Innovative Activities in "Low and Medium-Low" Technology Industries: A survey on the mechanisms of diffusion of innovation[1]

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ABSTRACT: This study evaluates the characteristics of technological innovation from the assumption that this phenomenon is part of a process composed of different modes of production of technical and scientific knowledge. In order to do this, we will also examine a number of other activities made within the firm, some of them closely related to the diffusion of technology, besides the "traditional" research and development (R & D). Hence, the article focuses on the discussion of innovation in Low and Medium-low technology (LML) industries. For the examination of the characteristics of innovative activities, we confront the industries of some countries using data from the Pesquisa de Inovação Tecnológica (PINTEC, 2010) and the Community Innovation Survey (CIS, 2009) for Brazilian companies and countries of the European Union, respectively. The findings indicate that there are significant differences in the characteristics of innovation in different countries and industries; and suggest important structural and institutional factors as determinants of technological activities.

Keywords: innovative activity; technological diffusion; low and medium-low technology industries.

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1. Introduction

The technological innovation is one of the central points of transformation of the capitalist system structure. Schumpeter (1942; 112) states that “the impulse that initiates and maintains the movement of the capitalist machine derives from new commodities, new production or transportation methods, new markets for the new forms of industrial organization that the capitalist enterprise creates”. The complexity of this phenomenon can be confined to two aspects of its nature: the (r)evolutionary and organic ones. It is (r)evolutionary for it takes time to show its true characteristics and its real effects. The process is also organic because the technological innovation introduced, for example, by an only enterprise promotes and induces transformations that can affect the whole economic environment (Schumpeter, 1942). In this perspective, we can admit that the relevance of technological innovation for the economical and social development configures itself as the process of diffusion occurs, that is to say, if it spreads itself through the economical fabric over time.

The recent economical changes (for example, the changes in the relative prices of commodities related to the manufactures or in the dynamics of the markets from emerging countries) and the technological progress from new scientific boundaries (the development of information technology, nanotechnology, biotechnology, etc.) are altering and intensifying the technological innovation process in different activities, in special in the industries of low and medium-low technologies (LML) - (indústrias de baixa e média-baixa tecnologias - BeMB, in the Portuguese acronym). As a consequence, it is required from the companies a growing capability of assimilating complex technologies, whether through intern development or through extern suppliers, of interacting and reinforcing the actions with different partners or collaborators – companies, universities, suppliers, competitors, venture capital companies, etc. – that allow them to reach (1) adaptations and technical improvement and the (2) creation of complementary technical-scientific knowledge, that end up (3) enlarging and energizing the research in several fields of science. To sum up, a process that provides feedback to itself to the systemic development of products and/or more sophisticated productive processes (Morceiro *et al.*, 2011).

Based on the evolutionary approach, this paper presupposes that the innovation process is wide and complex, by gathering a distinct group of agents and institutions, and is structured on very heterogeneous bases and motivated by different conditionings specific to each economical activity. In this perspective, in some industries, the traditional methods to measure innovation (patents or R&D costs) are enough to detect the essence of this process. Industries usually classified as LML are among those in which the use of such indicators is scarcely appropriate. Privileging the examination on LML industries, but not restricted to them, this study attempts to evaluate the innovation process in the industries of transformation and quarrying and advance in the discussion of the innovative dynamics through alternative indicators applied to different countries. In order to elaborate these indicators we used data from the Research on Technological Innovation (Pesquisa de Inovação Tecnológica - PINTEC, 2010) and the Community Innovation Survey (CIS, 2009) for Brazilian enterprises and that of the countries in the European Union, respectively.

With this intent, section 2 examines the process of innovation in LML industries, to point out the distinctive characteristics of this process from those usually described in the “traditional bibliography” on innovation. From the data of the Brazilian RTI and the CIS for the countries of the European Union with available information, section 3 proposes two indicators – Rate of Dispersion of Activities and Rate of Innovative Activity, both measured in terms of number of enterprises – to analyze and debate the characteristics of innovation in the different industries from the selected countries. The final considerations are presented in section 4.

2. The Characteristics of Innovation in the Industries of Low and Medium-Low Technologies

From the relation between R&D costs and production revenue, the OCDE (2003) arranges the industries of transformation effort in low (L), medium-low (ML), medium-high (MH) and high (H) technological intensity. In this classification, the traditional industries (textile, real estate, food, etc.) are grouped among the ones of lower technological intensity (LML). However, this indicator masks the true innovative dynamics in some of these industries and the action of the agents that take part in the process of Innovation (Hirsch-Kreinsen *et al.,* 2003; Acha and Von Tunzelmann, 2005).
The main deficiency of this classification is taking internal R&D as the only criteria to measure the new knowledge, ignoring the diverse forms and interactions between the different industries for the development of this knowledge or for the "substantial improvements of the already existing ones" (Hirsch-Kreinsen *et al.,* 2003). According to the Frascati Manual (OCDE, 2002), R&D[2] is only one step in the process of innovation that includes (…) "the creative work carried out systematically to increase the knowledge fields" (…) and the use of this knowledge to create new applications" (OCDE, 2002; cap 2; 43). In this perspective, the technological innovation encompasses both formal R&D, carried out in the R&D unities or laboratories, as well as the informal or occasional R&D, carried out in other unities and in different activities.

R&D measured through costs accounts only the efforts of the formal activities in basic and applied research, and of the experimental development, but does not compute the knowledge conquered through other daily activities – such as, for example, "learning by doing", "learning by using" or "learning by interaction" – and that are responsible for a significant sum of innovations and technical improvements (Dosi, 1988; 1124). In the adopted perspective, technological innovation in the company is understood as a process composed by various ways of learning – sometimes with a small sum, but, for being cumulative, becoming expressive in time – that can be identified through the examination of some activities carried out by the company (Rosenberg, 1982; cap.6; 187).

