise in energy prices may reduce the value of technology that is highly dependent on energy).

The practical procedure for developing a research stocks variable reflecting the time dimension is to build a research stock with an appropriate time shape.

The formula used to build the research stocks in this study is:

$$StR_t = (ExpRE_{t-4} \quad 0.2) + (ExpRE_{t-5} \quad 0.4) + (ExpRE_{t-6} \quad 0.6) + (ExpRE_{t-7} \quad 0.8) + \sum_{t=8}^{20} (ExpRE_{t-2} \quad 1.0) \tag{7}$$

where $ExpRE_{t-4}$ is spending in year t-4 etc.

We built in a time lag of four years between the initial investment in agricultural research (first year of the research project) and the impact on agricultural production at the farm level. The full impact is realized after eight years. Given the relatively recent development of EMBRAPA research, we did not build in a depreciation component. These estimates are based on previous studies (see Evenson and Cruz, 1989a).

For rural extension services, the timing between the investment (diffusion of new technologies, training etc.) and the impact at the farmers' level (increases output) is shorter than in the agricultural research case. Normally, most of the results of extension appear in the first three years after new techniques are made available to farmers.

The formula used to construct the stock for rural extension services is based on the staff of technical personnel working close to farmers (personnel at the municipalities or county office levels). The stock formula based on staff personnel is presented below:

$$StExt_t = (StaffExt_t \quad 0.25) + (StaffExt_{t-1} \quad 0.50) + (StaffExt_{t-2} \quad 0.25). \qquad (8)$$

This specification presumes that extension serves to speed up the adoption of technology. After three years the extension impact is zero on the presumption that other information sources and institutions would have been sufficient to enable adoption by them. (This may be too conservative because extension may have more permanent effects.)

5.2 The spatial dimension

Research conducted in one location will produce technology that is useful in other locations. But it is not necessarily equally useful in all other locations. We know that plant and animal performance is sensitive to climate and soil factors. The natural selection model of Darwin tells us that genetic diversity is associated with a high degree of location specificity of plants and animals to environmental niches. Modern plant and animal breeding programs have only partially overcome this "Darwinian" phenomenon. Research systems in Brazil have incorporated Darwinian targeting into their structure. EMBRAPA has a number of national commodity research centers and a number of ecoregional centers. Each state has state research programs and a number of branch or sub-state research locations are maintained as well.

The problem that we face in this study is to assign the research stocks from the national centers, regional centers and state programs to specific micro-regions (our unit of analysis). In

practice, there are two methods for doing this. One is the technology distance method (first introduced by Evenson and da Cruz, 1988) where research conducted in region "*j*" is assigned to region "*i*" in proportion to a technology distance index between them. Technology distance indexes are measures of the performance of region *j*'s best technology in region *i* relative to region *i*'s best technology in region *i*.

The second method used in this study is to "test" alternative assignments of research based on geo-climate and priority zone evidence. For example, in the work reported below we construct three alternative assignments for EMBRAPA national program research. They are:

(1) Assignment 1 where all micro-regions in the country are assigned the national program research stock. This is consistent with a complete "spill-over" of national program research from the national commodity center to other locations.

(2) Assignment 2 where national program research is assigned to "priority zones" as identified by national product center staff. This is a sub-set of the 92 agro-ecological zones (on average 40 percent). This assignment is consistent with spill-overs limited to these priority zones.

(3) Assignment 3 where national program research is assigned only to micro-regions in the agro-ecological zone in which the national research center program is located. This is consistent with very limited spill-over of research benefits.

A similar procedure is applied to EMBRAPA regional center research where a test is made between assignment to the region as defined by EMBRAPA and the assignment 3.

Mean square error tests are performed to select the assignment most consistent with the data. As we note below, these tests show that assignment 1 was best for national program livestock research. Assignment 2 was best for crop and agricultural research generally. For regional center research, assignment to the region was best. State research assignment to all micro-regions in the state was best. For the extension and infrastructure variables, no spill-over was specified.

5.3 Deflators (spill-over between commodity programs)

Crop and livestock research programs have components that are specific to each crop and components that are general in their impact. If specific components dominate and there is little spill-over between commodities, the appropriate aggregated research stock for a micro-region is "share-weighted" by the micro-region crop and livestock production shares. This implicitly

assumes that the commodity programs assigned to the micro-region have equal impacts on TFP over commodities. This procedure indirectly deflates the research stocks. A region with a low share for rice, for example, will not be affected by the level of rice research. As with spill-in assignments, tests of weighted and unweighted research variables were made. For state livestock research the unweighted stock performed best. For others, the weighted stocks performed best. For extension, two deflators, area and number of farms were used (see below).

6 Variables and model specification

Table 6 provides a summary of variables used in the study. They are classified as endogenous (dependent) variables and exogenous (independent) variables. There are four endogenous variables including the three TFP indexes and the extension contact variable, EXTC85. The analysis proceeds in two stages. First, an extension contact analysis is undertaken. Second, the TFP decomposition specifications are estimated including a predicted extension contact variable. Observations are on micro-regions as defined in the agricultural censuses. The Federal District and micro-regions, where matching between censuses was impossible, were not included. A total of 370 micro-regions were included in each of the four years.

Table 6
Variables Used in TFP Decomposition Analysis Definitions and Means 1970, 1985

Variables	Definition	Means 1970	Means 1985
I. Endogenous Variables			
CROPTFP	TFP index (1975 = 100) for Crops	97.81	132.40
LVSTKTFP	TFP index (1975 = 100) for Livestock	81.71	108.94
AGRTFP	TFP index (1975 = 100) for Agricultural Sector (Aggregate)	89.56	127.10
EXTCTC85	ln (P(1-P) where P is the percent of farmers in 1985 with extension contact (from 1985 Agricultural Census)		-3.20
II. Exogenous Variables: Extension Contact Analysis (Stage 1)			
POPDEN	Rural Population in 1985/state area	0.14	0.08
RURSCHOOL	Average years of schooling of rural population over age 10 (IBGE)	1.04	2.35
EXTFARM	Extension Staff (stocks)/number of farmers in 1980	0.415	0.1057
EXTAREA	Extension Staff (stocks)/area in farms	0.00001	0.00025
LIVSHARE	The share of livestock products in total agricultural value of product	0.3522	0.3917
AGRTFP(L)	Lagged AGRTFP	0	17.61
HZONE2	Dummy = 1 if micro-region is in macro climate zone 2	0.20	0.20
HZONE3	Dummy = 1 if micro-region is in macro climate zone 3	0.50	0.50

Table 6, continued

Variables	Definition	Means 1970	Means 1985
III – Exogenous variables: TFP Decomposition			
POPDEN, ZONE2, HZONE3	Same as in II		
PREDEXTC	Predicted extension contact (from extension contact analysis (Stage 1))	1.293	5.675
ROADDEN	Kms of federal roads in state/state area	0.0040	0.0046
INDCROP	Industrial research stock for crops (weighted)	0	877
INDAGR	Industrial research stock for all agriculture (weighted)	0	719
EMBNPCROP	EMBRAPA National Prog. Res. Stock – Crops		
All areas	Assigned to all micro-regions	0	35,276
Priority areas	Assigned to micro-regions in the priority areas	0	13,336
Agro-zone	Assigned to micro-region in one agro-zone	0	2,742
EMBNPLVSTK	EMBRAPA Nat. Prog. Res. Stock – Livestock		
All areas	Assigned to all micro-regions	0	92,831
Priority areas	Assigned to micro-regions in the priority areas	0	13,260
Agro-zone	Assigned to micro-region in one agro-zone	0	5,749
EMPNPAGR	EMBRAPA Nat. Prog. Res. Stock – Aggreg.		
All areas	Assigned to all micro-regions	0	57,522
Priority areas	Assigned to micro-regions in the priority areas	0	13,122
Agro-zone	Assigned to micro-region in one agro-zone	0	4,603
EMRCPCRP	EMBRAPA Reg. Centers Crop Res. Stock		
Region	Assigned to micro-regions in the region	0	4,262
Agro-zone	Assigned to micro-regions in the agro-zone	0	1,918
EMRCPLVSTK	EMBRAPA Reg. Centers Livestock Research		
Region	Assigned to micro-regions in the region	0	3,748
Agro-zone	Assigned to micro-regions in the agro-zone	0	1,695
EMRCPAGR	EMBRAPA Reg. Centers Agric. Research		
Region	Assigned to micro-regions in the region	0	8,489
Agro-zone	Assigned to micro-regions in the agro-zone	0	3,834
STATECROPR	State research stock on crops assigned to all micro-regions in state	1,020	57,751
STATELVSTKR	State research stock on livestock assigned to all micro-regions in state	4,836	48,937
STATEAGRR	State agricultural research stock assigned to all micro-regions in state	858	34,937
FERT2-FERT7	Dummy variables = 1 if micro-region is classified in soil fertility regions 2 through 7		
TEXT2-TEXT7	Dummy variables = 1 if micro-region is classified in soil texture regions 2 through 7 (TEXT1 is the reference class)		
DRAIN2-DRAIN6	Dummy variables = 1 if micro-region is classified in soil 2 through 6 (DRAIN1 is the reference class)		
Y70, Y75, Y80	Dummy variables = 1 if year = 1970, 1975 and 1980 (Y85 is the reference category)		

6.1 The extension contact analysis variables

The 1985 Agricultural Census reports the proportion of farmers contacted by the extension service. This variable is subject to two problems as a prediction of TFP change. First, it is endogenous in that it is at least partly determined by farmers. Second it is available only for 1985. Both problems can be solved by developing a prediction specification for the 1985 data and then using the prediction variables (which are available for other years) to predict extension contacts for all four census years. In this way we can take advantage of the richness of the 1985 data and avoid the endogeneity problem.

The form of the EXTCTC85 variable is logistic (ln (P/ (1-P)) on the grounds that extension contacts are diffused through the farm population in the same way that technology is diffused.

The specification of the extension contact equation attempts to correct for the simultaneity bias between productivity change and extension activity. We hypothesize that farmer's demand for extension is primarily a function of two things: farmer's schooling and past experience with technology and productivity change. Accordingly we include a farmer's schooling variable, RURSCHOOL, and lagged (five years) productivity change AGRTFP(L) (for 1970 we use current AGRTFP), as predicting variables.

The supply of extension services is measured by the EXTFARM and EXTAREA variables. The population density (POPDEN) and LIVSHARE variables control for broad general differences between regions and crop-livestock extension differences. The zone variables are designed to pick up differences associated with broad agro-ecological conditions.

6.2 The TFP decomposition variables

The TFP decomposition variables include:

a) The predicted extension contact variable (from stage 1).

b) EMBRAPA national program research variables with three assignment options as discussed above.

c) EMBRAPA regional center research variables with three assignment options as discussed above.

d) State research variables.

e) Industrial research variables (Discussed further below).

f) Infrastructure variables (POPDEN and ROADDEN).

g) Agro-climate variables, FERT2-FERT7, TEXT2-TEXT7, DRAIN2-DRAIN6.

h) Year variables: Y70, Y75 and Y80.

The dependent variables were constructed for each micro-region. Accordingly, we are not analyzing cross-section differences in productivity. We are analyzing changes in TFP over the 1970-1985 period. This is not a full "fixed effects" model, however, because we are taking advantage of cross-section variation in the independent variables. Specifically, we take advantage of the fact that some regions have low research investments, others have high levels of investment. If we were to index our research variables in fixed effects style (as with our dependent variable), we would have only the rate of change in research stocks to predict changes in TFP.

We do, however, attempt to control for cross-section heterogeneity by including very detailed soil drainage, texture, and fertility class dummy variables. These class are summarized in Table 7. We also include year dummy variables.

Table 7
Agro-climate Variables: Soil Drainage, Texture and Fertility Classes

Soil Class	Texture	Drainage	Fertility
1	Indiscriminate texture	Imperfect to bad drainage	Very low fertility
2	Sandy	Imperfect to drained	Very low to low & low to very low
3	Medium sandy	Bad drainage	Low
4	Sandy to clay & sandy to very clay	Moderate drainage to imperfect/bad drainage	Low to high & very low to high
5	Medium to clay & medium to very clay	Bad to well drained & well drained to bad drainage	Low to medium
6	Medium	Moderate to well drained	Medium
7	Clay to silty & clay to very clay	Moderate to well drained	Medium to high fertility
8	Clay	Well drained	High fertility

Source: EMBRAPA/SNLCS - Delineamento Macroagroecológico do Brasil, 1992/93.

The rationale for the extension and EMBRAPA and state research variables has been given above. The industrial research variables are important to this analysis because the industrial sector undertakes R&D to improve farm inputs sold to the agricultural sector. Because these firms do not "capture" or appropriate the full value of the improvements made by their R&D investments, these investments contribute to agricultural TFP. A simple example shows how this is so. Suppose a firm in Brazil develops as improved farm implement that in real term produces a service flow that is 10 percent greater than the service year from an existing implement. If it were to price its new machine at 10 percent higher than the new machine, it would have few sales. Thus it will price its new machine at less than ten percent over the existing machine because of its interest in promoting sales and because competitors are developing new machines. The firm's failure to capture the full ten percent improvement means that in TFP accounting in the agricultural sector, the new machine is counted as having a less than 10 percent higher service flow. And this results in TFP growth in the agricultural sector.

The INDCROP variable was constructed from the data in Table 8 on invention potential in Brazil. These inventions originate both in Brazil (50 percent) and abroad. (The U.S. is the major source - see Evenson and Putnam, 1990.) Brazilian inventions were weighted to be three times as valuable as foreign inventions in chemicals and two times as valuable as a foreign invention in other fields. A cumulated stock of inventions was constructed assuming 1970 to be one half of 1975 for each type of invention. INDCROP was created at the micro-region level by using micro-region cost share weights: chemicals and fertilizer for chemical inventions; tractors for machine inventions; animal power for animal husbandry inventions; and the output share of permanent and vegetable crops for horticulture inventions. We were not able to construct a satisfactory INDLVSTK variable, but in the INDAGR variable, the animal husbandry inventions are given additional weight through animal production shares. Both livestock and crop, as well as chemical, tractor and machine shares are used in INDAGR.

Table 8
Invention Patents Granted in Brazil (National and Foreign)

Field	1975	1980	1985
Chemicals	811	2,106	3,950
Machinery	218	556	1,032
Animal Husbandry	32	82	151
Horticulture	77	288	571

Source: Evenson and Putnam (1990).

Finally, we have included the POPDEN and ROADDEN variable as proxies for infrastructure and related investments.

7 Estimates

7.1 The extension contact analysis

Table 9 reports estimates for the extension contact specification. The most important finding here is that farmer's schooling levels (RURSCHOOL) lead to increased extension contacts. The coefficient on schooling is large and highly significant. Since extension supply (EXTAREA) is also significant (and held constant), this reinforces the interpretation of the schooling coefficient as reflecting farmer demand for extension services.

Table 9

Extension Contact Estimates, Agricultural Census 1985

Dependent Variable: EXTCTC85

Independent variables	Coefficient	"*t*" ratios
Intercept	-1.948	(0.61)
POPDEN	19.42	(0.61)
RURSCHOOL	4.500	(10.74)
EXTFARM	-0.497	(1.25)
EXTAREA	61.007	(2.16)
LIVSHARE	2.743	(1.67)
AGRTFP(L)	0.0206	(1.59)
HZONE2	1.676	(1.74)
HZONE3	2.986	(3.60)
R^2	0.3932	
AdjR^2	0.3783	
F value	26.40	
Prob F	0.0001	

The second variable, past TFP change (AGRTFP(L)), is only marginally significant (p = 0.11), but does support the proposition that successful past productivity experience creates demand for extension services. The negative coefficient on the livestock share (LIVSHARE)

indicates a lower demand for extension by livestock producers (although this may also affect lower supply, since the supply variable, EXTAREA, does not distinguish between crop and livestock extension). It appears that there are some differences in extension contact by agro-climate zone.

In the productivity decomposition analysis, a predicted extension contact variable (converted from logistic form to predicted percent of farms contacted) was created for all four years. Since schooling plays such a large role in the specification, this variable is perhaps best thought of as a farmer human capital variable.

7.2 TFP decomposition analysis

Tables 10, 11, and 12 report TFP decomposition estimates for the crops sector, the livestock sector and the aggregate agricultural sector, respectively. Each table reports a specification including the predicted extension variable and a specification excluding it. This is done in view of the relatively low levels of significance of the predicted extension variable to demonstrate that the exclusion of the variable has little effect on other coefficients. The coefficients for the year dummies, the soils dummies, and the intercepts are not reported as we do not consider them to have policy importance.

7.2.1 TFP decomposition for the crop sector

Crop sector TFP decomposition estimates reported in Table 10 shows the following:

a) All research programs contributed to TFP growth. This includes industrial R&D, EMBRAPA national program research, EMBRAPA regional centers and state research programs.

b) Mean square error tests for crop share weighting showed that weighted variables for all research categories outperformed unweighted variables indicating low levels of common research impact over crops.

c) Mean square error tests on spill-over assignments showed that assignment 2 (i.e., to priority zones) for national programs outperformed assignment 1 (to all zones) and assignment 3 (to zone of location) indicating that national programs do not serve all zones equally, but that they do have impact outside the zone of location (priority zones are approximate 37 percent of all zones). For regional centers, tests indicate that the centers serve the full region which includes more than the zone of location. State programs serve all the state micro-regions.

d) Industrial research has a significant impact on TFP growth in the crop sector.

e) The human capital-predicted extension variable is marginally significant ($P = 0.18$). This may reflect the fact that measures of extension activities are not very accurate. We do, however, consider this estimate to support the contention that human capital in agricultural is important to growth and efficiency.

f) The road density variable appears to indicate an infrastructure contribution. There appear to be no population density effects.

Table 10
Crop TFP Decomposition Estimates, Brazilian Agricultural Census Data: 1970-75-80-85 Years
Dependent Variable: Crop TFP Index (equal to 100 in 1975)

Independent variables	Specification (1) without extension	Specification (2) with extension
Population Density (POPDEN)	5.082 (0.37)	4.453 (0.33)
Road Density (ROADDEN)	232.47 (2.38)	227.77 (2.33)
Industrial Research (INDCROP)	0.00797 (2.74)	0.00650 (2.09)
EMBRAPA National Centers (EMBNPCRP) (Priority zones)	0.00022 (1.78)	0.00021 (1.71)
EMBRAPA Regional Centers (EMBRCCRP) (Region)	0.00194 (4.21)	0.0204 (4.37)
State Research (STATECROPR) (State)	0.0000248 (4.48)	0.0000252 (4.53)
Extension Contacts (PREDEXT) (Predicted logit)	-	0.575 (1.32)
R^2	0.2081	0.2092
AdjR^2	0.1906	0.1910
F value	11.87	11.54
Prob F	0.0001	0.0001

Notes: "*t*" ratios in parentheses. Soil conditions, zone and year intercepts included but not reported.

Table 11
Livestock TFP Decomposition Estimates, Brazilian Agricultural Census Data: 1970-75-80-85 Years
Dependent Variable: Livestock TFP Index (equal to 100 in 1975)

Independent variables	Specification (1) without extension	Specification (2) with extension
Population Density (POPDEN)	7.670	6.979
	(0.67)	(0.66)
Road Density (ROADDEN)	-13.94	-18.57
	(0.17)	(0.23)
EMBRAPA National Centers (EMBNPLSTK) (Priority zones)	0.000545	0.000562
	(6.01)	(6.01)
EMBRAPA Regional Centers (MBRCLVSTK) (Region)	0.00103	0.0107
	(1.76)	(2.84)
State Research (STATELVSTKR) (State)	0.0000357	0.0000302
	(2.02)	(1.58)
Extension Contacts (PREDEXT) (Predicted logit)	--	0.2817
		(0.75)
R^2	0.2914	0.2917
AdjR^2	0.2762	0.2760
F value	19.25	18.60
Prob F	0.0001	0.0001

Notes: "*t*" ratios in parentheses. Soil conditions, zone and year intercepts included but not reported.

Table 12
Aggregate Agricultural TFP Decomposition Estimates, Brazilian Agricultural Census Data: 1970-75-80-85 Years
Dependent Variable: Agricultural TFP Index (equal to 100 in 1975)

Independent variables	Specification (1) without extension	Specification (2) with extension
Population Density (POPDEN)	3.992	3.877
	(0.41)	(0.40)
Road Density (ROADDEN)	206.83	205.89
	(3.00)	(2.98)
Industrial Research (INDAGR)	0.01653	0.01618
	(5.52)	(5.20)
EMBRAPA National Centers (EMBNPAGR) (Priority zones)	0.00014	0.00014
	(1.84)	(1.82)
EMBRAPA Regional Centers (EMBRCAGR) (Region)	0.00050	0.00051
	(3.17)	(3.19)
State Research (STATEAGR) (State)	0.0000186	0.0000187
	(2.51)	(2.52)
Extension Contacts (PREDEXT) (Predicted logit)	--	0.1276
		(0.42)
R^2	0.3128	0.3129
AdjR^2	0.2976	0.2971
F value	20.56	19.87
Prob F	0.0001	0.0001

Notes: "*t*" ratios in parentheses. Soil conditions, zone and year intercepts included but not reported.

7.2.2 TFP decomposition for the livestock sector

Livestock TFP decomposition estimates reported in Table 11 show the following:

a) All public sector research programs contribute to TFP growth.

b) Mean square error tests for product share weighting showed that weighted variables for the two EMBRAPA variables outperformed the unweighted variable. The state unweighted variable, however, performed best. This may indicate that state livestock research programs are more oriented toward general livestock management issues and lack commodity specificity.

c) Mean square error tests showed that for EMBRAPA national programs, assignment 1 (to all zones) performed best. This is consistent with other evidence that livestock research is less location specific than crops research. For EMBRAPA regional centers, assignment 2 performs best indicating that these centers serve all zones in the region. State research serves the state.

d) The human capital-predicted extension variable, while positive, is not statistically significant ($P = 0.45$). This may reflect weak livestock extension, which is consistent with the extension contact analysis where the livestock share had a negative impact on contacts. It may also reflect measurement error.

e) We do not find population density and road density effects.

7.3 TFP decomposition in the aggregate agricultural sector

Aggregate agricultural TFP decomposition estimates are reported in Table 12. These estimates show the following:

a) All research programs contributed to TFP growth.

b) Mean square error tests showed that all share weighted research variables outperformed unweighted variables.

c) Mean square error tests for assignments showed that assignment1 (to all zones) for EMBRAPA national program research performed best. This is reflecting the livestock sector

results to a considerable extent. For EMBRAPA regional programs, assignment 2 (to all zones in the region) performed best. State research served the state. Thus we have evidence of quite pervasive impacts over many zones for EMBRAPA research programs.

d) Industrial research has contributed to TFP growth in agriculture in a significant way.

e) As in the livestock estimate, the human capital-predicted extension variable is of the expected sign, but is not statistically significant.

f) Road infrastructure has contributed to TFP growth. Population density is unrelated to TFP growth.

8 Economic implications of the TFP decomposition estimates

8.1 Economic measures

The estimates reported in Tables 10, 11 and 12 enable us to compute the following economic measures of investment success:

a) **EMPE: Estimated marginal productivity elasticities**

The EMPE is defined as:

$$\theta_x = (dTFP / TFP) / (dX / X)$$

These can be calculated for each investment category (EMBRAPA national programs. EMBRAPA regional centers, state research, extension, industrial R&D etc.).

b) **EMP: Estimated marginal products**

The EMP is defined as:

$$EMP = dQ_X / dX$$

For stock variables, this is the marginal product of a stock. However, it is also the marginal product of an increment to the stock since an investment in X in time "t" contributed to the stock in a cumulative way. Thus:

$dX / dI_x = X / I_x$ and this implies:

$$dQ_x / dX = dQ_x / dI_x$$

This generates a "stream" of benefits over time associated with the time shape weights W_t

c) **EM(B/C): Estimated marginal benefit/cost ratio**

Where:

$$B_0 = \sum_j^n W_t (dQ_x / dX) / (1+\gamma)^j)$$

$$C_0 = I_{xt}$$

In this case γ is an external rate (chosen to be ten percent).

d) **EMIRR: Estimated marginal internal rate of return**

This is defined as the rate I that solves:

$$I_{xt} = S W_{t+j} (d Q_x / dX) / (1+i)^j$$

Table 13 reports estimates of EMPE, EMP, EM(B/C) and EMIRR obtained from this study.

There is considerable variation in the estimates. The reader is reminded that these are based on estimated coefficients and that the standard errors ("t" ratios) of those coefficients indicate different degrees of confidence in the estimates.

Taken as a group, these estimated returns to investment are comparable to estimates obtained elsewhere (Appendix A provides a brief review of other studies undertaken in Brazil).

Perhaps the chief anomaly of these estimates are the lower EMPEs and EMPs for state research in the aggregate results than for the crops and livestock estimates. The same can be said for extension impacts. A further anomaly is the higher impact of private research in the aggregate estimates than in the crop estimate. To some extent, these anomalies are the result of our effort to obtain separate estimates for the impacts of very similar programs. EMBRAPA and the states have similar objectives.

