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Problematizing the "commercial liberalization-technology access-productivity" channel, Brazil post 1990

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ABSTRACT

The paper aims to show that the opening of the foreign commerce – central objective of Brazilian model adopted in the 1990's - did not materialize its effect on the productivity, through the access to imported technology. The combined analysis of international trade data, Granger Test results and technological innovation indicators helped to understand the dynamics involving the channel in focus in Brazilian industry. The lack of streams leaving from foreign technology to productivity, the stagnated behavior of innovation rates and the profile of this process (excessively concentrated on processes) denounces important nuances of fragility of Brazilian system of innovation, in particular those relating to the process of technological learning and the productive and innovative competences related weaknesses.

Key-words: commercial liberalization; foreign technology; productivity; Brazilian industry; innovation.

JEL Classification: O31; O33; O38.

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1. INTRODUCTION

Currently, it has been common place to posit innovation[1] at the heart of discussions about development, especially due to the process to be considered as a driving line for appropriation and internalization of economic surpluses and as the main engine for technological change. On the other hand, the mainstream literature usually does not take into account the specific features of different social, political and institutional contexts.

Frequently this orientation results in receipts to developing countries based on best practices/benchmarks, in order to drive their industrial policies. The debate around that, with focus on innovation, often involves commercial liberalization. As the investigation focuses on the effects of commercial openness, the traditional thought strives to establish a causality relation from commercial liberalization to productivity, whose materialization occurs through a few major channels.

[1] In this article we define innovation according to Oslo Manual of Organization for Economic Co-operation and Development (OECD): "[...] innovating firm is one that has implemented technologically new or significantly technologically improved products or processes during the period under review. [...] The minimum entry is that the product or process should be new (or significantly improved) to firm (it does not have to be to the world)" (OECD, 1997, p 32).

For our purposes it matters the following argument: commercial openness, by allowing to access cheaper and/or better foreign technology, naturally determines increases in productivity. Thus, one realizes that the openness implicitly stimulates technological innovation. Alternatively, other schools of thought point out that technology contains a tacit dimension e because of that it is hard to transfer. In part this idea helps to provide answers for the following question: why after fifteen years of a more intense openness process in Brazil the innovation process in its industry has been presenting poor evolution and characteristics of a late industrialization country, despite higher levels of productivity have been verified?

Our central aim is to investigate underlying aspects of the dynamics involving commercial openness and technical progress in Brazilian industry. Specifically we strive (i) to verify if the access to imported technology after intensification of liberalization explains the rise of productivity by the 1990's and (ii) to identify cognitive nature factors able to spread out the profile of technological innovation process in Brazilian industry in the current decade. We assume as central hypothesis here that is necessary to run a long learning path to modify the picture of innovation in Brazil. Access to imported technology itself is not enough.

The article contains four sections including this introduction. The following section presents a theoretical controversy over the impacts of commercial openness (placing emphasis on the technological aspect) between those representing the traditional thought and those adopting neo-Schumpeterian ideas.

The third section concerns the investigation of relevant features of commercial openness and its effects. We highlight the relation between the evolution of technology imports and the productivity performance in industry. The last section focuses on technological innovation, calling attention to the relevance of learning as a process that enables the creation of productive and innovative competences. Finally concluding remarks have place followed by references.

2. THE CONTROVERSY OVER THE IMPACTS OF COMMERCIAL OPENNESS

2.1 Conventional wisdom

Mainstream literature suggests three main channels through which liberalization leads to higher growth of productivity (Paus *et al*., 2003), as follows:

(i) competitive pressures from imported goods, through barriers reduction, compel domestic industries to restructure themselves - for instance, introducing technological innovations - or to leave the market;

(ii) changes in relative prices between tradable goods and imported substitutes ones turn exportations more attractive. The increasing of exportations causes productivity growth by means of scale effects and technical knowledge transfer from abroad;

(iii) lower levels of protection reduces costs of imports, enabling access for all firms to cheaper and/or better foreign technology, in particular capital goods. We focus on this last channel.

The traditional thinking prescribes commercial openness as an essential policy to promote technical progress. Under perfect competition, agents with substantive rationality and accessing all available information would make resource allocations efficiently. In the case of developing countries, as capital return is higher due to its shortage, there would be a natural tendency concerning the channelling of investments into these nations (Pinheiro, 2008).

According to the World Development Report 1991, aligned with Washington Consensus, commercial openness, along with deregulation of markets, should get agents used to act based on the true opportunity costs of resources which would cope with international prices, by means of a higher level of contestability (Katz, 1996).

The survival of domestic firms would be conditioned to restructuration (for instance, through acquisition of technology from abroad) and national production would get concentrated in sectors with comparative advantages. As technology is a public good, considered as given and accessible to all firms, this would imply technological spillovers would achieve all sectors of economic activity, producing economic development and higher levels of well being, despite

changes in patrimonial structure of enterprises (by means of merges and acquisitions), related to nationality of controller capital.

Capital and labor factors are conceived as homogeneous and incorporate the idea of technology. The firm's task concerns opting for the most appropriated technology, which would not be generated by those who use it, but supposedly those (individuals or firms) specialized in its production, in the absence of any explicit consideration about that (Pessali & Fernández, 2006).

Nelson (1991) considers we should not ignore recent progress achieved by neoclassical theory, insofar as it moves away from static equilibrium models and treats technical change as endogenous. Nevertheless, limitations still remain once traditional view (a) supports mobile equilibriums; (b) defends that increases in productivity steam from displacements along the production function from lower to higher points, as technology varies; (c) tries to isolate specific reasons that link productivity to growth, despite empirical evidences corroborating the systemic and complementary character of these reasons; and (d) does not take into account complex peculiarities related to institutional arrangements influencing the level of growth and productivity.