In the industries with low effort in formal R&D, such as the LML, the technological development is done largely from the incorporation of knowledge arising from other areas and applied to the conditions of the productive process (Hirsch-Kreinsen *et al.,* 2003). This perception is present in the taxonomy for enterprises (or sectors) based on the flow (sources or origins) of the technology proposed by Pavitt (1984). According to the author, the technological development depends on the interaction between industries with different technological characteristics and dynamics. To sum up, according to the authors'

[2] "The term R&D encompasses three activities: basic research, applied research and experimental development. Basic research consists on **experimental or theoretical works initiated mainly to obtain new knowledge** on the grounds of the observable phenomena and facts, **not aiming any particular application or use**. Applied research also consists on original works carried out to acquire new knowledge, but is fundamentally directed to a **practical specific objective**. The experimental development consists on **systematic works based on existing knowledge** obtained through research and/or through practical experience, and is directed **to the production of new materials, products or devices, to the installation of new processes, systems and services, or to the substantial improvement of the already existing ones**" (OCDE, 2002; 43; our emphasis)

taxonomy, the sectors present distinct patterns for technological development. However, if the classification is only for technological intensity (internal costs for R&D), these relations become inexistent. In the industries considered LML, for example, we may find both sectors “subdued by suppliers” and “intensive on scale”, both with very distinct technological dynamics, as mentioned above. Despite carrying out few formal internal R&D, the companies in this category maintain not only other mechanisms for innovation, but also relations with very complex external suppliers, which allow us to characterize their technological activities as a non-trivial process, or, at least, not as trivial as the intensity indicator leads us to believe. The technology flows include relations and chaining that surpass the mere relation of purchase and sale of commodities. These flows do not transfer only commodities or information, but, mainly, the new knowledge that may improve the productive processes and products, develop improvements or efforts to adapt the inventions, as well as induce the technological diversification of the suppliers and clients to other areas. In this sense, the user of new knowledge (even if it is “edge knowledge” only in the company’s scope) needs to be enabled or qualified to receive, incorporate and operate such knowledge in an efficient way.

The knowledge accumulated with time, result of the internal developments and the successive adaptations of new technologies to the organizational processes in operation, makes the routines (everyday) company-specific or individually unique and differentiated from the other competitors. Thus, all the new knowledge, especially that from external origin needs to be assimilated, adjusted and incorporated to the unique forms of organization of each company. In other words, if the knowledge needs to be internally processed to be appropriated by the company, then it is necessary that the company possesses certain technical capabilities. Furthermore, these technical capabilities and the established organizational routines allow the enterprise to revise, to adapt and improve the existing technologies. To sum up, the “simple” process of adaptation of technologies or the adjustments of existing routines require that some technological activities (formal or informal) be carried out inside the company.

This argumentation finds support in various authors, like Hirsch-Kreinsen *et al.* (2003). For the authors, the LML industries are characterized by complex technological bases, that involve knowledge on design and/or practices of engineering/production that are not only result of the internal and formal R&D. The Oslo Manual (OCDE, 2005) also follows this same direction, defining innovation as a broad group of activities, many of them not included in formal R&D, but highly relevant, such as: the final phases of development for pre-production, the production and distribution, the development activities with smaller degree of novelty, the support activities such as training and preparation for the market of product innovation, the development and implementation of activities for new methods of marketing or new organizational methods (OCDE, 2005; 103).

The R&D activity, as emphasized, is one of the activities of innovation inside enterprises. To evaluate this aspect, Kline and Rosenberg developed the “interactive model of innovation”, which previews the existent interactions and feedback mechanisms between the different elements involved in this process. These mechanisms, that are essential to reduce incertitude and inadequate information that are a part of the creative method, allow evaluating, reprogramming and correcting the possible failures in the process. In the interactive model proposed by the authors, scientific research is substituted by design as the initial stage of innovation, for it is considered fundamental to all the stages in the process, as well as the redesigns (when the feedback mechanisms are incorporated) are essential to the process of innovation (Kline and Rosenberg, 1986).

3. Innovative Activities in Quarrying and Transformation Industries

To the set of innovations linked to the arising of a new product/process, the Oslo Manual adds aspects related to the commercial dimensions of enterprises to broaden the scope of technological innovation. Furthermore, it also incorporates the sectorial interactions, organizational and marketing aspects, that expand the concept of innovation to the scope of the company, towards the “new to the company” (OCDE, 2005; 22).

Adopting this same perspective and in light of the anterior discussion, this section makes an examination of the main characteristics of the innovative activities from the quarrying and transformation industries in different countries (Brazil, Germany, France, Holland, Italy, Spain and EU-16 – an average of other 16 countries in the European Union with available information) based on two sources of information: 1) the Research of Technological Innovation (PINTEC) from 2010 for the data on Brazilian enterprises; and 2) the Community innovation survey (CIS) from 2009 to the countries in the European Union[3]. We point out that these publications follow the proposition of the Oslo Manual, incorporating seven types of activities considered technological (PINTEC, 2010; 8), all orientated to the development of new products/processes or substantial improvements, in the sectorial or national company scope: (1) Internal activities on R&D (R&D); (2) External acquisition of R&D (eR&D); (3) The acquisition of other external knowledge (EK) – the transference of technology originated from the purchase of the license of rights for the use of patents and brands; (4) The acquisition of machines, equipments and software (AMES); (5) Training (T); (6) The introduction of technological innovations in the market (IM); (7) The industrial project and technical preparations for production and distribution (PP).

In order to support the examination of the characteristics of technological activities carried out in the different industries and countries, we elaborated the two indicators described bellow. It is necessary to observe that these indicators deal with the number of innovative enterprises carrying out each one of the seven activities, differently from the relation between R&D costs and “traditional” sale on OCDE (2003). The option for an index based on the number of enterprises carrying out technological activities is justified by the objective of characterizing these activities, that is, examining to which extent they are disseminated in different industries. Furthermore, we chose to keep the sectoral classification of OCDE (2003), but we added two aggregated ones: LML and MHH – tables 1, 2 and 3 bellow.

3.1. Rate of Activities Dispersion (RAD) - (Taxa de Dispersão de Atividades TDA)

The first indicator – Rate of Activities Dispersion – measures the percentage of enterprises that carry out some type of technological activity, regardless the type and intensity with which the activity is concretized.