Table 13
Economic Calculations for Brazilian Research and Extension

Variables	EMPE	EMP	EM(B/C)	MIRR	Growth expanded: Percent	Growth expanded: Share of
I. Crop Sector						
EMBRAPA Research:						
National Programs	0.00596	2.16	12.5	38	2.80	.08
Regional Centers	0.00675	12.21	70.7	75	3.23	.09
State Research	0.00234	1.17	6.8	29	1.43	.04
Industrial Research	0.00265	2.65	15.4	44	5.70	.17
Extension	0.01353	1.35	7.8	33	2.52	.07
					18.91	.55
II. Livestock Sector						
EMBRAPA Research:						
National Programs	0.05726	27.90	16.1	90	11.24	.48
Regional Centers	0.00370	1.10	6.4	25	.57	.02
State Research	0.0091	6.36	36.8	63	1.32	.05
Extension	0.0063	0.60	30.5	23	1.36	.05
					14.40	.53
III. Agricultural Sector						
EMBRAPA Research:						
National Programs	0.0121	4.98	28.8	56	7.94	.24
Regional Centers	0.00356	2.93	17.0	46	.99	.03
State Research	0.00115	0.51	2.9	19	.65	.03
Industrial Research	0.00485	4.85	28.1	45	11.63	.31
Extension	0.0028	0.51	2.9	19	.62	.02
					15.63	.42

8.2 Growth accounting

It is important in TFP decomposition work that we achieve consistency between our estimates and actual growth experience. Growth accounting enables us to do this. The growth attributable to an explanatory variable is the growth in the variable times the EMPE for the variable. The two right-hand columns in Table 13 report our growth accounting based on estimated EMPE and mean changes in the relevant growth decomposition variables.

The growth accounting presented in Table 13 shows that our major variables "explain" half of actual growth. The leading contributors to growth are the EMBRAPA research programs, where from 6 to 12 percent of growth (9 percent in the aggregate) can be attributed to these programs, and the industrial R&D sector where a similar contribution is estimated. State research institutions probably contributed 5 percent to the 1985/1970 growth. If we consider our crops sector estimates, extension and human capital have probably contributed another 3 percent.

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Appendix A
Brazilian studies of economic impact evaluation of agricultural research

Table 1A
Brazilian Agricultural Research Evaluation: EMBRAPA's Experience

Authors	Specification Area	Period	IRR (%)
Cruz, Palma & Avila (1982)	Total Investment	1974/92	22-43
Cruz & Avila (1983)	World Bank Project I	1977/82 1977/91	20 38
Avila, Borges-Andrade, Irias & Quirino (1984)	Human Capital: Res. Training	1974/96	22-30
Roessing (1984)	Soybeans Res. Center: Total Investment	1975/82	45-62
Ambrosi & Cruz (1984)	Wheat Res. Center: Total Investment	1974/82	59-74
Avila, Irias & Veloso (1985)	IDB Project I: EMBRAPA Research Res. South System	1977/96 1974/96	27 38
Barbosa, Cruz & Avila (1988)	Total Investment: New Evaluation	1974/96	34-41
Kitamura *et alii* (1988)	EMBRAPA research: North Region	1974/96	24
Santos *et alii* (1988)	EMBRAPA research: Northeast Region	1974/96	25
Teixeira *et alii* (1988)	EMBRAPA research: Center-West Region	1974/96	43
Lanzer *et alii* (1988)	EMBRAPA research: South Region	1974/96	45
Barbosa, Avila & Motta (1988)	World Bank Project II	1982/87	43
Kahn & Souza (1991)	Manioc: Northeast Region	1987/97	29-46

Source: Avila (1993).

Table 1B
Brazilian Agricultural Research Evaluation: Others Studies

Authors	Specification Area	Product	Period	IRR (%)
Ayer & Schuh (1972)	São Paulo	Cotton	1924/67	77
Monteiro (1975)	Brazil	Cocoa	1923/75	16-18
Fonseca (1976)	Brazil	Coffee	1933/95	23-26
Moricochi (1980)	São Paulo	Citrus	1933/85	78-28
Avila (1981)	Rio Grande do Sul	Rice	1959/78	87-119
Monteiro (1985)	Minas Gerais & Esp. Santo	Cocoa	1958/85	61-79
Gonçalves, Souza & Rezende (1989)	São Paulo	Rice	1876/88	85-95
Evenson (1982)	Brazil	Aggregated	1966/79	69
Silva (1984)	Brazil	Aggregated	1970/80	60
Pinazza *et alii* (1984)	Var. NA5679: São Paulo	Sugarcane	1972/82	35
Ayres (1985)	Brazil & States: Paraná São Paulo S. Catarina Rio G. do Sul	Soybeans	1955/83	46 51 23 31 53
Evenson & Cruz (1989a)	Brazil	Wheat Maize Soybeans	1966/88	39 30 50
Evenson & Cruz (1989b)	PROCISUR Region (**)	Wheat Maize Soybeans	1969/88	110 191 179
Evenson (1990a)	Brazil	Field crops	1970,1975 & 1980	41-141
Evenson (1990b)	Brazil: South-Center Northeast	Field crops Livestock Per. Crops	1970,1975 & 1980	68-75 & 71-78

* Marginal internal rate of return.

** Cooperative Program in Agricultural Research for the South Cone of South America, including the national institutions of Brazil, Argentina, Uruguay, Paraguay, Bolivia and Chile.

Source: Avila (1993).

Appendix B
Brazilian agricultural research system

1. EMBRAPA DECENTRALIZED UNITS

a) Agroforestry or Agricultural Ecoregional Research Centers

CPAA - Agroforestry Research Center for Western Amazonia

CPATU - Agroforestry Research Center for Western Amazonia

CPAC - Cerrados Agricultural Research Center

CPAF-AC - Agroforestry Research Center of Acre

CPAF-RO - Agroforestry Research Center of Rondônia

CPAF-RR - Agroforestry Research Center of Roraima

CPAF-AP - Agroforestry Research Center of Amapá

CPAP - Pantanal Agricultural Research Center

CPAMN - Center for Agricultural Research in the Mid-North

CPAO - Center for Agricultural Research in the Mid-West

CPATC - Center for Agricultural Research of the Coastal Tablelands

CPACT - Agicultural Research Center for Temperate Climate

CPATSA - Semi-arid Agricultural Research Center

CPPSE - Center for Research on Cattle Raising in the Southeast

CPASUL - Center for Research on Cattle Raising in Southern Fields

b) National Commodity Centers

CNPA - National Research Center for Oleaginous and Fibrous Plants

CNPAF - National Rice and Beans Research Center

CNPC - National Goat Research Center

CNPF - National Forestry Research Center

CNPGC - National Beef Cattle Research Center

CNPGL - National Dairy Cattle Research Center

CNPH - National Vegetable Crop Research Center

CNPMF - National Cassava and Tropical Fruit Research Center

CNPMS - National Corn and Sorghum Research Center

CNPSO - National Soybean Research Center

CNPT - National Wheat Research Center

CNPSA - National Pig and Poultry Research Center

CNPUV - National Grape and Wine Research Center

c) Basic Theme Research Centers

CENARGEN - Nat. Genetic Resource and Biotechnology Research Center

CNPAB - National Agro-biology Research Center

CNPAT - National Research Center for Tropical Agroindustry

CNPDIA - National Center for Research and Development of Agric. Instrumentation

CNPMA - Nat. Res. Center for Monit. and Assessment of Environmental Impact

CNPS - National Soil Research Center

CNPTIA - National Center for Technological Research on Information in Agriculture

CTAA - National Agro-industrial Food Technology Center

d) Special Services

SPI - Information Production Service

SPSB - Basic Seed Production Service

NMA - Nucleus for Satellite Monitoring of Environment and Natural Resources

2. STATE RESEARCH INSTITUTIONS

a) South Region

IPAGRO - Agricultural Research Institute, RS State

IRGA - Rio Grande do Sul Institute of Rice, RS State

FUNDACEP - Agricultural Research Center Foundation, RS State

EPAGRI - Agricultural Corp. for Research and Development, SC State

IAPAR - Agricultural Research Institute of Paraná, PR State

OCEPAR - Cooperative Organization of Parana (Agric. Research Units), PR State

b) Southeast Region

IAC - Agronomic Institute of Campinas, SP State

IB - Biological Institute, SP State

IZ - Zootecnical Institute, SP State

PESAGRO - Agricultural Research Corp. of Rio de Janeiro, RJ State

EMCAPA - Corporation of Espírito Santo for Agric. Research, ES State

EPAMIG - Corporation for Agric. Research of Minas Gerais, MG State

c) Northeast Region

EBDA - Agricultural Research and Development Corp. of Bahia, BA State

EMDAGRO - Corporation for Agricultural Development, SE State

EPEAL Corporation for Agricultural Research of Alagoas, AL State

IPA - Agricultural Research Corporation of Pernambuco, PE State

EMPARN - Agricultural Research Corp. of Rio Grande do Norte, RN State

EMEPA - Corporation of Paraíba for Agricultural Research, PB State

EPACE - Corporation of Ceará for Agricultural Research, CE State

EMAPA - Corporation of Maranhão for Agricultural Research, MA State

d) North Region

The states in this region do not develop agricultural research. EMBRAPA research centers are responsible for the agricultural research.

e) Center-west Region

EMGOPA - Agricultural Research Corporation of Goiás, GO State.

EMPAER/MT - Corp. for Agric. Research and Rural Ext. of Mato Grosso, MT State

EMPAER - Corp. for Agric. Res. and Rural Ext. of Mato G. do Sul, MS State.

Appendix C
Total factor productivity index: input index

The input index was calculated with data from the Brazilian agricultural censuses taken at five-year intervals between 1970 and 1985 and from supplementary sources. This new input index for Brazilian agriculture should constitute an improvement over earlier indexes constructed from this source. Not only does it include data from the 1985 census, but it made use of additional state and municipal data from earlier years. Furthermore, separate input indexes have been constructed for crop and livestock production by allocating total inputs between crop and livestock raising activities.

That said, the index was computed under a number of data handicaps. Census takers seldom gather precise and consistent data on all of the aspects of economic activity in which we might be interested. The coverage of the agricultural censuses has changed over time as have the definitions and measurement units of the items actually collected. In general, the amount of information about inputs has increased with each succeeding census, especially between 1975 and 1980. For 1970, and to a lesser extent for 1975, the municipality data from the census computer tapes available at Yale University did not include a number of inputs, and proxies had to be constructed from the published state data or data from other years. The lack of consistency in measurements has created additional difficulties as it has been necessary to

make certain adjustments to the census data in some years in order to maintain consistency with others.

In terms of accuracy of the census data, of most concern were the municipality-level value and expenditure data. When taken together with the enumerated quantities, the imputed prices varied enormously. It is not clear whether this was due to reportage of historical values of costs by some farmers or some other reason. In consequence, the use of census value and expenditure data has been avoided where possible and in their place prices collected at the same time as the censuses have been used to calculate expenditures on inputs. In other places, state-level value data from the published censuses available at Yale University libraries have been used in place of municipality data. In the case of feed, vaccines, herbicides and pesticides, expenditure data were used in conjunction with price data to calculate input quantities. In these last cases, whether because of the seasonal nature of these inputs or some other reason, the input quantities and expenditure shares were fairly consistent over time, giving some confidence in their use for this purpose.

Given the incomplete nature of the data and the other problems outlined above, there were usually a number of reasonable ways to generate proxies from what data were available in the census and other sources. The purpose of this appendix is to explain how the input index was computed and why it was computed as it was. As the calculations did not vary much from census year to census year, the discussion is organized by input rather than year, with exceptions in some years noted.

Labor

The Brazilian agricultural census reports the number of family workers, permanent workers and temporary workers in each municipality, but the numbers of workers engaged in crop-raising, livestock- raising and forestry activities are available only at the state level. Unfortunately, there was no clear way to determine in which of a state's municipalities the forestry workers were concentrated, but at least the number of forestry workers was small in most states. The percentage of each of the classes of workers engaged in forestry activities was calculated for each state under the assumption that the proportion of forestry workers in each category was the same in all the municipalities in the state. Each class of worker at the municipality level was then divided between the two remaining activity categories using the state data.

For crops, the number of workers in each class at the state level was divided by the number of hectares of cropland in the state and then multiplied by the number of hectares of cropland

in the municipality. For livestock, the number of workers in each class at the state level was divided by the value of non-work livestock at the state level then multiplied by the value of non-work livestock in the municipality. From this the percentage of each class of workers engaged in each activity was calculated. This was multiplied by the number of workers of that class in the municipality.

The estimated number of full-time worker equivalents and expenditures on workers were calculated from these estimates. Each family worker was considered to be two-thirds of a permanent worker since family workers included many women and children who presumably did not work full-time in agriculture. Permanent workers were considered full-time workers. Temporary workers required special treatment as there were no data upon which some estimate might be made as to how much they worked relative to other classes of workers. Temporary workers do not work as regularly as permanent workers but earn more per day as they often work only at times of peak labor demand. In 1975, 1980 and 1985, the census contains expenditures on temporary and permanent workers. From these expenditure figures, the ratio of expenditures per temporary worker to expenditures per permanent worker by state was used to get an idea of how much work temporary workers did relative to permanent workers.

Temporary workers were taken to be two-thirds of the median 1980 state relative expenditure, or two-thirds of 0.3233. Expenditures were the number of full-time equivalent workers multiplied by the monthly wage of a permanent worker multiplied by twelve.

For 1970, the state data were not available so the distribution of workers between activities by state was calculated using the 1975 state activity and class distribution but adjusting the total worker population. Similarly, as there were no state livestock values, the 1975 proportion of non-work animals to total livestock value was applied to the 1970 municipality-level data. In 1970, the number of permanent and temporary workers was listed separately by activity. However, these data were inconsistent with the total number of permanent and temporary workers given for the municipalities. For the sake of consistency, therefore, we did not use these data and computed 1970 as for other years.

Tractors

There was little usable data in the census on agricultural machinery other than tractors. Tractors appear in the census in several horsepower categories so it was necessary to convert these numbers to the number of same horsepower equivalent tractors. As only the prices for 75 horsepower tractors were available, the number of 75 horsepower equivalent tractors was computed. The number of tractors in each class was multiplied by the midpoint of that class,

summed over all classes, and divided by 75. The percentage of tractors used in livestock and crops was then used to divide total tractors between crop and livestock production. Expenditures are the price of tractors multiplied by the number of tractors. Annual depreciation and operating costs were assumed to be equal to the purchase price.

For 1970 no municipal tractor data were available on tape. The number of tractors in each state in 1970 is available in the published census. Using the size distribution of tractors from 1975, the number of 75 horsepower equivalent tractors was derived from this figure.

For 1975 the published census lists categories of tractors under 10 horsepower, 10-50 horsepower, 50-100 horsepower, and over 100 horsepower. On the computer tape, the first two categories were consolidated. The resulting classification for tractors in 1975 is given below:

Horsepower category weight

Under 50	50-100	Over 100
25	75	100

The classification for tractors in 1980 and 1985 is given below:

Horsepower category weight given

Under 10	10-20	20-50	50-100	Over 100
5	15	35	75	110

NOTE: To test whether the new tractor classes had any impact on the final results, comparable measures to those available in 1975 were generated by adding up the bottom three categories and recomputing. These results were not substantially different from those calculated using all of the classes as given.

Animal power

There was only sufficient data to compute an animal input into crop production, not for livestock. The quantity of work animals is the number of oxen plus the number of horses at the state level divided by the number of hectares in the state planted in annual crops, or in annual crops but left fallow, multiplied by the number of such hectares in each municipality. The value of work animals in the state per hectare of annual crops and fallow was multiplied by the number of hectares in each municipality to find the value of the annual input. Expenditures were taken to be 20% of the value for depreciation and upkeep.

For 1970, there were only data on the number of oxen and the total number of horses by state. The number of work horses was calculated as the total number of horses multiplied by the 1975 ratio of work horses in the state. The value per hectare was taken to be the value of all livestock in 1970 multiplied by the 1975 share of work animals in the total value of livestock.

Land

The land input was taken to be the sum of hectares of land in permanent and temporary crops, weighted equally. Land given over to livestock production was taken to be the sum of natural and artificial pasture, again weighted equally. Expenditures are calculated from the state rental rate for land in crops and livestock multiplied by the number of hectares in each category in each municipality.

There is also data on land rented and expenditures on rent after 1970. This is missing for a sizeable number of municipalities and did not generate very consistent imputed rents, so the price series was used in its place. The same problem occurred when the rents were calculated at the state level.

Fertilizer

The quantity of fertilizer applied is not given in the census. However, the census does record the expenditure on fertilizer for each municipality. The quantity was derived by dividing local expenditure by the price of the most commonly used fertilizer in the state. The quantity of fertilizer used in crops at the municipality level was taken from the percentage of fertilizer used for crops at the same level. Likewise for livestock. Expenditure data were as given in the census.

Chemicals

The quantity of herbicides and pesticides applied is not given in the census, only the expenditure on chemicals for each municipality. The price used was that of a common chemical input. Calculations were the same as for fertilizer.

Feed

The quantity of feed given to livestock is not given in the census, only the expenditure on feed for each municipality. The price is the price of feed for the state. Feed is considered to be used only for livestock production. Calculations were the same as for fertilizer.

Vaccines

The quantity of vaccine given to livestock is not given in the census, only the expenditures on vaccines for each municipality. The price used was that of a common cattle vaccine. This input is considered to be used only for livestock production. Calculations were the same as for fertilizer.

An analysis of the impact of Argentine membership of Mercosur

Ann Bartholomew[§]

RESUMO

O Mercado Comum do Cone Sul (MERCOSUL) estabeleceu-se entre Argentina, Brasil, Uruguai e Paraguai em 1991 e passou a existir formalmente em 1995. Desde então, tem-se realizado progressos significativos em termos de redução de tarifas entre os países membros e o estabelecimento de uma tarifa externa comum. Como resultado, ocorreram mudanças significativas no volume, na direção e na composição de mercadoria dos fluxos de comércio. Este artigo procura examinar a filiação ao MERCOSUL da perspectiva argentina. Faz-se uma análise do efeito da reorientação do fluxo de comércio da Argentina na direção de seus parceiros no MERCOSUL e as mudanças decorrentes nos níveis de comércio intra-indústria. São discutidas as implicações, para a Argentina, das novas filiações da Bolívia e do Chile, bem como dos acordos internacionais com outras regiões. O impacto da estrutura institucional do MERCOSUL é avaliado, sendo apresentadas nas conclusões as questões que provavelmente afetarão o futuro progresso do processo de integração e a perspectiva da Argentina sobre tais questões.

Palavras-chave: Argentina, Mercosul, comércio.

ABSTRACT

The Common Market of the Southern Cone (Mercosur) was established between Argentina, Brazil, Uruguay and Paraguay in 1991 and formally came into being in 1995. Since then, significant progress has been made in terms of tariff reductions between the member countries and the establishment of a common external tariff. As a result, notable changes have occurred in the volume, direction and commodity composition of trade flows. This article seeks to examine the impact of Mercosur membership from the Argentine perspective. An analysis is made of the effect of the reorientation of Argentine trade flows towards its Mercosur partners and as a consequence changes in levels of intra-industry trade. The implications for Argentina of the new associate members of Bolivia and Chile and newly concluded trade accords with other regions are discussed. The impact of the institutional structure of Mercosur is also assessed, and issues that are likely to affect the future progress of the integration process and the Argentine viewpoint on these matters are presented in the conclusion.

Key words: Argentina, Mercosur, trade.

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Introduction

Mercosur, the customs union between Argentina, Brazil, Uruguay and Paraguay, was established in 1991 with the Treaty of Asunción. The objective of the treaty was to provide for the establishment of a common market between the member countries, with free movement of goods, services, capital and labour. The Treaty marked the beginning of a transition period which continued until January 1995, when the trade block formally came into being. During the transition period, the member countries carried out an ambitious agenda, including a program of reductions in tariff barriers, which led to tariff levels of zero for 90 per cent of intra-regional trade by 1995 and a commitment to progressively phase out the remaining 10 per cent by the year 2000. A common external tariff (CET) was agreed and was implemented in January 1995 to cover 85 per cent of product categories, with an average level of 14 per cent. The Asunción Treaty also provided for the coordination of sectoral and macroeconomic policy, although no specific objectives were set for this or the procedures implemented. The Treaty marked a new period of optimism regarding the benefits of regional integration, while the Mercosur initiative was seen as a complement to the general economic liberalisation process that member countries were carrying out during this period.

The objective of this article is to review the impact and achievements of Mercosur in its initial five years, in relation to Argentina. The first section will examine the regional integration process and the corresponding impact on trade flows, in terms of volume, direction and changes in composition of trade. It is, however, difficult to directly relate changes in trade flows to regional integration due to other inter-related factors taking place at the same time. For instance, increases in trade could be related to general increases in economic growth in Mercosur, trade creation and diversion effects, extended trade augmentation or suppression.[1] The second section addresses changes in intra-industry trade, which is the simultaneous import and export of goods in the same industry, while the third section surveys the implications of the new associate members, Bolivia and Chile. Fourthly, the institutional structure is examined; and finally the important issues affecting the future of Mercosur are assessed.

The trade liberalisation process

The speed at which Mercosur countries have implemented trade liberalisation measures has been particularly impressive. Tariffs have been phased out for 90 per cent of intra-Mercosur

1 Extended trade augmentation or suppression occurs through the process of implementing a common external tariff. If tariffs are lower than previously, then trade augmentation will occur, resulting in increases in trade. If tariff barriers are higher than previously, then the process of trade suppression results in a decrease in trade.

trade, while the remaining 10 per cent will be gradually phased out. Argentina and Brazil are scheduled to do this by 1 January 1999 and Uruguay and in Paraguay by 1 January 2000. These exemptions cover products that are particularly sensitive for the countries involved. Argentina for instance, has chosen for tariffs to remain on steel, textiles, shoes and paper, whereas for Brazil, textiles, rubber and wine are still protected. Uruguay has kept tariffs on textiles and chemicals, and Paraguay, textiles, shoes, paper and steel. Interestingly, all the member countries have opted for tariffs to remain on textiles, suggesting that none of them feel they have a comparative advantage vis-à-vis their regional partners in this sector.

With regard to the CET, the 15 per cent of goods that are excluded are mainly capital goods, telecommunication equipment, chemicals and petrochemicals. These sectors will be included in the CET by 1 January 2001, although telecommunications are allowed a longer transition period, with inclusion by 1 January 2006[2] These exemptions were permitted in order for the countries concerned to have a longer period to adjust to foreign competition or higher import prices. The former applies more to Brazil and the latter to Argentina, Paraguay and Uruguay, who already have lower import duties for these products.

Agreements covering cars and sugar have still yet to be negotiated, and, due to their sensitive nature, will not be included in free trade arrangements until the year 2000, although it is still by no means certain that they will be subject to a CET. Problems in reaching agreements on cars have arisen as a result of the structural differences in the Argentine and Brazilian car industries[3] and in their regulatory frameworks. Nonetheless, a transitional agreement reached on 22 January 1996 between Argentina and Brazil allows for companies located in either country to import vehicles and parts tariff-free from the other, on the understanding that they match such imports with exports.[4] The Mercosur Trade Commission has established a technical committee to put forward proposals outlining the automobile regime, which will come into force by the year 2000.

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2 The maximum CET for capital goods has been agreed at 14% and 16% for information and telecommunication products.

3 In 1995, Brazilian production of cars was 1.7 million a year and Argentine 400,000. Uruguay has a small number of producers and Paraguay none.

4 This agreement resulted from a bilateral dispute in 1995 over automobile import levels. Increases in Brazilian demand for automobiles were being met by imports from producers in Argentina. As a consequence, Brazil felt that trade in automobiles was becoming unbalanced in Argentina's favour.

Changes in the geographical composition of trade flows

Since these trade liberalisation measures were implemented, trade flows between member countries have increased rapidly. Intra-Mercosur exports increased from $3.6bn in 1990 to $16.2bn in 1996, an increase of 22.2 per cent a year between 1990 and 1996.(CEPAL, 1997) Although some of this increase in trade can be accounted for by the intra-regional trade liberalisation program, which began in 1991 and continued to reduce tariffs by semi-annual installments, it is unlikely that this would fully explain the huge increase in intra-regional trade by itself. The member countries also experienced economic growth during this period, which would account for part of the increase in trade. Trade creation could be taking place, which involves a shift in domestic consumption from a high-cost domestic source to a lower-cost partner source, as a result of the abolition of tariffs between trade block partners. By contrast, it may be a process of trade diversion which is being observed, i.e., the replacement of imports from a low cost supplier outside the trading block, by a higher cost supplier within the trading block. Alternatively, extended trade augmentation may take place, due to a general lowering in tariff barriers between the four countries, which will encourage trade between them. Lastly, extended trade suppression can result if tariff barriers are higher between the members than before the formation of Mercosur, although this is unlikely to have been the case for Mercosur as average tariff levels have fallen. The formation of Mercosur has played a part in the expansion of intra-regional trade although it is difficult to quantify by precisely how much.

This expansion in trade can be seen in the case of Argentina in Table 1. Argentina has not only experienced a general increase in the level of total exports and imports, there has also been a significant geographical re-orientation of trade flows towards its Mercosur partners. Between 1990 the year before the introduction of the customs union and 1996, Argentina experienced a rise in total global exports of 92 per cent, as compared to an increase in exports to its Mercosur partners of 331 per cent. At the same time, intra-regional imports increased by 553 per cent between 1990 and 1996 and imports which originate from the rest of the world rose by 463 per cent.

Table 1
Absolute Levels of Imports and Exports for Argentina, 1990-1996 (millions $)

Year	Exports to World	Imports from World	Exports to Mercosur	Imports from Mercosur	Exports to rest of world	Imports from rest of world
1990	12353	4077	1833	875	10520	3202
1991	11978	8275	1978	1804	10000	6297
1992	12235	14872	2327	3755	9908	11117
1993	13118	16784	3684	4214	9434	12570
1994	15839	21590	4803	5147	11036	16803
1995	20963	22162	6772	4511	14191	17651
1996	23732	23731	7907	5722	15867	18040

Source: Ministrio de Economia y Obras y Servicios Publicos Secretaria de Programacion Economica, *Republic of Argentina Economic Report, 1996*, April 1997, Year 6 number 20.