In addition, conventional wisdom still assumes that firms know their choice set and make the obvious correct choice. Differences among firms would be based on initial conditions or even on lucky that could determine a more favorable choice set to certain companies. However, "given the same conditions, all firms do the same" (Nelson, 1991, p. 65). "Innovation is treated as basically like any other choice" (*ibid.*, p. 66). Uncertainty is probabilistic (confused with risk).

2.2 Neo-Schumpeterian view

The heterodox wisdom, named neo-Schumpeterian, is concerned with the logic of innovation process and its impacts on economic activity (on growth, development, productivity). In general terms, the stream holds that it is necessary to ponder environment particularities which potentially absorb new technologies from commercial openness and could drive (or not) to increases in factors productivity.

Before introducing such peculiarities into the analysis, some premises must be considered. It is important to recognize technology as deeply embedded in knowledge which in turn has many roots transcending the mere access to information and involving a tacit dimension. This makes technology hard to transfer.

When a certain agent accesses a message (an explicit knowledge), his whole cognitive context is charged with giving meaning to this information and influences the message receiver's action, i.e., knowledge incorporated into the technology is multidimensional. This gets clear in Cowan and Foray's words who link knowledge to the whole cognitive context of each agent.

> *We find it useful to operationally define an item of information as a message containing structured data, the receipt of witch causes some action by the recipient agent – without implying that the nature of that action is determined solely and uniquely by the message itself. Instead, it is the cognitive context afforded by the receiver that imparts meaning(s) to the information message, and from the meaning(s) follow the specif nature of the induced action(s). The term knowledge is simply the label affixed to the state of the agent's entire cognitive context* (2000, p. 6).

According with this idea, Foray e Lundvall (2002) present a typology of knowledge and its respective roots: i) know-what e know-why, coming from information; ii) know-how, typically stemming from practice; and iii) know-who, coming from social practices and specialized environments of education.

Another proposal can be found in Sveiby (1998), by introducing the competence as a candidate synonym for knowledge, which would be composed of five reciprocally independent elements.

> i) Explicit knowledge: it involves knowledge about facts and is acquired mainly from information, almost always from formal education;
>
> ii) Skill: this "know how to do art" involves practical proficiency – physical and mental – and is acquired specially from training and

> practice. It includes knowledge about procedure rules and communication skills;
> iii) Experience: experience é obtained mainly from reflection about past mistakes and successes;
> iv) Judgments of value: it is represented by perceptions about what an individual believes to be right. They act like conscious and unconscious filters for the knowledge process of each individual
> v) Social network: it is formed by human beings reciprocal relations inside an environment and culture that are transferred through tradition (p. 42)[2].

From this reasoning, it follows that increases in productivity rates - through domination, creation and diffusion of new technologies – are not automatically tied (as a natural trend) to commercial openness. Technological spillovers would depend on (i) initial conditions in terms of knowledge stocks accumulated and mobilized by individuals, firms and nations; (ii) possibilities of forward and backward technological linkages; and (iii) institutional possibilities (including social and cognitive ones) that condition the adoption of such technologies. Furthermore, all these conditions are nation, region or firm specific. In fact, firms usually differ according their strategies, organizational structures, and technological and management capacities (Katz, 1996).

On the other hand, knowledge accumulation and its application aiming innovative ends can not run without a long path of learning, which happens through several means such as learning-by-doing; learning-by-interacting; learning-by-using, etc. (Foray & Lundvall, 2002). These processes cross over firm's domains and need to hit markets and institutions. All these elements experience dynamic phenomena of maturing and learning which have been little studied by scholars until now (Katz, 1996).

This analysis allows to argument innovation is a systemic, interactive and cumulative process, depends on endogenous capacities and is based on tacit knowledge. The technology generation is essentially localized and influenced by economic, political, social and

[2] Translated by the authors.

institutional features with regard to different contexts (Freeman, 1995 e 2005; Cassiolato, 2004; Lastres, Cassiolato & Arroio, 2005).

The channel we are investigating would not work naturally, given that simple emulation of best practices/benchmarks ignores this complexity. Another point to be highlighted: the necessary pre-requisites for a convergence between international prices and rates are not verified in real world, in which innovations can even raise uncertainty levels, once they addition the technological uncertainty dimension to the business uncertainty one.

The diffusion of new technologies demands institutional changes that can be done in various ways, depending on several factors such as local history, politics and culture (Freeman & Soete, 1997; Freeman, 2005; Johnson & Lundvall, 2005; Lundvall, 1992).

Finally, it is worth considering the learning issue and its connection to commercial openness in developing nations. In late industrialization countries, like Brazil, one can say there is a long and necessary learning process to be performed, as much for increasing innovation rates as for changing its profile. The simple access to foreign technology does not imply evolution, and low levels of industrial productivity growth seem to be the most natural tendency.

Scenarios in which imitation is virtually the only pattern of innovation embody incipient stages of accumulation and mobilization of competences, and the precariousness of learning processes taking place in these environments (although there can be more knowledge-intensive sectors and/or firms as exceptions). Individuals and firms from late industrialization countries have to consolidate learning processes enabling generation of incremental and/or radical innovations.

Differences among stocks of competences are associated with distinct learning processes. Learning-by-research and learning-by-interacting processes have to take place aimed at forming a diversified base of knowledge which in turn enables mobility in several new areas and access to networks. More complex activities must be fostered by means of expenses on training to be run inside firms.

Heavy investments on acquisition and mobilization of deeper/more specific knowledge and skills are required to build what Bell & Pavitt (1993) termed the industrial capabilities for technological change generation[3].

3. BRAZILIAN INDUSTRY: COMMERCIAL OPENNESS AND ACCESS TO FOREIGN TECHNOLOGY

Since the 80's the model of development focused on domestic market and imports substitution has been changed by the introduction of commercial liberalization and market deregulation policies. According to the official discourse, these measures were implemented aiming at modernizing industry structure. In this section, the intention is to show the main features of the intensification of this opening which took place in the 90's and their developments in Brazilian industry, with emphasis on technological aspect.