Rate of Activities Dispersion (%): $RAD = \frac{\text{number of enterprises that carry out the innovative activity}}{\text{total number of enterprises in the example}}$

The relations measured by RAD for each industry or aggregate (lines) and countries (columns) are presented in table 1 – the presentation order of the countries in the tables in this study follow the RADs. The results from this table allow some observations. The first of them is that the RAD keeps consistence with some “traditional” perceptions: (i) a

[3] The references are for the year of publication, but both researches deal with information on the activities of the year of 2008.

smaller number (lower, average and higher coefficient of variation) of companies of LML industries (36.8 and 38.2 respectively) carries out less technological activities than the General Average (43.8 and 38.7) and the MHH enterprises (54.6 and 23.2); (ii) in the industries – for example, pharmaceutics – in which the competitive logic is largely attached to the innovative capacity, enterprises are more strongly linked to the different forms of innovation than the companies in other economical activities; (iii) the companies in the "more advanced" economies (superior technical-scientific level) are more broadly linked to the innovative activities in their different forms than the enterprises in the "less advanced" economies. This last commentary can be exemplified with the LML industries in Germany, that show a innovation rate (58.8%) higher than the one registered in this same aggregate in Brazil (27.7%). Furthermore, the difference between the RADs in both countries is similar in the MHH industries (RAD of 80.3% and 43.6% respectively).

Other commentaries that we can extract from table 1 concern the averages and coefficients of variation (CV) [4]. These indicators show important differences. Keeping the same two countries (Germany and Brazil) as examples to the examination, the averages and coefficients of variation of RAD are very distinct (67.2 % and 34.9% - average; 19.6% and 33.9% - coefficients of variation, respectively). These characteristics show that the technological activities in Germany are not only more practiced, but also distributed in a more homogeneous way in the different economical activities than in Brazil. In other words, these coefficients show the heterogeneity of "innovative culture" and seem to corroborate the argument that the countries with high performance in high technology industries are also more competitive in those considered with low technological intensity (Robestson and Patel, 2007). Furthermore, this result seems to translate the importance of institutional and structural factors in these countries.

There are still two important observations regarding table 1, which corroborate the discussion in section 2 of this study – the necessity of a wide set of technological activities capable of including the diverse innovative dynamics of different sectors. Some LML industries have a bigger percentage of enterprises involved with technological activities than the MHH average in the country. This is case, for example, of the (1) tobacco industry in France and Holland, of the (2) rubber and plastic industries in Holland and of the (3) coke and oil refining in France and Spain. In particular, the coke and oil refining and the tobacco ones follow this characteristic, that is, are very high (despite the heterogeneity being a fact in common) and in levels superior to the MHH average. To sum up, the "culture of innovation" is more rooted in MHH, but that is not an exclusive attribute of this classification.

The second observation comes from the comparison of lines and columns on table 1. In the first case LML industries (average CV of 28.5%) show (little) heterogeneity, similar to the MHH ones (27.2). However, this same coefficient examined through the countries (columns) show that the MHH industries have a very homogeneous set (average CV of 23.2%), unlike the one found for the LML ones (average CV of 38.2%). In other words, despite also existing high heterogeneity in various MHH industries (such as the case of Other Materials of Transportation – CV of 47.6%), between the two classifications this asymmetry expresses itself more sharply regarding to countries than industries. This result

[4] Pearson's coefficient of variation (CV) provides the percentage between standard deviation and average, allowing comparisons between variables of distinct natures and providing an idea of data precision. The lower the CV, the more homogeneous will be the data and the smaller the variations of chance. In general, the CV is considered low – showing a very homogeneous set of data – when it is lower or equal to 25%, interval also adopted in this study.

is coherent with the one found by Malerba and Orsenigo (1997), despite the fact that this later work examines industries only internationally, but not in aggregates – in item 4 we compare the results of this study.

Table 1 – Rate of Activities Dispersion (RAD) by Industry (%)

	Germany	France	Italy	Netherlands	EU-16[2]	Spain	Brazil	Average[1]	CV[1]
Quarrying	36,9	28,7	24,6	28,4	26,6	14,3	17,1	26,1	32,4
Food products	52,6	34,4	37,7	26,8	31,7	22,3	31,1	32,4	37,3
Beverages	56,8	37,5	50,2	41,7	43,9	-	29,3	43,7	42,4
Tobacco products	61,5	100	-	66,7	52,8	-	24,8	57,0	40,4
Textiles and related products	67,3	37,7	29,4	37,2	29,2	16,9	26,2	31,1	52,2
Wood and related products	53,8	35,4	42,8	23,3	29,1	20,9	24,6	30,3	37,3
Coke and refined	60,7	71,4	35,5	44,4	60,2	69,2	34,8	56,7	33,7
Rubber and plastic	65,2	50,0	47,9	62,8	40,8	30,3	28,6	42,7	39,3
Furniture and other prod.	64,2	31,0	38,5	23,7	30,7	20,6	28,7	31,7	40,8
Non-metallic mineral	64,3	46,1	44,6	45,7	33,8	17,8	25,3	35,6	38,9
Basic metals	64,0	35,2	41,6	29,4	35,5	19,0	33,9	35,9	34,3
Chemical prod.	87,1	70,9	64,4	61,0	55,0	57,9	46,5	58,2	24,1
Pharmaceutical prod	81,5	66,5	77,3	66,7	62,5	74,5	60,7	65,2	22,8
Electronic and optical	86,2	64,7	71,4	57,2	59,0	59,5	49,9	60,7	33,6
Electrical equipment	76,6	49,8	50,1	48,5	50,5	42,1	42,2	50,8	35,5
Machinery and equipment	84,7	56,4	54,3	43,6	46,7	36,9	43,7	48,6	33,3
Motor vehicles	73,4	43,4	58,7	38,9	45,6	39,2	42,3	46,6	28,8
Other Transport Equipment	72,5	51,8	31,5	34,8	46,3	43,1	19,9	45,1	47,6
Average	67,2	51,9	48,5	43,4	43,3	38,0	34,9	43,8	25,5
Coefficient of variation	19,6	36,4	31,0	33,6	27,0	54,1	33,9	38,7	-
Average LML	58,8	46,1	39,3	39,1	37,7	25,7	27,7	36,8	28,5
Cv LML	14,8	46,5	20,2	38,4	28,6	65,8	17,9	38,2	-
Average MHH	80,3	57,7	58,2	50,1	52,2	50,4	43,6	54,6	27,2
Cv MHH	7,6	17,4	26,0	23,8	12,9	27,5	28,2	23,2	-

Notes: (1) The average and the Coefficient of Variation (CV) were calculated from all the countries of European Union with information available in the CIS and from the PINTEC from Brazil.

