# Technological Sovereignty, Industrial Efficiency and Development: Evidence from Brazil

**By Edmund Amann**[1]

**Abstract:** Since the end of the 1980s the Brazilian economy has become increasingly exposed to the forces of globalisation. As trade and market liberalisation have progressed, so the industrial sector has been obliged to undergo a substantial transformation. This paper examines the nature of this transformation focusing on three key themes: productive efficiency, industrial restructuring and technological sovereignty. While, at least in terms of productivity and cost competitiveness, efficiency has undoubtedly increased, the evidence concerning the impact of liberalisation on technological sovereignty is somewhat more ambiguous. However, it is clear that, in many instances the reliance of the Brazilian industrial sector on foreign sources of technology has markedly increased. This, in turn raises a number of troubling issues, not least the ability of emerging market economies to hold on to established areas of technological competence as globalisation continues to unfold.

## Introduction

Over the past decade, the Brazilian economy has undergone profound transformation. Eschewing the inwardly orientated, state-driven industrialisation strategies of the past, policy makers have embarked upon a bold policy of reform emphasising re-integration into the global economy and the imposition of thoroughgoing market liberalisation. That these policies have been implemented represents a substantial rupture with much of Brazil's post-war development experience and has set industry substantial new challenges. The objective of this paper is to assess the nature of these challenges and ascertain their impact on industrial strategy and performance, and, more specifically, on Brazil's technological sovereignty.

In analysing the impact of Brazil's market and trade liberalisation strategies upon industrial performance and technological sovereignty the paper focuses on three key issues. In first place, the evolution of productivity is analysed with a view to

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establish both its relationship with policy reform and underlying shifts in enterprise behaviour. Second, the paper touches on a theme central to the current reform process: mergers, acquisitions and industrial restructuring. In doing so, it is argued that developments in this area are as yet at a preliminary stage but that a tendency towards greater average industrial concentration is unmistakable. Third, the discussion turns to the central (and often overlooked issue) of this paper: the linkages between economic openness and technological sovereignty. Specifically, an attempt will be made to chart the development of Brazilian national technological self-reliance and sovereignty through the liberalisation period, considering its relationship with increasing openness. However, before getting to grips with any of these issues it is well worth reflecting back on the nature of the reform process itself.

**Brazil after a decade of trade and market liberalisation**

For much of the post war period, the Brazilian economy was characterised by an adherence to an inward orientated strategy of industrialisation in which the state played an increasingly significant role, both as a regulator of industrial activity and as a producer in its own right. This strategy was not without its successes. During the 1950s, the industrial sector expanded at an unprecedented rate and Brazil entered into the production of relatively sophisticated industrial products, especially in the consumer durables sector.

When the orthodox import substitution industrialisation (ISI) drive of the 1950s began to expire amid slowing growth and mounting inflation, the newly installed military regime executed a swift *volte face* in the mid 1960s imposing a more open style of ISI with a heavy emphasis on export promotion. This “Post ISI” strategy proved highly effective with GDP and Industrial GDP growth attaining record annual levels between 1967 and 1973 (Baer, 1995). However, this strategy proved only temporarily successful in that it was predicated on rapid growth in international export markets and a low oil price. With the advent of the first oil price increase in 1973, Brazil was forced to abandon the Post ISI strategy. In its place was substituted an intensified ISI strategy in which the authorities encouraged the backward integration of the industrial sector through the promotion of capital goods and basic industries.

Unfortunately, this policy, while effective in maintaining respectable levels of growth, could function only with substantial injections of international capital. While Petro-Dollars proliferated the strategy remained viable albeit at the cost of substantial debt accumulation. With the second oil crisis of 1979 and the advent of tighter monetary policy in the OECD countries, access to the cost-effective finance of current account deficits came to an end. By the early 1980s, Brazil like many other Latin American economies was struggling to pay its debts and the strategy of ISI lay in tatters. For much of the 1980s, while it was recognised that ISI no longer offered a viable development strategy, nonetheless no alternative was actively sought. However, by the late 1980s the first signs of change were discernable. With the advent of civilian government in 1985, the new President, José Sarney, began to consider seriously the possibility of a comprehensive opening up of the economy as a means of injecting some much needed dynamism. The government’s deliberations bore some fruit in 1987 with the initiation of a limited programme of trade liberalisation directed at removing some non-tariff barriers (NTBs), in particular those which actively prohibited or severely restricted certain categories of import (Pinheiro & Almeida, 1994). At the same time a cautious privatisation programme was launched, encompassing the steel and petrochemicals industries.