3.1 Commercial openness: characteristics and developments

During the short government of President Fernando Collor de Melo (1990-1992), liberalizing policies were introduced essentially intending the following objectives: insertion of Brazilian economy in the globalizing market, macroeconomic stabilization, productive modernization and restructuring, and redefining of the State's role in economy. The economic plans adopted in this period (Collor I and II) pursued as major goals the stabilization and (forced) modernization of productive sector and more specially the introduction of longer term structural changes.

The commercial opening intensification was largely supported by liberal bias diagnoses concerning the relative productive and technological delay of Brazilian industrial enterprises: excessive domestic market protection tended to discourage entrepreneurial fighting behavior (as such incessant search for cost decreasing, continuum productive growth and constant

[3] Types of knowledge, skills and experiences with potential to generate and manage technical change. Generally, they are organized in even more specialized P&D laboratories, design offices, project management teams, production engineering departments, etc.

introduction of innovations) causing in this way certain accommodation in private and public managers[4].

The defense of the "liberalization-technology access-productive" channel as discussed earlier strongly supported the elaboration and implementation of a set of industrial policy measures named general guidelines for Industrial and Foreign Trade Policy (PICE). The intention was to follow a schedule of elimination of goods entry barriers, from which resulted a tariff reduction as one of the most relevant changes. In four years, the average rate was lowered from 32% to 13% (Moreira e Correa, 1997).

Another measures were adopted together with tariff reduction such as the end of the system of prior informed consent for imports, the end of Annex C of Foreign Trade Portfolio (CACEX), the suspension of the requirement of annual programming for import, the extinction of market exclusivities and the elimination of export processing zones (ZPEs); all these non-tariff changes occurred in a very short period of time (around a year).

Industrial companies located in Brazil were under pressure to reorganize their business strategies in the face of greater competition, especially from imported products, and the recessive context of the time. The government itself was charged with disseminating the basic guidelines for competitive insertion of Brazilian Industry in the global market through a "plan of modernization".

Between September 1990 and February 1991, institutional mechanisms were created aimed at the transformation of the national productive sector as follows: Quality and Productivity Brazilian Program (PBQP) [5], Support Program to Technology Training in Industry (PACTI) [6],

[4] See Barros and Goldenstein (1997) and Franco (1998).

[5] It was launched in 1990 as a government action to support the modernization efforts of Brazilian Industry, through quality and productivity promotion aiming at competitiveness upgrading of Brazilian goods and services.

[6] From the perspective of the makers, the objective of PACTI was to support, guide and coordinate actions relating to technology training in industry, seeking to increase the competitiveness of goods and services produced in the country.

Industrial Competitiveness Encouraging Program (CIP) [7] and the Executive Groups of Sectoral Policy (GEPS) [8].

With the implemented changes, industrial companies would tend to adopt news methods of rationality attached to their productive strategies, featuring a search for better productive efficiency. Kupfer (2005) arguments:

> Echoing international trend, the early years of the decade of 1990 in Brazil were marked by rapid economic liberalization, induced by simultaneous institutional reforms in the context of trade, of international financial insertion, and of state productive sector. These reforms corresponded to a shock in the industry competitive environment and, as it could not be different, placed Brazilian industrial structure in motion, inaugurating a period of intense change (p. 203)[9].

Returning a little in time, one can understand that, in an interval of 14 years (1981-1994), Brazilian industry moved up quickly towards greater international integration, both by the side of exports in the 80's, as the imports in the 90's. The opening was very strong in all segments from 1980 (Bielschowsky & Stumpo, 1996).

Between the mid-80 until 1994, Brazilian Trade Balance presented surplus (Figure 1). From 1995 until 1999, there was a trend reversion reflecting a very particular economic situation after Real Plan, when strong exchange appreciation, accelerated expansion of imports opening and sharp demand growth were jointly observed.

[7] The PCI was created in February 1991 intending to develop frontier technology sectors such as computing, fin chemical and biotechnology, and to stimulate productivity restructuring in sectors able to compete in prices and quality in the world economy.
[8] The GEPS were related to sectoral chambers, being the most known that of automobile sector. The chambers were formed in assemblies involving entrepreneurs, syndicates and government which tried to implement proposals to encourage production and employment generation.
[9] Translated by the authors.

One can state since 1980 the growing international integration of Brazilian industry has been occurring in two phases. Firstly, during the 80's it happened by the remarkable rising of export coefficient. In this period, the preservation of imports protection, induced by foreign debt crisis, retained imports in a very low level, setting up what is termed "substitutive industrialization". In the other phase (first half of 90's), the opening led to rapid growth of penetration coefficient of imports[10], along with export coefficient increasing[11].