(2) The EU-16 represent other 16 countries of the European Union not listed in the table and with information available in the CIS: Austria, Belgium, Bulgaria, Croatia, Slovakia, Slovenia, Finland, Hungary, Latvia, Malta, Norway, Poland, Portugal, Czech Republic, Romania, Sweden.

Source**:** Elaboration with the data from CIS (2009) and PINTEC (2010)

Lastly, table 1 shows part of the innovation profile in Brazil. Compared to the one in other countries, the practice of innovative activities is significantly less widespread in the Brazilian economy. The Brazilian RADs are among the lowest calculated ones, whether examined in terms of industries (inferior to almost all the countries), or observed in terms of the average of countries (general and aggregate). Furthermore, as the coefficients of variation (CV) in the country are also among the lowest in the examples, the "little widespread innovative culture" is more homogeneous than in other regions. Doubtlessly, this characteristic has profound reflexes on the competitiveness of the country.

3.2. Rate of Innovative Activity (RIA) - (Taxa de Atividade Inovativa - TAI)

The second indicator – the Rate of Innovative Activity (RIA) – attempts to examine the effort of companies through a set that also gathers the innovative activities developed beyond the limits established by the R&D departments. This indicator has as objective evaluating the characteristics of the innovation process in the enterprises that develop technological activities and showing the concentration in the different types of activities. The indicator is calculated as follows:

Rate of Innovative Activity (%)**:** *RIA(i)* = $\frac{\text{number of enterprises that carry out the inovative activity (i)}}{\text{total number of enterprises with innovative activities}}$

The RIA describes the percentage of enterprises that carry out the technological activity of type (i) concerning the total of innovating enterprises (number of enterprises that carry out at least one technological activity). In this sense, the RIA expresses the most practiced technological activities by the enterprises of each industry in the different countries (lines in the tables 2 and 3) or, alternatively, by the enterprises of the various industries in a determinate country (columns). We point out that these activities can be complementary and influence the innovation process of the enterprises in different ways, for there are distinct industrial conditions and various institutional arrangements in each country. Tables 2 and 3 show the RIAs for each one of the seven technological activities (i = 1, …7) described by the PINTEC (2010; 8) and listed above. In these tables, the innovative activities are listed in a descending order of importance, that is, according to the average percentage of the RIAs.

Tables 2 and 3 show that the acquisition of machines, equipments, software (AMES) is the most practiced activity by the enterprises in the example that carry out any type of innovation (72.2% or 32% of the total of researched enterprises). This activity is also that in which the enterprises of the LML industries focus their technological activities (around 75%). Furthermore, the coefficient of variation shows that this characteristic is relatively homogeneous (CV inferior to 29%) in these industries. In this same classification, the analysis concerning the countries (columns in tables 2 and 3) shows that this activity is also very adopted – CV superior to 25%, except in Slovakia and Norway. Despite the averages – general and in the countries – being slightly inferior to the ones obtained for the LML industries, the scenario above does not alter itself substantially for the MHH: elevated averages and very (countries: inferior to 20%) or slightly (industries: inferior to 35%) heterogeneous CVs.

To sum up, both in terms of industries, in any of the technological classifications, as for countries, independently from the technical-scientific level, the AMES is a widespread practice, a type of innovation adopted indiscriminately. These results allow two preliminary observations: (1) the technological innovation is a process that also requires external sources to a high degree; (2) the "new for the company" (to reduce discrepancies or to be close to the technological boundaries) is a fundamental factor for competitiveness. If the observations are correct, on some aspects they complement the results of Pavitt (1984), for, when generalizing the AMES, it raises the complexity of the innovative process (fact that restates section 2.2.1.), for it is perceived as permeated by actions and relations that feed themselves back. The following analysis supports the defense of these points.

Table 2 – Distribution of the Three Main Innovative Activities in the Innovating Enterprises (%)

	The acquisition of machines, equipments and software (AMES)								
	Gr	Fr	It	Ne	Eu -16[2]	Sp	Br	A[1]	CV[1]
Quarrying	95,0	60,0	96,0	65,0	74,6	48,0	93,0	75,1	27,4
Food products	67,4	55,9	91,2	78,0	79,2	51,5	76,8	76,7	17,9
Beverages	73,0	57,9	88,0	46,7	74,0	-	78,3	72,4	24,2
Tobacco products	100,0	-	-	75,0	79,2	-	56,9	78,4	27,7
Textiles and related products	68,7	47,0	81,7	70,6	68,0	36,8	82,9	67,0	27,2
Wood and related products	76,3	63,4	91,2	79,3	79,3	60,2	89,0	78,5	20,1
Coke and refined	91,9	53,3	81,4	62,5	70,1	33,3	74,6	68,1	29,4
Rubber and plastic	71,5	54,1	82,8	56,5	78,4	45,1	85,4	74,8	25,2
Furniture and other prod.	74,8	55,9	80,4	73,4	72,3	47,7	82,7	71,5	23,7
Non-metallic mineral	60,2	61,6	91,1	67,3	78,4	50,4	85,7	75,8	23,1
Basic metals	71,1	62,5	86,6	69,8	81,4	51,6	83,5	78,6	20,8
Chemical prod.	66,5	51,8	45,4	48,8	67,4	27,4	70,7	62,2	35,2
Pharmaceutical prod	83,8	51,9	69,8	56,8	73,0	20,0	69,8	67,9	33,3
Electronic and optical	74,5	50,3	68,3	55,6	74,7	31,0	70,7	70,1	26,9
Electrical equipment	85,0	51,0	82,3	69,8	71,7	34,8	60,9	69,5	27,8
Machinery and equipment	72,8	42,4	73,3	45,3	74,3	33,4	74,6	69,3	27,8
Motor vehicles	87,7	41,4	89,7	44,9	68,8	41,0	68,8	66,9	31,0
Other Transport Equipment	77,6	51,3	83,1	50,0	74,2	31,9	81,9	70,7	29,2
Average	77,7	53,6	81,3	62,0	74,4	40,3	77,0	72,2	20,4
Coefficient of variation	13,8	12,0	14,8	18,8	5,7	26,9	12,4	16,6	-
Average LML	77,3	57,2	87,0	67,6	75,9	47,2	80,8	74,6	19,6
Cv LML	16,4	8,8	6,1	14,3	5,8	17,1	11,8	14,0	-
Average MHH	78,3	48,6	73,1	53,0	72,0	31,4	71,1	68,1	25,7
Cv MHH	9,7	9,5	19,8	16,4	4,0	20,7	8,9	14,3	-

