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ARTICLE

Technological Strategies in Brazil's Manufacturing Industry: A Study Based on Innovative Activities

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Abstract

The purpose of this article is to identify the technological strategies adopted in the Brazilian manufacturing industry. Technological strategies were analyzed for drafting of innovation and imitation product and process indicator, and, complementarily, by an additional indicator for organization and marketing innovations. The indicators were applied to 19 sectors of the Brazilian manufacturing industry (PINTEC, 2014) and to the counterparts of a set of selected European countries (CIS, 2016). For the purposes of analysis, the industrial sectors were grouped according to the criterion of technological intensity proposed by the OECD and the results compared with the sectoral innovation standards. The conclusions pointed out that the predominant strategies in the Brazilian industry are typically passive, in marked contrast to the active ones prevalent in developed countries.

Keywords | Strategies; Innovation strategies; Innovative activities; Manufacturing industry

Estratégias Tecnológicas na Indústria de transformação do Brasil: Um estudo a partir das atividades inovativas

Resumo

O objetivo deste artigo é identificar as estratégias tecnológicas adotadas na indústria de transformação brasileira. As estratégias tecnológicas foram analisadas a partir da construção de indicadores de inovação e de imitação de produto e de processo e, complementarmente, de um indicador adicional para inovações organizacionais e de marketing. Os indicadores foram aplicados a 19 setores da indústria brasileira de transformação (PINTEC, 2014) e nas contrapartes de um conjunto de países europeus selecionados (CIS, 2016). Para efeitos de análise, os setores industriais foram agrupados segundo o critério de intensidade tecnológica proposto pela OCDE e os resultados confrontados com os padrões setoriais de inovação. Os resultados apontaram que as estratégias predominantes na indústria brasileira são tipicamente passivas, em claro contraste com as ativas prevalecentes nos países avançados.

Palavras-chave | Estratégias; Estratégias de Inovação; Atividades Inovativas; Indústria Transformação.

1. Introduction

The study of strategy has a long tradition in the field of 'military art' (MINTZBERG *et al.*, 2006; ANCONA, 1989; WHITTINGTON, 2001) and, more recently, has also been the subject of research in the social sciences. In this area, business managers, especially, and political scientists have excelled in incorporating the notion/concept into their research methodologies and theoretical approaches (RUMELT *et al.*, 1991; MINTZBERG *et. al.*, 1998; SIMON, 1986, 1993; LINDBLOM, 1981). In addition, we can mention some prominent economic and technological historians, such as A. Chandler, D. Hounshell, W. Lazonick, P. David e N. Rosenberg.

Instead of what Marshall imagined,[1] the economists who came after him, notably those in the mainstream, never gave more importance to the notion of strategy. A partial but nevertheless relevant exception was the case of the game theory, which in the meantime adopted a very limited meaning of the concept of strategy. Besides being incompatible with the more usual conception, the strategic focus of this approach has become more a specific extension of the well-known theory of the expected subjective utility than a real incorporation of the notion of strategy into economic theory (SIMON, 1986, 1993; ANCONA, 1989).

Over the several generations, a limited number of economists have more or less explicitly employed the notion/concept of strategy. More recently, different economists have incorporated strategies into their themes of study and research (LANGLOIS, 2003; RUMELT *et al.*, 1991; PAVITT; STEINMUELLER, 2002; FREEMAN; SOETE, 1997; LOASBY, 2010; FOSS; STIEGLITZ, 2012).

However, most of the economists who have underscored this concept are heterodox authors, especially those focused on research in innovations and technological changes, notably the evolutionary/neo-Schumpeterian current, which has used more specific notions of innovative and/or technological strategies.

The objective of this article is to identify the technological strategies adopted in the Brazilian manufacturing industry. In this perspective, the study compares, ranks, and classifies innovative strategies in the Brazilian industry by confronting the experiences of a group of European countries selected. For this, indicators of technological intensity were elaborated from the results of the PINTEC (2014) *surveys* for Brazil and CIS (2016) surveys for European countries, which share

1 In **Appendix C** to Vol. II (from the Brazilian edition) of the Principles of Economics (Princípios de Economia), Marshall dealt with the notion of strategy. "Only recently, and largely thanks to the salutary influence of the criticism of the Historical School, was the pre-eminence, in Economics, given a distinction corresponding to that existing between *strategy and tactics* in the war party" (MARSHALL, 1985, v. II, p. 353, emphasis added).

the methodology proposed by the OECD Oslo Handbook (OECD, 2005). The drafting of intensity indicators was based on the notion that the types of innovation – mainly, but not strictly technological – are incorporated into products, processes, organizations, and marketing. Moreover, innovative strategies are assumed to be grouped into two specific classes of sectors: those intensive in innovation and those intensive in imitation. The result of this systematization was the construction of 5 metrics of technological intensity defined at the sectorial level: (i) intensive sectors in process innovation; (ii) intensive sectors in product innovation; (iii) intensive sectors in process imitation; (iv) intensive sectors in product imitation; (v) intensive sectors in organizational and marketing innovations.

The analysis is based on three main conjectures. The first is that innovation strategies can be analyzed from the innovative procedures adopted and measured by intensity indicators. The second is based on the assumption that a good technological strategy – for companies in countries that are not yet advanced in the catching-up process and, therefore, are not yet able to adopt offensive or even defensive strategies (FREEMAN; SOETE, 1997), as in the case of the vast majority (with the possible exceptions of Petrobras and Embraer) of companies in the Brazilian economy – it is the one that follows the expected technological trajectory for the industry (PAVITT, 1984; MARSILLI, 2001; CASTELLACCI, 2008) and, therefore, it allows comparing the strategies established through the indicators with the "expected standard" for the technological regime. To these two assumptions, we added a third assumption, delimiting the scope of technological strategies, assuming that those strategies somehow correspond with the behavior of innovative strategies proposed by Freeman and Soete's typology (1997).

In addition to this introduction, the article has three sections. The second section starts discussing briefly the decision-making theory to propose to define strategy based on ideas developed by Simon (1993). The third addresses innovation strategies, highlighting technological strategies. The fourth section begins with the description of the database used, continues by addressing the indicators elaborated for this study, advances by reviewing the results obtained, and concludes with brief methodological comments. The final considerations are presented in the last section.

2. The decision-making theory and strategies

Within what is known as decision-making theory has prevailed the normative approach, with the highlight of the very influential theory of the subjective

expected utility. This theory defines the conditions of perfect rationality and utility maximization in a world of certainty or in conditions in which the probability distributions of all relevant variables are made available to decision-makers (SIMON, 1986, p. 2; VERCELLI, 1991; FISHBURN, 1987; ARTHUR, 1992).

In short,

> *the theory of the subjective expected utility assumes that: 1) the decision-maker has a well-defined utility function and therefore is able to establish a cardinal relationship as the unit of measure of his or her preference with respect to a specific set of future events; 2) the decision-maker may stipulate the totality of future series of events and thus establish a joint (objective or subjective) probability distribution; 3) the decision-maker is confronted with a well-defined group of possibilities from which to make his or her choice; and (4) the decision-maker will opt for the alternative or choice that maximizes the expected value of his utility function (SIMON, 1983).*

> *[…] This theory, however, faces difficult problems whenever there is conflict of real or potential interest, non-coherent behavior, and especially when they are combined with uncertainty, incomplete information, and limited rationality (CARVALHO et al. forthcoming; SIMON, 1986, 1983; SHACKLE, 1992; SEN, 1987).*

Game theory, conceived in 1944 by the mathematician von Neumann and the mathematical economist Morgenstern, was very likely the most ambitious and mathematically sophisticated attempt to answer questions to the theory of the subjective expected utility (SIMON, 1986, 1983). The standard approach to game theory considers that the agents: (1) are typically rational – that is, their preferences are compatible with the axioms of rational choice theory so they can be treated as maximizers of the subjective expected utilities; (2) have equal and common knowledge of their rationality and full of the rules of the game. However, critically alerting to the consequences of such assumptions, Simon (1986, p. 7-8) emphasizes that the argument of rational choice can only be accepted by assuming that the course of one action is imposed on others, which makes the maximizing choice preferable to all others. However, it is not possible to guarantee that there will always be an action that imposes itself on the others, and it is plausible to assume that a set of alternative solutions is equally consistent with the premises of rationality.