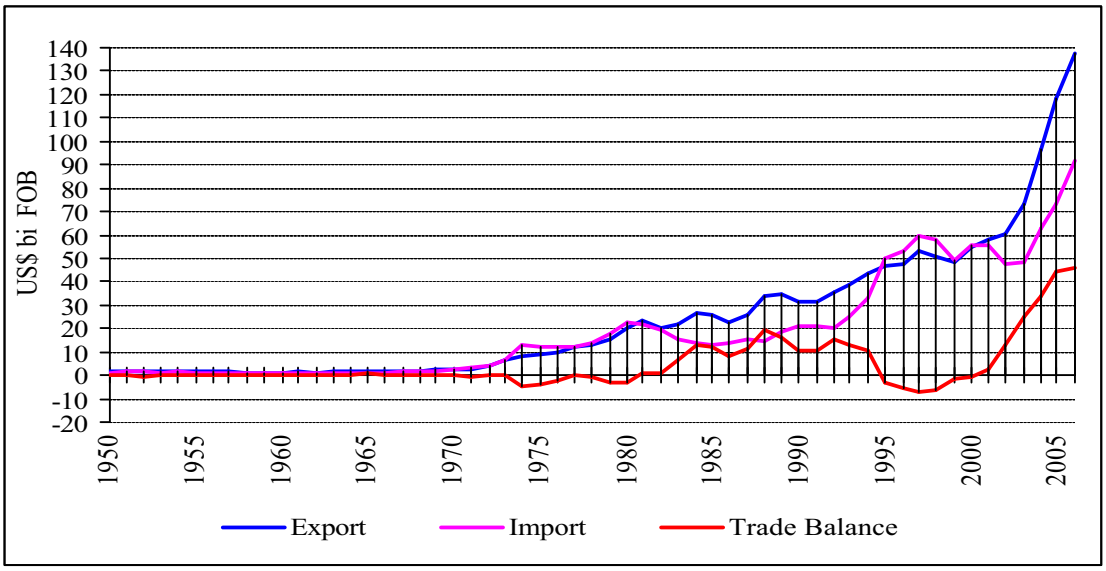

Figure 1 - Brazilian Trade Balance, 1950 – 2006.

Source: Foreign Trade Secretariat (SECEX). Available at: http://www.secex.gov.br. Access: Aug.-23-2007.

We can make a comparative analysis of the evolution attached to penetration coefficients of imports as much for overall transformation industry as for some selected sectors, which can be used as proxies of technology access by Brazilian industry (figure 2)[12]. In general terms, one can say there was a coefficient growth trend in all the components in the 90's. In the case of transformation industry, this trend remained from the beginning of 1992 until mid-2001 (when Argentine crisis, terrorist attack in United States and energy black-out in Brazil took place).

[10] It refers to the part of apparent consumption supplied by imports (Levy & Serra, 2002).
[11] Measured by the ratio between exports and production value (*ibid*., 2002).
[12] The choice was based on the idea that these are more technological content sectors (greater added value and more knowledge intensive sectors in relative terms).

Between 1991 and early 1998, among the components investigated, the highest penetration rates were observed in the Chemical Components Producer Sector, although impacted by strong seasonal influence (peaks in the first quarter always – Q_1). In the following decade this sector becomes to present a downtrend reaching no longer the peak of Q1-1999 (47%), the Real Plan crisis year. From 1991 to 1998, the Machinery and Tractors Sector also was influenced by seasonal forces (peaks in Q_4 mostly) and reached the highest level in 1999 (36%, Q_1 and Q_2). From this point it has been on a descent path.

Since the second quarter of 1998, the Electronic Devices Sector coefficient has been not only the leading one but also grew sharply, reaching 82% in Q_4-2002, despite the descent path verified from the early 2003. Besides not to exhibit seasonality, its trajectory seems to have been immune to the big turbulences observed during 1997-2002, resulting from crises such as those experienced by Asia (1997), Russia (1998), Brazil (followed by strong currency depreciation in 1999), the 2001 afore-mentioned crises and the 2002 uncertainties caused by probable election of the current Brazilian President. The same analysis can be applied for the overall Transformation Industry, whose peak was noted in Q3-2002 (17%).

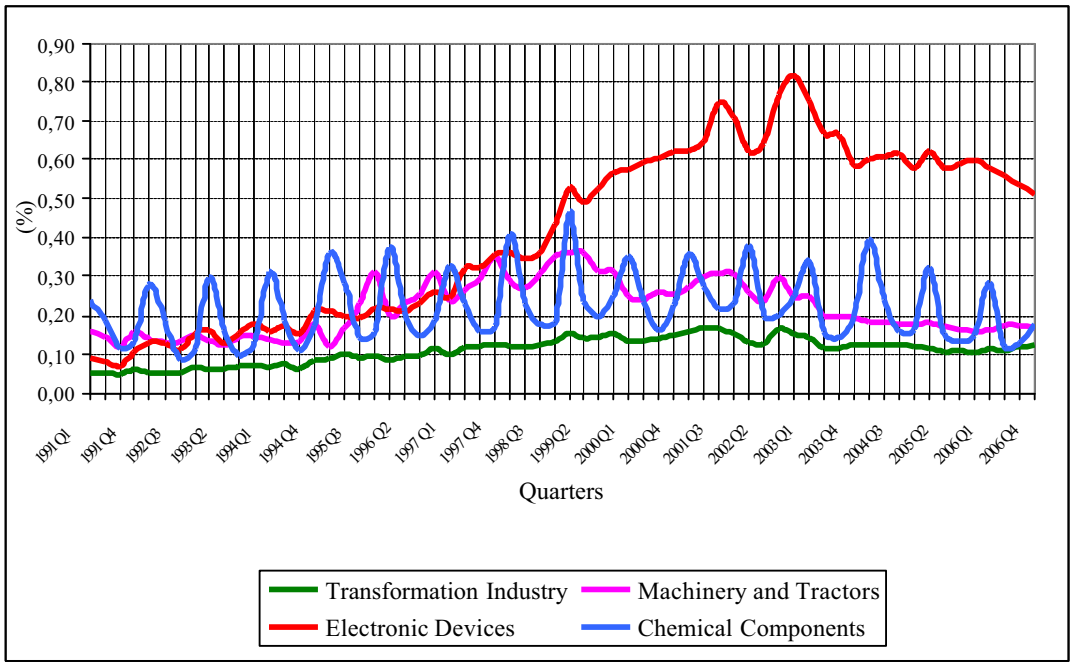

Figure 2 - Comparative of Evolution of Penetration Coefficients of Imports for Transformation Industry and Selected Sectors – Brazil, 1991-2006.