Tables 2 and 3 demonstrate this geographical reorientation of trade flows by percentage share. Table 2 shows that in 1990, 15 per cent of exports were intra-Mercosur; by 1996, this figure had increased to 33 per cent. Correspondingly, the share of Argentina's exports to the North American Free Trade Area (NAFTA) and the European Union (EU) has declined as a percentage of total exports. In 1990, 17 per cent of exports went to NAFTA, whereas by 1996, this share had fallen to 10 per cent. Similarly, in 1990, 31 per cent of Argentina's exports went to the EU, while by 1996 this had declined to 19 per cent.

Imports from Mercosur countries, as shown by Table 3, were already significant in 1990 for Argentina, and their share has increased at a lesser rate than exports, from 21% in 1990 to 24% in 1996. NAFTA's share of Argentine imports changed little, at 25% in 1990 and 26% in 1996, while the EU's share of imports increased from 29% in 1990 to 32% in 1996. This demonstrates that Argentina's imports by geographical area did not experience such large shifts as trade in exports.

Table 2
Argentina's Exports by Geographical Area, 1990-1996

	Brazil	Paraguay	Uruguay	Mercosur	NAFTA	EU	Rest of World
1990	12%	1%	2%	15%	17%	31%	37%
1991	12%	1%	3%	17%	13%	34%	37%
1992	14%	2%	3%	19%	13%	31%	37%
1993	21%	3%	4%	28%	12%	28%	32%
1994	23%	3%	4%	30%	13%	26%	31%
1995	26%	3%	3%	32%	10%	21%	37%
1996	28%	2%	3%	33%	10%	19%	38%

Source: International Monetary Fund, *Direction of Trade Yearbook* 1995 and *Direction of Trade Statistics* June 1997.

Table 3
Argentina's Imports by Geographical Area, 1990-1996
(by percentage of total imports)

	Brazil	Paraguay	Uruguay	Mercosur	NAFTA	EU	Rest of World
1990	18%	1%	3%	**22%**	25%	29%	24%
1991	19%	0%	2%	**21%**	21%	24%	34%
1992	22%	0%	2%	**24%**	24%	26%	26%
1993	21%	0%	3%	**25%**	25%	26%	25%
1994	20%	0%	4%	**24%**	25%	33%	18%
1995	21%	1%	2%	**24%**	26%	31%	19%
1996	22%	1%	1%	**24%**	26%	32%	14%

Source: International Monetary Fund, *Direction of Trade Yearbook* 1995 and *Direction of Trade Statistics* June 1997.

Due to these geographical changes in trade flows, concern has been expressed, most notably by Yeats (1996), about the possible trade diversion effects of the Mercosur. In particular, the dramatic increases in intra-regional exports have been identified as a possible source of trade diversion as the sectors in which trade has increased are those in which it is suggested that Mercosur does not have a comparative advantage. These products are capital intensive goods which member countries cannot export competitively to the rest of the world. They are also still protected by higher than average tariff barriers. However, trade diversion occurs when a lower cost supplier outside the customs union is replaced by a higher cost supplier from within the customs union. Thus, what is important in determining levels of trade creation and trade diversion is changes in geographical flows of **imports** rather than **exports**.

In order to have an idea of whether imports from countries outside Mercosur have been displaced by increased imports from Mercosur members, the ratio of Argentine imports intra-regionally and extra-regionally as a percentage of Gross Domestic Product (GDP) is examined in Table 4. The data shows that generally the ratio of total imports to GDP has been increasing since 1990. When this is disaggregated by region, it can be seen that imports from Mercosur as a percentage of GDP were 0.6 per cent in 1990 and 2.0 percent for the rest of the world. By 1996, the figure for Mercosur had increased to 2.0 percent of GDP and for the rest of the world 6.1 per cent. This would suggest less likelihood of trade diversion as the intra-regional and extra-regional shares of imports have both increased and at similar rates.

Table 4
The Ratio of Argentine Imports as a Percentage of Gross Domestic Product (GDP)

Year	Total Imports ($m)	Total Imports as a % GDP	Imports from Mercosur ($m)	As a % of GDP	Imports from rest of world ($m)	As a % of GDP
1990	4077	2.6	875	0.6	3202	2.0
1991	8275	4.9	1804	0.7	6297	3.9
1992	14872	6.5	3755	1.6	11117	4.8
1993	16784	6.6	4214	1.6	12570	4.6
1994	21590	7.6	5147	1.8	16803	5.9
1995	22162	7.9	4511	1.6	17651	6.2
1996	23762	8.0	5722	2.0	18040	6.1

Source: Inter-American Development Bank, *Statistics and Quantitative Analysis* 1995. INDEC, *Statistical Yearbook of Argentina*, Vol 11, 1995.

Viner (1950) stressed that in order to assess whether a customs union is beneficial or harmful, it is the relative strength of the trade creation and trade diversion effects which should be examined. Trade creation is the replacement of expensive domestic production by imports from a partner country, thus, what is needed is the trade creation effects to outweigh the trade diversion effects.

Changes in the commodity composition of trade flows

It is important to assess whether these changes in geographic trade flows have also resulted in changes in the commodity composition of trade. Table 5 presents data on the commodity composition of exports of Argentina to Brazil, Argentina's main trading partner within Mercosur, which, in 1996, accounted for 78% of Argentina's intra-regional exports.

Table 5
The Structure of Argentina's Exports to Brazil for Selected Years Between, 1990-1996
(by percentage share)

	Primary products	Manuf. of Agri Origin	Manuf. of Ind. Origin	Fuel & Energy
1990	39	22	39	0
1991	40	23	36	2
1992	43	14	36	7
1993	31	12	39	18
1995	24	18	45	13
1996	22	16	43	19

Source: Ministerio de Economia y Obras Y Servic·s Publicos Secretaria de Programacion Economia *Republic of Argentina Economic Report 1995* April 1996, Year 5. Centro do Economia Internacional, *Comercio Exterior Argentino* Nov. 1996, Vol 4, N. 10.

The data demonstrate that significant changes in the commodity composition of exports to Brazil have occurred. The data indicate that the share of primary products has declined from 39 per cent to 22 per cent in 1996, while the share of exports of manufactured goods of agricultural origin has also diminished, from 22 per cent in 1990 to 16 per cent in 1996.

Correspondingly, the share of manufactured products of industrial origin rose from 39 per cent of exports in 1990 to 43 per cent in 1996. The most dramatic increase is seen in the fuel and energy sector, which had a zero share of exports to Brazil in 1990, but a 19 per cent share in 1996.

In comparison, the figures in Table 6 show total Argentine export figures for selected years between 1990 and 1996, excluding Brazil. These figures demonstrate that exports to the rest of the world did not follow the same trends as the pattern of Argentine exports to Brazil. The share of primary products in total exports did not alter significantly between 1990 and 1996, unlike exports of primary products to Brazil, which declined. The share of exports of industrially manufactured goods declined from 26 per cent of exports in 1990 to 21 per cent in 1996, whereas exports of industrially manufactured products to Brazil increased. Agro-industrial manufactured exports hardly changed, with a 40 per cent share of exports in 1990 and 43 per cent in 1996, a smaller decline than that for the same category of exports to Brazil. The share of exports of fuel and energy again remained relatively unchanged, with total exports in this sector at 9 per cent in 1990 and 11 per cent in 1996. In contrast, this sector's share of exports to Brazil rose at a dramatic rate during this period.

Table 6
The Commodity Composition of Argentina's Total Exports (excluding Brazil) for Selected Years Between, 1990-1996 (by percentage share)

	Primary Products	Manuf. of Industrial Origin	Manuf. of Agricultural Origin	Fuels and Energy
1990	25	26	40	9
1991	26	23	44	7
1992	26	21	44	9
1993	23	22	44	7
1995	23	26	43	9
1996	25	21	43	11

Source: Ministerio de Economia y Obras Y Servicios Publicos Secretaria de Programacion Economia *Republic of Argentina Economic Report 1995* April 1996, Year 5. Centro do Economia Internacional, *Comercio Exterior Argentino*, Nov. 1996, Vol 4, N. 10.

An analysis of the imports of Argentina in 1996 by commodity composition and geographic origin is shown in Table 7 [5] The figures demonstrate that the share of imports of intermediate goods originating from Argentina's Mercosur partners is high at 30.3 per cent, as compared to the shares of NAFTA and the EU at 24.9 per cent and 26.1 per cent respectively. Capital goods, however, are still overwhelmingly imported from outside the region, with Mercosur's share at 16.1 per cent, NAFTA's at 35.8 per cent and the EU's at 32.8 per cent. Also, more spare parts and passenger vehicles are imported from the EU than Mercosur. This demonstrates that Argentina is still heavily reliant on extra-regional sources for its major imports.

Table 7
Imports of Argentina by Type of Good, 1996
(Millions of US$)
Relative Share (%)

	World	Mercosur	NAFTA	EU	Mercosur	NAFTA	EU
Capital Goods	5385	868	1928	1764	16.1	35.8	32.8
Intermediate Goods	7735	2345	1928	2019	30.3	24.9	26.1
Fuels	764	160	66	147	20.9	8.6	19.2
Spare Parts	3800	1227	710	1274	32.3	18.6	33.5
Consumer Goods	3309	809	615	790	24.4	18.6	23.8
Passenger Vehicles	1157	311	167	607	26.8	14.4	52.5
Others	11	2	4	3	18.1	36.4	27.2
Total	22162	5722	5419	6602	25.8	24.4	29.9

Source: Ministerio de Economia y Obras Y Servicios Publicos Secretaria de Programacion Economia *Republic of Argentina Economic Report 1996* April 1997, Year 6, Number 20.

5 The import figures shown in table 7 are calculated as freight on board (FOB). This explains the discrepancy between the total import figures shown here and in previous tables.

Intra-industry trade

Another way of assessing the degree of integration that is occurring in a region is by measuring levels of intra-industry trade (IIT) i.e the simultaneous export and import of commodities in the same industry. High levels of intra-industry trade would suggest that productive structures are complementary between trading partners, and increasing levels of IIT would indicate gains in terms of specific sectoral specialisation. Studies of the EU have shown increasing levels of intra-industry trade.(Verdoorn, 1960 and Balassa, 1963) The value of total IIT is the value of total trade after subtraction of net exports or imports. This is then expressed as a percentage of each country's combined exports or imports. The resulting index varies between 100, when exports of an industry equal imports and 0 when there is no IIT and there are either exports but no imports or no exports but imports. In order to provide a comparison, the index of IIT in the United States in 1985 for Standard Industrial Trade Classifications (SITC)[6] sections 3 and 5 to 9 were 63.0, for West Germany 70.0, and 81.0 for the United Kingdom.(Globerman and Dean, 1990) Empirical analysis assessing the experience of other regional groupings has demonstrated that industrial adjustment as a consequence of trade liberalisation is likely to be less disruptive if adjustment takes place though intra-industry as opposed to inter-industry specialisation.[7] This is due to the fact that the process of adjustment occurs within firms within the same industry rather than in different industries. Thus, the argument follows that this will lead to lower adjustment costs and fewer changes in income distribution.

Table 8 shows the IIT index of manufactures for Argentina for 1989 and 1995, expressed as a percentage and calculated using the Grubel and Lloyd index of intra-industry trade at SITC 3 digit level, sections 5 to 8.[8]

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6 A degree of consensus has emerged in the literature on IIT, that the third digit level of SITC coincides with what is commonly defined an industry.

7 Greenaway and Milner (1983 and 1985).

8 The Grubel-Lloyd multilateral index of a country (I) for an industry (k) is defined in the analysis as follows: Bik=[{Xik+Mik)-lXik-Mikl}/ (Xik+Mik)] *100. Where X is the value of exports and M the value of imports for (k) an 'industry' at a given level of statistical aggregation. Bik measures intra-industry trade as a percentage of total trade of industry k in country I. Similarly, the bilateral index of ITT of country I with country j is defined as: Bij=[1-lSXij-Mijl/ S(Xij+Mij)] * 100.

Table 8
Intra-industry Trade Index of Manufactures for Argentina 1989-1995
(as a percentage)

	Rest of World	Brazil	Paraguay	Uruguay
5. Chemical and related products 1989	45.6	60.5	0.0	37.9
1995	40	61	2	36.2
6. Manufactured Goods 1989	25.9	33.6	2.5	25.4
1995	31.7	41	6.1	35.5
7. Machinery and transport equipment - 1989	47.2	69.5	3.1	56.5
1995	15.2	70.4	0.7	57
8. Miscellaneous manufactured article - 1989	28.5	34.1	0.0	47.7
1995	29	60.8	15.6	64.5

Source: Computed from United Nations Comtrade Statistics.

What is striking about the trends in ITT for Argentina is that ITT with the world as a whole has decreased in two categories of manufactured goods, with a particularly dramatic decrease in section 7. machinery and transport equipment. This is due to large increases in imports in this category from the European Union, which have not been matched by corresponding exports from Argentina to the European Union. Section 6, manufactured goods, has increased, while section 8, manufactured goods, has remained at almost the same level. Interestingly, ITT with Brazil has risen in all four categories, particularly in section 8, miscellaneous manufactured articles. Argentina's intra-industry trade with Uruguay has also increased for all manufactured goods, apart from section 5, chemical and related products, which marginally declined.

Paraguay has extremely low levels of IIT with Argentina, although levels increased in all categories apart from section 7. machinery and transport equipment.

This data on IIT demonstrates that between Argentina and its Mercosur partners, levels of IIT are on the whole increasing, and, according to economic theory, this would appear to suggest that the changes in trade flows due to regional integration which Argentina is experiencing are likely to involve less disruption as levels of intra-industry trade are higher than with the rest of the world, and adjustment can take place through intra-industry as opposed to inter-industry specialisation.

The widening of Mercosur

The members of Mercosur have always professed to follow a policy of 'open regionalism' with expansion as a principal goal. This acknowledges the objective of regional integration as a stepping stone towards full insertion into the global economy. Also, Argentina views future expansion as necessary to act as a counterweight to the economic power of Brazil.(Stevens, 1996) However, there is an inevitable tension between the objectives of 'widening' and 'deepening' and the time framework within which it will occur. Brazil has strongly supported the expansion of the trade block to increase the market size of Mercosur. Argentina, on the other hand, has displayed more caution, arguing that a prerequisite to expansion is the deepening of the integration process between the original members.(Gosman, 1996)

Economic theory also indicates that regional groupings will be more beneficial when they include more countries. This rests on the assumption that the larger, the market the more scope for efficiency gains due to enhanced levels of competition and, more importantly, the likelihood of trade diversion is diminished, as the cheapest supplier of a product is more likely to be inside the trade block than outside. Larger size also brings the possibility of better terms of trade as a consequence of an improved international bargaining position.(El-Agraa, 1994)

Chile became the first associate member, with a free trade agreement that began on 1 October 1996. The agreement allows for 85% of products to be duty free by the year 2004 and with longer time periods for more sensitive products. Chile is an important trading partner of Argentina. In 1996, Chile was Argentina's third largest trading partner, representing 7 4 per cent of total Argentine exports. For Chile, Argentina represented the second largest country by origin of its imports in 1996, with 9.4 per cent of Chilean imports coming from Argentina. The major imports originating from Argentina were petroleum products and chemicals.[9]

9 Economist Intelligence Unit, *Chile: Country Report*, 2nd quarter, 1997.

Despite Chile being an important trading partner for both Argentina and Brazil and also the main foreign investor in Argentina, the agreement with Chile proved difficult to negotiate. First, Chile's external tariff averages 11% as compared to an average of 14% for Mercosur's CET. Secondly, the Chileans were reluctant to include agriculture in the free trade agreement as they felt they had less competitive advantages in many products vis-à-vis Argentina, although they finally agreed to do so, after receiving a transition period of 18 years.

The benefits of Chilean membership to Argentina derive from potential increases in exports to Chile, further rises in investment from Chilean companies and the demonstration/imitation effects of competing with technologically advanced Chilean companies.(Nofal, 1996) An important outlet to the Pacific is also gained, allowing improved access to Asian markets. In return, the Chileans gain access to an increased market and the corresponding export opportunities.

Bolivia signed a free trade agreement with Mercosur on 17 December 1996, which came into force on January 1 1997. Argentina is an important trading partner of Bolivia, its fourth largest export market in 1996, with natural gas its major export, 92.4 per cent of Argentine imports from Bolivia in 1996. Argentina primarily exported chemicals, and rubber manufactured products to the Bolivian market in 1996.[10]

The first preferential tariff rates were effective as from May 1997, and import duties will be phased out within 10 years for most products, 18 years for sensitive items.(*Buenos Aires Herald*, 19.12.96) Bolivia, like Chile, will be an associate member, becoming a non-voting partner in what has been termed a '4+1' agreement.

The Bolivian government hopes that associate membership will not only provide increased market access, but competition will act as a spur to the business sector to improve its efficiency and competitiveness. In contrast, the business community have voiced fears over what they see as Bolivia's competitive disadvantage, which they believe may lead to unemployment in certain industries. For Argentina, the gains lie in Bolivia's energy sector, which already exports a significant amount of natural gas to Argentina.

10 Economist Intelligence Unit, '*Bolivia; Country Report*, 2nd quarter 1997.

In February 1997, negotiations with the other Andean Pact[11] countries began. The Brazilians in particular regard closer links with Colombia and Venezuela as important in order to encourage growth in the lesser developed regions of the North and Northeast of the country, geographical proximity being an important factor in encouraging agreements with these countries. It is also a reflection of the objective stated by Cardoso to "*expand the sphere of influence of Mercosur in South America and open the way to full continental integration.*"(*Buenos Aires Herald*, 17.12.96) As part of this objective, Menem invited the Central American[12] countries and Panama to open negotiations in May 1996. Argentina and the other Mercosur countries were, however, less sympathetic to Venezuela's request for membership, due to the economic problems that Venezuela was experiencing.

Mercosur is also seeking an association agreement with the Caribbean Community (Caricom) and talks will begin between the two regional groupings after negotiations with the Andean Pact have finished. It is expected that any agreement would focus on energy, telecommunication, tourism and agriculture.

A Cooperation agreement has also been signed between Mercosur and the European Union. The interregional frame agreement was signed on 15 December 1995. This agreement acknowledges the European Union's position as one of Mercosur and Argentina's largest trading partners and a leading investor and therefore aims to consolidate existing ties. The agreement covers a range of issues and broadly aims to achieve more interregional political and economic associations. The agreement represents increased opportunities for trade with the EU and investment flows from European countries. It also provided credibility and international recognition for Mercosur. For Argentina, the agreement was the culmination of a series of unsuccessful initiatives to gain trade concessions with the European Union. More generally, the European Union acts as a balance to the increasing influence of the United States, in particularly after the formation of the North American Free Trade Agreement (NAFTA). For the EU, on the other hand, it was an opportunity to counter American influence in the region.

Disappointment was expressed about the agreement by the Mercosur countries as it did not represent a trade or investment liberalisation agreement. However, the need for future discussions was acknowledged as a prerequisite for commercial accords after the year 2000.

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11 The members of the Andean Pact are Colombia, Venezuela, Ecuador, Bolivia and Peru.

12 The members of the Central American Common Market are Costa Rica, El Salvador, Guatemala, Honduras and Nicaragua.

Any future discussions would involve negotiation on highly sensitive issues, such as agricultural products, where Mercosur is in direct competition to the EU producers. In particular, Argentina exports products such as beef, wheat and dairy products, which compete directly with the member states of the European Union. Any tariff concessions on these products would conflict with the objectives of the Common Agricultural Policy, which provides subsidies and price support to European farmers. However, the recent possibility of a revised EU budget by 1999 that results in a decrease in agriculture subsidies would provide a more positive environment for negotiations. From the Argentine point of view, an agreement that provides increased access for farm products is essential.

In December 1994, at the Summit of the Americas, the member countries of Mercosur agreed, along with 30 other countries in the Western Hemisphere, to initiate negotiations for a Free Trade Area for the Americas (FTAA) to be completed by 2005. However, since this date, there have been differences in opinions, particularly between Brazil, speaking on behalf of Mercosur, and the United States, on how the negotiations towards the FTAA should proceed. Mercosur favours a gradual approach to talks on tariff reductions, beginning with negotiations on business deregulation and facilitation. Then trade related rules and dispute settlements would be discussed, and only later would tariff reductions be discussed. The rationale for this position is that their economies are not at present strong enough to cope with further tariff reductions. Another concern is that the FTAA is an attempt to weaken Mercosur's strength, a view further compounded by the United States nominating Argentina as a 'close non-Nato Ally' a move which upset both Brazil and Chile.[13] Nonetheless, the benefits to Mercosur of participation in an FTAA depend primarily on the preferential access granted to American markets as, currently, many important products have difficulty entering United States markets.

The institutional structure

Since its beginning, it has been clear that Mercosur's institutional structure would not involve the extensive bureaucratic structure which characterises the EU. Indeed, the objective was to create a minimum of supranational institutions with contact to take place at an inter-governmental level. The protocol of Ouro Preto, signed on 17 December 1994, established the institutional structure of Mercosur as follows:

13 This was incident was then excerbated by Menem criticising Brazil's bid for a permanent seat on the UN Security Council. Indeed, Jose Sarney, the former Brazilian President accused Carlos Menem of being an instrument of the US who wished to 'destabilise' Mercosur at the expense of an FTAA (Financial Times, 26 August 1997).

The Council of the Common Market

The Common Market Group

- The Mercosur Trade Commission
- The Joint Parliamentary Commission

The Economic and Consultative Forum

- The Mercosur Administrative Secretariat

The Council of the Common Market, The Common Market Group and the Mercosur Trade Commission are the three main bodies. The Administrative Secretariat is relatively small and provides support to the Common Market Group, while the Joint Parliamentary Commission and the Economic and Consultative Forum are both consultative bodies.

The Common Market Council is composed of the Ministers of Foreign Affairs and Economic Affairs of the four countries and decisions are made by consensus and become binding after ratification by each parliament. The Council meets twice a year and the presidency rotates every six months. The Council has responsibility for political decisions and ensuring that timetables and objectives are met.

The Common Market Group has responsibility for the implementation of the Treaty and decisions taken by the Council, while the Trade Commission administers the common trade policy. A number of working groups have also been established to examine various issues relating to the integration process.

A dispute mechanism has been established under the Brasilia Protocol (1991) if negotiations fail to reach a solution acceptable to all parties. This enables the Common Market Group to obtain expert technical advice and refer the dispute to the Council of the Common Market to adopt appropriate recommendations. However, due the lack of a supra-national court, treaty obligations cannot be enforced upon a member state, while legal enforcement at a national level depends on the interpretation by national courts of Treaty obligations.

As a result, Mercosur's institutional bodies have no powers to force member governments to comply with their rulings. Decision-making is on a consensus basis while officials are representatives of their respective governments and are there to defend their national interests. This has led many commentators to remark that this may lead to future problems due to

differences in national agendas within the member countries.(Bouzas, 1995) For instance, in September 1997, the Argentine Senate overrode President Menem's veto of a law imposing tariffs of 20 per cent on imports of Brazilian Sugar. Also, Brazil, in April 1997, introduced restrictions on short-term import financing. After strong opposition from Argentina, Uruguay and Paraguay, the three member countries were given a temporary exemption.(*Financial Times*, 12 September 1997)

Up to now, disputes have been solved by negotiations between the parties involved. For example, when Argentina introduced a statistical tax[14] in 1992 to control spending and raise revenue, Paraguay and Uruguay were exempted after protesting, although Brazil continued to face the levy.(Bouzas, 1995) Similarly, in April 1995, Brazil, in order to combat a surge in imports and inflationary pressures, raised tariffs on 109 products from 32 percent to 70 percent, while quotas were introduced on automobile imports.(Inter-American Development Bank, 1996) This not only attracted internal condemnation from Brazil's trading partners, but also the attention of the World Trade Organisation, who ruled that it went against Brazil's commitments to trade liberalisation. However, the lack of a dispute resolving mechanism with any legal footing continues to work against the interests of Argentina, and the smaller members, Paraguay and Uruguay, as there is no formal mechanism to protect their interests against the strength of Brazil[15] and its tendency to act unilaterally in trade measures.

It would appear that a prerequisite of the success of future aims of both widening and deepening the Mercosur would require some degree of supra-nationality. Uruguay and Paraguay have been particularly vocal in stressing the need for a Mercosur bureaucracy, while Argentina has more recently begun to emphasize the need for some common institutions. However Brazil has consistently demonstrated its opposition.

Conclusion

Despite the progress achieved so far in Mercosur, serious issues will need to be addressed in order for regional trade to continue increasing in the future. Harmonisation of policies, in particular, is an area that will have to be addressed. For instance, free movement of goods is an essential prerequisite for a common market. Currently, goods that have cleared customs and

14 The tax ranged from between 3 to 10% and was a response to a large increase in imports from partner countries.

15 An example of Brazil's often unilateral action on trade and investment policy, was the announcement by Cardoso in December 1996 of fiscal incentives for automobile manufactures who invest in the poorer northern regions of Brazil. This resulted in strong protests by Argentina, Paraguay and Uruguay.(*El Cronista*, 20.12.96).

paid the common external tariff face the further levying of import duties by the importing Mercosur partner. Also, differences in methods of customs valuation defeat the objective of having a CET, and bureaucracy at borders compounds the problem. The harmonisation of intellectual property rights, services, government procurement, air transport, competition policy and consumer protection are all additional issues that are in need of consideration.