Given that strategy is usually associated with choice, understanding the particular way in which the process of choice is carried out – from the viewpoint of the assumptions adopted – becomes crucial for the study of the concept of

strategy. In the game theory, the term *strategy* is employed in a very specific (and restrictive) sense and is not compatible with how the notion has been most often adopted within the framework of social sciences or even most of the approaches to innovation strategies and technology (FREEMAN; SOETE, 1997; TIDD *et al.*, 2005; PAVITT; STEINMUELLER, 2002). In this first approach, strategy is associated with choice, but not any choice, because the actions are interdependent: the agent has no complete knowledge, since he/she does not know what, exactly, his/her opponent will do, although he/she knows what opponent can do – given that he/she supposedly has knowledge of all possibilities of action (SHACKLE, 1992, p. 161, 183). Albeit the exact result is not known, the result is not new, properly (GEORGESCU-ROEGEN, 1971, p. 122). It is not, therefore, a situation of typical rational choice, but a "quasi-rational choice of conduct" (SHACKLE, 1992, p. 183).

2.1 Strategies: contextualization

Contrary to the standard view of game theory, the most widespread meaning of the notion of strategy – which is also adopted in this article – considers the presence of novelty or unforeseen as the most powerful element of strategic decisions (SHACKLE, 1992, p. 161). In this sense, it is not possible to specify a choice that is superior to the others, because each of them allows the emergence of the potential genuine surprises. This section seeks to organize alternative approaches to the traditional view of the decision-making process, based on rational choice, seeking some conceptual advancement from a theoretical perspective appropriate to the study of innovative strategies.

This task can begin with Simon's contributions (1986, 1983 and 1993) within the so-called decision-making theory in general and especially in the more specific field of strategy. The author proposed a specific and very concise definition by stating that strategy is decision-making that deals with the fundamental goals of the organizations (SIMON, 1993, p. 131).[2] Besides a starting point, this notion of strategy is potentially compatible with most of the main characteristics that are usually attributed to itsef (LANGLOIS 2003; MINTZBERG *et al.* 1998). In fact, to become broadly compatible with these characteristics it is necessary to expand the original, somewhat restrictive, scope of Simon's (1993) definition to incorporate

2 Translation adapted. In the original, "[s]trategy, one might say, is decision making that deals with the 'Big Questions'" (SIMON, 1993, p. 131). Although the similarities are significant, this definition differs from the strategy proposed by Chandler (1991), given that Simon (1986) treats part of it as *problem-solving*.

not only the ultimate goals of the companies but also the intermediate ones and the respective means.

Despite the lack of consensus on the definition of the notion of strategy, there is, however, reasonable agreement on its main characteristics. Thus, we consider that they: 1) affect an entire firm or at least a significant portion of it – a strategic business unit, for example; 2) concern, by nature, to the long term and are based more on the conceptions of the future (forecasts and expectations) than on solid knowledge; 3) are attributed to the managers of the highest level of the company or, at least, of the divisional level; 4) include the choices of products and services to be offered and the course of action necessary to enable them; 5) encompass the design and configuration of the action plans that determine how the company positions itself for competition in the market; 6) imply the choice of an appropriate scope and diversification (LANGLOIS, 2003; MINTZBERG *et al.*, 2006).

In addition, we can postulate that strategies – usually characterized by three-step processes (design, implementation, and adaptation) (TIDD *et al.*, 2005) – are also typically formalized in plans, arising from a relatively detailed planning. In turn, these plans jointly structure, integrate, and coordinate the fundamental goals of companies (*big questions*), their higher-level decisions and intermediate targets (MORRONI, 2006; RUMELT *et al.*, 1991).

According to the comprehensiveness and complexity, the strategies (and their plans) can be fragmented into partial, relatively specific subparts (WHITTINGTON, 2001; MINTZBERG *et al.,* 2006). Concerning strategies, companies usually adopt an adaptive behavior (or *sequential aiming*), which can be characterized as a dynamic process of retroactive adjustments of intermediate targets, made possible by new information and knowledge gathered in the organization itself or in the economic environment – including competitors, as well (MORRONI, 2006; SIMON, 1986).

This procedure is based on the successive examination of partial goals, which allows the implementation of adaptive and sequential decision-making. This procedure consists, also, of the performance *feedback* resulting from the trial-and-error process (MORRONI, 2006; SIMON, 1986, 1983; CYERT; MARCH, 1992).

The objectives of these behaviors are to improve strategies, decrease their costs and the time involved in retroactive adjustments, i.e., to raise the degree of flexibility of strategies and implementation procedures, as well as to prevent a precocious engagement in a strategy and its respective implementation process (MORRONI, 2006; SIMON, 1986, 1983; CYERT; MARCH, 1992; VERCELLI, 1991).

3. Taxonomies of innovation strategies

The typologies are used in the analysis of strategies to group them into specific categories, making possible some level of systematization for the analysis of sectoral strategies based on business strategies. The process of competition between firms in the market can create a dynamic of interaction with each other so that successful strategies can be imitated, while unsuccessful ones gradually become disused. This process of selection by the market (NELSON; WINTER, 1982) produces patterns of behavior among firms, which allows them to be analyzed in categories within a more general – the sectoral – context. Thus, standards of strategic conduct in specific groups of companies both receive influence from this context and influence it, which makes feasible sectoral strategy analyses from the corporate level. Among the proposals for classifications of better-known business strategies, Ansoff (1965) formulated a typology that became popular, based on four general strategies: 1) market penetration; 2) diversification; 3) product development; and 4) market development. Later, Porter (1980) developed a taxonomy designed from three generic strategies: 1) cost leadership; 2) differentiation; and 3) focus. The latter can be deployed, in turn, in 3a) focus on cost and on 3b) focus on differentiation (PORTER, 1980; MINTZBERG *et al.*, 2006). Although useful and very influential, these taxonomies are excessively generic and, therefore, restricted, in heuristic terms (NELSON; WINTER, 1982), given the high diversity of existing business strategies.

Under the neo-Schumpeterian tradition, the typology of innovation strategies proposed by Freeman (FREEMAN; SOETE, 1997) adopts, as we know, six cases (or ideal types) of strategies: 1) offensive, 2) defensive, 3) imitative, 4) dependent, 5) traditional, and 6) opportunistic (or niche).

In theory, not all conceivable strategies are concretely available to all types of companies at any time. In fact, characteristics such as firm size, the intensity of sectoral competition, sources of knowledge (NELSON; WINTER, 1982; PAVITT 1984, 1990; DOSI, 1988; FREEMAN; SOETE, 1997), technological characteristics – opportunity, appropriability, cumulativeness – and properties of the knowledge base (technical or not) influence in different ways the possibilities of strategies effectively within the reach of different companies (MARSILLI, 2001; DOSI; PAVITT; SOETE, 1990). Also, the adoption of a strategy is conditioned to the availability of internal resources and/or the ability to access and absorb knowledge external to those existing in the firm.

Let us remember that the strategies that companies can adopt are widely impacted by their national contexts – including the national innovation systems implemented by firms – and by their respective economic policies (FREEMAN; SOETE, 1997; CASTELLACCI, 2008).