	Internal activities on R&D (R&D)								
	Gr	Fr	It	Ne	Eu -16[2]	Sp	Br	A[1]	CV[1]
Quarrying	40,0	40,0	29,0	74,0	38,0	40,0	28,0	39,3	34,2
Food products	41,8	74,2	33,7	73,9	45,8	50,3	11,1	46,3	47,3
Beverages	22,2	59,3	36,6	80,0	66,6	-	9,2	58,7	51,4
Tobacco products	31,3	100,0	-	100,0	19,6	-	38,9	51,6	78,0
Textiles and related products	74,1	65,8	49,8	79,8	48,0	62,0	6,3	50,4	55,7
Wood and related products	49,0	45,0	37,5	71,2	44,5	28,7	8,6	43,1	41,1
Coke and refined	67,6	46,7	55,9	75,0	77,1	55,6	27,6	64,9	31,8
Rubber and plastic	75,5	72,8	63,6	87,9	52,2	53,7	20,4	55,1	44,0
Furniture and other prod.	60,5	63,9	47,6	76,5	52,6	42,7	8,1	51,8	40,0
Non-metallic mineral	78,9	55,2	40,9	93,9	56,9	47,7	3,2	55,9	49,0
Basic metals	59,1	60,1	35,9	81,9	47,4	49,8	11,1	48,0	41,9
Chemical prod.	92,9	87,1	73,5	93,4	68,8	80,5	48,2	72,3	29,6
Pharmaceutical prod	94,1	79,9	89,3	70,5	82,5	87,4	47,9	81,0	19,6
Electronic and optical	87,6	89,8	75,5	96,8	72,5	82,5	43,0	74,4	26,4
Electrical equipment	85,6	88,7	64,0	88,1	69,0	75,7	24,5	69,6	32,8
Machinery and equipment	74,1	83,5	62,4	93,9	70,1	72,6	21,0	69,4	31,6
Motor vehicles	75,0	77,6	66,0	68,5	65,5	58,0	19,5	64,0	31,9
Other Transport Equipment	98,4	88,5	87,5	82,8	63,7	75,9	22,8	67,6	34,8
Average	67,1	71,0	55,8	82,7	57,8	60,2	22,2	59,7	34,2
Coefficient of variation	33,6	24,6	33,9	12,0	27,2	28,5	65,0	31,1	-
Average LML	54,5	62,1	43,1	81,3	49,9	47,8	15,7	51,4	41,2
Cv LML	34,9	26,9	25,3	11,2	29,7	20,4	72,5	29,1	-
Average MHH	86,8	85,0	74,0	84,9	70,3	76,1	32,4	71,6	28,3
Cv MHH	10,8	5,6	14,7	13,5	8,7	12,3	40,9	15,9	-

	Training (T)								
	Gr	Fr	It	Ne	Eu -16[2]	Sp	Br	A[1]	CV[1]
Quarrying	45,0	42,0	42,0	48,0	40,3	8,0	34,0	39,0	34,4
Food products	56,4	53,9	44,3	41,4	48,9	9,1	37,5	46,5	38,2
Beverages	42,3	49,3	41,5	46,7	46,9	-	23,7	44,5	31,7
Tobacco products	75,0	-	-	25,0	57,5	-	46,8	53,2	41,4
Textiles and related products	43,9	51,1	36,0	38,5	39,9	7,7	29,5	38,4	41,0
Wood and related products	52,9	50,4	39,7	51,5	46,4	10,3	43,4	45,0	33,5
Coke and refined	83,8	96,7	54,2	50,0	60,4	11,1	51,9	58,8	40,6
Rubber and plastic	59,7	45,2	52,1	39,9	45,4	13,5	48,5	44,7	41,7
Furniture and other prod.	62,4	54,6	51,0	52,9	48,8	10,1	48,7	48,2	32,6
Non-metallic mineral	52,5	52,9	33,4	50,3	41,0	8,7	29,8	40,1	50,9
Basic metals	47,4	56,5	42,7	59,6	49,9	16,0	41,2	48,3	32,5
Chemical prod.	50,5	52,8	37,7	51,2	47,0	15,3	44,2	45,3	40,4
Pharmaceutical prod	66,6	56,6	60,3	43,2	61,9	18,4	52,2	56,9	35,4
Electronic and optical	68,3	57,3	48,6	54,2	60,4	17,2	54,0	57,3	31,0
Electrical equipment	69,0	56,1	32,8	72,2	55,6	17,3	46,1	53,7	30,6
Machinery and equipment	65,3	53,0	43,0	50,6	53,5	14,3	42,8	51,1	33,6
Motor vehicles	76,2	42,8	60,6	36,0	55,9	12,8	31,9	52,3	36,1
Other Transport Equipment	53,6	50,0	63,0	32,8	56,1	19,1	44,6	52,4	44,2
Average	59,5	54,2	46,1	46,9	50,9	13,1	41,7	47,8	29,6
Coefficient of variation	20,3	21,9	20,6	22,7	13,9	29,6	21,1	25,5	-
Average LML	56,5	55,3	43,7	45,8	47,8	10,5	39,6	45,0	32,3
Cv LML	23,3	27,5	15,7	20,2	13,8	25,8	23,6	21,6	-
Average MHH	64,2	52,7	49,5	48,6	55,8	16,4	45,1	51,9	30,9
Cv MHH	14,1	9,6	24,5	27,1	8,7	14,0	16,0	20,9	-

Notes: (1) The average and the Coefficients of Variation (CV) were calculated for all the countries of the European Union with information available in the CIS and from the PINTEC on Brazil. (2) The EU-16 represent 16 other countries of the European Union that are not listed in the table, but with information available in the CIS: Austria, Belgium, Bulgaria, Croatia, Slovakia, Slovenia, Finland, Hungary, Latvia, Malta, Norway, Poland, Portugal, Czech Republic, Romania, Sweden.

