S1.1 History and conditions for success

Measuring technology-based MSMEs innovation rate in Brazil

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1. Introduction

Micro, small and medium-sized enterprises (MSMEs) have been for a long time the subject of attention from economic analysts because of their potential for income generation and employment (La Rovere, 2001) and, more recently, for their role in the reduction of regional inequalities.

Statistics about the importance of industrial MSMEs in Brazil, according to data from 2005 of the Brazilian Institute of Geography and Statistics (IBGE)[1], show that they account for 99% of the total number of companies in Brazil and are responsible for 56% of formal employment, generating around 24% of the gross value of the industrial production.

At the end of the twentieth century, the intensification of scientific and technological progress combined with the emerging globalization of the economy and the dissemination of new patterns of production management promised to radically change the basis of technical and industrial standards competition between companies in the world (Bernardes, 1998). According to scholars (e.g. Sbragia et al, 2004), such transformation actually occurred in industries that are in the technological frontier - aerospace, microelectronics, telecommunications, computers, fine chemicals and biotechnology - which constitute a significant portion of production in more advanced economies. According to these studies, producing technological advances in these sectors is the primary stage of the current competitive cycle, as well as innovation is the main product or service they sell.

A study by the Institute of Applied Economic Research (IPEA) (De Negri and Salerno, 2005), involving 72,000 industrial enterprises which account for about 95% of Brazilian industrial production, showed that companies that innovate and differentiate products generate higher quality jobs, employing better skilled workforce, better paid and more stable employment. Innovate and differentiate products allow companies to export more value-added products, obtaining price premium on its exports.

In this emerging new economy, a private group of companies has been increasing due to its important contribution to economic growth and job creation – the technology-based MSMEs. In fact, the sector where the company operates has an important role in the process of technological innovation: in the higher technological content sectors there are more opportunities for individual and collective innovations, while in those with a low content these opportunities have been more restricted (IBGE, 2007). As a general objective, this work aims to contribute with the knowledge about the Brazilian technology-based MSMEs. The specific objective is to develop a profile of technology-based MSMEs in relation to their innovation rate.

1.1. Motivation

The choice of technology-based MSMEs as an object of study can be justified by two

[1] All the acronyms used in this work are referent to the names in Portuguese, excepted by MSMEs.

arguments: (i) related to economic order - encouraging the creation of MSMEs is seen as one of the responses to the high rates of unemployment and economic stagnation (Lundstrom and Stevenson, 2002) and (ii) related to technological development, which highlights the growing importance of MSMEs in the process of generation and dissemination of technological innovations (Rothwell and Zegveld, 1982, ACS and Audretsch, 1990). For the complementary character of these two arguments, scholars (De Negri and Salerno, 2005) state that companies which innovate are different from their competitors, as well as more productive, have higher market shares, pay better wages and export more. In particular, the technology-based MSMEs differ significantly from MSMEs in general when it comes to efforts to innovate (Fernandes and Cortes, 1999; Fernandes, Cortes and Oishi, 2000, Fernandes et al., 2000).

1.2. Methodology

For the purpose, the research can be considered "descriptive" as taxonomies proposed by Vergara (2002, 2005) and Gil (1991, 1997). According to these authors, descriptive research has as its fundamental goal the description of the characteristics of a given population or phenomenon, or else the establishment of relations between variables. In descriptive research, there is no interference from the researcher, who only attempts to understand the frequency with which the phenomena occur. Such research may also establish correlations between variables and define its nature, but without the commitment of explaining the phenomena it describes (Vergara, 2002; Gil, 1991, 1997).

For the present work, literature and documental researches were carried out for the construction of the theoretical framework on the central themes. The theoretical framework served as a conceptual orientation, restricting the range of topics to be studied with conceptualization and classification, comprising the specialized vocabulary and organizing knowledge in structured concepts. Also, such theoretical framework allowed the establishment of specific sets of definitions and, finally, had the task of gathering briefly the state of the art on the object of study: technology - based MSMEs.

After establishing the theoretical framework, the work was developed according to the following steps: (i) special tabulations from the Brazilian Survey of Technological Innovation (PINTEC) have been requested to the IBGE according to the definition of the object of study, (ii) receiving and formatting of PINTEC data for later analysis, and (iii) analysis, interpretation and presentation of results.

It is important to highlight that PINTEC was chosen as the primary source of data because of its scope (national and sector coverage) and the possibility of a more dynamic longitudinal analysis than could be offered by alternative methodological strategies. The use of PINTEC data also presented the advantage of saving time and cost in comparison with the strategy of case study,

which would necessarily involve fieldwork.

2. Technology-based MSMEs

2.1. Micro, small and medium-sized enterprises (MSMEs)

The concept of MSMEs constitutes an important element in the formulation of public policies aimed at economic development (Filion, 1991). However, there is no single, universally-accepted criteria for classifying MSMEs. Different organizations classify companies according to different concepts to meet specific purposes.

Different criteria are therefore used in Brazil to establish the classification of MSMEs. For example, the simplified system of taxation (SIMPLES) adopts the criterion of gross revenue as required under the Act 11307/062[2], which provides that micro enterprise is one whose annual revenue is less than or equal to R$ 240 thousand[3] and small enterprise is one whose annual revenue is between R$ 240 thousand and R$ 2.4 million.