Source: Ipeadata. Available at: http:\\www.ipeadata.gov.br. Access: Aug.-23-2007. Drafted by the authors.

Using the coefficient of variation (CV) as a criterion to evaluate instability related to the penetration level of imports, one can suggest that the 1990 decade was more turbulent for all sectors than the current one, notably for both Electronic Devices (CV = 54,92%) and Chemical Components Sectors (CV = 41,93%) (Table 1).

Table 1 – Descriptive Statistics Concerning the Penetration Coefficients of Imports by Industrial Sectors – Brazil, 1991-99 and 2000-06.

Statistics	Transformation Industry			Machinery and Tractors			Electronic Devices			Chemical Components		
	1991-99	2000-06	Tot	1991-99	2000-06	Tot	1991-99	2000-06	Tot	1991-99	2000-06	Tot
Mean	0,09	0,13	0,11	0,22	0,22	0,22	0,24	0,63	0,41	0,21	0,23	0,22
SD	0,03	0,02	0,03	0,08	0,05	0,07	0,13	0,07	0,22	0,09	0,08	0,09
CV(%)	34,68	14,50	30,32	38,08	21,88	31,69	54,92	11,44	53,81	41,93	12,87	38,99

Source: Ipeadata. Available at: http:\\www.ipeadata.gov.br. Acess: Aug.-23-2007. Drafted by the authors.

By comparing the mean of coefficients between the two phases, we can realize the expansion of imports penetration in the current decade, mostly to Electronic Devices Sector. The Machinery and Tractors Sector has been the single exhibiting stability associated to the average coefficient (22%).

One aspect calls attention: the average rate for the Transformation Industry Sector as a whole was significantly smaller than those for each one of the segments investigated. This makes to believe that in recent years the domestic demand has been supplied increasingly by national production from low-technology-content sectors (less inclined to knowledge absorption and value aggregation).

Another interesting way of observing the behavior of imports is through the quantum index. Looking at Figure 3 we note a big jump in imports of either capital goods or intermediate goods from the second half of the 1990's, especially of the former set. It seems this group was influenced by the 1999 currency depreciation, becoming to decline from this point, but presenting higher levels if compared to those seen before Real Plan.

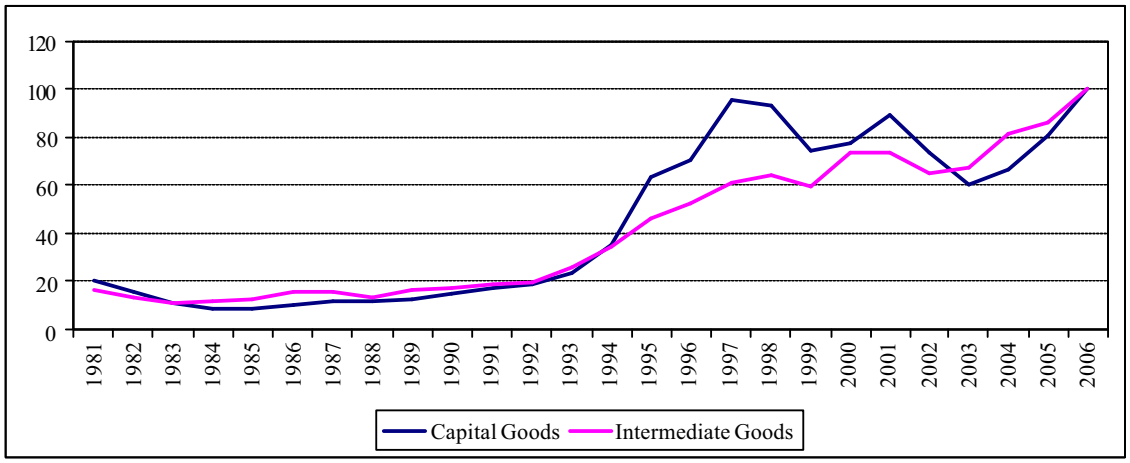

Figure 3 – Quantum Index of Imports of CapitalGoods and Intermediate Goods (2006 = 100).

Fonte: Ipeadata. Available at: http:\\www.ipeadata.gov.br. Access: Aug.-23-2007. Drafted by the authors.

In short, from the early 1990 decade, data confirm a sharp increase concerning the degree of access to foreign technology by the sectors in question. The next step will be to attempt at verifying if this was a key factor for productivity growth.

3.2 Causality between foreign technology access and productivity: applying Granger Test.

As direction of causality is discussed in the context of commercial liberalization, the debate usually surrounds variables such as export and productivity (the "commercial liberalization-exports-productivity" channel pointed out in the second section). Paus et al. (2003), by

reviewing the literature concerned with this subject, showed non-conclusive results given that also could be plausible to suppose companies, with higher levels of productivity, being more able to compete in international markets, exporting.

However, in a similar way, we understand that doubts can also be cast on the direction of causality involving access to foreign technology and productivity. The Granger Test (Granger, 1969) can throw light on this issue, by turning possible to investigate if one variable helps to explain the occurrence of other variable (in the sense of precedence).

Granger (1969) defined a concept of causality which is - under certain circumstances – easily handled. The argument is that one cause can not succeed an effect. Thus, if variable z causes variable y, the former can improve the prediction of y. In other words, one intends to know if z coefficients are statistically significant in the prediction of y.

The basic way to determine Granger causality is to evaluate if a contemporary and lagged variable should be or not incorporated by an equation. Once the number of lags is defined, the next step is to check the significance of the parameters which determine causality. The model is set as follows:

$$z_t = \sum_{i=1}^{p} a_i z_{t-i} + \sum_{j=o}^{p} b_i y_{t-i} + \varepsilon_{zt} \quad \textbf{(1)}$$

$$y_t = \sum_{i=0}^{p} c_i y_{t-i} + \sum_{j=1}^{p} d_i z_{t-i} + \varepsilon_{yt} \quad \textbf{(2)}$$

To determine if y_t causes z_t (equation 1) and if zt causes y_t (equation 2), the F Test is applied aiming at testing the following null hypotheses: $b_j=0$ e $d_j=0$. In a model with p lags, y_t does not cause z_t if and only if all b_j coefficients are equal to zero. Therefore, if y_t does not provide a good explanation for z_t, so y_t does not cause z_t in Granger sense (Enders, 1995).