In other words, the previous qualifications make the spectrum of innovation (and/or technological) strategies much more diverse and nuanced than the typology itself allows us to deduce initially. To these considerations, we should also add the possibilities of strategy variations over time, and combinations of more than one strategy concomitantly, as companies, especially the large ones, are often multi-products, multi-technologies and, often, multimarkets (FREEMAN; SOETE, 1997; MARSILLI, 2001; PAVITT; STEINMUELLER, 2002).

The considerations above allow us, first, to admit that the use of typologies enables the recognition of patterns of behavior of companies that manifest themselves at the level of firms (FREEMAN; SOETE'S typology, 1997) and also at the sectoral level – taxonomies of Pavitt (1984) and technological regimes (MARSILLI, 2001) – and, in this sense, the study of strategies is not circumscribed to the limits of individual business strategies – where they originate – and may benefit from the emergence of standards arising from selection and imitation processes (NELSON; WINTER, 1982) that operate at the level of markets/industries. The space for sectoral technological strategies – made possible by a convenient aggregation that, in turn, comes from the industrial systematizations themselves – is defined, successively, by the frontiers of technical-scientific knowledge, determined by the trajectories of a paradigm (DOSI, 1988) or by the technological regimes (MARSILLI, 2001) in force, respectively. Under these conditions, it seems possible to associate technological strategies with the characteristics of sectoral innovation patterns, as proposed in item 4.2, from Pavitt's (1984) taxonomy.[3]

Second, still considering the previous discussion, it is reasonable to assume that technological strategies can vary significantly within the same industry, particularly in the international context, due to the differences between resources, capacities, and institutional characteristics. In these terms, even in the face of the impossibility of determining *ex-ante* which technological strategy is the best among all conceivable, it is reasonable to assume that the more intense the innovative effort, the greater

3 For example, sectors that follow the *science-based* pattern should be dominated by offensive, defensive, imitation, or even dependent strategies, but leaving little room for the adoption of traditional strategies. However, sectoral innovation patterns may or may not be assimilated or adopted as a (competitive) business innovation strategy. In theory, each pattern of the first typology may comprise different strategies of the second.

the possibilities of a strategy – which accompanies the sectoral standard – to be relatively successful.

4. Technological strategies in the Brazilian manufacturing industry

The purpose of this section is to evaluate the predominant technological strategies of the Brazilian manufacturing industry. For this, in the first sub-item, the databases and indicators proposed for the analysis in sub-item 4.2 are described. This analysis is supported by the following assumptions: (i) the sectoral strategy follows the strategies adopted by the companies of a given industry and varies according to the typology of Freeman and Soete (1997); (ii) innovation strategies can be analyzed from the innovative procedures (here measured by intensity indicators); (iii) in the sample, the best strategy of the sector is given by the highest value of the sample in intensity indicators that typify the sectoral pattern of innovation; (iv) the best technological strategy follows the expected innovative standard for the industry (PAVITT, 1984).[4] If the first three items support the analysis resulting from the indicators, the fourth allows comparing these results with the sectoral technological trajectory (expected strategy).

4.1 Description of the database and indicators

The aim of this section is to evaluate the predominant technological strategies of the Brazilian manufacturing industry. For this, the indicators of intensity and technology are initially calculated in 19 sectors of the Brazilian industry and 12 European countries.[5] Information for Brazil were obtained from the Innovation research prepared by IBGE – PINTEC (2014), and information for European countries was taken from the Community Innovation Survey – CIS (2016), made available by the European Statistics System.

The paper by Campos and Ruiz (2009) was used as a methodological reference for sectoral patterns of innovation in Brazilian industry, compatible with the taxonomy proposed by Pavitt (1984), as well as indicators of innovation and imitation of product and process. Similarly to this study, it is possible to obtain the focus on the technological strategy of each sector. For Brazil, from PINTEC data on the proportion of companies that consider *of high impact the introduction of*

4 Proposals for these relationships are presented in charts 1 to 4 of item 4.2.

5 Germany, Austria, Croatia, Slovakia, Finland, Greece, Hungary, Italy, Macedonia, Norway, Portugal, and Serbia.

innovations to improve product quality (focus on product - $Foco_{prod}$) or the *reduction of production costs* (focus on process - $Foco_{proc}$).

Regarding data from European countries (CIS), the focus on the technological strategy of the sectors was obtained considering the proportion of companies that *introduced innovations for the improvement of existing goods and services* (focus on product - $Foco_{prod}$) or *price reduction* (focus on process innovation - $Foco_{proc}$).

The intensity indicators in imitation or innovation of process and product are described below:

- **Intensity in process imitation** ($Processo_{Im}$) – Sum of Expenses with the acquisition of external R&D and other external knowledge[6] as a proportion of the sector's revenues ($R\&D_{ext}$) and Expenses with the acquisition of other external knowledge as a proportion of the companies' revenues (OC_{ext}), weighted by the focus on the technological trajectory in process ($Foco_{proc}$).

$$Processo_{Im} = (P\&D_{ext} + OC_{ext}) * \frac{Foco_{proc}}{Foco_{proc} + Foco_{prod}} \quad (1)$$

- **Intensity in process innovation** ($Processo_{In}$) - Expenses with the acquisition of internal R&D as a proportion of the sector's revenues ($P\&D_{int}$), weighted by the focus on the technological trajectory in process ($Foco_{proc}$).

$$Processo_{In} = (P\&D_{int}) * \frac{Foco_{proc}}{Foco_{proc} + Foco_{prod}} \quad (2)$$

- **Intensity in product imitation** ($Produto_{Im}$) – Sum of Expenses with the acquisition of external R&D and other external knowledge as a proportion of the sector's revenues ($P\&D_{ext}$) and Expenses with the acquisition of other external knowledge as a proportion of the companies' revenues (OC_{ext}), weighted by the focus on the technological trajectory in product ($Foco_{prod}$).

6 According to PINTEC's methodological notes for completing the questionnaire (IBGE, 2012), the term "Acquisition of other external knowledge" includes technology transfer agreements arising from the purchase of a license for patent exploitation rights and use of trademarks, acquisition of know-how, and other types of technical and scientific knowledge from third parties. "The difference between the external acquisition of R&D and the acquisition of other external knowledge is that, in the first, a person/institution is hired to develop R&D or a part of it, and in the second, the company acquires a previously developed knowledge." (IBGE, 2012, p. 16). For the acquisition of external R&D and other external knowledge, the company does not develop innovative activities using specific qualifications, therefore they refer to situations in which the company acquires an external knowledge and, therefore, are associated with an imitation pattern.

$$Produto_{Im} = (P\&D_{ext} + OC_{ext}) * \frac{Foco_{prod}}{Foco_{proc} + Foco_{prod}} \quad (3)$$

- **Intensity in product innovation** ($Produto_{In}$) - Expenses with the acquisition of internal R&D as a proportion of the sector's revenues ($P\&D_{int}$) weighted by the focus on the technological trajectory in product ($Foco_{prod}$).

$$Produto_{In} = (P\&D_{int}) * \frac{Foco_{prod}}{Foco_{proc} + Foco_{prod}} \quad (4)$$

- **Intensity in organizational and marketing innovations** - Number of companies that carried out organizational and marketing innovations in relation to the total number of companies investigated in each industrial sector.

CHART 1
Description of the variables used to draft indicators, based on PINTEC (2014) and CIS (2016)

Indicator	Intensity in process imitation ($Processo_{im}$)	Intensity in process innovation ($Process_{in}$)	Intensity in product imitation ($Produto_{im}$)	Intensity in product innovation ($Produto_{in}$)	Intensity in organizational and marketing innovations
Variables	Expenses with external R&D; Expenses with the acquisition of other external knowledge	Expenses with internal R&D activity	Expenses with external R&D; Expenses with the acquisition of other external knowledge	Expenses with internal R&D activity	Companies that have implemented organizational and marketing innovations
	Process Focus - Number of companies that declared high impact and importance of reducing production costs.	Process Focus - Number of companies that declared high impact and importance of reducing production costs.	Product Focus - Number of companies that declared high impact and importance of improving product quality.	Product Focus - Number of companies that declared high impact and importance of improving product quality.	