The harmonisation of economic policy is another area that will need to be examined. The use of industrial subsidies and incentives by Brazil obviously puts the other member countries at a disadvantage. At the same time, there is a lack of coordination of economic policy between Argentina and Brazil. Both are experiencing similar economic problems, in particular high rates of unemployment, caused by restrictive monetary policy and overvaluation of their exchange rates designed to curb inflation. Therefore, to a certain extent, there is cause for a certain degree of concern as to how these economies will be affected by these factors in the near future and what measures they will put in place to solve them and whether they will be compatible.

At the 11th meeting of the Council of Mercosur, in December 1996, Argentina demonstrated its preference for deepening rather than broadening Mercosur, stressing the need for the inclusion of areas such as services into the free trade agreement in the near future and the harmonisation of regulation on capital movements, labour markets, the environment and energy. Deepening it will not only encourage further integration and increases in intra-regional trade and investment, but will also strengthen Mercosur's position in trade negotiations with other regions, such as NAFTA and the EU. Brazil has indicated its preference for the option of widening, showing less enthusiasm for harmonisation due to its reluctance to give up its ability to act unilaterally.

As this article has outlined, significant progress has occurred in the integration process, with large increases in trade between Argentina and its Mercosur partners. Nonetheless, the extent to which the issues outlined above are resolved will in turn control the speed at which further integration and progress takes place and the degree to which Argentina can reap further gains from regional integration.

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In memoriam

Álvaro Antônio Zini Jr.

Professor Titular de Economia - FEA/USP
1953 – 1998

Em abril último deixou-nos o Professor Álvaro Antônio Zini Jr., após uma longa e angustiante batalha contra o câncer.

É enorme a lacuna deixada pelo Prof. Zini, tanto para os que com ele conviviam, como nós editores de *Economia Aplicada*, quanto para a comunidade acadêmica em geral. Como homenagem da Fipe e do Departamento de Economia da FEA/USP, assim como de todo o seu corpo docente, publicamos nesta edição uma de suas últimas obras, fruto de sua incursão na área do crescimento econômico regional e das tendências das desigualdades regionais no Brasil. O artigo foi apresentado para publicação já na sua última semana de vida, tendo o Prof. Zini se desculpado por não ter podido realizar a revisão que entendia ser necessária e que gostaria de ter feito se tivesse tido condições.

Combativo como era, participou ativamente dos debates sobre os principais assuntos da economia brasileira, de maneira corajosa e aberta. Apresentamos o trabalho como testemunho da qualidade de sua obra e de sua importante contribuição para mais esse debate acadêmico. Sua contribuição para a análise da economia brasileira vai além dos restritos meios acadêmicos, estendendo-se para sua participação na grande imprensa, seja por artigos e entrevistas, seja por sua coluna semanal no jornal *Folha de São Paulo*.

O Prof. Zini era extremamente produtivo, diligente, empreendedor, como comprova o sumário de seu *curriculum* que a seguir apresentamos. Mais do que a quantidade, a relação abaixo testemunha a qualidade de sua produção acadêmica, tanto no Brasil quanto no exterior. E dá uma medida da perda sofrida com o seu passamento.

Curriculum Resumido

Titulação e Escolaridade

Professor Titular (1995), Livre-Docente (1993), da Faculdade de Economia e Administração da USP.

Doutor (Ph.D.) em economia pela Universidade de Cornell, EUA, 1988. Tese: "Exchange Rate Policy and Stabilization in Brazil"

Mestrado em Economia; Universidade de Campinas - 1982. Tese: "Avaliação do Setor Financeiro no Brasil: das Reformas de 1964/65 a 1980"

Bacharelado em Economia - Universidade de São Paulo - 1976.

Pesquisador-visitante, Departamento de Economia, Universidade de Harvard, 1994.

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Latina, American Express Bank Review Award, Ensaios em Finanças Internacionais, Londres, 1989.

Associação Nacional dos Centros de Pós Graduação em Economia (ANPEC), Artigo científico publicado em revista de economia no Brasil, 1989.

Prêmio BNDES para Teses de Mestrado, BNDES, Rio de Janeiro, 1985.

Organização dos Estados Americanos, bolsa de estudos na Universidade de Cornell, 1985-1987

Fundação Inter-Americana, Washington, bolsa de estudos para doutorado nos Estados Unidos, 1983-85.

Experiência Profissional

- Professor de Economia Internacional, Universidade de São Paulo, desde 1980.
- Consultor Econômico da AAZ consultoria.

- Professor Visitante, Universita Degli Studi di Rome - La Sapienza, 1996 a Fev/1997.
- Professor visitante, Harvard University, 1994.
- Pesquisador-visitante, Banco Inter-americano (BID), Washington DC, 1993.
- Colunista de Economia, jornal *Folha de São Paulo*, coluna dominical, desde julho de 1994.

Trainee no Banco Mundial em Washington (verão de 1986) e no FMI (verão de 1985).

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- Conferência Internacional - "Brasil X Argentina. Uma Parceria Para o Futuro", 1992.
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- Curso Intensivo sobre - "Modelos Endógenos de Crescimento", agosto de 1996 (em comemoração aos 50 anos da FEA).

- Aula Magna - "Brasil as Novas Fronteiras do Crescimento", FEA/USP (27/02/1997).

Regional income convergence in Brazil and its socio-economic determinants*

Álvaro Antônio Zini Júnior§

RESUMO

Este estudo analisa a evolução da renda per capita real dos estados brasileiros, examinando se a divergência de renda cresceu ou diminuiu entre 1939 e 1994. São apresentadas evidências robustas de convergência de renda per capita entre estados, tanto no sentido absoluto como no sentido condicional, embora as velocidades verificadas sejam baixas. São também analisados fatores socioeconômicos que podem explicar as diferenças nos desempenhos dos estados. Observa-se que indicadores de capital humano, investimento na indústria e na infra-estrutura em geral induzem o crescimento, enquanto a concentração da propriedade da terra contribui para diminuir o crescimento dos estados.

Palavras-chave: desigualdade regional, crescimento econômico.

ABSTRACT

This study looks at the evolution of real income per capita across states in Brazil to examine the question of whether regional divergence of income increased or diminished from 1939 to 1994. Robust evidences of per capita income convergence across states are reported under the *conditional* and the *unconditional* convergence hypotheses, although the speed of convergence was low. Socio-economic factors that may explain the differences in state performances are examined and indicate that human capital, investment in industry (and in infrastructure in general) induced growth while concentration of land property helped to deter growth.

Key words: regional inequality, economic growth.

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1 Introduction

In the neoclassical growth model, differences in regional income per capita should decrease over time and evolve to a steady state equilibrium level, or, more realistically, to a situation where there is a narrow gap between regions. This study looks at the evolution of real income per capita across states in Brazil from 1939 to 1994 to examine the question of whether regional divergence of income increased or diminished in this period.

The interest on the issue of regional (or spatial) income distribution was revived in the 1990s because it serves to test some central predictions of the neoclassical model of growth and because it has implications on policy recommendations concerning the promotion of regional growth.

Barro and Sala-i-Martin (1991, 1992a and 1992b) extended the tests of income convergence associated with the controversy of growth models to the area of regional economics. In these works, the authors documented solid evidence of income convergence across states in the United States between 1880 and 1987 and among 73 regions of Western Europe from 1950 to 1985. They also found evidence of convergence within Japanese prefectures over the period 1930 to 1990. Statistically significant findings of convergence between regions and countries of the European Community have also been reported by Ben-David (1993).

These studies tested for *unconditional convergence*, that is, if there were a tendency for the dispersion of income across regions to narrow over time toward a common steady-state average, and for *conditional convergence*, that is, if different areas tend to a steady-state level of income that may be conditional on the area's specific endowments. In both cases, the rate of growth is dependent on the initial level of income, implying that the poorer areas grow faster than the richer ones.

Regarding developing countries, Jian, Sachs and Warner (1995) *did not* find convergence in their study of regions in China over the period 1952-1993, but found inconclusive evidence of income dispersion. This result is noteworthy given China's professed faith in income equality in this period. However, Bajpai and Sachs (1996) found evidence of income convergence using data for India from 1961 to 1993. Cashin and Sahay (1996) detected *unconditional convergence* for India during 1961-1993 but found income dispersion across states in *conditional convergence tests*.[1]

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1 *Unconditional (or absolute) convergence* is the hypothesis that income per capita in different countries or regions of a country converges to a long-run steady state level that is equal in all areas because all have the same production function (supposing equal access to technology). The test for *unconditional convergence* is known as the *σ-test* where σ^2 represents the variance of a sample. *Conditional convergence* is the hypothesis that the long-run steady state level of per capita income is dependent on geographical, technological or institutional factors that may be different in different countries or regions. *Conditional convergence* is tested by the so-called *β-test*. See Barro and Sala-i-Martin (1992a and 1995) on these hypotheses and tests.

This study focuses on Brazil to test for convergence using data from 1939 to 1994. Robust evidence of income per capita convergence across states is reported under both the *conditional* and the *unconditional* convergence hypotheses using the tests proposed by Barro and Sala-i-Martin. Special attention was paid to the compilation of a "long" time series and to the socio-economic variables used in structural regressions.

Our main findings are that per capita income disparity across states decreased in Brazil for the period from 1939 to 1994, although the speed of convergence was low. Looking at sub-periods, disparity increased from 1939 to 1955, decreased from 1955 to 1965, went up again from 1965 to 1975, came down substantially from 1975 to 1985, and increased slightly from 1990 to 1994. Socio-economic factors that may explain the differences in state performances are examined and indicate that human capital, investment in industry (and in infrastructure in general) induced growth while concentration of land property helped to deter growth.

The paper starts with a summary of Brazil's economic history in the 19th century to give a broad explanation for the income disparity across regions shown in 1939 when our time series begins. This background refers the reader to the charged political debate about the uneven regional development in Brazil - see Cano (1985) or Campolina Diniz (1995) on the topic. The paper presents solid evidence that, contrary to common belief, it was not the industrialization of the Southern states of the country, in particular that of *São Paulo* in the 50s and 60s, that explains regional discrepancies in income. Rather, these differences took shape in developments that happened around the turn of the century.

In the following section, the data set is presented, the growth rates of different states from 1939 to 1994 are discussed, and econometric tests to detect convergence are performed. The paper then examines some of the structural factors that may explain the differences in performance across states. In the concluding section, the main findings are reviewed and the issue of whether or not Brazil's regional development agencies have been instrumental in diminishing the difference in per capita income is raised.

2 Regional income disparity in Brazil: historical roots

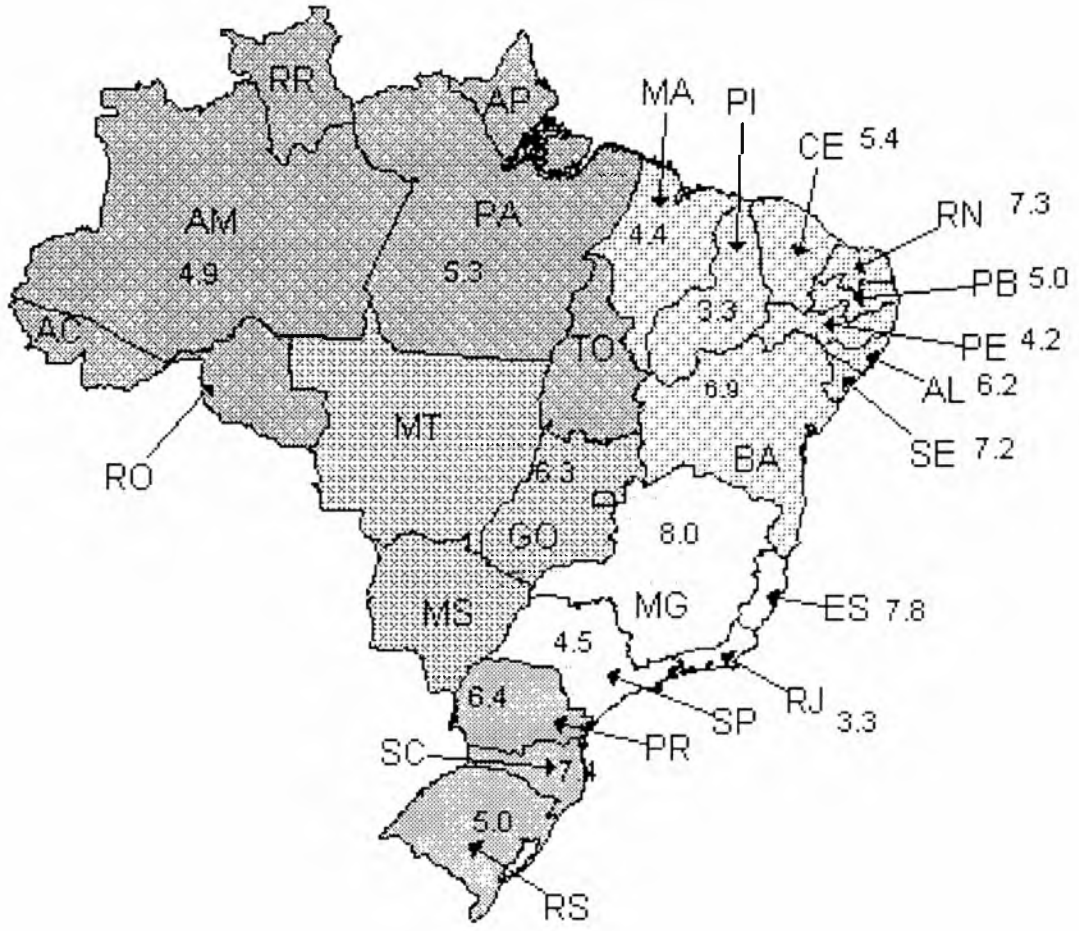
Considerable discrepancies in per capita income across regions of Brazil exist and have led to charges of policy discrimination against the Northeast in favor of the South.

Table 1
Distribution of Population and GDP Across Regions of Brazil

	1939				1994		
	Share of territory (%)	Share of GDP (%)	Share of population %	Income p. capita / average (%)	Share of GDP (%)	Share of population %	Income p. capita / nat. average (%)
North	42	3	4	73	5	7	72
Northeast	18	17	35	48	14	29	49
Southeast	11	63	44	141	56	43	133
South	7	16	14	113	18	15	118
Center-West	22	2	3	71	7	7	101
Brazil	100	100	100	100	100	100	100
Size of variable	8,547 Km^2	R$ 29.3 bi.	40 million	R$ 721	R$ 595.4 bi.	154 million	R$ 3,873

Obs. Values of GDP and of income per capita are expressed in constant prices of 1995. One real was worth approximately one dollar in 1995 (R$ 1 = $ 1).

Figure 1
Brazil: Division by States and Regions



Although the roots of the problem are complex, the fact is that differences in income per capita across regions are high. Table 1 presents data on the proportion of GDP, the proportion of population and the ratio of GDP per capita compared to the national average for the five regions that make up the country. Figure 1 shows a map of Brazil and its geopolitical regions.[2]

According to IBGE, the North comprised 42% of the territory and had 7% of the population in 1994; the Northeast had 18% of the territory and 29% of the population; the Southeast accounted for 11% of the territory and 56% of the population; the South, 7% and 18%, respectively: and the Center-West 22% and 7%. Demographic density was 70 persons/ km^2 in the Southeast, 40 in the South, 28 in the Northeast, 6 in the Center-West and 3 in the North.

2 Brazil is divided in 26 states, one federal territory and one Federal District, where the city of *Brasília* is located. The map on Figure 1 shows a map of Brazil and the numbers inserted in each state are the number of times real income per capita grew from 1939 to 1994.

In 1994, income per capita in the Southeast was 1.33 times the national average, 1.18 in the South, about even in the Center-West, 0.74 in the North, but only 0.49 in the Northeast. Such disparity seems to have taken shape in the last years of the 19th century. It was slightly higher in 1939, when our series begins, than in 1994. There are good reasons to suppose that the difference in income was wider in the 1910s and 1920s than in 1939. It is important to remember that income was still very depressed in the Southeast in 1939 because the area's active export-oriented economy (coffee) suffered the full brunt of the disruption of international trade. To understand the roots of this income disparity, a summary of Brazil's economic history will be presented.

By 1808, Brazil had a huge territory (8.5 million Km^2) but was sparsely populated: 2.4 million people, see Table 2. Except for decaying sugar plantations in the Northeast, tobacco in *Bahia*, scattered towns in the exhausted areas of gold extraction in *Minas Gerais*, government and commerce in *Rio de Janeiro*, very little economic activity was taking place elsewhere.

Table 2
Brazil: Distribution of Population by Regions, 1808-1994

	1808	1872	1900	1939	1970	1994
North	4%	3%	4%	4%	4%	7%
Northeast	50%	47%	38%	35%	30%	29%
Southeast	35%	41%	44%	44%	43%	43%
South	7%	7%	10%	14%	18%	15%
Center-West	3%	2%	3%	3%	5%	7%
Population (millions)	2,4	10,1	17,3	40,1	93,1	153,7

Source: IBGE (1987), *Estatísticas Históricas do Brasil* and *Sinópse Estatística, 1995*.

Figure 2
Brazil: Distribution of Population Across Regions

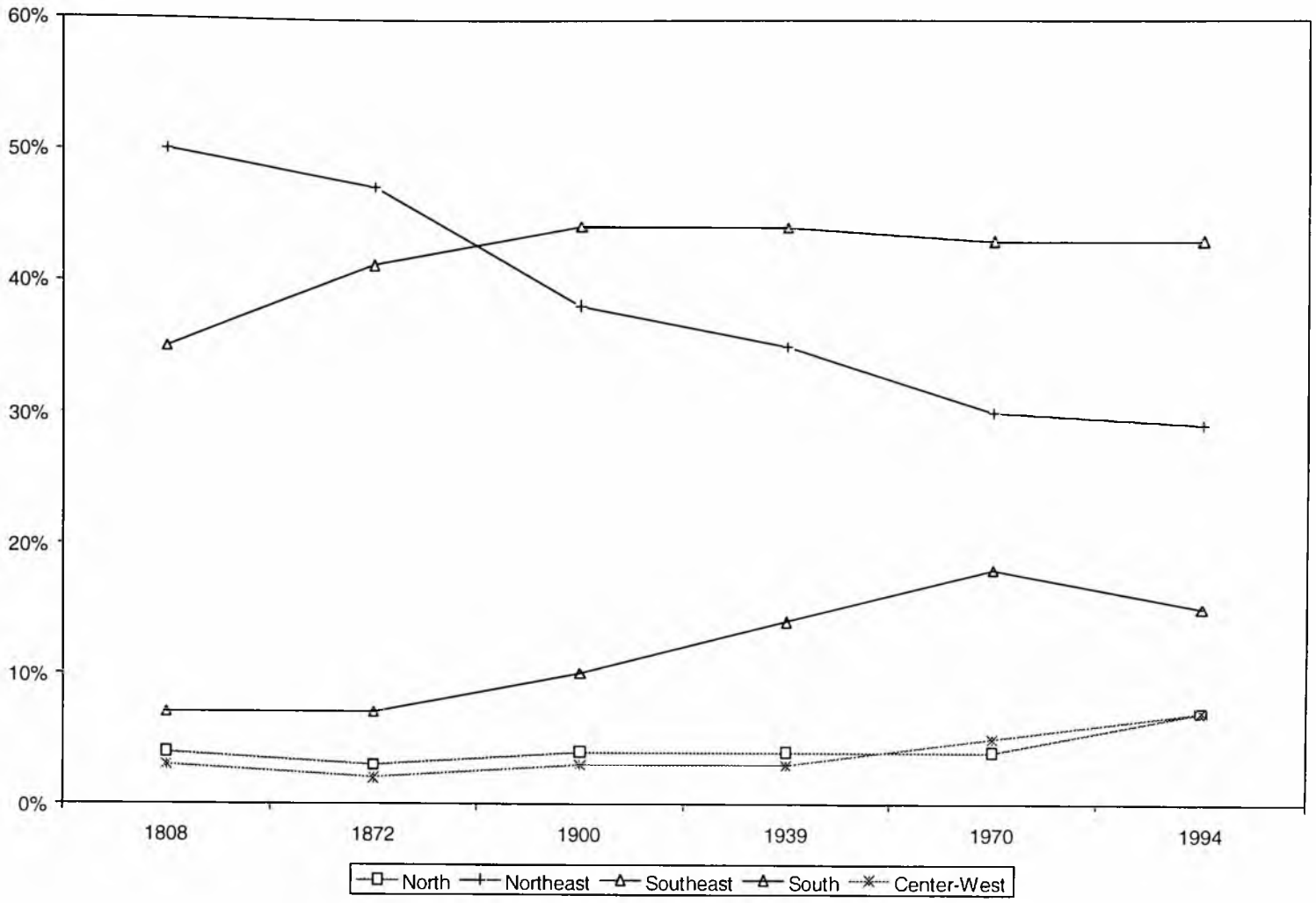


Table 2 and Figure 2 show the relative shares of population by regions. Some numbers are worth stressing:

(i) The North had about 4% of the population from 1808 until 1970 and increased this share to 7% in the last two decades.

(ii) The Northeast had 50% of the population in 1808 but has had a secular decline in its relative position, a trend that goes back to the early decades of last century.

(iii) The Southeast had 35% of the population, mainly because of families that remained in *Minas Gerais* after the gold cycle (population of 350,000) and people living around *Rio de Janeiro* (235,000).

(iv) The South had 7% of the population during most of last century but increased its relative proportion steadily from 1872 to 1970; in the past decades, however, it has become an exporter of people.

(v) The Center-West had 3% of the population from 1808 until 1960 but has gained people since the inauguration of *Brasília* in 1960 and the opening of the agricultural frontier in the Central Plateau in the 1970s.

The first half of the XIXth century, was marked by the Independence of Brazil from Portugal, the organization of a national government that was able to keep the country united despite its low population, but on the economic front there was very little growth. By 1850 the country was governed by a conservative emperor backed by traditionalist land owners not very fond of the rapid changes and the way to organize the economy that was transforming England. Good and safe money was based on traditional farming with the use of slave labor. Those who ventured to use new capitalist methods like Irineu Evangelista de Souza (Visconde de Mauá) encountered suspicion and opposition.[3]

The growth of coffee exports started to transform this situation in the 1860s. By 1870 coffee farming reached the rich soils of the *São Paulo* plateau, and export-led growth profoundly changed the country. According to IBGE, gross domestic product grew 100 times from 1900 to 1994; population increased 9.0 times and real per capita income multiplied by a factor of 11.1.[4]

A sustainable growth process started in the Southern states of Brazil in the late 19th century, with the wealth generated by coffee, cattle raising in the South and the sizable inflow of free labor.[5] Immigrants from Italy, Spain, and Germany started to migrate to Brazil in very small numbers by the 1830s, adding to a small inflow that had been coming from Portugal since colonial times. European immigration grew enormously after 1870 to supply the demand for labor in the booming coffee plantations because the alternative supply of labor, slavery, had been prohibited in 1850.[6] By the 1910s, immigration became more diversified with people coming from Poland, Russia, Hungary, Syria, Turkey, Lebanon, and Japan. The inflow of immigration provided the basis for future urban and industrial growth.

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3 The fascinating book by Caldeira (1995) on Mauá and the way business were conducted in mid-19th century Brazil powerfully shows how distant the country was from capitalist institutions at this time.

4 As Maddison (1989) documented, from 1880 to 1980, Brazil was among the fastest growing economies in the World. But growth started from a very low basis and the country is still among the middle income group. Per capita income was $3,870 in 1994.

5 For instance, the city of São Paulo had about 30,000 people in 1850, 200,000 in 1890 and jumped to 11 million in 1991.

6 For a general Brazil's history from the Portuguese navigations to the 1990s, see Fausto (1983, 1994), or the classical but dated books by Prado Jr. (1967) and Furtado (1968).

Most immigrants were farm laborers, but a significant fraction was made up of urban artisans, tradesmen and some future entrepreneurs. What is more important is that even these very poor European and Asian peasants had much better knowledge of diversified agriculture and other crafts than the local population of slaves and the small group of local wage earners. In terms of economic growth models, it can be said that the supply of human capital increased in quantity and quality.

Most of the immigrants went to live in the states of *São Paulo, Paraná, Santa Catarina, Rio Grande do Sul* and in *Espirito Santo.* The prosperity generated by coffee in *São Paulo* and by cattle raising in *Rio Grande do Sul* contrasted with the decay of the sugar plantations in the Northeast, and this is crucial to understand the income disparity that took shape around the turn of the century.

The Northeast was the first area to be colonized in Brazil. Sugarcane was the economic basis of the occupation of the regions with higher rainfall, starting late in the 16th century. The area became an important exporter of brown sugar in the 17th and the 18th centuries based of large plantations manned by slave labor. But, by 1800, the Northeast had lost its competitiveness because it did not modernize, and the Caribbean emerged as a greater producer of sugar. Big farm holdings (*latifúndios*), monoculture, slavery and strong political bosses (*coronéis)* did not lead to a capitalist development in the sense of engendering the creation of an industrious bourgeoisie and an urban capitalist order. The decline of the Northeast's proportion of the population, shown in Table 2, indicates that the area had become a net exporter of population, strongly suggesting its loss in economic vigor.

Meanwhile, the Amazon North was, and still is, a very vast but relatively empty economic area. The Center-West also had a low population, and its economy consisted of scattered cattle raising. The end of Monarchy and the beginning of the Republican era in 1889 brought hopes that the exercise of power would become less centralized and be shared with local governments. But this did not happen, and the period from 1889 to 1930 ended up being called "the coffee and milk Republic" because Presidents would come either from the state of *São Paulo* (coffee) or *Minas Gerais* (dairy products).