However, these steps paled into insignificance compared with what was to follow at the beginning of the next decade. The election to office of President Fernando Collor de Melo in 1989 brought to power a charismatic political neophyte committed to tackling the statist ways of the past and imposing a radical liberalising agenda. President Collor’s most radical steps were taken in the field of trade policy. In the first year of the presidency, 1990, virtually all NTBs were abolished (ibid.). The latter encompassed not only outright import prohibitions but also an elaborate system of quotas, technical requirements and public sector procurement rules favouring domestic producers. The virtual abolition of NTBs eliminated at a stroke the most effective and pervasive forms of protection from associated with Brazilian ISI. With the effective jettisoning of NTBs, such protection as was afforded to industry now rested entirely on tariff barriers. However, these, too, were to be reduced in scope.

**Table 1 Tariff Rates (All Products) 1990-1994**

| **Tariff** | **1990** | **1991** | **1992** | **1993** | **1994** |
|---|---|---|---|---|---|
| Average | 32.2% | 25.3% | 21,2% | 17.7% | 14.2% |
| Mode | 40.0% | 20.0% | 20.0% | 20.0% | 20.0% |
| Standard Deviation | 19.6% | 17.4% | 14.2% | 10.7% | 7.9% |

Source : Fritsch & Franco 1991 p.20

Between 1990 and 1994 an ambitious programme of tariff reform was instituted, reducing average tariffs by half while simultaneously sharply lessening tariff dispersal. Following the signing of the Treaty of Asunción in 1991, further impetus was lent to the strategy of trade reform with the creation of Mercosul, a customs union embracing Brazil, Argentina, Paraguay and Uruguay. In anticipation of the formal inauguration of Mercosul on 1st January 1995, the authorities initiated extra deep cuts in tariffs applying to imports from the latter three countries. Thus, by the mid 1990s, Brazil had effected a rapid transition from an inward orientated economy characterised by an elaborate and opaque system of trade protection to one in which trade barriers were both transparent and increasingly slight.

The adoption of the Real in 1994 heralded a new era of economic stability. However, the containment of inflation in this new environment was predicated on the pegging of the new currency to the US Dollar. With inflation still running well above international averages the result was that the Real appreciated rapidly in real terms. Largely as a result, the trade surplus, which had accumulated in the early 1990s, began to shrink rapidly, eventually transforming itself into a deficit.

Prompted by this development, the government, now under President Fernando Henrique Cardoso found itself under pressure to control the surge in imports. As a result, the drive towards trade liberalisation was tempered somewhat in the late 1990s, especially in the field of automotive trade where tariffs applying to non-Mercosul imports of assembled vehicles increased from some 20% to 35%. However, the experiences of the automotive sector were somewhat unusual and the generally open character of the Brazilian economy has been maintained into the present decade. Before turning to the impacts of trade reform, it is worth considering two other crucial policy variables that have been recently exercising a profound impact on the evolution of Brazilian industry: privatisation and market de-regulation.

**Privatisation and market de-regulation**

While the speed of the trade liberalisation programme may have dipped in the late 1990s, the same cannot be said for two crucial areas of reform; privatisation and market de-regulation. In the case of privatisation, it has already been noted that the late 1980s witnessed the launch of a limited programme encompassing state owned steel and petrochemical enterprises. The early 1990s saw the privatisation of the remainder of the steel industry in addition to a few other enterprises engaged in basic industries. However, it was not until the beginning of President Cardoso’s first term in 1995 that the privatisation programme got under way in earnest.

As a preliminary step towards the implementation of a more comprehensive privatisation programme, the government was obliged to pass constitutional amendments ending the state’s exclusive right to operate in such activities as telecommunications, electricity generation and distribution and oil exploration and production. In addition to terminating the exclusive rights of the state, the constitutional amendments passed in 1995 also opened up key sectors to foreign participation. In particular, foreign enterprises were permitted to enter such previously prohibited activities as offshore oil exploration and rail transport. At the time of their passage, these substantial constitutional alterations provoked widespread controversy. However, the government recognised that their adoption was crucial in order to address the legacy of years of under-investment in key infrastructure and strategic industries.

With constitutional obstacles out of the way, the government over the seven years between 1995 and 2002 proceeded with the world’s largest and most ambitious privatisation programme. The table below gives some indication as to the scale of the programme.