For this study, the 19 industrial sectors investigated were grouped, for the purposes of presentation, according to the technological intensity criterion proposed by the OECD: sectors of low, medium-low and medium-high and high technological

intensity[7]. Regarding the countries, unfortunately, there is no homogeneity in the sample of the European nations, since some countries that answered the CIS survey did not provide information for all industrial sectors, thus compromising the possibility of totally uniform construction of the indicators analyzed in this paper. In sectors such as beverage manufacturing, for example, only Germany, Austria and Serbia disclosed data that enable drafting the indicators. The results of intensity indicators are presented in tables 1 to 4.

The second step of the methodology – after having selected the best performance of each intensity indicator (reference strategies) and considering the sectoral pattern (predominant types of innovative activities) proposed by Pavitt (1984) – is to systematize the Brazilian sectoral strategies. Tables 1 to 4 summarise this assessment.

4.2 Results

Tables 1 to 4 present the five intensity indicators proposed for this study according to the four categories of technological intensity. For each sector, the data are arranged to compare the performance of Brazil in each indicator with the best positioned country in the sample. In addition, we highlight (proportion) the Brazilian indicators that obtained Low (up to 40% of the highest value), Medium-Low (+40% to 60%), Medium-High (+60% to 80%) and High (+80%) behaviour are highlighted (proportion). From these results, considered together with the sectoral characteristics, sectoral technological strategies are evaluated according to the typology of Freeman and Soete (1997).[8]

According to the Oslo Manual (2005), new *marketing* methods contemplate both significant changes in the concept of an existing product, including packaging, repositioning a product in the market, pricing policies, or the opening of new markets – in general, they are innovations aimed at sales promotion. Also according to the Oslo Manual, organizational innovations incorporate new organizational methods – from (re)directing responsibilities and decisions, to new methods that

7 **Sectors of low technological intensity**: 1) Manufacture of food; 2) Manufacture of beverages; 3) Manufacture of textile products; 4) Manufacture of clothing; 5) Manufacture of leather articles and footwear; 6) Manufacture of paper, pulp, and paper products; 7) Manufacture of furniture; 8) Manufacture of miscellaneous. **Sectors of medium-low technological intensity**: 1) Manufacture of rubber and plastic products; 2) Manufacture of non-metallic minerals; 3) Metallurgy; 4) Manufacture of metal products. **Sectors of medium-high technological intensity**: 1) Manufacture of chemicals; 2) Manufacture of machinery, appliances, and electrical materials; 3) Manufacture of machinery and equipment; 4) Manufacture of vehicles and auto parts. **Sectors of high technological intensity**: 1) Manufacture of pharmaceutical products; 2) Manufacture of computer, electronic, and optical equipment; 3) Manufacture of other transport equipment.

8 These tables show the Brazilian indicators that reach at least an average proportion in relation to the best performance.

change processes, routines, and relationships with suppliers. As shown in tables 1 to 4, column 5, this is the common innovative activity, most intense in the Brazilian industrial sectors and, almost always, with results above those presented by European countries. This circumstance, associated with the general results (commented below), seems to indicate an economy little focused on innovation and imitation – in particular, offensive or defensive business strategies – and more focused on adjustments (repositioning) and sales efforts, given the disadvantages in qualifications and prevailing innovative strategies – imitative, dependent, traditional and, eventually, niche, when it lacks more sophisticated technical content.

Table 2 presents the five intensity indicators applied to sectors of low technological intensity. The food industry, which is characterized by diversity of size, was classified by Pavitt (1984) as production-intensive. In this context, sectoral technological development occurs through product innovations and, mainly, marketing (carried out by leaders and emphasizing product and brand differentiation) – imitated by others – and organizational changes in response, especially, to innovations in process – developed internally, but mainly by specialized suppliers. The imitation indicators of process and product for Brazil were (0.02%) and (0.03%), respectively. On the other hand, Serbia – which has adopted a strategy to make significant efforts in imitation of process and product – presented indicators of (0.62%) in the first case and (1.67%) in the last. Among the European countries in the sample, Serbia was the country that implemented the greatest imitation efforts. On the other hand, Norway presented the largest indicator for process innovation (0.25%) and Finland was the first in product innovation efforts (0.49%), respectively.

In short, as well as for three other Brazilian industries of the same category – Textile Products, Clothing Articles (sectors where the introduction/imitation of new products constitutes the main strategy to maintain market shares or to conquer new markets) and Miscellaneous Products – the reduced indicators of intensity of Food Manufacturing, relative to the best performance, seem to indicate that the technological strategies adopted by Brazilian companies are not compatible with the sectoral standard.

The relative position of Brazil in the product innovation introduction indicator is comparable to the best performance in only three of the eight sectors of low technological intensity: Beverages (0.05%), equal to Austria's performance, Leather (0.52%), surpassed only by Germany (1.09%), and Furniture Manufacturing (0.30%), just below about 40% in Austria (see Table 1). In this same set, the ability to introduce process innovations is marked, in turn, by two different performances

– Beverages, which presented the best indicator of the sample (0.04%), and Leather and Footwear, which reached 83% of Germany's effort (0.23%). It is noteworthy, as expected, the reduced values of all national and European indicators of this classification in comparison with the others.

TABLE 1
Intensity indicators in imitation and innovation by sectors of low technological intensity – Brazil and country with better performance in the indicator

	Process				Product				Organizational and Marketing Innovations	
	Imitation		Innovation		Imitation		Innovation			
Manufacture of food										
Brazil		0,02		0,05		0,03		0,09		27,38
Leader	Serbia	0,62	Norway	0,25	Serbia	1,67	Finland	0,49	Brazil	27,38
Class (%)	L	3,2	L	20,0	L	1,8	L	18,4	H	**100,0**
Manufacture of beverages										
Brazil		0,02		0,04		0,02		0,05		45,33
Leader	Serbia	0,08	Brazil	0,04	Serbia	0,56	Austria	0,05	Brazil	45,33
Class (%)	L	25,0	H	**100,0**		3,6	H	**100,0**	H	**100,0**
Manufacture of textile products										
Brazil		0,03		0,05		0,06		0,09		34,71
Leader	Norway	0,12	Norway	0,64	Austria	0,14	Italy	0,85	Brazil	34,71
Class (%)	L	25,0	L	7,8	ML	42,9	L	10,6	H	**100,0**
Manufacture of clothing										
Brazil		0,01		0,08		0,03		0,14		39,69
Leader	Italy	0,08	Italy	0,31	Italy	0,34	Italy	1,32	Brazil	39,69
Class (%)	L	12,5	L	25,8	L	8,8	L	10,6	H	**100,0**
Manufacture of leather articles and footwear										
Brazil		0,03		0,19		0,07		0,52		46,37
Leader	Serbia	0,27	Germany	0,23	Serbia	0,72	Germany	1,09	Brazil	46,37
Class (%)	L	11,1	H	**82,6**	L	9,7	M	47,7	H	**100,0**
Manufacture of paper, pulp, and paper products										
Brazil		0,03		0,24		0,02		0,16		38,67
Leader	Norway	0,05	Brazil	0,24	Italy	0,20	Finland	0,46	Finland	43,84
Class (%)	ML	60,0	H	**100,0**	L	10,0	L	34,8	H	**88,2**
Manufacture of furniture										
Brazil		0,04		0,15		0,09		0,30		39,71
Leader	Croatia	0,06	Norway	0,70	Croatia	0,19	Austria	0,71	Brazil	39,71
Class (%)	MH	**66,7**	L	21,4	M	47,4	ML	42,3	H	**100,0**
Manufacture of miscellaneous										
Brazil		0,05		0,21		0,08		0,35		32,37
Leader	Norway	0,67	Norway	1,52	Norway	0,67	Norway	5,87	Serbia	36,23
Class (%)	L	7,5	L	13,8	L	11,9	L	6,0	H	**89,3**

Source: Own elaboration from CIS (2016) and PINTEC (2014)
Note. Class (Classification): Medium-Low (MB); Medium-High (MA); High (A); Low (B)

Regarding the ability to introduce process innovations, Brazil also presented significant results in the Pulp and Paper Manufacturing sector (0.24%), being the first among the countries analysed. For this sector, the imitation indicator of products (0.02%) developed by competitors did not become the main strategy, being only a half-developed activity. Norway (0.05%) was the best performing nation in this case.