While the 1920s was a time of rising prosperity in Southern Brazil and in Bahia with its tobacco and cocoa, it was also a period of increasing political dissatisfaction. In 1930 Getúlio Vargas, an ex-Governor of *Rio Grande do Sul*, led a successful insurrection and took power. The 1930 Revolution was backed by different groups and could have degenerated into regional fights that could fragment the country, but its leaders were able to consolidate their control on power. Basically, the Vargas' era represented a exchange of the old elite by newer groups: young politicians, professionals, army officers and industrialists.

The new government, contrary to its stated credo, centralized decision making in part as a reaction to the international crisis. The disruption of international trade in the 1930s precipitated a fall in all export earnings (especially coffee), and Vargas was pressed to adopt interventionist policies to protect domestic income; thus import substitution policies were adopted and eventually became the strategy for industrialization - see Suzigan (1986). On another front, the firt Vargas' period (1930-45) was instrumental in consolidating capitalist institutions and in turning the political backbone of the country into a predominantly urban society. To modernize economic relations, Vargas signed laws regulating the labor market and gave a new role to the Armed Forces, enabling them to oversee the construction of basic infrastructure and the integration of the different areas of the country.[7]

Vargas started his government as a democrat but became enamored with the Fascist doctrine. In 1937, he closed Congress and imposed an authoritarian Constitution. He was President until 1945, when the end of World War II brought a wave of democratization to the continent and was deposed. In 1950 he was elected President again by a large majority of the popular vote. He stayed in power until 1954, when he committed suicide due to increasing pressures on him to leave office.

Getúlio Vargas was the most important Brazilian politician this century; he had great qualities: a deep understanding of the nation's desire to become modern and prosperous and a skilled sense of how to run the government. He and his main advisers agreed that Brazil needed a steel mill to set the foundations of heavy industry, and they bargained hard with the US to rent the technology to produce steel in exchange for Brazil's joining the Allied forces in World War II. Finally, the city of *Rio de Janeiro* lived, with Getúlio, its most magnificent age. It was the undisputed political and cultural capital of Brazil.[8]

But he also had faults and a authoritarian bias. His suicide in 1954 shocked the country and could have ended in political instability because of his popularity. However, elections were held, and Juscelino Kubitschek was elected President in 1955. He proved to be a very skillful politician and defused the political crisis: from 1956 to 1960, Kubitschek was the "*Bossa*

7 On the Vargas governments, see Carone (1965), Skidmore (1969), Levine (1970), Baer (1989) or Fausto (1994).

8 Starting in the Vargas period there is an ongoing debate on the uneven development of Brazil. The debate became politically charged in the 1960s and the Federal Government's policies were accused of benefiting the South in detriment of the North and the Northeast. In the 1930s, after some years of catastrofic drought in the Northeast, public works, like the construction of dams, were initiated in the area and migration to the Amazon was stimulated. In the late 1950s, fiscal incentives to locate industrial plants in the North and the Northeast were devised and Sudene and Sudam, two regional development agencies, were devised to plan the economic development of these areas.

Nova" President. By adopting *desenvolvimentismo* or *developmentalism* as his banner, he ignited Brazil's imagination with an economic doctrine that combined import substitution, government-led industrialization and job creation.[9]

From 1956 to 1961, Brazil grew as never before, and confidence in the future of the country ran high. The auto industry built plants in São Paulo using the steel produced in *Volta Redonda* (where the steel mill negotiated by Vargas had been built). In a self-reinforcing process, factories for car components, electrical and mechanical equipment, and sundry consumer goods were set up, and many new jobs were created. An undervalued exchange rate provided a cross-subsidy for the importation of capital goods and helped to boost the formation of an emerging class of industrialists.

In the 1960s, the inbalances present in the previous period of booming growth became evident, but the difficulties to correct them with the existing institutions led to a period of political polarization. In 1964, the military took power, fearing that country was becoming socialist.

The policies of the military toward the North and Northeast were to strengthen the power of Sudene and Sudam in the hope that fiscal incentives would change the situation.[10] However, nothing was done to modernize the political system. In the 1970s, important investment projects, like the construction of the *Transamazon* road, the project of a national telecommunications system and the construction of a sizable network of federal roads linking the North, the Northeast to the Center-West and the South, were undertaken and played a role in preventing the increase in the income disparity by facilitating internal migration and the expansion of the economic frontiers to areas of difficult access. Also in the 1970s, subsidies geared to the promotion of industries in these areas increased many times. An assessment of the full effect of these policies is beyond the scope of this paper, but many of the favored investment projects never got off the ground, and the money was deviated to other activities.

The recent past - 1980/94 - has been a period of a difficult fiscal crisis and no growth in per capita income. The debt crisis and the external transfer of resources unbalanced the public budget in the early 1980s and dismantled the structure of savings-financing that existed in the

9 On import substitution, see Furtado (1967) or Baer (1989). For an insightful and early analysis of the limitations of import substitution as a development strategy, see Tavares (1972). On the Kubitschek s government, see Skidmore (1969), Benevides (1979), or Fausto (1983).

10 Sudene is a development agency responsible for granting fiscal incentives and managing the use of federal income-tax rebates to promote investments in industry and in services the Northeast; Sudam does the same for the North.

economy. High inflation and frustrated attempts to fight it marked these years. In 1994, the *Real Plan* ended a situation of almost hyperinflation.[11] On the positive side, a functioning democracy has taken root, and a new development strategy, less dependent on the public sector, is taking shape.

3 What does the data say?

The data set includes data on per capita income expressed in 1995 constant prices and other variables used in the structural regressions explained in the next section.

Data on GDP per state are present for 1939, 1947, and every five-year period from 1950 to 1994 (12 observations). Income per capita per state was obtained by dividing the state's GDP by its population. GDP per state for the period that goes from 1939 to 1985 comes from IBGE (1987 and 1992) and from 1985 to 1994 from IPEA (see Considera *et alii* (1996)). There are minor differences in the way state GDP has been computed by IBGE and IPEA but they do not affect the tests made because the dispersion of per capita income is not affected by these differences.[12] Nominal figures were corrected by the GDP price deflator, taking 1995 as the base year (1995 = 1), and values in *cruzeiros* were converted to *reais* using the rate of exchange of R$ 1.00 equal to CR$ 2,750.00 (in 1995, one *real* was approximately equal to one *dollar* thus the figures can be read as if they were expressed in dollar terms).

Brazil is presently divided into 26 States and one Federal District, where the city of *Brasília* is located. Until 1960 GDP per state was reported for 20 states and comprised of the whole country. This division was maintained for the subsequent period in this study because it would be virtually impossible to disentangle the data for former territories that are states now. Thus data for the states of *Acre, Roraima and Rondônia* were added to the state of *Amazonas* after they started being reported on an individual basis, data for *Amapá* was added to *Pará*, figures for the city of *Rio* were added to the state of *Rio de Janeiro* and the new Federal

11 On Brazil's economic policies in the 1980's and the *Collor plan*, see Zini Jr. (1992); on the *Real Plan*, see Sachs and Zini Jr. (1996).

12 Computational procedures used by IPEA are explained in detail in Considera *et alii*. (1996).

District, *Brasília,* was added to *Goiás*. In 1985, *Mato Grosso* was split in two and so was *Goiás* in 1988, but the older state boundaries have been preserved in this study. This means that figures for the state of *Tocantins*, which now belongs to the Northern region, are reported as belonging to the Center-West, but this does not cause a problem for this study because the data base is constructed in terms of per capita ratios.

Table 3 has information on the growth of income per capita from 1939 to 1994 by states and regions. Brazil's total GDP grew 20 times in real terms since 1939· the population increased 3.7 times and income per capita increased 5.4 times. To have some perspective, the World Bank indicates that World GDP grew 7 times from 1940 to 1990 and income per capita increased 3 times.

Table 4 reports the proportion of GDP for each state. Looking at regions, the Southeast's proportion was lowered from 63% to 57%; the South gained two points, going from 16% to 18%; the Northeast went from 17% to 14%, while the North and the Center-West increased their shares from 3% to 5% and from 2% to 7%, respectively.

The recent strong growth of the Center-West has three main reasons: the moving of the capital to *Brasília* in the 1960s, the expansion of the agricultural frontier to *Mato Grosso* and the Central Plateau; and, more recently, by soybean farming in the *Cerrados*. The region's flatland favors mechanization and the use of calcareous stone from nearby mines corrects the soil's acidity.

Table 3 shows that the five states with greatest gains in real per capita income from 1939 and 1994 were *Minas Gerais* (8.0 times), *Espírito Santo* (7.8), *Santa Catarina* (7 4), *Rio Grande do Norte* (7.3) and *Sergipe* (7.2). The national average went up by a factor of 5.4. The five states with lowest growth were *Rio de Janeiro* (3.3 times), *Piauí* (3.3), *Pernambuco* (4.2), *Maranhão* (4.4), and *São Paulo* (4.5 times). All states at least tripled their income per capita during 1939-94 and six grew more than seven times.

Table 3
Income Growth by State and Income Per Capita

	1939-94	1947-94	1939-50	1950-60	1960-80	1980-94	Income per capita	
							1939	1994
BRAZIL	5,4	5,1	1,2	1,4	3,2	1,0	721	3873
North	5,2	5,4	1,1	1,3	3,4	1,1	533	2785
Amazonas	4,9	4,9	1,1	1,1	4,2	1,0	623	3063
Pará	5,3	5,6	1,1	1,4	2,9	1,2	484	2574
Northest	5,5	5,6	1,1	1,5	2,7	1,2	344	1883
Maranhão	4,4	6,7	0,7	1,7	2,6	1.4	301	1331
Piauí	3,3	4,0	0,9	1,0	2,9	1,3	315	1053
Ceará	5,4	6,0	1,0	1,7	2,7	1,2	300	1624
Rio Grande da Norte	7,3	6,0	1,4	1,5	2,4	1,5	308	2257
Paraíba	5,0	4,6	1,3	1,7	1,8	1,3	280	1397
Pernambuco	4,2	4,3	1,1	1,4	2,6	1,1	485	2021
Alagoas	6,2	5,1	1,4	1,4	2,8	1,1	278	1729
Sergipe	7,2	7,2	1,2	1,4	2,9	1,6	344	2468
Bahia	6,9	6,6	1,2	1,5	3,5	1,1	335	2320
Southeast	5,0	4,7	1,2	1,4	3,2	0,9	1019	5141
Minas Gerais	8,0	6,4	1,5	1,3	3,8	1,1	447	3572
Espírito Santo	7,8	7,7	1,2	1,4	4,4	1,1	461	3613
Ria de Janeiro	3,3	3,5	1,1	1,2	2,6	1,0	1672	5530
São Paulo	4,5	4,2	1,2	1,5	3,0	0,8	1297	5884
South	5,6	5,3	1,2	1,4	3,2	1,1	814	4560
Paraná	6,4	5,9	1,1	1,6	2,7	1,3	720	4633
Santa Catarina	7,4	5,7	1,5	1,2	4,0	1,0	581	4293
Rio Grande do Sul	5,0	4,9	1,1	1,3	3,4	1,0	930	4627
Center West	7,6	10,0	0,8	1,7	4,8	1,1	511	3907
Mato Grosso	5,1	6,1	1,0	1,5	3,3	1,1	662	3344
Goiás	6,3	8,5	0,8	1,8	3,6	1,2	433	2710
Federal District					35,1	1.1		8938

Table 4
Shares of GDP por State and Regions

	1939	1980	1970	1980	1994
North	2,7	2,2	2,2	3,2	4,6
Amazonas	1,1	0,9	1,0	1,5	2,2
Pará	1,6	1,4	1,2	1,6	2,4
Northeast	16,7	14,8	11,7	12,0	14,0
Maranhão	1,2	1,1	0,8	0,8	1,2
Piauí	0,9	0,4	0,4	0,4	0,5
Ceará	2,1	2,0	1,4	1,5	1,6
Rio Grande do Norte	0,8	0,9	0,5	0,6	1,0
Paraíba	1,3	1,4	0,7	0,7	0,8
Pernambuco	4,4	3,5	2,9	2,5	2,7
Alagoas	0,9	0,8	0,7	0,7	0,8
Sergipe	0,6	0,5	0,4	0,4	0,7
Bahia	4,5	4,2	3,8	4,3	4,9
Southeast	62,9	62,8	65,5	62,3	56,5
Minas Gerais	10,3	10,0	8,3	9,4	9,8
Espírito Santo	1,2	1,0	1,2	1,5	1,7
Rio de Janeiro	20,3	17,0	16,7	13,7	12,2
São Paulo	31,1	34,7	39,4	37,7	32,8
South	15,6	17,8	16,7	17,0	17,5
Paraná	3,0	6,4	5,4	5,8	6,7
Santa Catarina	2,3	2,6	2,7	3,3	3,4
Rio Grande do Sul	10,3	8,8	8,6	7,9	7,4
Center West	2,1	2,5	3,9	5,6	7,3
Mato Grosso	1,0	1,0	1,1	1,7	2,3
Goiás	1,2	1,4	1,5	1,9	2,4
Federal District			1,3	2,0	2,6
BRASIL	100	100	100	100	100
GDP in R$ bil. (constant 1995 prices)	29,274	85,364	179,292	464,402	595,361

São Paulo, Rio de Janeiro, Rio Grande do Sul and *Minas Gerais* are the four states where most of Brazil's GDP is produced, but their joint share fell from 72.0% in 1939 to 62,2% in 1994-see Table 4. *São Paulo* increased its participation slightly from 31.1% to 32.8% because of higher than average increase in population; *Rio's* share went down from 20.3% to 12.2%, a drop that, to some extent, is due to the transfer of the Federal Government to *Brasília*; but the data also indicates that the state has been growing at a slower than average rate since the 1950s. *Rio Grande do Sul* lost in relative terms, going from 10.3% to 7.4%, and *Minas Gerais* kept its share around 10.0%, whereas *Paraná, Santa Catarina, Mato Grosso, Goiás, Amazonas, Pará, Bahia, Ceará* and *Espírito Santo* gained ground.

GDP data for 1939 is open to criticism because it was computed by IBGE in the late 1940s when the national accounts' methodology was being tested in Brazil. Annual calculation of the national accounts started being made only in 1948. The numbers for 1939, therefore, are not as good as later data. For this reason, Table 3 also reports the growth factor for 1947-94 and at later intervals. If 1947-94 is taken as the relevant time interval, the growth list changes a little: *Goiás* (8.5), *Espírito Santo* (7.7), *Sergipe* (7.2), *Maranhão* (6.7), *Bahia* (6,6) and *Minas Gerais* (6,5) come on top; at the other end, are *Rio de Janeiro* (3.5), *Piauí* (4.0), *São Paulo* (4,2), *Pernambuco* (4.3) and *Paraíba* (4.6). The list is almost the same as the one for 1939-94, except for *Goiás* and *Maranhão,* whose performances were much better in the second period (*Goiás* both because of the transfer of *Brasília* to its geographic center and the latter development of the *Cerrados Plateau* and *Maranhão* due to the high investments in the *Carajás* iron ores and the accompanying infrastructure).

Two tests to detect whether per capita income across states tended to converge were applied. One is the *unconditional convergence* or σ *test*, the other is the *conditional convergence* or β test.[13] The σ *test* consists of calculating the variance of the logarithm of income across states at different periods in time. If the index decreases, *convergence* is taking place in the sense that dispersion is going down. *Conditional (or* β*) convergence* is a trend toward a steady state level of per capita income that is dependent on each region's specific endowment of factors, institutions and geography. If *convergence* holds, per capita income tends to grow faster in poorer than in richer areas, therefore, the speed of convergence depends on the initial level of income per capita.

13 One limitation of the β *test* is that it takes into account the size of the sample. Thus, the larger the sample, the smaller the estimated coefficient of the independent variable. Also a decrease in dispersion shown by the σ *convergence test* is not equal to β *convergence* because the two indicators, although related, take into account different factors, see Barro and Sala-i-Martin (1995).

The σ *test* was performed for three measurements of dispersion: the sample variance, variance divided by the sample mean and the coefficient of variation (standard deviation divided by the mean). The reason is that when the sample mean increases, the variance can go up just because of this growth. The dispersion measurements are reported in Table 5.

Figures 3 and 4 show the coefficient of variation of the log of income per capita across states and across regions; a trend line was fitted in each graph. Table 6 reports the results of trend lines fitted for different indicators of dispersion across states and regions for 1939-94 and 1947-94. The coefficient of variation falls faster across regions than across states indicating that regional data show a faster convergence. But regions are not homogeneous sets. For instance, two of the high growth states are in the Northeast as well as three with the lowest growth ratios; thus it seems better to focus on states rather than at the regional aggregates when studying the factors that explain the differences in growth rates reported in Table 3.

Figures 3 and 4 are helpful to delineate sub-periods regarding the measurement of disparity. Disparity increased from 1939 to 1955, decreased from 1955 to 1965 (this includes the period of rapid industrialization in the Kubitscheck government), went up again in 1965-1975, came down substantially from 1975 to 1990, and increased slightly in 1990-1994. The increase in income disparity from 1965 to 1975, when the income tax rebates overseen by Sudene and Sudam reached their highest levels, suggest that the policy was ineffective in reducing the income gap between the North and the South.

The β *test* involves a non linear regression of the proportionate growth in per capita GDP between the two extremes of the series (dependent variable) againt the logarithm of the initial per capita GDP (independent variable) plus a constant. The test comes from the neoclassical growth model discussed by Barro and Sala-i-Martin (1991 and 1995). In discrete time intervals, the average growth rate of per capita income over the interval from 0 to T is given by

$$(1/T).\log(Y_{iT}/Y_{i0}) = \alpha - [(1-e^{-\beta T})/T]\log(y_{i0}) + \mu_{io,T}. \qquad (1)$$

where β is the speed of convergence, $\mu_{io,T}$ is the average error between 0 and T (it is assumed that the random variable μ_{it} has 0 mean and variance σ^2), and is distributed independently of $\log(y_{i,t-1})$ and of lagged or future disturbances. The constant term $\alpha \equiv x + [(1-e^{-\beta T})/T]\log(y^*)$, where y^* is the steady state level of the growth rate of y_i and x represents a shift parameter to allow for productivity or for exogenous shocks. Tables 7a and 7b show the results of the β *test*.

Table 5
Measurements of Income Dispersion

	Log of y by States		
	Variance	**Variance/Mean**	**Coefficient of variation**
1939	0.0498	0.0185	0.0830
1947	0.0580	0.0216	0.0897
1950	0.0568	0.0208	0.0871
1955	0.0775	0.0276	0.0991
1960	0.0513	0.0178	0.0784
1965	0.0434	0.0148	0.0710
1970	0.0667	0.0221	0.0857
1975	0.0720	0.0226	0.0843
1980	0.0665	0.0197	0.0764
1985	0.0535	0.0157	0.0680
1990	0.0431	0.0126	0.0608
1994	0.0457	0.0132	0.0621
	Log of y by Regions		
1939	0.0341	0.0123	0.0665
1947	0.0485	0.0176	0.0797
1950	0.0493	0.0175	0.0789
1955	0.0637	0.0219	0.0867
1960	0.0410	0.0138	0.0683
1965	0.0369	0.0122	0.0636
1970	0.0512	0.0163	0.0720
1975	0.0617	0.0187	0.0751
1980	0.0455	0.0130	0.0609
1985	0.0327	0.0093	0.0515
1990	0.0284	0.0081	0.0479
1994	0.0314	0.0089	0.0501

Figure 3
Measurements of Dispersion Across States
Coefficient of Variation of Log of y Across States

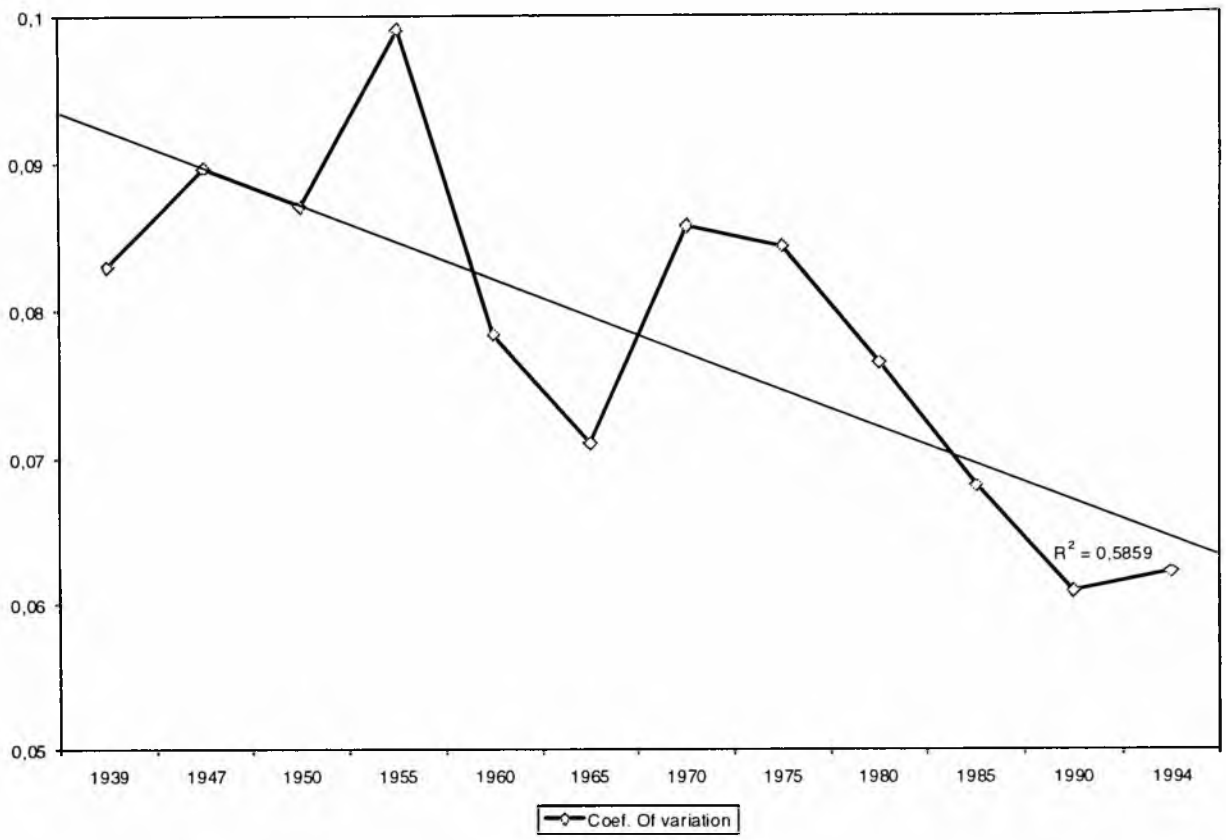

Figure 4
Measurement of Dispersion Across Regions
Coefficient of Variation of Log of y Across Regions

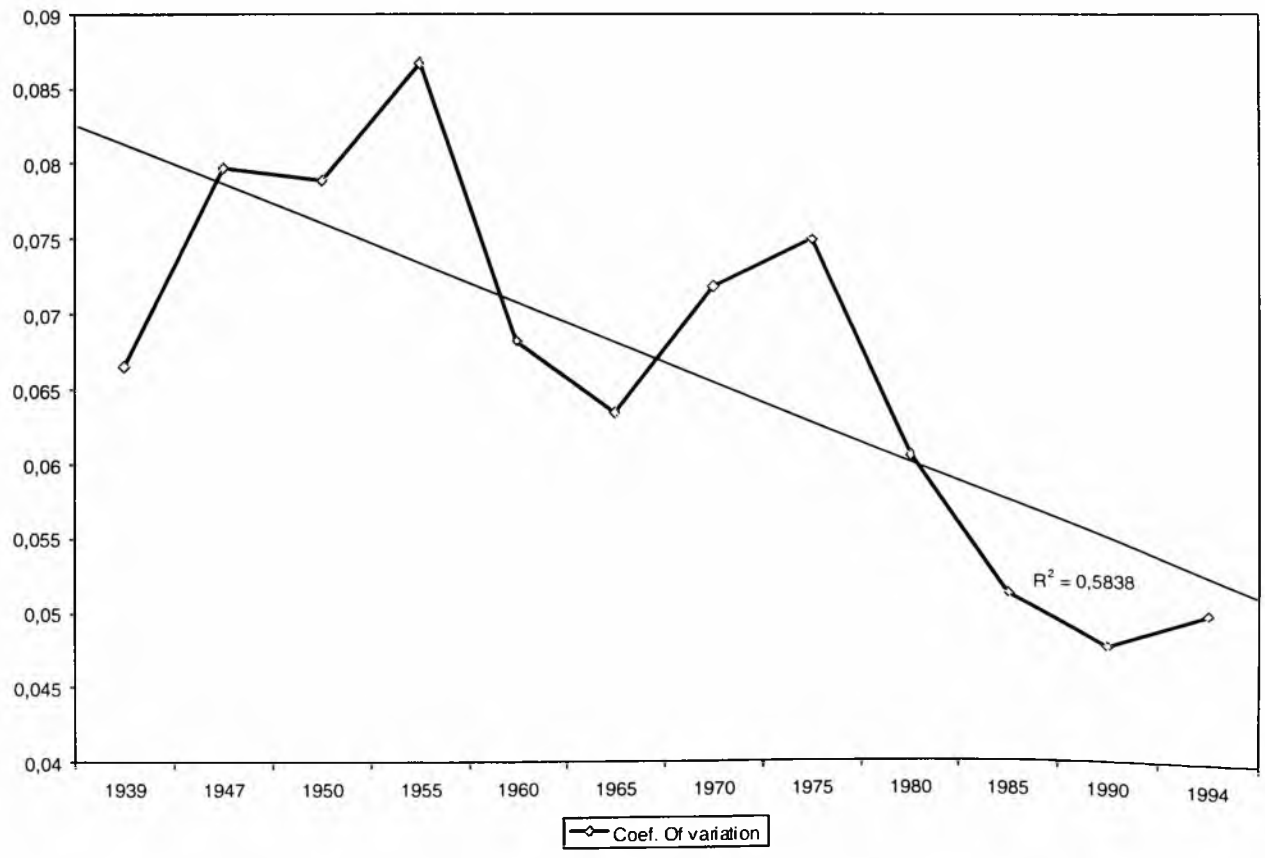

Table 6
Regressions With a Trend line for Different Measuments of Dispersion of Per Capita Income Across States and Regions of Brazil

	Period	Variable	Estimated trend coef.	Standard deviation	R^2	DW
States	1939-94	variance/mean	-0.0007*	0.0003	0.30	1.69
		standard dev./mean	-0.0025*	0.0007	0.59	1.71
		variance	-0.0006	0.0010	0.04	1.53
	1947-94	variance/mean	-0.0009*	0.0004	0.42	1.90
		standard dev./mean	-0.0030**	0.0007	0.67	1.97
		variance	-0.0012	0.0011	0.11	1.67
Regions	1939-94	variance/mean	-0.0007*	0.0003	0.36	1.42
		standard dev./mean	-0.0027*	0.0007	0,58	1.36
		variance	-0.0012	0.0009	0.14	1.34
	1947-94	variance/mean	-0.0010**	0.0003	0.59	1.81
		standard dev./mean	-0.0035**	0.0006	0.77	1.80
		variance	-0.0021+	0.0010	0.34	1.62

Obs.: ** indicates significance at 1% level; * significant at 5% level; + significant at 10% level.