**Table 2 Brazilian Privatisation Receipts, 1991-2002 (US$bn)**

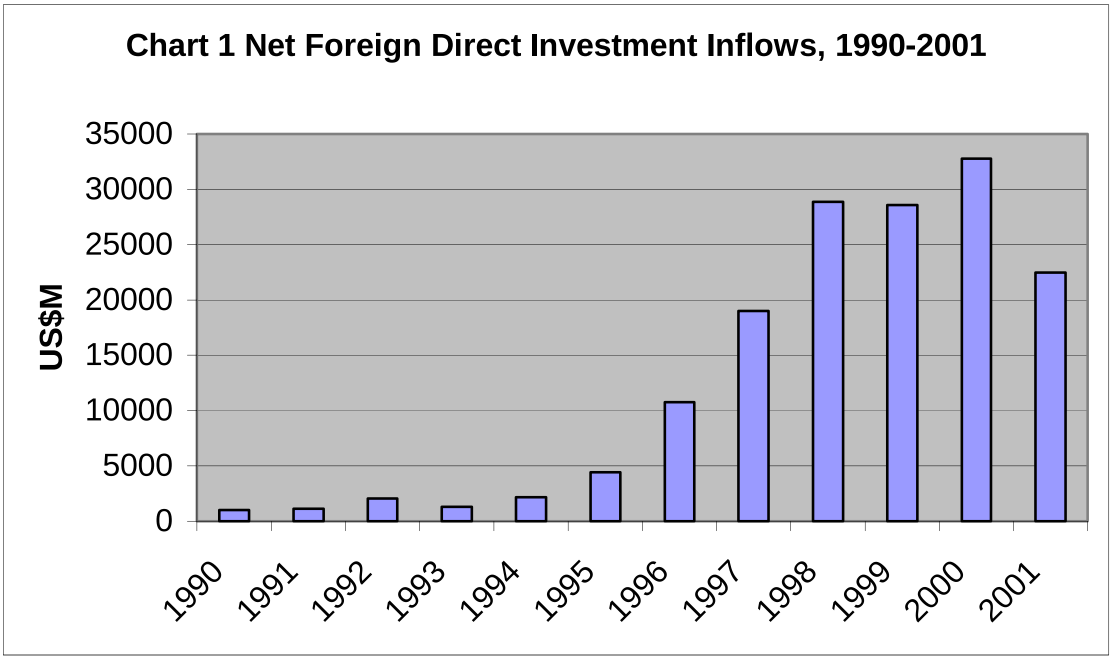
| 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002* |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1.9 | 3.2 | 4.0 | 2.2 | 1.5 | 6.2 | 26.3 | 35.7 | 4.2 | 10.2 | 2.8 | 2.0 |

*To June

Source: BNDES

The privatisation programme over the past seven years has embraced all of the major public utilities sectors with privatisations occurring in telecommunication, electricity generation and distribution, highways, railways, water and sanitation, gas and ports. In addition there has been a substantial programme of privatisation in the state owned banking sector, with the last of the large state banks, Banespa, being privatised on November 20th this year in a deal worth over US$3bn. The programme has also embraced a number of other sectors, not least the mining and mineral extraction industry and insurance.

As the privatisation process has proceeded, one of its most notable features has been the rising tide of foreign direct investment (FDI) as foreign enterprises have purchased privatised companies and then invested substantially in upgrading facilities and implementing new technologies. Chart 1 below demonstrates the extent by which foreign investment has accelerated so sharply over the past few years, especially since 1995.




Source: Banco Central do Brasil

However, privatisation represents only part of the picture so far as market liberalisation is concerned. In addition to the privatisation programme the government has also been actively promoting a strategy of de-regulation in once heavily regulated sectors. Nowhere is this truer than in telecommunications where the auctioning of new concessions for the operation of fixed line and cellular services has been taking place with increasing frequency. Indeed, by 2003, the telecommunications regulator, ANATEL will have presided over the complete de-regulation of the sector with enterprises being granted total freedom of entry and exit. Similarly, in the case of electrical power generation and transmission, the privatisation programme has been accompanied by measures which allow for new entrants into the sector to challenge the privatised incumbents.

As the state has divested itself of productive capacity across a range of key sectors, it has sought to exercise a degree of control over their evolution through the development of an elaborate regulatory framework. As a result, each key public utility sector now benefits from the presence of a regulator whose demonstrated commitment has been to promote market openness and competition (Pires & Piccini, 1999). While regulatory uncertainties continue to plague certain sectors (e.g. electricity) they have certainly not proven sufficient to slow the mounting volumes of foreign investment which continue to pour into the modernisation and upgrading of Brazil's infrastructure.

In sum, the past decade has seen an unprecedented withdrawal by the state from direct participation in the production process. This has been associated with a rising tide of FDI as state owned enterprises have been transferred to the private sector. Relinquishing its role as producer, the state has transformed itself into a regulator, replicating the experiences of governments throughout the region and beyond. While privatisation and market de-regulation have proceeded, the authorities have also been promoting a policy of trade liberalisation instituted in earnest under the Collor government in 1990. Unsurprisingly, given the seismic break with the past that these policy developments represent, their impacts on the performance of the Brazilian industrial sector have been profound. It is to this issue which we turn next.