Source**:** Elaboration with the data from CIS (2009) and Pintec (2010)

In terms of practiced innovative activities, the AMES is followed by internal R&D (general average of around 60% - or 26% of all the researched enterprises). However, the diffusion of enterprises in this last activity occurs in a relatively heterogeneous way – coefficient of variation (CV) above 30%. A relevant aspect of internal R&D is the fact that in some countries the percentage of companies of determinate LML industries practicing the activity is superior to the average of MHH industries – see, for example, the non-metallic minerals and rubber and plastics in Holland, or tobacco in Brazil. Furthermore, there are various cases of LML industries that show an innovative rate of R&D superior to the general average of the country – see, for example, the quarrying industry in Brazil. This result may be derived from the concentration of the local market and/or, most probably, it is related with the role of leadership exercised by one – or more – national enterprise.

The third innovative activity most carried out internationally is training (T) – general average of 47.8%. As pointed by Lundvall (1988), this type of activity is directly linked to AMES, that is, there is a certain complementarity. In this sense, its classification and importance are justified. Even if by a small difference, the positions of the two first technological activities are inverted in the case of MHH industries – averages of 68.1% (AMES), 71.6% (R&D) and 51.9% (T). However, since we are dealing with a set of countries with different levels of technical-scientific knowledge, the three activities are diffuse.

The three following activities listed in table 3 – PP, IM, and R&De – are also significant to the process of innovation – general average between 41% and 33%. Despite being less spread than the later, the seventh and last activity – the acquisition of other external knowledge (EK) – see table 3 – is also relevant to some industries, for example, the coke and refining of petroleum in EU-16 (62%) and Spain (44%). Apart from this above mentioned observation for R&D and the acquisition of machines, equipments, software (AMES), for the other types of innovative activities the relations between the LML and the MHH industries maintain themselves stable: the RIAs of the last ones are superior to the first ones, that is, all the types of technological activities are carried out by an also expressive number of companies of industries considered of higher technological level. The immediate conclusions of the later commentaries are: (i) the RIAs justify the insertion of the set of seven activities for a detailed analysis of the innovation process in distinct industries, for this set is practiced in a significant level by all the enterprises of all industries; (ii) the proposed indicators do not establish a rupture with the "traditional perception" obtained from the indicators of R&D intensity, but allow advances already announced before and others mentioned below.

In general, the LML companies have as a source of innovation other sectors (especially the specialized suppliers), which characterizes the innovative process as diffusion of technology, that is, it is more linked to the incremental and process innovations, a fact that strengthens the relations of user-producer type, learning by interacting, etc. The innovation for the user is in the process of technological diffusion, since there is incorporation of a technology that in most cases already exists in market. However, the externally acquired innovations demand effort from the user companies that are "far from being simply a decision of buying and using, the diffusion will imply a process of "learning, modification of the existent production organization and, frequently, even a modification of products" (Dosi, Pavitt and Soete, 1990, p. 119). These aspects are directly related to the innovations in LML industries.

Table 3 – Distribution of Other Types of Innovative Activities in Innovating Enterprises (%)

	The industrial project and technical preparations for production and distribution (PP)								
	Gr	Fr	It	Ne	Eu	Sp	Br	A[1]	CV[1]
Quarrying	47	19	13	57	37	7	34	34	42
Food products	53	38	25	39	32	11	32	32	33
Beverages	64	19	26	40	39	-	39	38	53
Tobacco products	100	-	-	25	39	-	60	49	70
Textiles and related products	60	39	27	36	32	17	26	33	51
Wood and related products	56	38	29	31	33	12	28	33	38
Coke and refined	81	77	27	25	73	-	48	62	39
Rubber and plastic	63	45	44	34	40	15	29	40	42
Furniture and other prod.	64	35	41	38	36	15	38	37	39
Non-metallic mineral	66	37	27	45	35	9	37	36	43
Basic metals	56	33	32	33	36	14	32	35	26
Chemical prod.	69	51	12	38	51	11	47	46	43
Pharmaceutical prod	77	48	34	25	53	8	50	47	46
Electronic and optical	87	53	49	49	53	13	48	52	36
Electrical equipment	67	63	45	42	52	14	24	50	40
Machinery and equipment	69	50	42	43	49	17	37	48	30
Motor vehicles	71	36	42	36	48	13	44	46	36
Other Transport Equipment	87	53	47	28	45	9	56	45	50
Average	69	43	33	37	44	12	39	41	30
Coefficient of variation	20	34	34	23	24	26	26	32	-
Average LML	65	38	29	37	39	12	37	36	32
Cv LML	23	42	30	25	29	27	27	34	-
Average MHH	75	51	39	37	50	12	44	47	32
Cv MHH	12	16	33	23	6	27	24	23	-

	The introduction of technological innovations in the market (IM)								
	Gr	Fr	It	Ne	Eu	Sp	Br	A[1]	CV[1]
Quarrying	43	6	22	13	28	21	21	26	54
Food products	43	39	22	52	39	25	39	38	36
Beverages	71	34	23	40	55	-	24	49	39
Tobacco products	75	-	-	13	46	-	34	43	48
Textiles and related products	46	29	25	39	35	31	27	34	37
Wood and related products	25	22	20	26	28	22	26	27	41
Coke and refined	81	87	29	38	51	44	30	51	55
Rubber and plastic	55	30	28	36	34	26	50	35	36
Furniture and other prod.	46	34	29	38	38	28	33	37	32
Non-metallic mineral	51	38	29	53	36	29	26	36	44
Basic metals	31	20	18	27	31	18	21	29	41
Chemical prod.	59	47	12	56	51	33	43	48	42
Pharmaceutical prod	66	43	35	48	58	23	62	54	37
Electronic and optical	61	48	44	55	45	36	48	46	27
Electrical equipment	49	44	28	50	43	34	54	43	33
Machinery and equipment	44	41	29	32	42	35	32	40	35
Motor vehicles	39	29	12	27	31	23	27	29	37
Other Transport Equipment	64	32	18	34	44	19	40	41	60
Average	53	37	25	37	41	28	35	38	28
Coefficient of variation	29	46	32	35	23	26	34	36	-
Average LML	52	34	25	34	38	27	30	36	30
Cv LML	34	62	17	39	24	28	28	35	-
Average MHH	55	41	25	43	45	29	44	42	33
Cv MHH	19	18	47	27	19	25	28	30	-