One must note the test is just able to capture direct effects between variables. In order to formalize the idea, suppose that Ω_t is a matrix picking up a set of information with all available relevant data in the t period. Assuming $z_t(h|\Omega_t)$ as the h-step forward optimum predictor (with minimum mean square error), the z_t process is developed based on Ω_t

information. If z_t can be more efficiently predicted with $?_t$ information and being aware that y_t is in $?_t$, so y_t causes z_t, in Granger sense (Lütkepohl, 1993).

The biggest problem involving the choice of $?_t$ is that not all information is available to the predictor. Hence, the term causality indicates the cause and effect relationship between certain available variables.

Variables used:

i) Labor productivity in transformation industry ($LPROD_{trfi}$), measured by the ration between the industrial production indexes and the number of people employed in transformation industry; and

ii) Penetration coefficients of imports, assumed as proxies for foreign technology access and applied to the following industrial sectors: Transformation Industry (as a whole) (PC_{trfi}); Machinery and Tractors (PC_{mctr}); Electronic Devices (PC_{elec}) and Chemical Components (PC_{chem}).

The quarterly series have been available at http:\\www.ipeadata.gov.br and the period (1991:01 – 2002:04) was chosen due to data availability and to involve the phase of commercial openness intensification (government of Fernando Collor) and its developments including the successive governments.

The variables productivity and penetration coefficients of imports of the Machinery and Tractors Sector and the Electronic Devices Sector are included in the equations in first differences, because, according to the Unit Root Test (Augmented Dickey-Fuller Test - ADF test), they are integrated of order 1- I(1) - or non-stationary in level. All the data is seasonally adjusted as a precautionary measure (table 2).

Tabela 2 –ADF Test Results

Variables	**ADF Test**		**Mode of entry into the system**
	I(1)?	Specification	
$LPROD_{trfi}$	Yes	-	$D(LPROD_{trfi}\_SA)$

PC_{trfi}	No	Intercept and trend	PC_{trfi}_SA
PC_{mctr}	Yes	-	$D(PC_{mctr}\_SA)$
PC_{elec}	Yes	-	$D(CP_{elec}\_SA)$
PC_{chem}	No	Intercept and trend	PC_{chem}_SA

Source: drafted by the authors from EViews 5.0 results.

SA = seasonally adjusted; D before variables means data is in first differences.

We intended to verify the occurrence of causality between productivity and each one of the penetration coefficients, which were introduced one at a time into the equations. We started the test using five until one lag, through which we did not note endogeneity of the productivity in any simulation.

On the contrary, this variable- in Granger sense - explained the penetration coefficient of imports for the Transformation Industry Sector and Machinery and Tractors Sector (table 3). There was causality in none direction in the simulations involving productivity *vis-a-vis* coefficients for Electronic Devices Sector and productivity *vis-a-vis* Chemical Components Sector.

Table 3 – Granger Test Results

Causality direction (Granger sense)			**Lags**	**Error**
$D(LPROD_{trfi}\_SA)$	→	PC_{trfi}_SA	3 e 2	5% e 9%, respectively
	→			1%, 1%, 6% e 7%,
$D(LPROD_{trfi}\_SA)$		$D(PC_{mctr}\_SA)$	5, 4, 3 e 1	respectively
$D(LPROD_{trfi}\_SA)$	None	$D(PC_{elec}\_SA)$	-	-
$D(LPROD_{trfi}\_SA)$	None	PC_{chem}_SA	-	-

Source: drafted by the authors from EViews 5.0 results.

SA = seasonally adjusted; D before variables means data is in first differences.

The results of Granger Test suggest that the productivity of the Brazilian transformation industry was not much affected by the access to foreign technology after 1990, at least in the short-term. This strengthens the arguments of those supporting the following: the industrial

restructuring started in the beginning of the 90's was predominantly defensive and the productivity growth observed from this point (whose levels have been significantly higher if compared with the 1980's – figure 4) resulted essentially from cost-reduction strategies, specially regarding to workforce (dismissal, outsourcing, part-time and/or temporarily job, wage reduction, among others) [13].

Moreover, the lack of systemic, structural and institutional conditions stimulating innovative efforts and investments on new productive capacity induces a regressive industrialization process, i.e. concentration of imports on high-technology sector and exports on traditional ones (Kupfer, 2005).