The group of industries with low technological intensity is classified in Freeman and Soete (1997) among the sectors with predominant defensive, imitative, and traditional strategies; although some companies have the resources and skills to innovate, they prefer to avoid the uncertainties of the first releases. Thus, they bet on their ability to perfect/imitate the initial versions of the innovations introduced by the few offensive opponents. Regarding sectoral innovation patterns, this strategy is compatible with sectors dominated by suppliers and intensive in production, either by poor training in engineering and R&D or by technological trajectories defined by cost reduction and competitive differentials based on brands and advertising.

In most low-tech Brazilian sectors, there is a predominance of dependent strategies, characteristic of companies that are subordinate to or dependent on other companies, such as some subsidiaries of multinationals and subcontractors, such as the food sector in Brazil. Even not allocating high resources to R&D activities, companies in these sectors have some capacity to develop imitative activities with a view to product differentiation and process improvements.

Some atypical situations found in the Brazilian industry are observed in the Beverage Manufacturing and Pulp and Paper Manufacturing sectors. In both cases, sectoral indicators reveal that companies use offensive strategies. Innovative offensive strategies, according to Freeman and Soete (1997), are typical of situations where the relative positions of leaders and followers are quite changeable and much of the knowledge to innovate is internal to the firm, making the ability to introduce product and process innovations especially relevant to threaten competitors' market positions. In the case of the Brazilian industry, the indicators of technological intensity in product and process innovations, relatively high, characterize these two sectors, indicating that companies are quite concerned with competing for new market shares, developing technological capabilities above the national average.

The strategies for Brazilian industries of low-intensity technology are systematized in Chart 2.

CHART 2
Innovative strategies for sectors of low technological intensity in Brazil

Low technology	Sectoral patterns of innovation - Pavitt (1984)	Innovation strategies - Freeman and Soete (1997)	Results for Brazil
Manufacture of food	Scale-intensive	Defensive/Imitative	Dependent
Manufacture of beverages	Scale-intensive	Defensive/Imitative	Offensive (process)
Manufacture of textile products	Supplier-dominated	Defensive/Imitative	Dependente
Manufacture of clothing	Supplier-dominated	Defensive/Imitative	Dependent
Manufacture of leather articles and footwear	Supplier-dominated	Defensive/Imitative	Imitative
Manufacture of paper, pulp, and paper products	Scale-intensive	Defensive/Imitative	Offensive (process)
Manufacture of furniture	Supplier-dominated	Defensive/Imitative	Imitative
Manufacture of miscellaneous	Specialized suppliers	Defensive/Imitative	Dependent

Source: Own elaboration, based on the research results.

Table 2 presents the results of intensity indicators in imitation of product and process, in product and process innovation and in organizational and marketing innovation, for sectors of medium-low technological intensity. In the Plastics and By-Products Manufacturing sector, the evidence for Brazil demonstrates a clear imitative strategy. The intensity indicator in process innovation in Brazil was 0.08%, occupying the second position, behind only Norway (0.13%). Unlike the cases presented in sectors of low technological intensity, here the distance between Brazil and countries with better performance was not so significant. The imitative strategy was also evident in the case of product. The intensity indicator in product imitation for Brazil (0.18%) was lower only than that of Austria (0.27%).

Although the Brazilian ability to introduce innovations – product or process – has proven to be far below the countries that are best positioned in these sectors, Brazil has demonstrated a clear imitation strategy to reach the leading countries in the introduction of innovations. For the intensity indicator in product innovation, the result for Brazil was only 0.33%, while Austria, the country that occupied the first position, in this case, presented an effort of 2.09%.

In the sectors of Manufacture of Non-metallic Minerals and Metallurgy, the results of intensity indicators in process innovation, when compared to the best-positioned country, show a medium-low Brazilian performance (MB). Those last two sectors are classified, according to the taxonomy proposed by Pavitt (1984), as dominated by suppliers – due to the technological maturity that characterizes those activities -, causing their technological trajectories to be defined by cost reduction. In this sense, Brazil's efforts to introduce process innovations are apparently aligned with the technological characteristics of the international industry.

TABLE 2
Intensity indicators in imitation and innovation by sectors of medium-low technological intensity – Brazil and the country with the best performance in the indicator

	Process				Product				Organizational and Marketing Innovations	
	Imitation		Innovation		Imitation		Innovation			
Manufacture of rubber and plastic products										
Brazil		0,08		0,15		0,18		0,33		33,84
Leader	Norway	0,13	Norway	0,59	Norway	0,27	Austria	2,09	Brazil	33,84
Class (%)	M	61,5	L	25,4	MH	**66,7**	L	15,8	H	**100,0**
Manufacture of non-metallic minerals										
Brazil		0,03		0,11		0,07		0,22		31,05
Leader	Norway	0,04	Finland	0,22	Malta	0,84	Austria	1,01	Brazil	31,05
Class (%)	MH	**75,0**	M	50,0	L	8,3	L	21,8	H	**100,0**
Metallurgy										
Brazil		0,02		0,14		0,03		0,20		28,9
Leader	Norway	0,11	Norway	0,24	Germany	0,17	Austria	1,29	Brazil	28,9
Class (%)	L	18,2	M	58,3	L	17,6	L	15,5	H	**100,0**
Manufacture of metal products										
Brazil		0,02		0,09		0,04		0,17		31,22
Leader	Norway	0,15	Norway	1,59	Croatia	0,18	Norway	1,59	Brazil	31,22
Class (%)	L	13,3	L	5,7	L	22,2	L	10,7	H	**100,0**

Source: Own elaboration from CIS (2016) and PINTEC (2014)
Note. Class (Classification): Medium-Low (MB); Medium-High (MA); High (A); Low (B)

The technological characteristics of the sectors investigated in table 2 allow classifying their innovative strategies, following the proposal of Freeman and Soete (1997), as predominantly Defensive. The degree of technological maturity of industries hinders abrupt changes in market positions between companies, which makes competition more cost-effective. The defensive strategy characterizes these activities by the high performance of European sectors in indicators of innovation and imitation, revealing that companies in these sectors have skills to imitate and innovate. In the Brazilian case, only the Rubber and Plastic By-Products Manufacturing industry are

qualified to adopt an imitative strategy, which differs from the Defensive strategy due to the fact that it does not present good performance in innovation indicators. In other sectors of medium low technology, Brazil adopts the Traditional strategy, in which companies do not develop significant technological innovations, and process improvements are the result of capital goods acquired and made available in the market by specialized suppliers.

Chart 3 systematizes innovation strategies from the performance of the indicators observed in table 2.