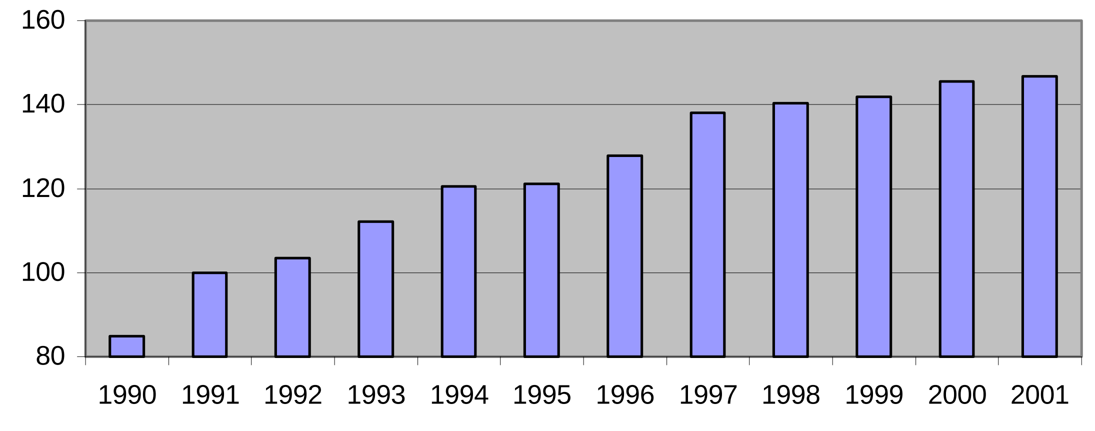
## The implications of trade and market reform for Brazilian industrial performance

One of the most compelling arguments for the pursuit of trade and market reform is that it potentially embodies the ability to induce competitive improvements across a range of industrial sectors (Little, Scitovsky and Scott, 1970). That such improvements were urgently required on the eve of the reforms is beyond question. During the 1980s, productivity growth, whether measured in single factor or total factor terms, entered a period of considerable stagnation. Compared with its newly industrialised counterparts in East Asia, it had become clear that Brazil was falling behind in the productivity race at a time when, more than ever, it urgently needed to catch up. However, measures that might have provoked such change remained effectively absent right up to the coming to power of President Collor in January 1990.

However, immediately following his accession, President Collor administered a policy shock to the industrial sector, the magnitude of which had not been widely anticipated. With the effective abolition of the vast majority of NTBs and the announcement of a programmed scaling down in tariffs, industry was suddenly confronted with an enormous competitive challenge. The timing of reform programme was, in many ways, unfortunate since it coincided with a steep recession induced by the implementation of exceptionally tight monetary policy. Faced with domestic recession and the immediate prospect of market opening, industrial enterprises were forced to address the productivity gap which had opened so significantly in the previous decade.

Initially, enterprises' response was characterised by a strategy that Dantas (1990) aptly termed 'defensive modernisation'. This highly reactive strategy involved a substantial scaling down of the workforce and the scrapping or mothballing of older capacity or vintages of capital equipment. Where possible, capital equipment would be upgraded, often through the use of newly available imports. The central objective of this strategy was to swiftly reduce capacity to meet expected levels of demand. In the process average labour and capital productivity would be expected to rise and, accompanying this, unit cost would fall. At this early stage of policy liberalisation the majority of enterprises were able to adopt no more ambitious strategies than this, given the acute time and resources constraints that pertained. Nevertheless, despite the crude, if not draconian, nature of the defensive modernisation strategy, it proved highly effective in reversing a legacy of years of productivity growth stagnation. As the chart below shows, labour productivity growth began to sharply pitch upwards after 1990, a trend which was fortunately sustained.

**Chart 2 Evolution of Labour Productivity in Manufacturing (1991=100)**




Source: IPEA

As the Brazilian economy entered the early 1990s, the context for a reformulation of the defensive modernisation strategy became more propitious. In first place, with the adoption of the Real in 1994, the economy had embarked upon a path of relatively stable and, above all, non-inflationary growth. Rather than having to slash capacity in response to plummeting domestic demand, enterprises were able to plan in terms of a recuperating domestic market, and with the inauguration of Mercosul, in terms of an expanded set of regional export opportunities. At the same time, the more favourable domestic macroeconomic and regulatory context had begun to encourage the more active participation of foreign enterprises in the Brazilian industrial sector. Long established foreign enterprise subsidiaries began to formulate expansionary plans while other newer entrants were attracted in through privatisations, market de-regulation or simply accelerated growth in domestic market demand.

This newer, more buoyant context gave rise to a second phase of competitive change which can be termed "systemic modernisation". In essence this involved an attempt to effect competitive improvements – especially as they concerned productivity – through the reformulation of the production process. Specifically, systemic modernisation has involved a number of key strategies, whose implementation has been widespread across Brazilian industry. These strategies have included:

- **Re-organisation of the shop floor**. With the increasing move towards flexible specialisation a number of enterprises have been reconfiguring the layout of the shop floor with the objective of facilitating smoother production flows and the substitution of production cells for assembly lines.
- **Investment in computer numerically controlled machine tools and other current generation capital equipment**. With a more liberal import regime now in place, enterprises have been investing growing quantities of resources in new capital equipment. This new equipment is often characterised by a substantial electronic/automated component and is strongly associated with the move towards flexible specialisation.
- **The pursuit of Total Quality Management (TQM)**. This strategy has proved virtually universal within the Brazilian manufacturing sector with growing numbers of enterprises now achieving ISO 9000/9002 certification or its equivalents.
- **The outsourcing of activities where appropriate or possible**. In a development which has become endemic throughout Brazilian industry,

increasingly both core and non-core activities are outsourced to sub-contractors. In an extreme development of this manufacturing philosophy, production at the new VW factory at Resende in Rio de Janeiro state is entirely carried out by sub-contractors. VW itself just retains responsibility for product design, marketing and quality control.