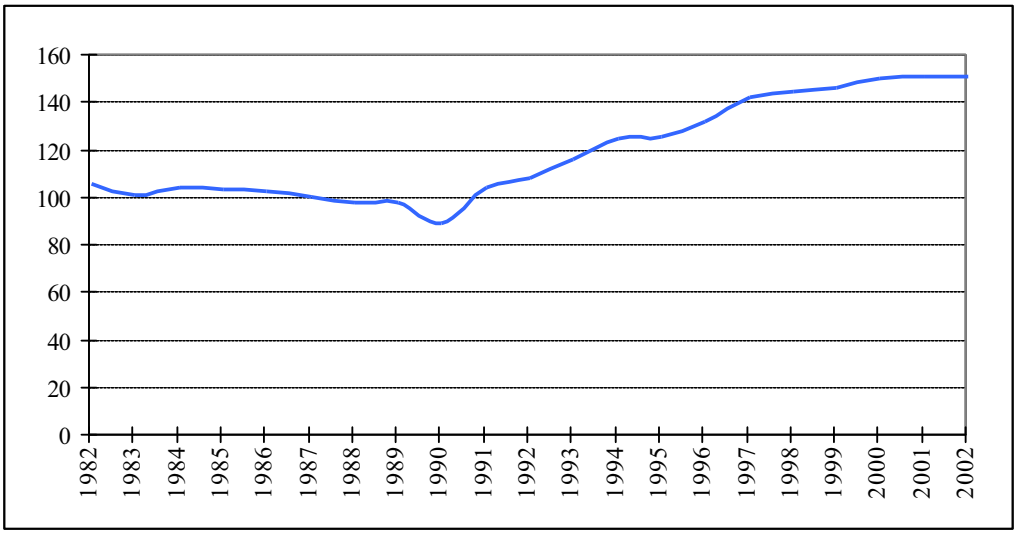

Figure 4 – Labor Productivity Index for Transformation Industry – Brazil, 1982-2002 (1991 = 100).

Source: Ipeadata. Available at: http:\\www.ipeadata.gov.br. Acess: Aug-23-2007. Drafted by the authors.

Five hypotheses can be drawn from the results presented so far.

i) Certain firms (notably big ones), with past experience of learning and mobilization of productive and innovative competences, had reached higher levels of productivity previously

[13] There is a large literature aimed at confirming this hypothesis, such as Cacciamali e Bezerra (1997), Kupfer (2005) e Laplane e Silva (1994).

to the openness allowing them to create conditions for controlling technologies and greater capacity for making investment. These advantages - generated in the past - enabled access to cheaper/better quality foreign technologies.

ii) With the intensification of liberalization, survivor firms were those that successfully implemented cost reduction strategies. The resulted productivity growth permitted them to generate investment capacity, including in imported technologies.

iii) In order to produce effects on productivity in the short and medium term, new technologies require some factors absent in Brazil until now, such as previous stocks of knowledge and productive/innovative competences, whose existence cannot be verified unless a long process of learning takes place.

iv) Embodied technologies can perform poorer than do disembodied ones, which permit us to put emphasis on the importance of underlying tacit dimension of technology.
v) Foreign technologies, in the aggregate, may not have been much more technologically advanced if compared with those existing domestically. This also can explain the weak effects on productivity.

This last insight throws light on an important opening issue: there are not elements to assert that the imported technologies have been significantly different from those existing internally. The analysis of the Brazilian technological innovation process can help to elucidate this question.

4. TECHNOLOGICAL INNOVATION IN BRAZILIAN INDUSTRY

The first official Brazilian Survey on Technological Innovation (PINTEC 2000)[14], realized by Brazilian Institute of Geography and Statistics (IBGE) took place one decade after the beginning of the opening intensification, turning impossible to make comparisons between strategies adopted by industrial firms in the current decade and those implemented soon after liberalization, taking into account behavior of variables like penetration coefficients.

[14] The last edition (2005) became to include service sectors.

Even so, as results of three editions (2000, 2003 and 2005) are available, we can highlight some traits concerning firms' strategies in this context, despite the huge sectoral heterogeneity of Brazilian industry. A first finding is that the great majority of companies are not innovators and this picture has remained stable.

In the first survey, embracing 1998-2000 years, only 31.5% of industrial firms implemented any product or process innovation. This share rose to 33.3% between 2001-2003 and to 33.4% between 2003-2005 (figure 5)[15].

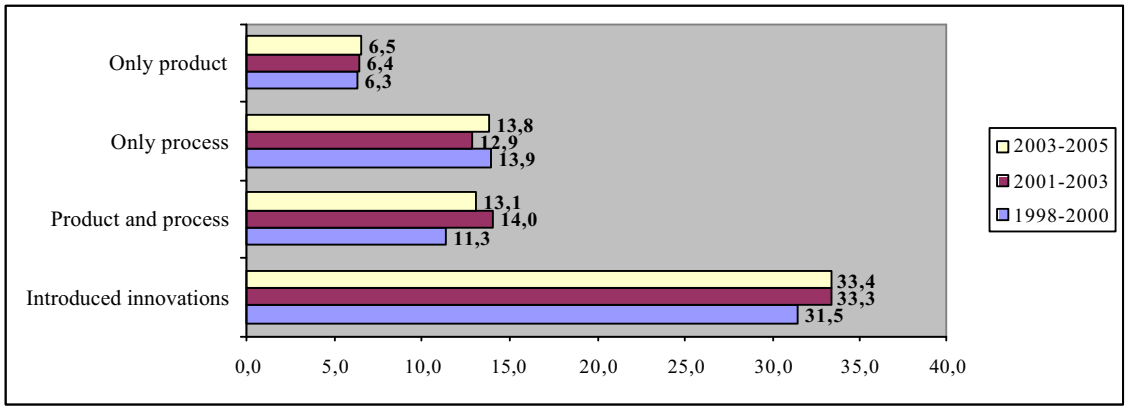

Figure 5 - Percentage share of industrial firms that introduced innovation – Brazil, 1998-2000, 2001-2003 and 2003-2005.

Source: PINTEC/IBGE.

It is also possible to realize the very small share of product innovators companies, a way of innovation that demands higher innovative efforts[16]. Industrial enterprises' innovations are concentrated mostly in processes, notably through acquisition of machinery and other

[15] In Brazil, the average innovation rate is strongly influenced by small (10 to 49 employers) firms' behavior. They represent 79.4% of the whole amount investigated.

[16] According to PINTEC methodology the proxies for innovative efforts are expenses in: acquisition of external R&D, acquisition of other external knowledge (as software) to introduce technological innovations in market, internal R&D activities, industrial projects, training and machinery and equipments.

equipments[17]. While these technologies are new for individual firms, their use is already much disseminated in the market.