CHART 3
Innovative strategies for sectors of medium-low technological intensity in Brazil

Medium-low technology	Sectoral patterns of innovation - Pavitt (1984)	Innovation strategies - Freeman and Soete (1997)	Results for Brazil
Manufacture of rubber and plastic products	Production-intensive	Defensive	Imitative
Manufacture of non-metallic minerals	Supplier-dominated	Defensive	Traditional
Metallurgy	Supplier-dominated	Defensive	Traditional
Manufacture of metal products	Specialized supplier	Defensive	Traditional

Source: Own elaboration, based on the research results.

Table 3 below presents the five indicators calculated for sectors of medium--high technological intensity. In this group, Brazil has a low capacity to imitate and innovate, both in product and in process. The only caveat to be mentioned is those of innovative organizational and marketing activities, for which the values obtained are high for Brazil and also for European countries – unlike the industry discussed previously.

In the group of medium-high technology sectors, most companies are subsidiaries of foreign multinationals and follow the technological strategies determined by the parent companies. In Brazil, the low performance observed in the indicators of innovation and imitation demonstrates that the country does not develop strong training for R&D. This fact, coupled with the strong presence of multinational companies in these sectors, reinforces the typification of the innovative strategy as Dependent, as systematized in Chart 3.

TABLE 3
Intensity indicators in imitation and innovation by sectors of medium-high technological intensity – Brazil and the country with the best performance per indicator

	Process				Product				Organizational and Marketing Innovations	
	Imitation		Innovation		Imitation		Innovation			
Manufacture of chemicals										
Brazil		0,09		0,24		0,19		0,51		23,30
Leader	Norway	0,40	Norway	0,85	Germany	0,43	Germany	2,29	Finland	35,04
Class (%)	L	22,5	L	28,2	ML	44,2	L	22,3	MH	66,5
Manufacture of machinery, appliances, and electrical materials										
Brazil		0,04		0,7		0,06		1,13		22,48
Leader	Serbia	0,24	Finland	1,66	Germany	0,66	Germany	4,80	Finland	33,78
Class (%)	L	16,7	L	42,2	L	9,1	L	23,5	MH	66,5
Manufacture of machinery and equipment										
Brazil		0,03		0,24		0,07		0,55		33,26
Leader	Norway	0,12	Norway	0,99	Germany	0,55	Austria	3,91	Serbia	38,31
Class (%)	L	25,0	L	24,2	L	12,7	L	14,1	H	86,8
Manufacture of vehicles and auto parts										
Brazil		0,06		0,30		0,15		0,80		41,16
Leader	Norway	0,34	Norway	1,66	Germany	1,06	Germany	3,94	Brazil	41,16
Class (%)	L	17,6	L	18,1	L	14,2	L	20,3	H	100,0

Source: Own elaboration from CIS (2016) and PINTEC (2014)
Note. Class (Classification): Medium-Low (MB); Medium-High (MA); High (A); Low (B)

Regarding sectoral innovation patterns, except for the Machinery and Equipment Manufacturing sector (specialized supplier), the others are intensive in production. In this case, the need to make the most of economies of scale is prevalent in these sectors, making process innovations more relevant than product innovations. The innovation indicators for the European countries investigated show that those who occupy prominent positions in relation to technological performance not only adopt offensive strategies in relation to process innovation but also in relation to product innovation. Germany, as noted in table 3, leads intensity indicators in product innovation in most medium-high technology sectors. In the Brazilian case, unlike the European standard, contrary to the offensive innovative strategy, we observe a reactive strategic standard, in which process changes depend on customer requests or foreign matrices.

Table 4 presents the results of the indicators selected for the group of sectors of high technological intensity. In the sectors of this group, the results found for Brazil reveal that the country has technological resources to innovate in process and product in the sectors of Manufacture of Pharmaceutical Products and Manufacture of Other Transportation Equipment. In the Manufacturing of Other Transportation

Equipment sector, Brazil led the group of countries selected, both in the intensity indicator in process imitation (1.77%) and in the intensity indicator in product imitation (3.71). The country also had the best performance in the intensity indicator in organizational and marketing innovations (46.27%).

CHART 4
Innovative strategies for sectors of medium-high technological intensity in Brazil

Medium-high technology	Sectoral patterns of innovation - Pavitt (1984)	Innovation strategies - Freeman and Soete (1997)	Results for Brazil
Manufacture of chemicals	Production-intensive	Offensive	Dependent
Manufacture of machinery, appliances, and electrical materials	Production-intensive	Offensive	Dependent
Manufacture of machinery and equipment	Specialized supplier	Offensive	Dependent
Manufacture of vehicles and auto parts	Production-intensive	Offensive	Dependent

Source: Own elaboration, based on the research results

In the Manufacturing of Pharmaceutical Products sector, a standard similar to that observed in the Manufacturing of Other Transportation Equipment sector was found. In the first case, Brazil is among the economies that have an average performance in imitation (1.21%) and high innovation in process (1.92%), possibly reflecting the manufacturing character of the domestic industry, especially subsidiaries of foreign companies, but without comparable innovative strategies for products. In the second case, relations are reversed with regard to process – strong imitation, leader; medium innovation – but imitation in product gains relevance (leadership, closely linked to the qualifications of the aircraft, railway equipment, and military vehicles sectors). In short, while the Pharmaceutical sector presents itself with an active strategy in processes, the Manufacturing of Other Transportation Equipment focuses on the strategy of imitation of processes and products.

The Manufacturing of Computer, Electronic, and Optical Equipment sector of the country presents a low performance in all indicators analyzed, which allows classifying the innovative strategy of this sector as Dependent. Due to the strong presence of foreign multinational companies in this sector, the low innovative and

imitative performance of this activity in Brazil seems to assign the country – at least in the near future – the role of a simple supplier of the local consumer market.

TABLE 4
Intensity indicators in imitation and innovation by sectors of high technological intensity – Brazil and the country with the best performance per indicator

	Process				Product				Organizational and Marketing Innovations	
	Imitation		Innovation		Imitation		Innovation			
Manufacture of pharmaceutical products										
Brazil		1,21		1,92		1,42		2,24		24,41
Leader	Serbia	2,26	Brazil	1,92	Serbia	3,76	Germany	10,00	Macedonia	50,00
Class (%)	ML	53,5	H	**100,0**	L	37,8	L	22,4	ML	48,8
Manufacture of computer, electronic, and optical equipment										
Brazil		0,21		0,48		0,55		1,23		21,58
Leader	Norway	0,85	Norway	3,95	Germany	1,75	Austria	10,76	Austria	50,92
Class (%)	L	24,7	L	12,2	L	31,4	L	11,4	L	42,4
Manufacture of other transport equipment										
Brazil		1,77		0,75		3,71		1,57		46,27
Leader	Brazil	1,77	Austria	1,40	Brazil	3,71	Austria	5,88	Brazil	46,27
Class (%)	H	**100,0**	ML	53,6	H	**100,0**	L	26,7	H	**100,0**

Source: Own elaboration from CIS (2016) and PINTEC (2014)
Note. Class (Classification): Medium-Low (MB); Medium-High (MA); High (A); Low (B)

Regarding sectoral innovation patterns, all sectors of the high-tech group are science-based (Chart 4). The appropriability of the economic benefits of technical progress comes from patents, secrets, and skills specific to the companies, which develop a high capacity to introduce process and product innovations. Those characteristics make the offensive and defensive strategies prevalent in these sectors in advanced countries and the imitative strategies and, to a lesser extent, the defensive ones prevalent in countries successful in technological catching up.