- **The pursuit of Just In Time (JIT) inventory management strategies**. With the cost of holding inventory (and financing it) increasingly on the minds of companies, the deployment of JIT strategies has increased enormously over the past 5 years.

Over the past few years, these strategies have diffused substantially throughout the Brazilian industrial sector, as a number of studies (e.g. Amann, 2000; Ferraz et. al, 1997) make clear. Their impact on productivity has also been, without doubt, equally pervasive.

Following a trend established at the beginning of the decade, productivity growth was sustained into the late 1990s. While a component of this productivity growth must be ascribed to the natural impacts of a recovery in demand, nonetheless, a number of studies indicate that structural reform of the production process itself played a significant, if not dominant role[2]. An indication of the acyclical nature of recent productivity growth is occasioned by an examination of data on hourly, as opposed to per-employee per year labour productivity. The data reveal a sustained upturn in hourly labour productivity over the past five years, in line with the implementation of changes in the nature of the production process[3].

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[2] See, for example, Amann (2000), Ferraz et.al. (1997)
[3] IBGE output and employment data in Pesquisa Industrial Mensal

Accompanying the improving underlying competitiveness of the Brazilian industrial sector has been an increased focus on exports. Originally configured to supply the domestic market in a context of heavy protection, over the past decade, Brazilian industry has taken faltering steps to increase its participation in both regional and extra-regional export markets. Prompting this development have been a number of factors, not least the growing competitiveness of the domestic market, the increasing availability of competitive official export finance packages and, since January 1999 a highly competitive real effective exchange rate. As a result of these influences, especially the latter, industrial exports have risen over the past two years, contributing to the movement of the trade balance from deficit to surplus (EIU, 2000). As Brazilian firms have become more heavily involved in export markets, competitive imperatives in these markets have lent further force to the process of structural modernisation already under way.

**Mergers, acquisitions and corporate restructuring**

One of the most significant areas of change over the past decade has been in the field of industrial structure and concentration. For most of the post war period patterns of ownership and concentration throughout the Brazilian industrial sector remained surprisingly stable. This was by no means accidental. Prompted by the desire to maintain adequate levels of market competition in the context of a protected economy, anti-trust policy was rigorously enforced and average industrial concentration ratios across sectors remained low by OECD standards (Amann, 2000). However, any benefits that this policy may have offered to consumers had to be set beside efficiency losses arising through chronic under-utilisation of capacity and wasteful duplication of investment.

However, with the progressive liberalisation of trade from 1990 onwards, the authorities appear to have adopted a more permissive attitude to merger and acquisition activity. Faced with the need to compete in an ever more open domestic market and aiming to penetrate more successfully export markets, enterprises found it increasingly to their advantage to take over domestic rivals or agree to joint mergers. With the stabilisation of prices after 1994, foreign capital has played an increasingly important role in this process with MNC subsidiaries acquiring domestic rivals or themselves merging as a result of takeovers engineered in their home countries.

Taking all of these factors together, the past decade has seen something of an explosion in M+A activity. As the data below indicate, the number of M+A transactions rose from just 13 in 1990 to 256 in 1999. The total value of transactions increased even more spectacularly over the same period from US$639m to US$16314m.

**Table 3: Value and Number of M+A Transactions in Brazil, 1990-1999**

| | **1990** | **1991** | **1992** | **1993** | **1994** | **1995** | **1996** | **1997** | **1998** | **1999** |
|---|---|---|---|---|---|---|---|---|---|---|
| **Number of Transactions** | 13 | 27 | 41 | 55 | 63 | 97 | 139 | 171 | 287 | 256 |
| **Total Value (US$m)** | 639 | 1541 | 2814 | 4914 | 1475 | 4502 | 9131 | 25372 | 50674 | 16314 |

Source: Ferraz & Iooty, 2000 p. 13

While M+A activity has risen across the Brazilian industrial economy, some sectors have been far more affected than others. Following the completion of the privatisation programme in the early 1990s, the steel sector has seen a wave of takeovers as enterprises have attempted to rationalise capacity and achieve scales of production consistent with those of producers in other parts of the world, notable in East Asia

(Amann & Nixson, 1999). Perhaps the single most significant merger has occurred in the beverages sector where, in 1999, two of Brazil's largest brewers, Brahma and Antarctica, combined to form Ambev, now the world's third largest beer producer.