The computed β coefficient for 1939-94 was 0.0029 (Table 7a), much lower than the estimated speed of convergence for the U.S. However, the sign is correct, and the size of the coefficient increases to 0.0045 when 1947-94 is considered.

Barro and Sala-i-Martin (1995) show that when regions are subject to region-specific shocks (like droughts or excessive rainfall), the error terms show serial correlation. They recommend using dummy variables to take into account regional effects. This was done and the estimated β coefficient is reported in Table 7b. The speed of convergence increases when regional dummies are present; the estimated coefficient shows the right sign and increases to 0,008 for 1939-94 and reaches 0,009 for 1947-94 (both are statistically significant).[14] Barro and Sala-i-Martin estimated the speed of convergence for the US was 0.018 when dummy variables were introduced. An additional improvement would be to include variables representing the sector composition of GDP per state to account for the possibility of sector-specific shocks. Since the main interest of this paper is to detect whether convergence of income took place in Brazil, and as the answer is positive, the computations for sector-specific shocks were not undertaken.

14 The consistent negative sign on the dummy for the Northeast indicates a regional handicap that slows down growth. The dummy does not distinguish whether this is due to geographic or due to socio-economic factors or to both.

Table 7.a
Regressions of Personal Income Across Brazilian States: β Test - Part I

	a	β	R^2	regression standard error
1939-94	0.0221	0.0029 (0.0018)	0.12	0.0020
1947-94	0.0264	0.0037* (0.0015)	0.22	0.0019
1939-50	0.0238	-0.0008 (0.0075)	0.01	0.0073
1950-60	0.0393	0.0085 (0.0058)	0.10	0.0066
1960-70	-0.0128	0.0088 (0.0090)	0.002	0.0082
1970-80	0.0431	0.0024 (0.0048)	0.01	0.0056
1980-94	0.0469	0.0117** (0.0023)	0.56	0.0030

Obs: ** significant at 1% level; * significant at 5% level; + significant at 10% level.

Non linear least square estimation of: $[1/T] \log (y_{iT} / y_{i0}) = \alpha + (1 - e^{-\beta T})/T \log y_{i0} + \mu_{it}$ where i varies over 20 states and T is the time interval.

Table 7.b
Regressions of Personal Income Across Brazilian States: β Test With Dummy Variables - Part II

	a	β	d_{NE}	d_{SE}	d_S	d_{CW}	R^2	regression st. error
1939-94	0.042	0.008** (0.0017)	-0.0021 (0.0014)	0.0025 (0.0015)	0.0028+ (0.0015)	0.0006 (0.0017)	0.54	0.0017
1947-94	0.042	0.009** (0.0018)	-0.0018 (0.0014)	0.0020 (0.0015)	0.0023 (0.0015)	0.0018 (0.0016)	0.59	0.0016
1939-50	0.031	0.010 (0.0101)	-0.0006 (0.0059)	0.0075 (0.0062)	0.0072 (0.0063)	-0.0079 (0.0067)	0.35	0.0067
1950-60	0.036	0.0087 (0.0105)	0.0038 (0.0058)	0.0046 (0.0065)	0.0048 (0.0066)	0.0011 (0.0069)	0.25	0.0068
1960-70	0.048	-0.0106 (0.0123)	-0.0090 (0.0067)	0.0051 (0.0079)	0.0005 (0.0080)	-0.0036 (0.0082)	0.27	0.0082
1970-80	0.101	0.187** (0.0060)	-0.0091* (0.0038)	0.0025 (0.0043)	0.0045 (0.0043)	0.0028 (0.0044)	0.52	0.0044
1980-94	0.062	0.0157** (0.0050)	-0.0006 (0.0030)	0.0016 (0.0032)	0.0038 (0.0032)	0.0013 (0.0032)	0.61	0.0032

Obs: ** significant at 1% level; * significant at 5% level; + significant at 10% level.

Non linear least square estimation of: $[1/T] \log (y_{iT} / y_{i0}) = \alpha + (1 - e^{-\beta T})/T \log y_{i0} + d_j D_{jt} + \mu_{it}$ where D_j is a dummy variable, j varies over 4 regions (NE, SE, S, CW) and T is the time interval.

The low speed of convergence reflects the dispersion of rates of growth across states. Figures 5 and 6 plot the rate of growth of each state against the log of the state initial income per capita income. The dispersion of experiences, which is indicated by the low R^2 the fitted trend line, is reflected in the low speed of convergence. However, it should be stressed that the hypothesis of convergence cannot be rejected either by the σ or the β tests made in this study.

Figure 5
Log (y_39) vs. Growth Rate

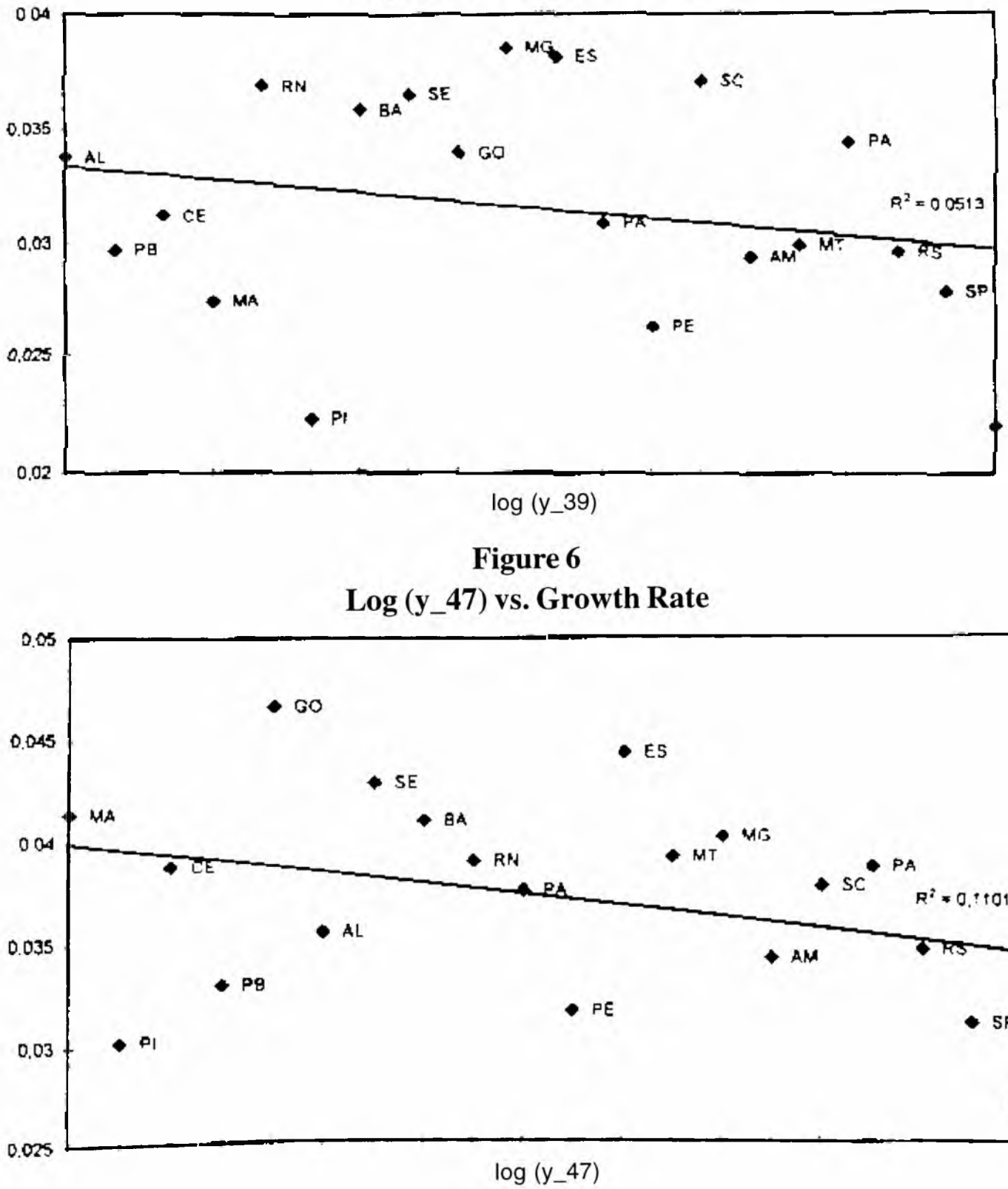

Figure 6
Log (y_47) vs. Growth Rate

The low speed of convergence is also consistent with other studies made with Brazilian data. Ferreira and Ellery (1996) and Schwartsman (1996) report a weak tendency toward income convergence across Brazilian states using data from 1970 to 1990, but both studies have the limitation of testing for a long-run trend using a relatively short time interval. Azzoni (1996) found weak conditional income convergence and inconclusive findings relating to the s-test with data for 1939-90. However, his data set comes from heterogeneous sources, and nominal figures on income were deflated using the general price index rather than the more appropriate GDP deflator. Overall, the results reported here are more robust in not rejecting the convergence hypothesis.

4 Structural Regressions

Structural regressions to explain the growth of per capita income using structural factors discussed in the modern literature on growth were then estimated. In a neoclassical growth model, it can be shown that the growth of per capita income depends on the growth of the ratio of capital per unit of efficient labor. The growth of this ratio can be decomposed into a quantitative factor (growth of capital/labor ratio) and a qualitative coefficient that captures the effects of improvements on human capital, technological gains embodied in the new capital and the role of socio-economic variables, like the organizational setup that may or may not be conducive to the more efficient use of inputs - see Jorgensen *et alii* (1987).

The importance of improvements in the supply of human capital is undisputed today. To try to gauge this factor, two non-complementary ratios were selected: the ratio of illiteracy in a state's population and the ratio of schooling, defined as the fraction of the population that had the junior high school diploma (implying at least 8 years of formal schooling).[15] To approach the change in quantity and quality of the capital stock, we constructed a variable that proxies the evolution of investments in industry in each state.[16]

15 We tried to have data on the population with high-school diplomas but this information was not available in the 1940 and 1950 censuses. However, the proportion of junior high school diplomas seems an equally appropriate measure because for in many states this ratio was smaller than 1 percent in 1939.

16 The index divides the change in industrial GDP of each state at five year intervals by by the state's industrial GDP at time (t - 1). The increase of industrial GDP over the initial GDP is a proxy for investment in the sector assuming that the capital-output ratio stayed the same during the five year interval. In some cases, negative numbers resulted, as would be the case with net investment. Then these fractional numbers were added to one to have an index that proxies changes in the capital-labor ratio. The additional asssumption is that such an index is representative of equivalent capital formation in the other sectors of the economy; we take that as a valid working simplification.

Two other variables were devised to represent the socio-economic environment. An index of exports over state GDP to indicate the state export orientation (the hypothesis is that the more export oriented, the more prone to growth the state is because it is used to selling in competitive markets). This hypothesis is based on Sachs and Warner (1995), who report a robust association between export orientation and domestic growth in a cross-country study that controls for impediments to trade. The second variable is an index of property concentration (area of farms larger than 1,000 hectares divided by the area occupied by farms smaller than 50 hectares). The idea is that big, unproductive land holdings do not help growth whereas in those areas where rural property is more evenly split, more families have access to credit, and agriculture tends to be more diversified.

Since most of the socio-economic variables came from census data spaced at 10 year intervals, the following procedures were adopted to assemble the data set. The data on income per capita was fitted to start in 1940 (multiplying the numbers for 1939 by the rate of growth of GDP in 1940) and for every five year thereafter (this only required scaling back the data for 1947 to 1945 because from 1950 on the data was already at five year intervals). Figures on illiteracy, schooling and land ownership were gathered at ten year intervals, and the five year break was computed by interpolation. Numbers for 1994 were obtained from a preliminary estimate made by IGBE (PNAD). Data on state exports (in dollar terms) come from annual reports of the IBGE, but they have an important problem: the numbers reflect exports sent from ports or airports located in each state. Therefore, data for landlocked states (like *Minas, Goiás, Mato Grosso*) severely understates their exports. In the case of *Minas* (an important exporter of minerals, and of some industrial goods) this is a serious problem and inflates the numbers of *São Paulo, Rio de Janeiro and Espírito Santo.*

A log linear equation was estimated by the generalized least square to take advantage of all the information presented in the cross-section time-series data set. An equation with a fixed constant term was estimated first, and then an equation with varying constant terms for each of the states in the sample. The likelihood ratio test of the hypothesis that all constant terms were equal versus not equal resulted in an "*F*" of 12.502; thus the hypothesis that all constants were equal was rejected. The estimated coefficients are shown in Table 8. The different constant terms can be interpreted as the long term growth potential of each state, resembling the intercept coefficient in equation (1).

Table 8 reports a positive relation between gains in literacy and formal schooling and growth, and both are statistically significant. Investment in industry, as a proxy for improvements in the capital stock, had a positive and significant effect. The negative sign on the coefficient of land ownership indicates that a concentrated structure of land ownership is detrimental to growth;

the coefficient is statistically significant at a 5% level.[17] The coefficient on exports is positive, as expected, but its size and significance are small, probably due to data problems.

Table 8
Structural Equation for Brazil With Data by States
(Generalized least square estimation: fixed structural coefficients but varying constant term)

	Constant	Illiteracy	Schooling	Investment	Land Own	Exports	R^2	S.E. regression
		-0.448**	0.490**	1.047**	-0.053*	0.007	0.98	0.141
		(0.08)	(0.02)	(0.14)	(0.027)	(0.006)		
Constants	A M	PA	MA	PI	CE	RN	D.W.	Log likel.
	8.67	8.22	8.12	7.93	8.03	5.28	n.a.	132.9
	PB	PE	AL	SE	BA	MG		
	8.12	8.20	8.30	8.30	8.34	8.47		
	ES	RJ	SP	PR	SC	RS		
	8.21	8.29	8.61	8.45	8.30	8.38		
	MT	GO						
	8.63	8.45						

Obs: All variables are in logs. Standard errors reported bellow estimated coefficients.
** significant at 1% level; * significant at 5% level; + significant at 10% level.

Table 9
Structural Equation with Regional Data and Varying Constant Coefficients
(Seemingly unrelated regressions estimation: fixed structural coefficients but varying constant term)

Region	Constant	Illiteracy	Schooling	Investment	Land Own	Exports	R^2	S.E. regression
		-0.384**	0.512**	1.289**	-0.116**	-0.030*	0.98	0.107
		(0.09)	(0.03)	(0.15)	(0.03)	(0.016)		
North	8.608							
Northeast	8.274							
South	8.452							
Southeast	8.578						D.W.	Log likel.
Center-West	8.685						1.61	94.2

Structural Equation with Regional Data, Varying Constant and Explanatory Coefficients
(seemingly unrelated regressions estimation)

Region	Constant	Illiteracy	Schooling	Investment	Land Own	Exports	R^2	S.E. regression
North	7.72	-0.617	0.901**	1.113*	0.667**	-0.011	0.99	0.11
		(1.26)	(0.29)	(0.42)	(0.23)	(0.07)		
Northeast	9.30	0.054	0.678*	0.557	0.182	0.103		
		(1.50)	(0.30)	(0.93)	(0.15)	(0.08)		
Southeast	10.02	-0.092	0.769**	1.686**	-0.108	0.152**	DW	Log likel
		(0.48)	(0.24)	(0.26)	(0.12)	(0.04)	2.71	138.3
South	13.09	1.475+	1.216**	0.391	0.009	0.039		
		(0.81)	(0.33)	(0.42)	(0.06)	(0.05)		
Center-West	9.37	0.026	0.647**	1.318**	-0.137**	-0.071+		
		(0.40)	(0.15)	(0.54)	(0.05)	(0.04)		

Obs: All variables are in logs. Standard errors reported bellow estimated coefficients.
** significant at 1% level; * significant at 5% level; + significant at 10% level.

17 A recent study of Bruno and Squire (1996) also report evidences in support of this hypothesis in a cross-country study.

Next, the data was grouped into five regions, and the growth equation was estimated using the seemingly unrelated regression technique. Estimation of the structural equation with fixed structural coefficients but varying constant term resulted in coefficients, shown in Table 9, which are comparable and consistent with those reported in Table 8. The negative coefficient on land concentration increased, and its standard error decreased. The sign on the index of exports, however, became negative. This may be due to faulty data or may indicate that the hypothesis of a positive effect does not hold in this case.

The second half of Table 9 reports the estimated parameters when both the constant and the structural coefficients are allowed to vary. The coefficients show much more variation, but one cannot make robust inferences with these numbers because they are based on regressions with only 4 degrees of freedom (11 observation).

Some other variables could improve our structural equation, and two natural candidates would be the size of federal transfers to each state and the growth of the transportation network (km of roads and railways). Time and resource limitations prevented us from doing this. Other variables such as *good governance*, exports and capital stock per state are can be studied with better data in future studies.[18] Notwithstanding those limitations, it seems appropriate to say that the results reported here are robust and the structural regressions have a good explanatory power.

5 Concluding remarks

This study adds to the literature on regional income convergence by studying Brazil with data from 1939 to 1994. The results of the σ and the β tests did not reject the hypothesis of income convergence across states, however, the speed of convergence is rather low (around 0.8 to 0.9 percent per year).

The net winners in income growth were *Minas Gerais, Espírito Santo, Sergipe, Rio Grande do Norte, Maranhão, Bahia, Paraná, Santa Catarina, Mato Grosso and Goiás.* The Center-West region had 3% of the population and produced 2% of Brazil's GDP in 1939; these numbers went up to 6% and 7%, in 1994.

18 The higher than average growth of per capita income in states like *Minas Gerais, Espírito Santo, Sergipe* and *Maranhão* and the fact that they have benefited more than other states with the construction of federal roads, railways and ports either to export iron ore (*Companhia Vale do Rio Doce*) or oil (*Petrobras*), suggest that investments in the "national integration" network of roads and railways probably had a high social rate of return and induced growth.

Observing the growth of income and of population, one observes two dynamic areas in spatial terms. One "cone" starts in *São Paulo* and points to the Center-West-North. This area encompasses the Southern portion of *Minas, the two Mato Grossos (North and South), Goiás,* and *Rondônia*, where the new agricultural frontier is. The second "cone" goes from *São Paulo* to the South and Southwest (*Buenos Aires and Cordoba*) reflecting the expanding Mercosur market. Announced investment projects in transportation in these areas are consistent with the findings reported here.

On the issue of the income gap between the North and the South, income disparities remain large and troublesome. However, the numbers reported here indicate that the differences in per capita income have more to do with the economic transformation that took place in the latter part of the 19th century rather than with the industrialization process after 1940. In 1939, a year when *São Paulo*'s GDP was still depressed because of the breakdown of international trade (coffee exports suffered the brunt of the external shock), its income per capita was 1.8 times higher than the national average and *Rio de Janeiro*'s was 2.3 times bigger, whereas the North had an income per capita of 0.7 the national average and the Northeast's 0.5. In 1994, *São Paulo*'s income was 1.6 times the national average, Rio's was 1.4, the North's was 0.7 and the Northeast's, 0.5 times.

São Paulo maintained a high income per capita, despite the high growth of its population resulting from internal migration (the population in Brazil grew 3.8 times from 1939 to 1994 and 4.7 times in São Paulo). The industrialization that took place after 1940, therefore, did not increase the difference in per capita income but rather the reverse occurred when the Center-South states are taken into account. It is relevant to stress that the popular view that the industrialization policies helped to increase the gap between the North and the South is faulty and remedies based on this perception are built on a wrong footing.

One such policy is the role devised for Sudene and Sudam. Although these two agencies have approved some billions of dollars of tax rebates and other fiscal incentives for investment projects (mainly in industries) in the past 30 years, they did not achieve their goal of bridging the difference between the North and the South. In states where personal income is highly concentrated, policies that favor capital intensive projects induce more concentration of income. Thus, these agencies have helped to preserve an archaic structure of power, creating few jobs, rather than trying to promote growth from the bottom up.

There are, however, signs of change. There is a new generation of politicians in many states in the area, independent of the old political bosses. The North and the Northeast need to modernize their political and social structures and remodel their growth strategy, moving from big projects financed by the Federal Government to grassroots oriented growth. Such strategy

would be based on empowering local talent and abilities. Land reform and programs like the minimum-income per family linked to keeping children in schools probably have a higher social rate of return by bringing new consumers to the market than the present income tax rebates for investment projects. More spending on basic education is needed bacause all educational indicators of the region are below national averages. Lastly, long-run sustained growth will largely depend on the capacity to create and improve the links with the international market and promote competitive export activities.

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Como eu pesquiso

Princípios de economia*

Benjamin M. Friedman§

A maioria dos empreendimentos intelectuais defende até o fim a perspectiva de uma satisfação particular expandir as possibilidades de pensar sobre nós mesmos e sobre o mundo onde vivemos. A Economia não é exceção. Com certeza, a economia tem suas particularidades - uma mistura idiossincrática de teorizar *a priori* e usar métodos empíricos, um compromisso com a aplicação do método científico, a despeito da inabilidade para pôr em prática experimentos que possam ser reproduzidos ou mesmo controlados, uma proximidade com certos assuntos políticos conflitantes e, assim por diante - e, como economistas, estamos bem conscientes delas. Mas, no fim, o que é mais poderoso é a similaridade com outros ramos do empreendimento intelectual, incluindo não só as ciências Físicas, mas História, Filosofia e, mesmo, Literatura e as Artes. Com certeza, os princípios essenciais que contribuem para fazer uma boa ciência econômica são, provavelmente, muito similares ao caminho que leva à satisfação em muitos outros empreendimentos intelectuais: tenha uma agenda e conheça sua importância. Esteja atento; olhe ao redor. Seja ambicioso, mas não superambicioso. Tenha perseverança. Decida quem é a audiência e aprenda como atingi-la. Mantenha as idéias em perspectiva.

Esses princípos devem parecer óbvios ou vazios, ou ambos, mas duvido que os entendia como entendo agora, à época em que me tornei um economista e, com certeza, não quero dizer que me tenha mantido fiel a eles durante todo esse tempo desde então. Economia, novamente em comum com tantos outros empreendimentos, é muito mais uma questão de aprender fazendo. Penso que ao longo do percurso tenha aprendido quais são as satisfações em estudar Economia e quais os princípios gerais de trabalho úteis para atingi-las. Meu objetivo aqui é, por isso, não tanto me reportar ao que fiz ou mesmo ao que faço agora, mas extrair de ambos o que, acredito, funciona melhor.

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Tenha uma agenda e conheça sua importância

A agenda da Economia é entender um importante aspecto da experiência humana: por que nos comportamos assim em certas circunstâncias, tanto individual como coletivamente; que conseqüências seguem do fato de nos comportarmos dessa maneira; e, à luz desse comportamento e de suas conseqüências previsíveis, o que devemos fazer, individual ou coletivamente, para melhorar nossa condição nesse mundo. Dizer isso, especialmente para profissionais treinados, deve parecer trivial ou vulgar. Mas, certamente, não é trivial e, se for vulgar, é também muitas vezes esquecido.

Uma distinção entre abordagens empíricas e axiomáticas para as questões à mão é familiar em muitas ciências e Economia, novamente, não é exceção. Em meu próprio trabalho sempre me senti mais à vontade seguindo uma abordagem empírica, ou seja, a de iniciar por algum aspecto do comportamento econômico que, de fato, se observa, e procurar uma explicação. Por que a produção agregada e a renda crescem algumas vezes mais rapidamente em alguns períodos do que em outros e, algumas vezes, não apresentam crescimento? Por que as taxas de juros variam e por que variam entre si como o fazem? Como as empresas decidem quanto tomar emprestado e sob que forma? A abordagem axiomática - começar com uns poucos princípios básicos e determinar que conseqüências seguem, logicamente, de algumas suposições específicas adicionais - foi crucial e tem sido fundamental para a investigação econômica, se não mais. Porém, normalmente, o grande risco em aplicar a lógica impecável para obter uma conclusão de alguma suposição existe quando nenhuma das duas mantêm, de fato, uma relação efetiva com o comportamento das pessoas e das instituições reais e, portanto, das economias reais, que considero o objeto de estudo próprio do nosso tema.