Innovation process is influenced by a range of factors as illustrated in figure 6. The three innovation surveys have shown economic factors – as high costs and risk and shortage of funding – overcoming other ones when problems and obstacles for innovation come into discussion.

Nevertheless, the share of firms ranking related capabilities/ knowledge features as hampering factors is also significant as reported by PINTEC 2005: lack of qualified personnel (44.9%); lack of technical services (34.9%); lack of information on technology (33.4%); lack of information on market (30.3%)[18]. In addition, it is interesting to note telecommunication sector ranking lack of qualified personnel as the higher barrier (assigned by 60.3% of innovative firms)[19].

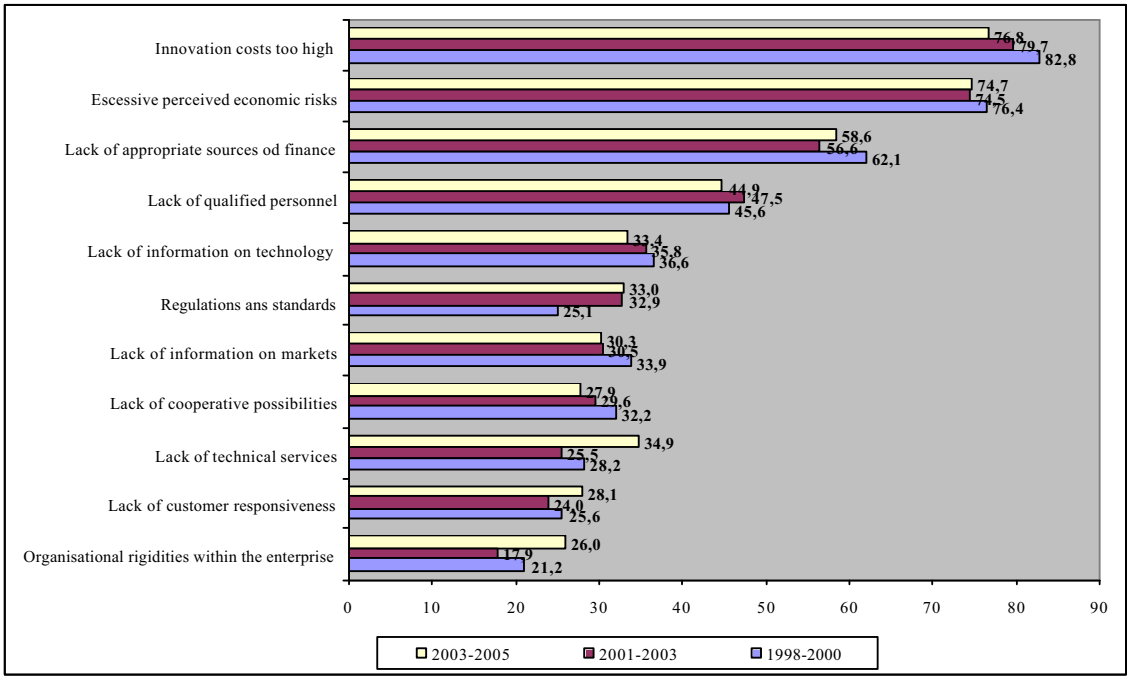

Figure 6 – Ranking of hampering factors cited as important by innovative industrial firms – Brazil, 1998-2000, 2001-2003 e 2003-2005.

Source: PINTEC/IBGE.

[17] In 2005 these kind of acquisitions represented the higher expenses/revenue rate (1.34%) in the structure of innovation spending, followed by 0.57% in R&D and 0.36% in industrial design.

[18] These shares embody the number of firms assigning to these factors high and medium importance score.

[19] PINTEC 2005 investigated firms belonging to high technology intensive sector (telecommunication, computing and R&D). The previous surveys only investigated industrial sector.

In summary, innovation rate has performed poorly along this period. Innovation occurs mostly through imitation and is concentrated in products/processes that are new for firms, but already known in the world market. The same was identified by Viotti (2004) who assigned this landscape as a result from Brazilian industry overall strategy which is still far from radical innovation stages. A long way of technological learning is to be developed towards incremental (improvements in process and products) and radical innovations.

CONCLUDING REMARKS

By attempting to contribute for debating the referred channel, we questioned the argument concerning the natural trend occurring after commercial opening which reveals itself theoretically and empirically inconsistent. The supporting premises are not verified in real world, especially because ignores peculiarities of the context into which technology moves.

In the case of Brazilian industry, specificities must be weighted when one analyses the effects derived from introduction of imported technology. Weaknesses associated with innovative and productive competences are essential factors preventing control, generation and diffusion of new technologies.

The combined analysis of international trade data, Granger Test results and technological innovation indicators helped to understand the dynamics involving the channel in focus. The lack of streams leaving from the foreign technology to productivity, the stagnated behavior of the innovation rates and the profile of this process (excessively concentrated on imitation) denounces important nuances of fragility of the Brazilian system of innovation, in particular those relating to the process of technological learning.

This landscape challenges industrial policy which in turn must take innovation as a central strategy from a systemic and dynamic view. This direction requires a narrow linkage between macroeconomic policy (interest and tax burden, for instance), firm's demands and institutional and physical infrastructure especially surrounding Science, Technology and Innovation.

Assuming that technology control, generation and diffusion have a tacit dimension, depend on endogenous capacities and are located (and so the only access to imported technology is not sufficient), it should be taken in account the importance of fostering sectors able to diffuse technical progress (software, semiconductors, etc.) spreading solutions to practically all economic sectors.

In short, this work showed that, from a technological point of view, the model adopted in the 90's (when State left to be a key agent inducing industrial development) did not achieve great results. Commercial openness, being the only implemented industrial policy strategy, did not materialize its effects on productivity, through the access to imported technology. This scenario seems to be strongly linked to internal capabilities related boundaries.

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