The analysis of the results of the indicators for the Brazilian high-tech industry allows classifying its innovative strategies as basically Defensive, except in the case of the computer equipment industry. The option for the defensive strategy owes, in these cases, to the fact that, although Brazil has the capacity to introduce process innovations, the intensity indicator performance in product innovation is low. According to Freeman and Soete (1997), in science-based sectors, the choice of offensive/defensive strategy is based on the development of skills to introduce innovations in the process, focusing on

gains in productive efficiency, and product, focusing on quality to conquer new markets. In the Brazilian case, the Manufacturing of Pharmaceutical Products and Manufacturing of Other Transportation Equipment industries adopt a defensive strategy, supported by process innovations (the first) to obtain productive efficiency gains and strong imitation in process and product (the second). The high performance of the Manufacturing of Other Transportation Equipment industry in imitation of product, although it does not allow us to classify its innovative strategy as offensive, seems to indicate those companies may innovate in product in the future.

CHART 5

Innovative strategies for sectors of high technological intensity in Brazil

High technology	Sectoral patterns of innovation - Pavitt (1984)	Innovation strategies - Freeman and Soete (1997)	Results for Brazil
Manufacture of pharmaceutical products	Science-based	Offensive	Defensive
Manufacture of computer, electronic, and optical equipment	Science-based	Offensive	Dependent
Manufacture of other transport equipment	Science-based	Offensive	Defensive

Source: Own elaboration, based on the research results.

4.3 Brief methodological comments

Regarding the basic characteristics of the strategies, it seems to be possible to highlight the evaluations of the complex present and the uncertain future – the expectations and the predictions associated with it. In other words, the strategies relate to the procedures to be adopted – to achieve the fundamental objectives/goals of the companies/organizations -, under conditions in which full knowledge of future events is unknown and that, therefore, the behavior of other relevant agents cannot be anticipated with certainty or even based on an equivalent probability distribution. That is, the strategies are characteristic of the non-ergodic conditions (TIDD *et al.*, 2005; SHACKLE, 1972; HICKS, 1980; DAVIDSON, 2011). These

circumstances are also applicable to innovative strategies – especially when the latter also involve the technological dimension – since market uncertainties are also added to the uncertainties related to the technique.

From the perspective outlined here, the *strategies* result from adaptive and sequential decision-making, with occasional retroactive adjustments, from performance *feedback*. This concept gains amplitude with the addition of innovative strategies of Freeman and Soete's typology (1977). In this context, this study, which seeks to establish (dominant) sectoral strategies from a business decision, assumes that they can be – and often are – changed over time. In other words, the actions adopted may most likely undergo changes and adjustments.

This article adopted the methodological conjecture that innovation strategies can be partially and indirectly inferred from procedures observed in industrial sectors, which report on intensity in innovation and imitation – both of product and process and organizational and marketing. Thus, to try to establish strategies via procedures, five indicators of innovation and imitation were built (tables 1 to 4), which made it possible to classify the 19 sectors of the Brazilian manufacturing industry according to the taxonomy of technological trajectories proposed by Pavitt (1984). Finally, those technological trajectories were confronted with the innovation pattern attributed to each industry from the extrapolation of the innovation typology developed by Freeman (FREEMAN; SOETE, 1994) (Charts 1 to 4). The results obtained require, however, some important comments that will be made in the following item.

5. Final Remarks

First, the indicators proposed appear to be consistent with the literature, since there is a clear tendency to increase their values as the sectoral technological intensity increases. However, the indicators show variations within and between classifications. Those results do not seem to conflict with one of the conjectures of this study, i.e., companies' resources and capabilities can determine distinct innovative (and technological) strategies in industries in different countries, not all of which are strictly compatible with the strategies expected for the sectoral standard. Thus, by revealing "deviations" from the expected strategy, the study seems to correctly indicate cases of industrial weaknesses (strategies different from those expected for the sectoral technological trajectory).

A second comment concerns indicators relating to new *marketing* methods (column 5, tables 1 to 4). In almost all cases, the Brazilian indicators remained among the highest in the sample. However, in European countries, those activities were high only in sectors of medium-high and high technology. Thus, and considering that those innovations are more focused on promoting sales – and also the set of results for the other indicators -, Brazil seems to be more focused on adjustment strategies (repositioning) and sales efforts, a fact that may characterize a bias for low--profile technological strategies with immediatism and little ambitious commercial purposes. This preliminary conclusion is apparently consistent with the other results,

Regarding the intensity indicator in imitation, the results verified in most sectors investigated do not allow us to affirm that Brazil largely adopts strategies to intensify imitation efforts (columns 1 and 3, tables 1 to 4) – at least half of the sectors have a low level (less than 40% of the best-performing country index) in imitation activities. A similar situation also occurs with innovation indicators (columns 2 and 4) – at least 60% of sectors have low intensity in innovation activities. Those dominant traits seem to reveal the incipient technological strategies and the competitive fragility of most national industry. The medium-high technology sectors, a key group for many developed countries, constitute a striking case of Brazilian technological (and competitive) strategy, since there are practically no innovative (all 4 sectors practice low rates) and imitative (7 out of 8 cases) comparable activities. In short, it seems that there are no clear actions that enable most national sectors to reach the countries that lead the introduction of process and product innovations.

Some exceptions deserve comment. The low-tech category presents cases different from the dominant national standard. The Pulp and Paper sector – intensive in production and with little product differentiation and where the national industry is best positioned – has the best comparative performance in process innovation and, because it meets the innovation standard, was classified as an offensive strategy. The same strategy was also attributed to the Beverage Manufacturing sector, for presenting a similar pattern in process innovation, and, mainly, for being innovative in product. It is noteworthy that the two industries require resources available in the country – land for reforestation, in the first case, water and proximity to the consumer market, in the second – and are characterized by a strong presence of foreign companies that enjoy the "local advantages." Those were the only two cases characterized as implementing offensive strategies.

In the other sectors of that classification, as well as in the groupings of medium--low and medium-high technologies, the industries were typified with strategies

below the expected sectoral standards of innovation: respectively, with imitative, dependent, or traditional strategies, all translating innovative and imitative activity levels lower than the reference cases.

Brazilian high-tech indicators reveal an apparently paradoxical situation. Despite the technological weakness of other industries – particularly sectors of medium-high technology – the innovative activities of the high-technology group are relatively dense. The insufficient technological qualification of the other sectors does not seem to greatly impair the innovative activities in the high-tech group. Brazil is so peculiar that developing high-tech activities seems to dispense, to a certain extent, with equivalent knowledge in sectors of lower levels of technological intensity. This apparent inconsistency is explained, at least partially, by the characteristics of the sectors and activities involved.

The pharmaceutical sector is strong in process imitation and weak in innovation and product imitation, thus characterizing an 'offensive strategy in process.' In fact, the strong presence of multinationals in the country – accompanied by a policy of technology transfer from the parent companies – associated with the positioning of Brazilian companies in the generics segment, entails a 'lame' strategy that prioritizes manufacturing. In short, it does not exactly typify an offensive (or even defensive) strategy, which involves innovation skills in product and process, as it is predominant in science-based sectors.

The Manufacturing of Other Transportation Equipment adopts a strategy that resembles the previous one, but which is clearly focused on process and product imitation, complemented by intensive activities (in a medium-low degree) in process innovation. In those terms, due to the emphasis on imitative activities, this group seems to adopt a basically defensive strategy. In the latter, there are some sectors in which national companies have developed specific skills: aircraft (especially), military vehicles, and railway equipment.

Finally, the unfortunate case of Manufacturing Computer, Electronic, and Optical Equipment, that presents a low performance in all indicators analyzed. Its characteristic of a "maquiladora" industry – assembly of components imported, to a large extent, by branches of foreign companies – seems to explain its low innovative and imitative performance in Brazil. Thus, the reactive role, that is, innovative activities performed only if pressured by the parent companies or by the contractors, characterizes a strategy similar to the Dependent one. We should remember that this sector is a supplier of the "basic technologies" of what is being called Industry 4.0.