	External acquisition of R&D (eR&D)								
	Gr	Fr	It	Ne	Eu	Sp	Br	A[1]	CV[1]
Quarrying	16	24	13	35	35	24	5	29	57
Food products	16	31	8	41	21	31	4	21	67
Beverages	9	-	17	40	38	-	5	31	95
Tobacco products	38	-	-	50	51	-	6	43	80
Textiles and related products	31	24	16	47	26	24	2	25	65
Wood and related products	17	14	13	31	19	14	4	18	66
Coke and refined	27	44	47	25	65	44	2	47	55
Rubber and plastic	20	24	16	48	28	24	7	26	54
Furniture and other prod.	21	19	21	37	20	19	4	20	63
Non-metallic mineral	27	22	15	61	29	22	4	28	69
Basic metals	19	23	15	31	24	23	8	23	51
Chemical prod.	35	36	30	53	40	36	9	38	43
Pharmaceutical prod	64	65	50	64	51	65	19	53	42
Electronic and optical	39	34	42	58	38	34	14	38	39
Electrical equipment	30	27	23	37	43	27	4	37	72
Machinery and equipment	28	30	17	40	39	30	8	35	54
Motor vehicles	40	46	34	36	42	46	8	40	40
Other Transport Equipment	43	42	56	64	53	42	4	49	54
Average	29	32	26	44	37	32	7	32	48
Coefficient of variation	45	40	59	27	35	40	68	49	-
Average LML	22	25	18	41	32	25	5	27	48
Cv LML	37	34	60	26	44	34	43	47	-
Average MHH	40	40	36	50	44	40	10	42	40
Cv MHH	30	32	40	25	14	32	59	36	-

	The acquisition of other external knowledge (EK)								
	Gr	Fr	It	Ne	Eu	Sp	Br	A[1]	CV[1]
Quarrying	33	17	5	17	25	-	12	22	45
Food products	32	15	9	17	21	2	12	19	71
Beverages	26	7	22	20	29	-	10	23	41
Tobacco products	38	-	-	-	-	-	13	17	113
Textiles and related products	22	14	13	17	22	2	10	19	67
Wood and related products	25	15	9	19	23	4	17	20	52
Coke and refined	35	33	14	-	62	44	11	45	76
Rubber and plastic	22	16	18	26	22	2	10	20	49
Furniture and other prod.	26	16	14	24	20	3	13	19	59
Non-metallic mineral	22	16	13	21	29	3	7	25	85
Basic metals	23	12	13	22	22	2	11	20	66
Chemical prod.	33	15	12	22	19	2	13	18	49
Pharmaceutical prod	34	44	23	23	37	4	11	32	46
Electronic and optical	30	20	19	18	29	3	21	26	53
Electrical equipment	33	16	15	25	28	3	13	25	55
Machinery and equipment	34	16	10	18	23	2	13	21	56
Motor vehicles	21	13	32	6	30	4	19	26	61
Other Transport Equipment	33	27	22	33	33	6	15	30	60
Average	29	18	15	20	28	6	13	24	47
Coefficient of variation	19	48	43	28	37	185	26	49	-
Average LML	28	16	13	20	27	8	11	22	48
Cv LML	21	41	36	16	46	187	22	49	-
Average MHH	31	22	19	21	28	3	15	26	47
Cv MHH	15	51	41	40	21	37	24	35	-

Notes: (1) The average and the Coefficients of Variation (CV) were calculated for all the countries of the European Union with information available in the CIS and from the PINTEC on Brazil. (2) The Eu represent 16 other countries of the European Union that are not listed in the table, but with information available in the CIS: Austria, Belgium, Bulgaria, Croatia, Slovakia, Slovenia, Finland, Hungary, Latvia, Malta, Norway, Poland, Portugal, Czech Republic, Romania, Sweden.

Source**:** Elaboration with the data from CIS (2009) and Pintec (2010)

However, we must make two other remarks. Firstly, our results show that the set of activities proposed for survey is also relevant to the MHH industries, usually with rates twice higher. In this sense, due to their general adoption by the enterprises that carry out innovative activities, these activities are indeed relevant. Secondly, the hierarchic classification of these activities depends on technical characteristics of each industry. For example, in the food industry (classified as LML), the activities related to the organizational and process innovation are more relevant (acquisition of machines, equipments and software - AMES, 76.7%), as relevant (training – T, 46.5%) our almost as relevant (industrial project and other technical preparations for production and distribution – PP, 32%) as internal R&D (46.3%). For being an intensive sector in scale that demands sophisticated internal and external organizational strategies (along the productive chain), this set of technical activities is essential. Furthermore, it is an industry in which the radical product innovations are not frequent (the product's cycle of life is long, in general) and most of the innovations is by products differentiation; thus, there is an expressive concentration (38%) of enterprises carrying out the activity of "introducing new technological innovations in the market (IM)", that is, related to the marketing activities. We point out that this activity is almost as spread in the LML industries as in the MHH ones.

Tables 2 and 3 show also that the sectorial innovation characteristics among the countries (analysis of the columns on the tables complemented with table 1) are not the same. Some countries have the innovative activities concentrated in different industries, a fact that can be linked to the institutional and structural conditions that can differentiate the technological development of each country[5]. In this sense, we can trace particularities between the technological activities of the countries. The countries holding advanced technical-scientific knowledge maintain rates comparatively higher in the different types of technological activities and in all industries – Germany is an exemplary case. The average RIAs decrease from a country to another allowing us to establish an almost perfect innovative hierarchy between them – Holland (despite the average level of RIA, all enterprises that carry out technological activities do it in an intense and generalized way in terms of industry and types of activities), France, Italy, etc. It is worth emphasizing that, in general, the "difference" between the countries occurs with a sharper reduction on the number of enterprises carrying out technological activities in the LML industries than in the MHH ones – this is the case, for example, of Italy. As this difference increases between the countries, the MHH activities are also reduced.