The approval of the latter merger was significant, less for the scale of the transaction itself than for the authorities' rationale in allowing it to go ahead. Acknowledging consumer concerns that the merger would result in significantly lowered levels of competition (Ambev now accounts for 70% of domestic beer production), the authorities were none the less persuaded by the argument that only through such a merger could the Brazilian drinks sector effectively face off growing competition from MNCs such as the Anheuser-Busch and Interbrew. The application of similar logic, namely the creation of national champions, also appears on the point of being applied in the pulp and paper sector much to the disquiet of some observers.
While it is obvious that raised investment and shop-floor re-organisation have given rise to substantial gains in competitiveness, such a conclusion is far more difficult to draw in the case of mergers and acquisitions. A recent study by Ferraz, Iooty & Rocha (Ferraz, Iooty & Rocha, 2000) demonstrated that, for a sample of 120 enterprises acquired between 1990 and 1997, profitability did not markedly improve after take-over. In fact, overall financial performance was surprisingly poor, especially in the immediate two years following acquisition. However, it must be stressed that such results are by no means confined to Brazil: very similar data can be uncovered in the case of Europe, Japan and North America.

**Globalisation, Technological Strategy and Technological Sovereignty**

Historically, the development of Brazilian industry has been characterised by an overwhelming dependence on foreign sources for technology, in particular basic product technologies. Paradoxically, therefore, while the strategy of ISI promoted increasing industrial autarchy it also gave rise to growing technological dependence. Recognising this problem and the potential constraints it might have placed on the future course of industrialisation, the state began to play a growing role in fostering domestic technological development both within the public and private sectors. This policy reached its zenith in the mid 1970s with a comprehensive series of measures designed to subsidise R+D in the private sector, while monitoring technology transfer agreements and promoting technological investments in the public utilities (Schwartzman, 1995).

With the implementation of severe budgetary cuts in the early 1980s, the scope of the state's technology policies was severely curtailed. However, this did not prevent the launch of an ambitious initiative designed to promote the growth of the domestic information technology sector. Unfortunately, by the beginning of the 1990s, even this much-trumpeted initiative had fallen into disarray, as under President Collor, the state's technology budget was further reduced. Since the mid 1990s, however, the improving fiscal capacity of the state has made room for a cautious re-launching of technology policy initiatives.

In particular, there has been a substantial expansion in resources dedicated to assisting industry in its modernisation drive and promoting the incorporation of home-grown technologies into this. In contrast to the past, the current range of technology policies focus sharply on increasing the capacity of the private sector to innovate and then implement appropriate technological solutions. Of the plethora of measures that have emerged over the past few years perhaps the most significant has been Law 8661 of 1993 (Suzigan & Villela, 1997). The Law has provided the basis for a number of individual funds, each targeted at a particular sector, the majority being concentrated in manufacturing industry. In addition, the privatisation of the public utilities has afforded the government a further opportunity to reconstruct technology policy. Most significantly, a new fund has been established to promote domestic technological innovation in the telecommunications sector, encouraging privatised enterprises to make use of a privatised R+D institute, CPqD. In July 2000, an additional fund came into being to support innovation in the electricity generation and distribution sectors. Thus, it is fair to talk in terms of a recent renaissance in Brazilian technology policy initiatives. But what, if anything, have been their impacts so far?

Though it may be too early to judge, such evidence as exists suggests that old patterns of technological dependence remain firmly entrenched. Using R+D expenditure as a percentage of annual turnover - admittedly a crude measure of the technological vitality of the industrial sector – it becomes evident that the liberalisation drive of the past decade has failed to induce substantially greater technological intensity within the private sector. The data reveal that corporate R+D spending has hovered at around 1% of turnover for much of the past decade, a figure much below Brazil’s key emerging market counterparts such as South Korea and Taiwan. More generally, as Table 4a reveals below, in international terms, the proportion of GDP expended on R&D has remained very low. Nevertheless, it is important to recognise that, in proportion to GDP Brazil’s total national spending on R&D did tend to rise year-on-year from 1992 to 1999. Thus, in very broad terms there appears to be an association, at least, between market opening, the development of new policy initiatives and an upturn in R&D expenditures.

**Table 4a. R+D Expenditures (% of GDP) in Selected Countries, 1990-1995**

| Countries | 1990 | 1991 | 1992 | 1993 | 1996 |
|---|---|---|---|---|---|
| Germany | 2.76 | 2.63 | 2.5 | 2.48 | 2.48 |
| United States | 2.72 | 2.86 | 2.81 | n.a | 2.48 |
| Japan | 3.08 | 3.05 | 3 | n.a | 2.78 |
| Canada | 1.45 | 1.51 | 1.51 | 1.5 | 1.48 |
| Italy | 1.3 | 1.32 | 1.38 | 1.41 | n.a |
| Brazil | 0.72 | 0.69 | 0.56 | 0.77 | 0.87 |
| Argentina | 0.33 | 0.34 | 0.36 | 0.39 | 0.46 |

Sources : Matesco & Hasenclever (1996) p.467, Brazilian Ministry of Science & Technology, (1998) p.1, Gabinete Científico-Tecnológico (1997), p.78, Schwartzman et al. (1995) p. 9