If, as assumed in this study, technological strategies – which are the main bases of innovative procedures – are essential for competitiveness and establish, to a large extent, the perspectives for a country's industry, then the Brazilian weaknesses are evidenced in the results presented here. In moments such as the current one, of profound technological and institutional changes, the strategies of the Brazilian manufacturing industry have been shown, in the vast majority of cases, outdated and inadequate and, therefore, demand energetic and urgent action from public and private institutions and companies themselves.

References

ANCONA, C. Tática/estratégia. *In*: ROMANO, R. (dir.) *Estado-Guerra*. Enciclopédia Einaudi. Lisboa: Imprensa Nacional, 1989. v. 14

ANSOFF, H.I. *Corporate strategy:* an analytic approach to business policy for grow and expansion. New York: McGraw-Hill, 1965.

ARTHUR, B.W. *On Learning and adaptation in the economy.* Santa Fe Institute, 1992. (SFI Working Paper, 92-07-038).

CAMPOS, B; RUIZ, A.U. Padrões Setoriais de Inovação na Indústria Brasileira. *Revista Brasileira de Inovação*, v. 8. n. 1, p. 167-210, 2009.

CARVALHO, E.G. de *et al.* Strategy: Notes for an Economic and Historical Approach. *Revista Nova Economia* (forthcoming).

CASTELLACCI, F. Technological Paradigms, Regimes and Trajectories: Manufacturing and Service Industries in a new Taxonomy of Sectoral Patterns of Innovation. *Research Policy*, v. 37, n. 6-7, p. 978-994, 2008.

CHANDLER, A.D. Jr. *Strategy and structure*: chapters in the history of the American industrial enterprise. Cambridge: MIT Press, 1991.

CYERT, R.M.; MARCH, J.G. *A behavioral theory of the firm*. Englewood Cliffs: Prentice-Hall, 1992.

DAVIDSON, P. *John Maynard Keynes*. São Paulo: Actual, 2011.

DOSI, G. Sources, Procedures and Microeconomics Effects of Innovation. *Journal of Economic Literature*, v. 26, n. 3, p. 1120-1171, 1988.

DOSI, G.; EGIDI, M. Substantive and procedural uncertainty: an exploration of economic behaviours in changing environments. *Journal of Evolutionary Economics*, v. 1, n. 2, p. 145-168, 1991.

DOSI, G.; PAVITT, K.; SOETE, L. *The economics of technological change and international trade*. Hertfordshire: Harvester Wheatsheaf, 1990.

FISHBURN, P.C. Utility Theory and Decision Theory. *In*: EATWELL, J. *et al. The new Palgrave dictionary of economics*. London: Macmillan, 1987.

FOSS, N. J.; STIEGLITZ, N. Modern resource-based theory(ies). *In*: DIETRRICH, M; KRAFFT, J. *Handbook on the economics and theory of the firm*. Cheltenham: E.E, 2012.

FREEMAN, C.; SOETE, L. *The economics of industrial innovation*. Cambridge: MIT Press, 1997.

GEORGESCU-ROEGEN, N. *The entropy law and the economic process*. Cambridge: HUP, 1971.

HICKS, J. *Causality in economics*. Oxford: Basil Blackwell, 1980.

IBGE. *Pesquisa de Inovação PINTEc – 2011*: instruções para o preenchimento do questionário. Nota Técnica. IBGE: Rio de Janeiro, 2012.

LANGLOIS, R.N. Strategy as economics versus economics as strategy. *Managerial and Decision Economics*, v. 24, p. 283-290, 2003.

LAWSON, T. *Economic and reality*. London: Routledge, 1997.

LINDBLOM, C.E. *The policy-making process*. Englewood Cliffs: Prentice-Hal, 1980

LOASBY, B.J. Capabilities and strategy: problems and prospects. *Industrial and Corporated Change*, v. 19, n. 4, p. 1301-1316, 2010.

MARSHALL, A. *Principles of economics*. 8th ed. (versão digitalizada) London: Macmillan and Co., 1985 (1920).

MARSILLI, O. *The Anatomy and Evolution of Industries*. Northampton: E.E, 2001.

MCFADDEN, D. *Rationality for economists*? Santa Fe Institute, 1998. (Working Paper n. 98-09-086).

MINTZBERG, H. *et al*. *Strategy safary:* a guided tour through the wilds of strategic management. New York: Free Press, 1998.

MINTZBERG, H. *et al*. *The strategy process:* concepts, contexts, cases. Englewood Cliffs: Prentice-Hall, 2006.

MORRONI, M. *Knowledge, scale and transactions in the theory of the firm.* Cambridge: CUP, 2006.

NELSON, R.R. *The Sources of economic growth.* Cambridge: HUP, 1996.

NELSON, R.R.; WINTER, S.G. *An evolutionary theory of economic change*. Cambridge: HUP, 1982.

OECD. *Oslo Manual*. Paris: OECD, 2005.

PAVITT, K. Sectoral patterns of technical change: towards a taxonomy and a theory, *Research Policy*, v.13, p. 343-373, 1984.

PAVITT, K. What we know about the strategic management of technology. *California Management Review*, v. 32, n. 2, p. 17-26, 1990.

PAVITT, K.; STEINMUELLER, W.E. Technology in corporate strategy: change, continuity and the information revolution. *In*: PETTIGREW, A. *et al. Handbook of strategy management*. London: Sage Publications, 2002.

PORTER, M. *Competitive strategy*: techniques for analyzing industries and firms. New York: Free Press, 1980.

ROSENBERG, N. On technological expectations. *In*: ROSENBERG, N. *Inside the black box*: technology and economics. Cambridge: CUP, 1982. p. 104-119.

RUMELT, R.P. *et al*. Strategic management and economics. *Strategic Management Journal*, v. 12, p. 5-29, 1991.

SCHUMPETER, J.A. *History of Economic analysis*. New York: OUP, 1994.

SCHUMPETER, J.A. *Capitalism, socialism* & *democracy*. London: Routledge, 2003.

SCHUMPETER, J.A. *Business cycles*: a theoretical, historical, and statistical analysis of the capitalist process. Mansfield: Martino Publishing, 2005. v. 1, 2.

SEN, A.K. Rational Behaviour. *In*: EATWELL, J. *et al. The new Palgrave dictionary of economics*. London: Macmillan, 1987.

SHACKLE, G.L.S. *Epistemics and economics:* a critique of economic doctrines. Cambridge: CUP, 1992.

SIMON, H.A. Rational Decision Making in Business Organizations. *The American Economic Review*, v. 69, n. 4, p. 493-513, 1979.

SIMON, H.A. *Reason in human affairs*. Stanford: SUP, 1983.

SIMON, H.A. *Decision Making and problem solving*. Report of the research briefing. NAS, 1986.

SIMON, H.A. Strategy and organization evolution. *Strategic Management Journal*, v.14, p. 131-142, 1993.

TEECE, D. Explicating dynamic capabilities: the nature and microfoundations of (sustainable) Enterprise performance. *Strategic management Journal*, v. 28, p. 1319-50, 2007.

TEECE, D. *et al*. Dynamic capabilities and Strategic Management. *Strategic management Journal*, v. 18, n. 7, p. 509-533, 1997.

TIDD, J. *et al. Managing innovation*: integrating technological, market and organizational change. Hoboken: John Wiley & Sons, 2005.

TVERSKY, A.; KAHNEMAN, D. *Judgment under uncertainty*: heuristics and biases. Science, v. 185, n. 4157, p. 1124-1131, 1974.

VERCELLI, A. *Methodological foundations of macroeconomics*: Keynes & Lucas. Cambridge: CUP, 1991.

WHITTINGTON, R. *What is strategy and does it matter?* Hampshire: Cengage Learning, 2001.

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