The compared examination of the coefficients of variation (CV) of the activities *vis-à-vis* the countries in tables 2 and 3 allows us to discover that there is a higher heterogeneity between the industries in different countries than between the industries in a same country concerning the adopting of different innovative activities. This characteristic may derive from an "innovative culture" more spread through the country and the differences in the national environment in the process of technological development. The Brazilian case is distinct. The percentage (RIAs) of enterprises with outlays in R&D (internal R&D), R&De (external acquisition of R&D) and EK (acquisition of other external knowledge) is significantly inferior to the other countries in the example – except for Bulgaria concerning the first type of activity, and Spain and

[5]Malerba (2002), Lundvall (1992), Nelson (1994), point to the local/national institutional structure as a factor that influences the technological development of the countries.

Norway concerning the third one. Moreover, the high coefficients of variation of the two first activities point to a very heterogeneous profile concerning the general average or to the two technological aggregates. To sum up, these activities are little practiced and very concentrated in a few companies, that is, the enterprise in Brazil are very little involved with the R&D activities characterized in a “conventional” way.

The innovative action of enterprises in the quarrying and transformation industries in Brazil is more expressive when linked to the activities related to the technological diffusion. If the internal R&D is just the fifth practiced technological activity, regardless the industry, the acquisition of machines, equipment and software (AMES) is pointed by the enterprises as the main form of innovation. Besides the Brazilian average being above the obtained for the example, this type of activity has a strong homogeneity, revealing one of the few cases in which the coefficient of variation (CV) is significant (according to the intervals adopted in this study). Also concerning the innovations of types T – training -, PP – industrial projects and other technical preparations for production and distribution – and IM – introduction of technological innovations in the market – the Brazilian averages are similar or little inferior to the international averages – despite the CV being a little above acceptable. According to Robertson and Patel (2007), this is a characteristic of technologically late regions or enterprises, a case in which the diffusion takes on a great importance to make up the technological catching-up.

4. Final considerations

This paper evaluates the characteristics of the technological innovation from the presupposition that this phenomenon is part of a process composed by different ways of production of technical-scientific knowledge and learnings. After a revision of the evolutionist bibliography, besides the “traditional” research and development (R&D), we added a broad set of activities developed in the scope of the company, linked to the incremental innovation, social interaction, diversification, user-producer relation, some of them closely related to the diffusion of technology.

This broader set of innovative activities allowed us to advance and complement the discussion in the process of innovation in the LML industries, besides confirming some of the “traditional” perceptions: (i) the companies in LML industries carry out less technological activities (they are less spread among the enterprises) than the MHH ones; (ii) the enterprises in the “more advanced” economies (superior technical scientific level) are more broadly linked to the innovative activities in their different forms than the “less advanced” economies. Furthermore, the proposed indicators point to a certain internal homogeneity in terms of technological activities in the economies with good performance in high technology sectors, that is, these activities are also more spread among the industries of low and average-low technological intensity. This fact seems to reflect the importance of institutional and structural factors in these countries.

However, we also observed that, in determinate countries, some LML industries have a higher percentage of enterprises involved with technological activities than the MHH ones. This result is apparently linked to countries with enterprises that are among the leaders in the international markets. In this sense, in determinate circumstances, the technological development can be “nucleated” in LML industries

From a set that attempts to include the diverse innovative dynamics of the different industries, we confirmed that the technological activities in BeMB industries are more focused in the acquisition of machines, equipment, software (AMES), followed by the internal R&D (R&D) and by the training activities (T). Concerning the MHH industries, the positions of the two first activities are inverted. However, despite being a set of countries with different levels of technical-scientific knowledge, all the activities are very relevant for all the industries, with special emphasis for these three.

The characteristics of sectorial innovation differ among countries, that is, there is a higher heterogeneity between the industries in different countries than between the industries in the same country. The Brazilian case is exemplary, for the percentage of enterprises with outlays on internal R&D is very low – it is only the fifth technological activity carried out by the enterprises – and the acquisition of machines, equipments and software (AMES) is pointed by the enterprises as the main form of innovation.

Malerba and Orsenigo (1997) examined the relations between patterns and innovative activities through the patent deposit in the American Patent Office (USPTO) and in the European Patent Office (EPO) for six developed countries (Germany, France, United Kingdom, Italy, Japan and EUA). The research begins with the argument that the "nature of the technological (and organizational) learning, interacting with the processes of market selection, define the specific regimens of industrial evolution, that, on their turn, generate observable empiric regularities" (Malerba and Orsenigo, 1997; 113) to conclude that: (1) the sectorial patterns for innovation are a function of some structural characteristics of technology – or, alternatively, there are sectorial patterns for innovation that are different through the sectors, but they "are *very invariable in different countries* for the same sector"; (2) some specific characteristics of learning processes (and knowledge accumulation) – or, alternatively, there are types of technological regimens – affect the specific pattern of innovative activities in a sector (Malerba and Orsenigo, 1997; 83 e 113; our italics).

The research results of these authors allow us to compare one of the results found in section 3. Pointing out that this study does not examines the innovation through innovative intensity (measured by the R&D outlays, patents, etc.), but evaluates the "culture and dispersion of the activities linked to innovation (number of companies involved in the different activities), it seems to endorse the second conclusion above, that is, the learning process influences the specific pattern of innovative activities in a sector – and, by extension, among the different sectors. However, section 3 above seems to contradict the first conclusion. If we relate the learning processes to the different types of innovative activities, than our results point to distinct sectorial patterns of innovation, especially when we compare countries in different stages of development (developed *versus* developing). Certainly a country like Brazil (and other countries with lesser degree of development), importing capital assets, that have in the acquisition of machines, equipment and software (AMES) the main source of innovation, has a capacity of producing and accumulating knowledge and producing technological innovation that is very different from other countries with relevant investments in "traditional" R&D. Thus, if the national industry is not satisfactorily compatible with the most advanced technologies, there are also differences between the sectorial patterns of innovation.

Finally, the indicators presented here must not be perceived as a rupture with the ones concerning R&D intensity from the "traditional perception". However, because they involve a broader set of innovative activities, our indicators allow a more detailed analysis and, because of that, more appropriate, of the innovation characteristics in the different industries and countries. In particular, these indicators seem more adequate to the examination of the innovation processes in the LML industries.

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