**Table 4b Spending on R&D as a percentage of GDP, 1999**

| | |
|---|---|
| Public Sector: | 0.55% |
| Private Sector: | 0.33% |
| **Total:** | **0.88%** |

Source: Ministério de Ciênca e Tecnológia

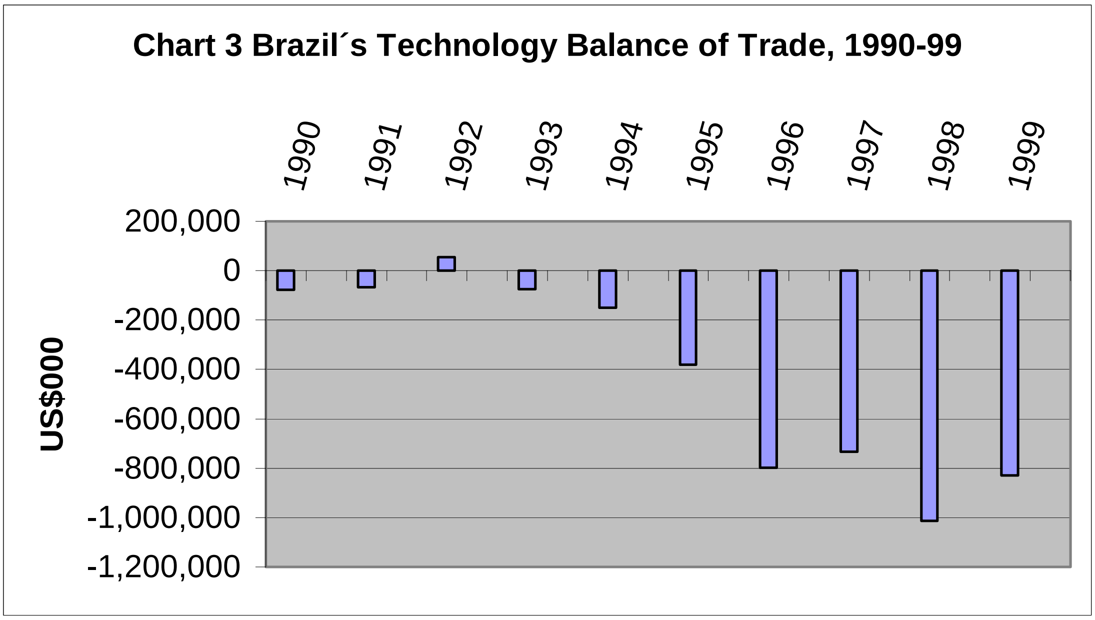
At the same time, especially over the past four years, there has been a substantial acceleration in imports of technologically sophisticated capital goods, substituting in many cases for domestically produced alternatives.

Indeed, this fact is emblematic of a wider dynamic within Brazilian industry, namely, an increasing tendency towards upgrading process technologies through international technology transfer. As Table 5 and Chart 3 reveal below this strategic choice has had profound implications for payments made overseas for technology with a marked upswing in such payments over the second half of the 1990s.

**Table 5. Brazilian payments made overseas for technology transfer, 1990-99 (US$m)**

| **Type of service supplied** | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 |
|---|---|---|---|---|---|---|---|---|---|---|
| Use of trademark | | | | 1 | 2 | 5 | 14 | 14 | 13 | 37 |
| Use of patent | 3 | 2 | 3 | 41 | 79 | 138 | 200 | 167 | 218 | 97 |
| Supply of technology | 32 | 26 | 31 | 40 | 48 | 222 | 379 | 514 | 597 | 480 |
| Industrial cooperation | 34 | 9 | 10 | 14 | 51 | 27 | 51 | 66 | - | - |
| Specialised technical service | 140 | 164 | 116 | 130 | 187 | 284 | 364 | 762 | 1393 | 1359 |
| **Total** | **209** | **201** | **160** | **226** | **367** | **676** | **1008** | **1523** | **2221** | **1973** |

Source: Instituto Nacional de Propriedade Industrial, *Panorama da Tecnologia*, VII, n. 15 May 2000




Note: The technology balance of trade includes ‘imports’ and ‘exports’ of the following items: patents, licences, technical assistance, trademarks

Source: Ministério de Ciênca e Tecnológia

Naturally, an increasing deficit on the technology balance of trade represents a cause for concern from a macroeconomic perspective. However, as the aggregate R&D data above would suggest, this growing imbalance is not necessarily indicative of declining domestic technological effort. In fact, when one examines data on domestic corporate spending on research and development, clear evidence emerges of an increase in technological activity, at least up until 1999 - the latest year for which data are available (see Table 6). Moreover, in selected areas Brazilian corporations have continued to operate at the frontiers of technology, gaining significant export market share in the process. By far the most important example in this regard lies in the field of the aerospace sector where Embraer has become a leading player in the passenger jet market (Da Silva, 1999).