No entanto, sob qualquer abordagem, é essencial ser capaz de dizer inicialmente por que vale a pena esse esforço. A questão inicial que tento responder para mim mesmo sempre que embarco em um novo projeto - quando começo uma nova linha de pesquisa (pelo menos para mim), ou persigo um intrigante objeto indefinido, abandonado pelo trabalho que estive fazendo, ou ofereço um novo curso para estudantes – é: "Por que estou fazendo isso?" O que posso aprender e por que deve ser proveitoso? O comportamento que quero examinar é importante em si próprio? Ou o conhecimento a ser adquirido é importante porque deve irradiar luz sobre algumas questões relacionadas? Nesse caso, por que essa outra questão é importante? A principal razão que me deixa mais à vontade para começar um trabalho a partir de uma abordagem empírica é que, dessa forma, acho mais fácil responder a essas questões - e, às vezes, elas podem ser difíceis - sobre o que estou fazendo e por quê.

Em contraste, tentar fazer pesquisa sem pensar por que, pontecialmente, vale a pena fazê-la é como praticar arco e flecha no escuro. Há uma pequena probabilidade de que qualquer

flecha atirada aleatoriamente atinja o alvo, e com um número suficiente de arqueiros atirando um número suficiente de flechas, inevitavelmente algumas atingirão o alvo. Similarmente, alguns economistas, inteiramente desconhecedores do contexto maior que poderia levar à valorização de suas descobertas, provavelmente, de alguma maneira, atingirão a mosca. Mas a probabilidade é muito maior se existir uma sensibilidade perspicaz de que esse contexto maior molde não só a seleção da questão a ser atacada mas também os meios para investigá-la. Algumas descobertas empíricas e alguns teoremas tornam-se importantes porque respondem às questões para as quais as pessoas genuinamente querem respostas; outras descobertas não, porque as pessoas não estão preocupadas com essas questões.

A implicação imediata desse ponto aparentemente óbvio é que, dada a limitação de tempo, nem tudo que é possível fazer vale a pena ser feito. Especificamente, nem toda extensão de um teorema vale a pena ser provada, nem toda observação empírica vale a pena ser explicada. Indo diretamente ao ponto, especialmente para os propósitos de pesquisadores mais jovens, o simples fato de que alguém publicou um artigo sobre um ou outro tema não o faz, por si só, digno de mais investigação. (O artigo original não deve ter tido algum mérito, mas esse é um outro assunto.) Ler os periódicos de economia é um excelente caminho para aprender métodos de pesquisa, mas muito pobre para escolher tópicos de pesquisa.

O que nos leva a boas questões de pesquisa? Aqui também, normalmente, tenho achado poderosas as atrações de uma abordagem empírica. Se o objeto da ciência econômica é, em primeiro lugar, entender certos aspectos do comportamento de indivíduos e instituições, ou suas conseqüências para a economia como um todo, então o caminho mais direto para encontrar esses tópicos é observar esse comportamento. Para o comportamento no agregado, isso significa simplesmente prestar atenção nas questões que as pessoas envolvidas estão fazendo. Para o comportamento individual, só observar. Para o comportamento das instituições, encontre uma maneira de observar.

Quando eu era um estudante de pós-graduação assumi uma série de empregos de meio expediente ou tempo limitado em vários setores do *Federal Reserve System.* Um deles era estudar a estrutura conceitual subjacente à apresentação de informação do *staff* do *Board* para o *Federal Open Market Committee.* (A questão-chave era como estruturar a condicionalidade dos eventos econômicos futuros sobre as próprias decisões de política monetária do *Committee.*) Outro, era servir a um comitê formado pelos representantes do *Board* e de Bancos regionais, para recomendar a melhor maneira de introduzir objetivos de crescimento monetário nas decisões políticas do *Open Market Committee.* (Naquela época - como ainda hoje - o *Federal Reserve* não estabelecia objetivos para as taxas de crescimento monetário.) Meu primeiro trabalho, depois de concluir minha educação formal, foi em uma firma de investimento em Nova Iorque. Eu não estava no departamento de economia (a firma

não possuía um naquela época), mas dividia meu tempo entre aquela seção da firma que trabalhava com corporações, nossos clientes, acerca das emissões de seus títulos e a seção que vendia títulos para investidores institucionais. Muito da minha pesquisa subseqüente - sobre a teoria de política econômica, sobre objetivos e instrumentos de política monetária, sobre decisões de empréstimo das corporações, sobre comportamento de *portfolio* e a determinação das taxas de juros, sobre o papel dos mercados creditícios em influenciar a atividade macroeconômica - derivou, diretamente, desses primeiros contatos com o comportamento econômico real. Pela mesma razão, mais recentemente tenho valorizado muito a oportunidade de trabalhar com algumas instituições financeiras, de forma mais sistemática ao longo do tempo, o que me permite observar e questionar como essas instituições conduzem seus negócios. (Em contraste, raramente aceito compromissos esporádicos.)

Independentemente da pesquisa ser empírica ou axiomática, no entanto, a questão da importância continua sendo fundamental. Para mim, aquelas primeiras oportunidades de ver de perto algumas instituições interessantes foram importantes não só para sugerir tópicos de pesquisa, mas para mostrar-me quem queria conhecer as respostas para aquelas questões e por quê. O objetivo - a fonte de satisfação do projeto como um todo - não é maximizar o número de artigos publicados para crédito de alguém, mas difundir tantos pontos de vista sobre o tema quanto possível. Se a primeira questão que me coloco é por que penso que um tópico em potencial é importante, a segunda é quem estará interessado, ou, melhor ainda, surpreso - ou, ainda melhor, frustrado - com as descobertas potenciais. Na maior parte do meu trabalho sobre política monetária, por exemplo, o objetivo era mostrar que os aspectos-chave do comportamento na economia na qual vivemos tornam inúteis as regras de caráter mecanicista para a conduta do Banco Central. Pensei (e ainda penso assim) que valia a pena realizar o trabalho não só porque o tema é inerentemente importante, mas também porque muitas pessoas preferem pensar o oposto. A última questão de fundo para qualquer pesquisador é sempre saber se as pessoas verão diferentemente aquele aspecto particular do tema porque trabalhei nele.

Esteja atento; olhe ao redor

Se o objetivo é elaborar a própria agenda de pesquisa de alguém à luz do comportamento real que observamos e procuramos explicar, estar atento ajuda. Fenômenos novos - a explosão do débito das corporações dos anos oitenta, por exemplo, ou o aumento do preço do petróleo nos anos setenta - são especialmente interessantes, ou porque representam uma nova forma de comportamento ou porque oferecem uma nova janela para analisar aspectos do comportamento econômico já familiares, mas somente de outros pontos de vista. Mas é

surpreendente quanto há para aprender da simples observação do que fazem e sempre fizeram pessoas e instituições, ou de prestar atenção nas pessoas, descrevendo o que fazem.

Uma razão para que esse tipo de observação do cotidiano seja tão importante é que o pensamento econômico (isto é, o pensamento dos economistas profissionais) é, muitas vezes, enganado pelas suposições que impusemos e, além disso, essas suposições são, elas mesmas, muito arbitrárias. Aspectos do comportamento diário, que não se adaptam convenientemente dentro da estrutura determinada por quaisquer que sejam as suposições em moda naquele momento, permanecem invisíveis para qualquer propósito prático. O racionamento de crédito é um exemplo sobre o qual trabalhei durante um tempo, ai de mim! No período anterior eu era bem respeitável. É embaraçoso relembrar hoje o ar de zombaria irrisória com o qual distintos economistas, não há muito tempo, rejeitavam ainda a possibilidade de que emprestadores deveriam adotar qualquer outra estratégia que não a de elevar a taxa de juros que cobravam, a fim de colocar em igualdade a oferta e a demanda por empréstimo. O fato de que quase todos que conheciam de perto os mercados de empréstimo pensassem que os banqueiros, às vezes, restrigiam o crédito simplesmente não era páreo, por assim dizer, para o fato de que não havia um modelo maximizador formal capaz de racionalizar esse comportamento. Mas, logo que alguém pensou em formalizar essas noções como informação assimétrica, seleção adversa e risco moral, o racionamento de crédito tornou-se naturalmente plausível, e um assunto, antes ignorado no círculo profissional instruído, tornou-se um campo aceito de investigação científica.

A questão não é que suposições simplificadoras (nesse caso, informação perfeita) não são úteis - de fato, elas são necessárias para pôr em prática qualquer análise séria -, mas que as suposições simplificadoras convencionalmente aceitas hoje são, com freqüência, altamente arbitrárias, portanto, sujeitas a mudanças e, por isso, não é humilhação escolher outras novas quando o comportamento observado não se adapta confortavelmente dentro do habitual. Exatamente como, por um longo tempo, o pensamento prevalecente teoricamente correto rejeitou mesmo a possibilidade de racionamento de crédito, por um tempo (misericordiosamente breve) a opinião prevalecente teoricamente correta acreditava que as expectativas das pessoas eram racionais, ações de política monetária preanunciadas não poderiam afetar produto ou emprego. Nesse caso, não faz muito tempo que numerosos economistas chamaram a atenção para o fato de que os modelos que apontavam para essa conclusão apoiavam-se não somente em uma noção, de fato específica (e, após alguma reflexão, talvez inconveniente) de "racionalidade", mas também em um conjunto de outras suposições questionáveis como ajustamento perfeito de preços e salários. Assim mesmo, por alguns anos, toda conferência sobre macroeconomia era obrigada a escutar, muitas vezes, a afirmação de que os economistas deveriam proceder como se esse modelo fosse uma boa

caracterização do mundo porque "é o único modelo bem elaborado que temos" Aqui, novamente, a presunção era que o comportamento simplesmente não poderia existir porque não havia (ainda) um modelo maximizador para explicá-lo.

Para o propósito de fazer economia teórica, o antídoto para tal estupidez é procurar novas suposições. Como no exemplo do racionamento de crédito, talvez a informação não seja perfeita. Como no exemplo da política monetária, talvez os mercados não se ajustem perfeitamente. A variedade de suposições convencionais sujeita a contestações é enorme. Talvez as utilidades pessoais não sejam independentes. Talvez a agregação seja importante. Talvez a dependência desse sobre aquele não seja linear. (Literatura muito interessante nos anos recentes explorou proveitosamente condições que geram múltiplos equilíbrios, mas, naturalmente, essa possibilidade segue imediatamente quando as relações comportamentais relevantes são não-lineares.)

Para o propósito de trabalho empírico, a mensagem é que um fenômeno observado não é menos interessante para estudar só porque ninguém elaborou um modelo maximizador para explicá-lo. De fato, nesse caso, descobertas empíricas podem ser a melhor pista para saber que suposições necessitam ser alteradas a fim de se atingir exatamente esse modelo. Como, ao longo do tempo, prestei atenção nas questões que meus amigos, em instituições políticas públicas e em firmas de negócios privados, faziam freqüentemente, fiquei impressionado por quão pouco nós - economistas - temos a dizer sobre o que eles querem saber. (Algumas vezes, impressionou-me quanto sabemos, mas aqui meu ponto é diferente.) Em parte, essas lacunas persistem porque é genuinamente difícil instruir-se sobre alguns tipos de comportamento e suas conseqüências. Mas, em alguns casos, nós não formulamos as questões corretas.

Uma outra razão sadia para prestar atenção no que está acontecendo e no que as pessoas estão dizendo é que o comportamento que estudamos muda. Não o comportamento no sentido do último "meta-modelo" fundamental, naturalmente; mas o que os economistas realmente estudam não é o meta-modelo e sim o comportamento de um exemplo geralmente minúsculo dele que considera o restante como dado. Exatamente por essa razão instituições - estabelecimentos legais, práticas de negócios, hábitos sociais, e assim por diante - são de grande importância para muitos aspectos do comportamento humano. E quando essas instituições mudam, as relações econômicas que dependem delas, de maneira óbvia ou sutil, também mudam. Há um sentido tautológico segundo o qual deve ser verdade que inflação é "sempre e, em todo lugar, um fenômeno monetário" mas não é nesse sentido que muitas pessoas, nos Estados Unidos, entenderam essa noção, há um par de décadas, antes que a inflação observada e o M convencional começassem a seguir caminhos distintos. Assumir, simplesmente, que respostas para importantes questões derivadas de experiência passada

permanecem corretas é não aproveitar muito do que é interessante e importante sobre nosso tema. Finalmente, outro motivo de por que ajuda olhar ao redor é que as questões que as pessoas fazem também mudam. Certamente assuntos como os custos reais da desinflação ou o valor de criar um mercado para títulos públicos de preço indexado ou o ganho na eficiência de indexar regras de imposto são sempre temas válidos para pesquisa econômica. Mas não é surpresa que mais pessoas prestem atenção nas descobertas da pesquisa sobre aquelas questões quando os preços estão subindo rapidamente do que quando os preços estão mais estáveis. Por essa mesma razão, não eram temas importantes nos Estados Unidos, antes de 1980, se o déficit orçamentário do governo em uma economia de pleno emprego inibia a formação de capital privado, ou sob que circunstâncias um déficit deveria ser monetizado. Isso não significava que anteriormente não fosse importante investigar essas questões. Mas mudou claramente o contexto que determina se qualquer linha específica de pesquisa se relaciona a um assunto de preocupação geral e, portanto, tem a habilidade potencial para provocar um impacto significante sobre a opinião dominante. As pessoas que não olharam ao redor não perceberam.

Seja ambicioso. Mas não muito ambicioso

Rabbi Tarphon, um notável erudito do primeiro século, declarou que "*Você não é exigido a terminar a tarefa, mas você não está livre para negligenciá-la totalmente.*" A injunção de Tarphon sempre me pareceu um útil farol para pesquisadores. Não negligenciar a tarefa é óbvio o suficiente, mas penso que é útil a idéia de não se exigir terminá-la para manter um sentido de determinação.

Um estranho curioso, lançando um olhar para a economia, provavelmente fica menos impressionado do quanto sabemos do que do quanto não sabemos. Poucas descobertas empíricas estabelecidas são genuinamente estáveis através do tempo e do espaço. Muitos resultados teóricos dependem de uma vasta série de suposições simplificadoras. Muitas dessas suposições - competidores atomísticos, utilidades independentes, relações lineares funcionais, agentes "representativos" idênticos, e assim por diante - tornaram-se, ao longo do tempo, suficientemente convencionais aos olhos dos pesquisadores práticos que parecem não exigir uma justificativa (de fato, elas freqüentemente são gratuitamente admitidas sem mesmo uma menção explícita); mas, para o estranho atencioso, elas parecem não só estranhas, mas efetivamente erradas (como naturalmente são). Especialmente para alguém que se inicia na carreira de pesquisador, a tentação resultante pode ser rejeitar todo o aparato de trabalho da economia moderna como epistemologicamente defeituoso e tentar construir um edifício totalmente novo em seu lugar.

Essa estratégia é uma receita para o fracasso. A insatisfação com a artificialidade de qualquer conjunto de suposições arbitrárias em moda no momento é uma motivação saudável para progredir. Procurar abandonar suposições comuns, úteis, de varejo é uma barreira para fazer qualquer progresso. Há uma tensão, mas não um conflito, em querer mudar alguns aspectos de como os economistas pensam enquanto se está ainda investigando somente uma mudança de cada vez. Há conflito, mas não inconsistência fundamental, em atacar uma suposição não atraente em uma linha de pesquisa, enquanto continua usando, porém, aquela mesma suposição atraente em outra linha de pesquisa onde o foco é diferente. A história de nossa ciência mostra que o progresso ocorre incrementalmente no campo intermediário entre terminar a tarefa e negligenciá-la totalmente. Economia é uma tarefa que a ninguém é exigido concluir, nem mesmo em uma vida toda, muito menos em um artigo. As conseqüências práticas de tentar concluir essa tarefa particular são, freqüentemente, indistinguíveis daquelas de simplesmente negligenciá-la.

Uma forma diferente de superambição em pesquisa econômica é o problema de Ícaro: tentar voar tão perto do Sol universal, no sentido de supor que uma área particular de pesquisa chegue mais próximo do meta-modelo fundamental do que ela pode (ou qualquer coisa que é realmente viável). O meta-modelo, por definição, leva em conta todos os fatores. Ele não muda com as circunstâncias não controladas porque controla todas as circunstâncias relevantes. Mas pesquisa econômica proveitosa focaliza somente umas poucas variáveis-chave por vez, deixando o resto de lado. Isto não é um defeito a ser infinitamente lamentado, mas um fato para ser proveitosamente relembrado.

Em particular, isso significa que a universalidade que devemos pretender para nossas descobertas, porque apropriadamente aspiramos por ela, não está por perto. Nossos resultados são resultados locais. Como ambientes e instituições mudam, mudarão até nossas relações empíricas favoritas, e até nossos teoremas favoritos dependerão de mais suposições do que normalmente enumeramos. Isso não desvaloriza nosso trabalho, só limita. Até agora, muitas das relações empíricas descrevendo o comportamento do mercado de crédito (e, especialmente, o comportamento das firmas que fazem empréstimos) que, há alguns anos pesquisei, não mais correspondem aos dados atuais. Devo aborrecer-me com isso, mas não tenho que considerar sem valor as lições básicas daquele trabalho. Os modelos que usei eram, quando muito, somente pequenos exemplos do meta-modelo, e como os fatores que omiti de minha análise mudaram, assim mudou o comportamento observado.

Um impulso intimamente relacionado, que também deve ser evitado, é a síndrome monocular - isto é, a tendência de os economistas reivindicarem explicações monocausais para fenômenos complexos. Para muitos, se não a maioria dos problemas, a estratégia de pesquisa

mais efetiva é não somente trabalhar para explicar um aspecto do comportamento econômico por vez, mas também focalizar somente uma parte da explicação por vez. Não raramente, um exercício útil é ver até que ponto pode-se ir para explicar o comportamento em questão com base em um fator causal sob investigação no momento. Tudo isso contribui para uma boa ciência econômica. Mas é importante não levar esses exercícios muito seriamente e, assim, concluir que, na realidade, algum aspecto importante do comportamento econômico tem somente uma força causal atrás dele.

Por razões que estão intimamente relacionadas tanto ao problema de Ícaro quanto à síndrome monocular, sempre relutei em extrapolar o que conhecemos de um contexto para outro onde aspectos essenciais do ambiente são diferentes. Um exemplo útil é o estudo da hiperinflação (sobre o qual certa vez também escrevi um artigo). Hiperinflações certamente são fenômenos interessantes por si só, nunca por causa de suas conseqüências políticas, algumas vezes poderosas. Mas, podemos aplicar as lições extraídas do exame da demanda por moeda durante hiperinflações, quando uma influência sobre a escolha do *portfolio* é ampliada numa magnitude tal que realmente não encobre todas as outras, para tirar conclusões sobre a demanda por moeda sob circunstâncias mais comuns? A experiência de eliminar vantajosamente hiperinflações pode informar nossa avaliação dos prováveis custos de uma transição de inflação moderada, mas persistente, para estabilidade de preços? Normalmente estou inclinado a ser cético sobre tais extrapolações. Em vez disso, se quero aprender sobre um tópico, tento estudá-lo em seu próprio contexto. (Pela mesma razão, quase sempre desaponto jornalistas estrangeiros que me pedem conselho sobre seus próprios governos. Não estou sendo politicamente cuidadoso ou excessivamente polido; só não acho que sei).

Ainda uma forma diferente de superambição em pesquisa econômica é demandar demais de um modelo e, em particular, empenhar-se em profundidades falsas. Aqui, o tratamento da demanda por moeda é o exemplo que mais rapidamente me vem à mente. Há alguns anos tornou-se moda argumentar que é ilegítimo tirar conclusões sobre política monetária de qualquer modelo que necessita de uma explicação interna para responder por que as pessoas retêm moeda. (Por razões que nunca entendi, muito dessa literatura considerava uma péssima idéia reconhecer que o motivo para reter moeda deveria ter alguma coisa a ver com sua utilidade em efetivar transações). Por que as pessoas retêm moeda é certamente uma questão útil e importante para a pesquisa econômica explicar. Mas, certamente, é também útil fazer uma pesquisa diferente assumindo que as pessoas, de fato, retêm moeda e prosseguir desse ponto. Insistir que ambos os esforços devem coabitar dentro do mesmo modelo é o mesmo que desejar que o manual do motorista contenha um capítulo sobre as origens da convenção de que os carros se movimentam no verde e param no vermelho, ou sobre por que diferentes países optam pelo lado direito ou esquerdo na estrada.

Tenha perseverança

Uma das decisões mais difíceis de se tomar ao engajar-se em qualquer programa, incluindo um programa intelectual, é por quanto tempo deve-se permanecer nele. Ninguém quer desistir muito facilmente só porque as pessoas inicialmente são resistentes a uma idéia que, aparentemente, vale a pena ou porque uns poucos exemplos de evidência parcial apontam para uma outra direção. Ao mesmo tempo, ninguém quer se prender a uma idéia por um longo tempo depois que uma evidência esmagadora a contradisse. Resolver essa tensão raramente é fácil.

Em média, normalmente estou mais inclinado a manter o rumo do que a abandoná-lo. Uma razão é que muito da ciência econômica sofre profundamente do problema da pequena amostra. Não é só porque não podemos conduzir experimentos que possam ser reproduzidos para explicar a maioria das questões econômicas, ou porque a história que temos não representa um experimento controlado. A dificuldade adicional é que, no que diz respeito às muitas das nossas questões, essa história é pequena. É pequena, em parte, porque ambientes e instituições são importantes e mudam. Devemos ter dados sobre o volume de empréstimos bancários desde o século 19, mas o mercado de empréstimo, hoje, difere dos mercados de épocas anteriores em muitos aspectos - securitização do empréstimo, aptidões para proteger-se financeiramente e competição do mercado comercial de papel, bem como da circulação vêem imediatamente à mente – de forma que a relevância de dados de décadas atrás é de valor limitado para muitas propostas de pesquisa. Nossa história é pequena também porque observações não são independentes através do tempo ou do espaço. Independentemente de dividirmos os dados anualmente, trimestralmente ou mensalmente, quantas observações puramente independentes o pós-guerra inclui de elevação e declínio da inflação? Quantas observações independentes a experiência do crescimento de vinte e quatro países do OECD contém? Ao mesmo tempo que essa linha de pensamento não é, certamente, base para se perder a esperança de jamais poder aprender com a análise empírica, me faz parar antes que eu mude rapidamente de idéia porque me deparei com um novo conjunto de regressões.

A mudança de moda contínua das suposições aceitáveis estabelece ainda outro motivo para resistir à pressão de abandonar uma idéia que parece útil para explicar o comportamento que observamos. Como o exemplo do racionamento de crédito mostra, o que a opinião respeitável julga impossível pode tornar-se parte do que "todo mundo conhece" com rapidez espantosa. Algumas vezes desejei saber se deveria continuar fazendo pesquisa sobre racionamento de crédito, uma vez que sempre acreditei que esse é um aspecto importante do comportamento do banco. Sei que não deveria ter desenvolvido o modelo maximizador crucial baseado em informação assimétrica e seleção adversa - minha ferramenta pessoal não é bem adequada

para essa tarefa particular -, mas, pelo menos, estou curioso sobre que evidência e discernimentos um programa sistemático de pesquisa empírica, exatamente sobre esse aspecto do comportamento financeiro, poderia ter produzido.

Mas, dizer que alguém deve manter o rumo, a despeito da oposição e mesmo de alguma evidência contrária, não é dizer que, de modo algum, não se deve mudar de idéia. O objetivo, apesar de tudo, é aprender. Algumas vezes o comportamento observado apresenta, de fato, proposições bem dramáticas, de uma maneira ou de outra. Por exemplo, eu costumava ser receptivo à idéia de que poupança tem taxas de juros positivamente elásticas e, por isso, era simpático à categoria geral de propostas políticas para estimular a poupança privada que dá origem a uma elasticidade positiva. Depois do declínio das taxas de poupança nos Estados Unidos, nos anos oitenta, em face dos aumentos verdadeiramente extraordinários nos retornos reais (deduzidos os impostos), mudei minha opinião. (De igual modo, penso que o mesmo declínio na poupança, em face dos déficits governamentais recordes em pleno emprego, foi igualmente muito devastador para a noção de equivalência ricardiana; mas, sobre isso, eu era um descrente há muito tempo).

Também aprendi que os Estados Unidos são muito mais que uma economia aberta do que eu costumava pensar. O maior engano que cometi foi pensar que o assunto político da última década e meia era subestimar quanto o déficit orçamentário do governo dos Estados Unidos deveria afetar o balanço líquido de exportação (e, por isso, mudar a direção dos fluxos de capital) e, correspondentemente, superestimar quanto deveria produzir nosso investimento doméstico. O modelo padrão de uma economia fechada, que forma minhas intuições econômicas mais básicas, não era adequado. Também aprendi que inflação de preço é um problema muito mais sério do que eu imaginava até mesmo, não acho que nossa profissão (eu inclusive) entendeu bem o por quê.