**Table 6 Evolution of Corporate Spending on R&D, 1993-1999 (Constant 1999 R$M)**

| 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 |
|---|---|---|---|---|---|---|
| 1166.0 | 999.5 | 1215.5 | 1528.6 | 2011.8 | 1724.3 | 2394.9 |

Source: Associação Nacional de Pesquisa, Desenvolvimento e Engenharia das Empresas Inovadoras (Anpei) Ministério de Ciênca e Tecnológia

Looking ahead, it appears that the continued expansion of the "technology deficit" depicted above will be ever more difficult to contain. With the passage of the Law of Patents in 2000, the intellectual property rights of foreign enterprises have been substantially strengthened. While this development may foster a greater readiness among such enterprises to transfer more advanced technologies to Brazil, an inevitable additional consequence must be some reduction in the scope that exists for reverse engineering and other foreign exchange-saving (though potentially patent-breaching) indigenous innovative activity.

As the previous section noted, the past few years have seen an increasing proportion of the Brazilian industrial sector pass into the hands of foreign owners. This process has been especially marked within some of the more technologically sophisticated industrial sectors such as automotive components, electronics and the mechanical equipment sector (Ferraz & Iooty, 2000).

In many respects, the growing presence of multi-national corporations (MNCs) has brought positive developments, not least a much-needed injection of capital and up-to-date managerial skills. However, by the same token it must be recognised that to an increasing extent, decisions concerning technological strategy in the Brazilian industrial sector have been taking place outside Brazil itself. In addition, the enhanced presence of foreign ownership across a range of industrial sector raises questions as to the long-run survivability of such local innovative capabilities as were established in domestically owned enterprises prior to their takeover by MNCs.

Leaving aside the issue of increasing MNC presence, it is perhaps inevitable that enterprise strategy has not been characterised by greater technological self-reliance given the urgency of the need to modernise and the risks, costs and long gestation periods inevitably associated with home-grown solutions. Nevertheless, the failure of the private sector at large to invest more intensively in indigenous technological solutions holds out a number of risks for the future, not least the possibility that Brazilian industry will remain tied to a portfolio of products increasingly advanced in the product cycle (Ferraz, Rush & Miles 1992). In this context, enterprises may find themselves ever more obliged to compete on cost rather than on non-price factors.

In sum then, the past decade has witnessed the Brazilian industrial sector placing increasing reliance on foreign sources of technology, a development which, in relative terms, has had unfavourable implications for domestic technological self-reliance and the range of home-grown technologies open to domestic economic agents. To this extent, it is possible to talk in terms of an erosion of technological sovereignty.

However, to repeat the point, despite the generally technologically dependent character of much of Brazilian industry, sectors have emerged over the past two decades whose evolution has been associated with considerable technological originality and enhanced technological sovereignty. Perhaps the most notable example of this has been the case of Embraer, the recently privatised aircraft manufacturer[4]. Building on a heritage of piston engined light transports, the enterprise has recently moved into the production of more advanced regional passenger jets, competing head-on with Bombardier, Dornier and SAAB. Petrobras, too, has developed a world-class capability in deep offshore drilling while the recently privatised telecommunications research institute, CPqD has successfully exported a number of fibre optic and digital exchange related technologies. Significantly, the recent success of these enterprises draws on a legacy of years of persistent state support in which policy makers effectively targeted selected global market niches. Given their accumulation of skills, experiences and hard won commercial success, it appears more than likely that these enterprises will be able to persist with their technologically intensive strategies even if, in national terms, such approaches remain the exception rather than the rule.

## Conclusions

Since the beginning of the 1990s, the progressive removal of barriers to trade and investment has exercised a profound influence on the evolution of the Brazilian

[4] For an excellent discussion of the early years of Embraer, see Silva (1999)

industrial sector. Shielded for years from the pressures of global competition for markets and resource, enterprises have been forced to fundamentally reconfigure their production strategies in order to survive. By and large, perhaps even to a surprising extent, the Brazilian industrial sector has succeeded in meeting the challenges imposed by the new competitive environment. Through capacity cuts, modernisation of plant and equipment and re-ordering of the production process, productivity levels have grown markedly over the past few years while unit costs have shrunk Simultaneously, policy shifts have encouraged a wave of mergers and acquisitions, the pace of which is currently accelerating.

Only in the area of technological self-reliance are strong echoes of past under-achievement to be detected. As has been pointed out, however effective Brazilian industrial enterprises were at driving up productive efficiency, they did so thanks to substantial imports of foreign technology. In the process, it has been argued that national technological sovereignty was eroded and technological dependence increased. Despite this rather sombre general picture there have been, however, some exceptions with the recent emergence of a number of technologically world-class enterprises. However, in order for the long run dynamism of the Brazilian industrial sector to be assured, the more technologically ambitious strategies adopted by these firms will need to become rather less the exception and rather more the rule.

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