Assim, mudar de idéia é também importante. Mas, de maneira geral, quando pairam dúvidas sobre um assunto, estou mais disposto a manter o rumo e espero até que outros mudem os seus. Muitos dos quadros nas paredes do meu escritório são retratos. O maior é de Winston Churchill, um homem de visões determinadamente mantidas, se já houve um. A partir do final dos anos vinte, Churchill não só estava fora do gabinete, mas sem influência real, com suas visões rejeitadas e, basicamente, ridicularizadas pela sabedoria convencional da época. Ele não se reelegeu até o começo da guerra tornar óbvio que ele esteve correto o tempo todo; nove meses depois foi eleito Primeiro Ministro. Ele estava com sessenta e cinco anos.

Decida quem é a audiência e aprenda como atingi-la

Ocasionalmente ouço um ou outro economista dizer que seria mais feliz só escrevendo artigos e colocando-os na gaveta da mesa, derivando ampla satisfação do ato repetido de criação analítica sem nunca mostrar seus frutos para outra pessoa. Eu nunca encontrei esse economista. Em alguns casos, ouvi um economista que conhecia ser descrito dessa maneira, mas, em cada caso, conhecia a pessoa o suficiente para perceber que o que era dito sobre ela não era verdade. Muitos economistas, talvez todos nós, não queremos somente fazer julgamentos interessantes, mas transmiti-los aos outros. Mais que isso, muitos de nós querem persuadir outra pessoa a aceitar nosso julgamento. Os principais meios de comunicação são falar e escrever. Dos dois, escrever é o que dura para sempre.

Em nossa época, escritos de acadêmicos em geral, e de economistas em particular, tornaram-se o alvo padrão de gracejos banais. Acho injusto. Com certeza, muito do que escrevem os economistas é simplesmente inútil. Mas, muito é completamente adequado e muitos economistas escrevem extremamente bem. Fazer com que jovens economistas pensem que eles herdaram, de alguma maneira, uma inabilidade profissional genérica, uma espécie de deficiência congênita contra a qual terão que lutar pelo resto de suas carreiras, não ajuda ninguém. O ponto é simplesmente que escrever bem é um aspecto importante para uma comunicação efetiva e um aspecto especialmente importante para persuadir efetivamente, e isso é verdadeiro tanto para economistas como para quem procura comunicar-se e persuadir nas inumeráveis outras profissões. Como tudo o mais, o principal segredo para o sucesso é trabalhar com perseverança. No caso de escrever, isso significa principalmente voltar atrás outra vez, outra vez e outra vez - descobrir exatamente a palavra correta, reestruturar uma sentença ou um parágrafo para inserir uma nova idéia e, algumas vezes mesmo, mudar todo o fluxo lógico. Meu colega, John Kenneth Galbraith, uma vez referiu-se "*à aparência de fluidez que se insinua na minha* (Ken's) *prosa em torno do oitavo rascunho.*" Ele estava, indiretamente, oferecendo-me um conselho e eu tentei levá-lo a sério.

Algumas dimensões do tema, contudo, são provavelmente mais difíceis para economistas. O que penso ser especialmente importante é que muitos economistas querem - apropriadamente - comunicar-se com várias audiências diferentes que costumam falar idiomas diferentes. Nós queremos, em primeiro lugar, falar entre nós mesmos. Mas economistas acadêmicos também necessitam falar com seus estudantes e economistas de empresas necessitam falar com outros em suas firmas ou para seus clientes. Muitos economistas também querem falar, de vez em quando, para os formuladores de política. Alguns, às vezes querem dirigir-se a um público mais geral.

O problema de idiomas diferentes é real. Minha primeira apresentação para o *Federal Reserve System* foi um trabalho de verão no Departamento de Pesquisa do *Federal Reserve Bank* de Nova Iorque. Até então, eu tinha estudado Economia por quatro anos na Faculdade e mais dois na Pós-Graduação. Embora muitas das pessoas com quem falei no Banco naquele verão fossem economistas profissionais, rapidamente observei que somente eu não entendia o que eles estavam dizendo.(Não quero dizer que não entendia porque a teoria subjacente que eles diziam era válida; literalmente, eu não entendia muito das conversações que aconteciam.) Como eventualmente descobri, eles estavam falando, de fato, sobre temas que aprendi. Mas eles usavam um vocabulário diferente do que eu conhecia e deixavam muito do contexto implícito.

Vocabulário e contexto são cruciais para se comunicar efetivamente, e faz pouco sentido dirigir-se a uma audiência em qualquer outro vocabulário que não o seu próprio, ou sem providenciar o contexto correto. Penso muito sobre o desprezo popular habitual pelo escrito acadêmico que deriva da reação de uma audiência, ou de patrocinadores, ou talvez mesmo de leigos interessados no material escrito por profissionais de pesquisa, que constituem uma audiência totalmente diferente. O vocabulário é estranho e, até mesmo, as palavras que deveriam ser familiares são deficientes no contexto para lhes dar significado próprio.

O populismo americano sempre exibiu uma tendência antiintelectual e, assim, os congressistas, que querem marcar pontos, divertindo-se com professores estúpidos, podem facilmente dar risadas lendo passagens selecionadas dos periódicos profissionais sobre, exatamente, qualquer disciplina acadêmica. Enquanto poucos leigos são propensos a pensar que eles deveriam ser capazes de entender astrofísica ou teologia Bizantina, contudo, muitos não-economistas pensam que deveriam ser capazes de entender assuntos de economia. Mais importante, cidadãos, em uma república democrática, não têm somente um direito, mas, de fato, uma obrigação de entender assuntos importantes de política econômica. Enquanto, freqüentemente, impressiona-me como poucos economistas têm conhecimento acerca das questões que leigos interessados, ou funcionários públicos, ou executivos de empresas fazem, em muitos casos penso que sabemos mais do que é útil. Porém, resta comunicar-lhes o que sabemos. Acho que é para nosso crédito que tantos economistas querem dirigir-se a essas audiências não-profissionais. Contudo, podemos fazer isso efetivamente somente se usarmos um vocabulário que eles possam entender e se providenciarmos o contexto que torna significativo o que dizemos.

Aqui também, o que faz esse tipo de comunicação ser bem-sucedido é, em grande parte, o esforço que nele colocamos. Se acho que os congressistas, ou banqueiros, ou homens de

negócios devem estar interessados nas descobertas da pesquisa que estou fazendo, tenho que aceitar o fato de que simplesmente fazer circular reimpressões dos meus últimos artigos de periódicos não adiantará. Tenho que decidir se quero ou não transmitir minhas idéias para aquelas audiências. E, se quero, então sei que tenho que escrever um relatório sobre essas idéias dirigido à audiência que pretendo atingir.

Alguns dos meus colegas acadêmicos que leram meu livro *Day of Reckoning*, bem como alguns amigos na comunidade financeira, disseram-me que teriam achado o livro mais fácil não mencionam um muito menor - se eu tivesse incluído algumas tabelas e esquemas de séries temporais para apresentar tendências e relações mais importantes nos dados. Eles estavam certos. (Uma pessoa, que não conhecia, enviou-me uma carta dizendo que supunha que eu tivesse escrito a partir de um conjunto de tabelas e perguntando-me se eu poderia providenciar-lhe uma cópia.) Mas não escrevi aquele livro particular para eles. Deliberadamente escolhi uma apresentação puramente literária - sem tabelas, sem seqüência de dados, sem diagramas e, certamente, sem equações - porque queria que fosse lido por pessoas que, simplesmente, deveriam esmagá-lo se, folheando-o, reconhecessem quaisquer desses esquemas. Eu sabia que, uma vez que a pessoa realmente decidiu ler o livro, algumas tabelas e esquemas bem escolhidos deveriam torná-lo mais fácil para muitos, se não para a maioria. Mas decidi que, para esse esforço particular em comunicação, a audiência que queria atingir incluía grande número de pessoas que, se vissem tabelas e esquema de dados, provavelmente nunca o teriam lido todo.

Escrever um livro dessa maneira - produzir uma apresentação puramente literária sobre um assunto que nós economistas habitualmente discutimos entre nós mesmos, usando tanto taquigrafia quanto atalhos - naturalmente consumiu tempo. Ele desviou-me da pesquisa que também poderia ter feito. (Esse livro não foi pesquisa; gostaria de imaginá-lo como um jornalismo de alta classe.) Mas não me apressei porque pensei que esse esforço particular para comunicar e persuadir era importante. Pareceu-me, de qualquer maneira, uma sensação de obrigação moral.

Mantenha coisas em perspectiva

Um de nossos Presidentes comentou, certa vez, que um dos maiores desafios pessoais para a pessoa investida com responsabilidade pública, especialmente em altos níveis, é tomar suas decisões apropriadamente, ainda que não tão seriamente. Penso que os eruditos enfrentam a mesma tensão. Nós devotamos nossas vidas à pesquisa e a ensinar questões que julgamos importantes. Levamos muito a sério essas questões e o nosso trabalho sobre elas, e estamos

certos em agir assim. Mas, fazemos a nós mesmos - e a outros também - um desserviço se caímos na armadilha de também levar a nós mesmos tão seriamente.

Evitar essa tentação particular é, sem dúvida, um assunto de muitas dimensões, mas, em minha própria experiência, duas se destacam especialmente. Primeiro, algumas amizades que tenho valorizado ao máximo durante anos foram (e ainda são) com economistas cujas visões, com freqüência, contradisseram diretamente a minha própria visão. Nós discordamos uns dos outros em nossos artigos, debatemos uns com os outros em conferências e argumentamos uns com os outros quando estamos juntos somente para desfrutar a companhia uns dos outros. Eu admiro esses amigos, e aprendi com eles. Contudo, mais importante, é que no fim eles eram meus amigos e eu os valorizava simplesmente por isso. Outro sábio eminente, Isi ben Judah, perguntou "Por que eruditos morrem prematuramente?" Sua resposta: "Porque eles abusam uns dos outros." Levar-nos menos a sério do que levamos as idéias sobre as quais trabalhamos deve ou não nos capacitar a viver mais, mas penso que ajuda a evitar que o nosso trabalho bloqueie relações pessoais que podem ser profundamente agradáveis.

O outro sentido que, tentando não levar a nós mesmos tão seriamente, foi importante para mim reflete uma lição que aprendi há uns anos quando trabalhava em um banco de investimento. Freqüentemente trabalhava com Robert Baldwin, um sócio mais velho, que se tornou, posteriormente, chefe da firma. Relembro-me claramente a experiência, em várias ocasiões, de sentar em seu escritório com uma equipe de outros sócios e membros do *staff*, tentando programar um importante encontro com um ou outro cliente maior. Alguém deveria sugerir uma data, todos na sala deveriam concordar e, então, Bob deveria checar seu calendário e declarar que era impossível porque era dia do jogo escolar de seu filho (ou jogo de *hockey*, ou o evento particular da época). Todos deveriam trocar olhares intencionais como se dissessem: "Este sujeito é um chato, mas temos que fazer a vontade dele". e, eventualmente, alguém sugeriria uma nova data. Enquanto isso, minha própria reação (silêncio) era mais na linha de "Este sujeito é o único aqui que entende o que é importante."

Fazer um balanço de nossos envolvimentos pessoais e profissionais é uma tensão que todos nós enfrentamos. Como usualmente ocorre com essas tensões, ajuda ter claro quais são as prioridades. Eu sempre tive as minhas muito claras. Minha esposa e filhos vêm primeiro.

Mas tudo isso me traz de volta para onde comecei: ter uma agenda é crucial, assim como saber por que ela é importante.

Minha vida acadêmica*

Clóvis de Faro§

Minha formação

Sofri uma grande influência intelectual do professor Homero Caputo, no meu curso de graduação em engenharia. Faço parte de uma geração mais antiga. Naquela época existiam apenas duas escolas de engenharia no Rio de Janeiro. Uma delas, que hoje é a UFRJ, era a antiga Escola Nacional de Engenharia que, posteriormente, seria incorporada à Universidade do Brasil. A outra era a Universidade Católica. Por influência de meu pai, ingressei na católica, no ano de 1961. Tendo decidido casar-me o mais cedo possível, resolvi pedir transferência, em 1962, para a Universidade Federal Fluminense, que oferecia a possibilidade de conclusão do curso em 4 anos e não em 5, como ocorria com as demais faculdades. Lá conheci Homero Caputo, um grande professor. Além de um sólido conhecimento teórico, ele se mantinha sempre atualizado. Sua principal virtude era a imensa capacidade de motivar os alunos. Nessa época comprei inúmeros livros e comecei a estudar por conta própria, com o intuito de especialização em mecânica dos solos.

Naqueles idos, eu nem sabia o que era economia. Economia tornou-se uma coisa mais popularizada, pelo menos no Rio de Janeiro, a partir de 1964, quando a figura do Ministro do Planejamento passou a ser dominante. Logo perdi a motivação pela engenharia. Havia me formado e, por meio de concurso público, passei a engenheiro do Estado da Guanabara. No entanto, o trabalho de engenharia não me motivava de jeito nenhum. Foi então que descobri um curso de aperfeiçoamento em engenharia econômica, que, no seu início, teve a participação do Mário Henrique Simonsen. Nesse curso, passei a interessar-me por coisas relacionadas à economia, principalmente na área financeira.

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§ PhD Stanford University, Diretor Geral e professor titular da EPGE da FVG, professor titular do curso de mestrado em Engenharia da Produção da UFF.

Ao terminar o curso de engenharia econômica vi-me impossibilitado de fazer o mestrado em economia. Naquela época, por uma exigência legal, quem não era formado em economia não podia fazer o mestrado. O próprio Mário Henrique Simonsen, que era engenheiro e o diretor do único curso de mestrado em economia então existente, foi obrigado a fazer, posteriormente, graduação em economia. No entanto, o hoje extinto Conselho Nacional de Economia possuía um curso de extensão, denominado Análise Econômica, que era bastante organizado. O curso era ministrado no período da manhã e eu obtive uma licença do governo do Estado para frequëntá-lo. Lá, deparei-me com o professor Jessé Montello, que também exerceu uma influência muito grande sobre mim. Ele era professor da área de estatística, matemática e econometria e conseguiu despertar em mim uma grande motivação. Ele foi discípulo do professor Porto Carrero, talvez um dos maiores probabilistas brasileiros. Jessé Montello era muito competente, estudioso e sempre atento ao que estava sendo feito lá fora em termos de pesquisa. Marcou-me muito com sua excelente didática.

Pouco mais de 2 meses após o início do curso do Conselho Nacional de Economia fui informado que havia passado no concurso para o Curso de Programação Econômica organizado pelo CENDEC, órgão do Ministério do Planejamento. O concurso para ingresso consistiu de uma prova muito centrada em economia e com pouca coisa de matemática. Nessa época, eu sabia muito pouco de economia. Eu não possuía formação de economista e o curso que eu havia feito de engenharia econômica só tinha uma tintura geral de economia. Tive, uma vez mais, a oportunidade de ser aluno do professor Jessé. Nesse curso, também tive o ensejo de ser aluno do Affonso Celso Pastore. Ele ministrou um excelente curso de microeconomia. Eu o admiro muito, ele é fora de série porque é um autodidata. Certa vez ele me disse: "*Olha, eu só irei para fora depois de esgotar tudo o que eu puder fazer aqui.*" O problema todo é que ele nunca conseguiu esgotar tudo; as coisas aparecem e ele está sempre fazendo novas coisas.

Após o término do Curso de Programação Econômica recebi um convite do Professor Cândido Mendes para ministrar um curso de matemática financeira. Na época, finanças ainda era uma coisa muito rudimentar, mesmo lá fora. Os livros de finanças de então eram livros que tratavam muito de aspectos institucionais, mas pouco de formalização; havia muito pouca modelagem. Desde então, a coisa mudou completamente; houve uma verdadeira revolução. O trabalho do Markowitz, publicado nos anos 50, significou uma revolução na área de finanças. Quando começei a ministrar aquela disciplina passei a organizar uma apostila, que acabou se transformando em livro, o *Matemática Financeira*, publicado em 1969, e que foi bem-sucedido do ponto de vista de mercado. Como, praticamente, não tinha concorrente, ele teve uma popularidade muito grande. Posteriormente, publiquei um livro mais atualizado, com algumas coisas mais sofisticadas, denominado *Cálculo Financeiro*, e que saiu em 1990.

Em 1968, fui fazer um mestrado em pesquisa operacional, que eu nem sabia direito do que se tratava. Inicialmente, minha pretensão era ir para Berkeley estudar com o Dantzig, que é o pai da programação linear. Com a ida do Dantzig para Stanford, acabei fazendo o mestrado em pesquisa operacional naquela universidade. Eu ainda não conhecia a parte mais sofisticada dos métodos de avaliação de projetos. Quando voltei para o Brasil fui trabalhar no IPEA, com o Graciano Sá, que havia feito o doutorado em programação matemática. Ele estava querendo desenvolver um modelo de otimização da distribuição de aço. No entanto, ele considerava ser necessário estudar um pouco mais sobre os métodos de avaliação e seleção dos projetos, para dar um tratamento mais formalizado ao tema. Eu não estava preparado para desenvolver tal assunto, mas começei a estudar por conta própria. O resultado desse esforço foi a monografia de número 2 do IPEA, publicada em 1971, que acabou resultando no primeiro capítulo do livro *Engenharia Econômica*, de 1972. Foi aí que comecei a interessar-me pelo tema, particularmente por alguns aspectos matemáticos como, por exemplo, a unicidade das raízes de um polinômio aplicada à taxa interna de retorno.

Por essa época resolvi fazer o doutorado, tendo voltado para Stanford em 1971. Lá dediquei-me à área de engenharia econômica, que era o assunto de meu interesse. No entanto, minhas pretensões foram barradas, pois, ao comentar um estudo do professor chefe da área, apontei alguns erros existentes no seu trabalho. Isso foi o suficiente para que eu obtivesse uma má avaliação em um trabalho fruto de leitura dirigida, sob a alegação de que não concordava com minhas posições! Esse manuscrito, com as observações dele, eu guardo até hoje. Esse trabalho foi publicado como artigo, "On The Internal Rate of Return Criterion", na revista *The Engineering Economist*. Entretanto, como aquele professor era o dono da área lá no departamento, eu tive brecada a minha pretensão de fazer doutoramento nesse campo.

Durante algum tempo fiquei meio perdido. Todavia, tive a oportunidade de deparar-me com um professor que tinha acabado de chegar no departamento. Ele sugeriu-me mudar de tema. Indicou-me a área de finanças internacionais, que era uma área nova, principalmente no campo da administração financeira para subsidiárias, multinacionais, levando em conta o problema de variações cambiais. Especificamente, sugeriu a leitura do livro do Lietaer, fruto de sua tese no MIT, que aplicava o modelo de Markowitz para o problema de administração financeira considerando o risco de câmbio. A maioria dos livros que tratavam do assunto estavam errados numa coisa trivial, que era misturar, na seleção de fontes de financiamento, problemas de inflação interna com desvalorização cambial e taxa de juros. Foi então que escrevi um artigo intitulado "The Impact of Inflation and Devaluation on the Selection of an International Borrowing Source", em co-autoria com James Jucker, que foi publicado no *Journal of International Business Studies*. Como eu não podia dedicar-me ao assunto que mais me interessava, acabei fazendo uma tese estendendo mais o trabalho do Lietaer. Usei as idéias do

Sharpe em minha tese de doutoramento, da mesma forma como este havia feito com o modelo do Markowitz. Publiquei um artigo sobre o assunto, "The Selection of International Borrowing Sources", *no Journal of Financial and Quantitative Analysis*, do qual até hoje tenho muito orgulho, pois foi o *"leading article"* e foi citado em vários livros de textos. Cheguei ainda a publicar mais um artigo sobre o assunto, mas não prossegui porque estava na hora de voltar ao Brasil.

Quando regressei ao Brasil, em 1974, já tinha 3 artigos publicados ainda como aluno e já possuía mais 2 que estavam em vias de publicação. Eu poderia ter ficado nos EUA. No entanto, achava que deveria voltar e retribuir de alguma forma o governo brasileiro, que havia financiado meus estudos. Como aqui não havia interlocutores na área de minha tese, voltei a dedicar-me ao assunto que mais me despertava interesse e que havia sido abandonado pelas razões já mencionadas. Foi então que me deparei com um trabalho, mais ou menos obscuro, de um autor chamado Vincent, que desenvolvera um teorema para separar as raízes de um polinômio. Eu logo percebi as possibilidades de aplicação na área de finanças, tendo então publicado um artigo no *Journal of Financial and Quantitative Analysis*. Quando o artigo já estava no prelo, o Richard Bernhardt enviou-me um trabalho dele que tratava do mesmo assunto; chegava ao mesmo resultado, mas de uma maneira totalmente diferente. Por isso, ficou conhecido como teorema Bernhardt–De Faro.

Pesquisa e ensino

A pesquisa, pelo menos no meu caso, tem que despertar o prazer em estar-se aprendendo, porque a pesquisa é, acima de tudo, um tentar descobrir. Por meio da pesquisa você descobre a sua própria ignorância. Aí, então, você começa a ler sobre o assunto e, muitas vezes, de forma fortuita, você percebe que alguma coisa está errada. Eventualmente, você tem a felicidade de descobrir alguma coisa que já foi feita, mas que você pode aperfeiçoar. Quase que naturalmente você vai sedimentando aquela idéia e vai adquirindo conhecimento, influenciado pelas leituras e por suas próprias indagações. É necessário que você tenha prazer de estar fazendo aquilo. Sem isso eu não me sentiria à vontade para fazê-lo.

Existem professores que realmente não têm capacidade didática, mas que são excelentes pesquisadores. Como existem também professores que não têm essa centelha da pesquisa, que é um dom, mas que são excelentes expositores. Na Universidade de Stanford, eu vivi uma situação extremamente curiosa. O Robert Litzenberger, um excelente pesquisador, estava dando aula no MBA. Os alunos fizeram uma greve pelo fato de não querer ter aulas com o referido professor porque ele não sabia ensinar. Em contrapartida, os alunos do doutorado

reuniram-se e exigiram a sua permanência no departamento, pois ele era um excelente pesquisador. Para certos tipos de cursos, como o de mestrado em *business*, geralmente com grandes turmas, o importante, às vezes, é a comunicação e a capacidade de motivação. Quando um professor vai dar aula num curso de doutorado, às vezes para uma turma de apenas cinco alunos, ele tem que ser muito mais capaz como pesquisador.

Em sua atividade didática, o professor, acima de tudo, encarna um personagem. Eu procuro ter a minha aula organizada. Não gosto de levar a aula em transparência. Acho que toda vez que vou ensinar alguma coisa tenho que dar margem ao aluno de duvidar daquilo que eu estou fazendo. Se eu levar a aula pronta, não vou dar essa possibilidade para o aluno. Em minhas aulas, eu não paro, encho vários quadros, buscando motivar o aluno e envidando todos os esforços para que ele não fique perdido naquilo que eu estou fazendo.

Co-autoria

Fiz muitos trabalhos em co-autoria. O trabalho individual depende do meu entusiasmo, e aí eu não tenho prazo determinado para entregar nada. Eu posso às vezes ficar com alguma idéia por dois ou três anos na cabeça. Escrevo um pouco, não fico satisfeito e acabo deixando de lado. O trabalho em co-autoria tem um aspecto interessante, porque começa a haver uma interação, em que um exige do outro. É uma coisa que eu acho muito boa quando existe simbiose. O problema é que é difícil arranjar o co-autor adequado. Eu fiz vários trabalhos em co-autoria que foram extremamente bem-sucedidos.

Há duas vantagens no trabalho de co-autoria. Primeiro, o conteúdo que sai costuma ser maior do que a soma das partes; e, segundo, no próprio desenrolar do trabalho há uma aceleração do processo. A grande dificuldade, no entanto, é que nem sempre me deparo com alguém que esteja interessado naquilo que eu estou fazendo e vice-versa. É até certo ponto fortuito. Em princípio, considero uma grande vantagem fazer coisas conjuntas.

Academia e finanças

A Bolsa de Chicago começou realmente a operar em larga escala no início da década de 70. E, simultaneamente, por pressão do interesse em saber-se como é que se precificava opções, estava lá o Robert Merton, de um lado, e o Black e o Scholes, de outro. Eles produziram, quase que simultaneamente ao surto de crescimento do mercado de opções, um ferramental extremamente sofisticado, baseado no uso de cálculo estocástico, com aplicação

imediata. Ou seja, foram respostas para necessidades imediatas dos mercados financeiros. No caso do Markowitz, foi diferente. Ele tentou explicar uma coisa que já existia há muito tempo, que era a maneira como os investidores faziam as suas aplicações. Ele fez aquilo para estudar o que já existia e, somente algum tempo depois, com o Sharpe, é que as coisas vieram realmente a ser aplicadas. Hoje a gente vê, em finanças, um modelo do Sharpe estendido sendo aplicado. Os administradores de carteiras de investimentos realmente usam, hoje em dia, o modelo originalmente formulado por Markowitz. Suas idéias só foram efetivamente aplicadas muito tempo depois, a partir da década de 70.

Já o trabalho de pesquisa em opções foi diferente. Começou um mercado e, paralelamente, estavam aquelas duas equipes trabalhando. E aí explodiu. Explodiu porque as pessoas começaram a ver que em finanças você faz coisas altamente sofisticadas e que têm aplicação imediata. O exemplo mais dramático disso talvez seja o próprio Fisher Black. Ele continuou produzindo trabalhos da mais elevada qualidade acadêmica ao mesmo tempo em que trabalhava como consultor. Posso também citar o José Alexandre Scheinckman, que hoje é o diretor do Departamento de Economia da Universidade de Chicago. O que ele publica academicamente é exatamente aquilo que o pessoal está usando no mercado financeiro. Por isso, o campo de finanças teve essa explosão. Trata-se de conhecimento altamente sofisticado com uma grande aplicação imediata.

estudos econômicos

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SUMÁRIO

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ARTIGOS