The Brazilian Service to Support Micro and Small Enterprises (Sebrae) and the National Bank of Economic and Social Development (BNDES) adopt different concepts for the classification of micro and small enterprises for the purpose of promotion. The first follows the criteria of the Statute of Micro and Small Companies, based on the number of employees and annual sales, while the second is based on gross operating revenues, as shown in Table 2.1.

Table 2.1 - Examples of industrial company classification according to their size

	Sebrae	**BNDES**
Micro	- Up to 19 employees - Annual revenue up to R$ 244 thousand	Gross operating revenue (annual or annualized) up to R$ 1.2 million
Small	- Up to 99 employees - Annual revenue up to R$ 1.2 million	Gross operating revenue (annual or annualized) over R$ 1.2 million and less than R$ 10.5 million
Medium	----------	Gross operating revenue (annual or

2 Available at: http://www.jusbrasil.com.br/legislacao/95780/lei-11307-06

3 U$ 1,00 = R$ 1,80

		annualized) over R$ 10.5 million and less than R$ 60 million
Large	----------	Gross operating revenue (annual or annualized) over R$ 60 million

Sources: Sebrae and BNDES[4]

In addition to the definition used for purposes of promotion, Sebrae adopted for study and research (eg: surveys on the presence of micro and small enterprises in the Brazilian economy) the concept of "employed persons"[5] in business, in accordance with the IBGE criterion, as shown below:

Table 2.2 - Base of definition IBGE/Sebrae

Company size	Industry	Services
Micro	up to 19 employees	up to 09 employees
Small	from 20 to 99 employees	from 10 to 49 employees
Medium	from 100 to 499 employees	from 50 to 99 employees

Sources: IBGE and Sebrae

The concept of MSMEs proposed by IBGE/Sebrae serve the purposes of this research given that: (i) ranks the medium enterprise without the need to consider the annual revenue, (ii) is used by the IBGE in order to produce Nationwide statistical studies, (iii) is used by Sebrae to operationalize its interventions at the micro and small enterprises and to accomplish its studies, and (iv) uses the number of employed persons, which tends to be an easier information to access (available on the RAIS in the Ministry of Labor and Employment[6]) than the revenue.

2.2 Technology-based MSMEs: Concepts and Definitions

There is also not a world consensus on the concept of technology-based companies. Starting with the name as known in the United States and Europe, particularly in the United Kingdom, NBTFs, which differs from "new technology-based companies" and "companies based on new technologies".

According to scholars (Rickne et al., 1999), a definition for NBTFs would be "a company whose strength and competitive advantage derived from the expertise of its members in the natural

4 Available at http://www.sebrae.com.br and http://www.bndes.gov.br

5 The concept of "employed persons" does not include only employees but also the owners. This concept does not differentiate the links between people working and businesses.

6 RAIS - Annual Social Information, available at http://www.mte.gov.br/rais/default.asp

sciences, engineering or medicine, and the subsequent transformation of this know-how into products or services to a market". NTBFs are said to operate in innovative and technology-intensive industries such as electronic engineering, computer science, physics engineering, industrial economics, chemical engineering, mechanical engineering, civil engineering and medicine. These industries are relatively homogeneous in terms of rapid technological changes, innovation of product, entrepreneurship, environmental uncertainty and high levels of competition (Karagozoglu et al, 1998, Preece et al, 1998).

Some key characteristics of NTBFs, identified by the Bank of England (Bank of England, 2001 apud Kiederich, 2007), are: (i) the value of NTBFs is dependent on the long-term potential growth, which is derived from the amount and quality of scientific knowledge and intellectual property that they have, (ii) at the beginning, the NTBFs lack of tangible assets that can be used as collateral, (iii) initially, the products developed by NTBFs have little or no track record, in majority have not yet been tested in the market and are usually subject to high rates of obsolescence.

Brazilian studies (Carvalho et al, 1998) identified as “EBT” (acronym in Portuguese for technology-based companies) the enterprises "engaged in the design, development and production of new products or processes, also characterized by the systematic application of technical and scientific knowledge (applied science and engineering).

According to Marcovitch et al (1986), high-tech companies "are those created to make products or services using high-tech." Analysing the definition originally proposed by these authors, Iron and Torkomian (1988) suggest individualize with this concept those companies that "have the rare or unique expertise in terms of products or processes that are commercially viable, that incorporate high level of scientific knowledge". Stefanuto (1993), in turn, proposes to consider EBT those national companies that, in each country, are among the technological frontier of its sector.

According to Fernandes et al (2004), if a profile of Brazilian technology-based MSMEs could be set, a starting point would be to consider the historical and geographical constraints to which they are exposed. This means recognizing the limits that these companies face in access to knowledge, markets and credit at a particular time, under the constraints of a given macroeconomic environment. Such limits are set in the context of a national innovation system less dynamic than that in which operate their American, European or Japanese competitors on the one hand, and a macroeconomic environment of restricted associations between financial capital and productive capital on the other.

For these authors, this assumption necessarily requires the translation of the understanding of the concept of “technology-based company” used in developed countries for the specific

conditions of a developing country. Thus, Fernandes et al (2004) suggest that there should be a differentiation between modernized and technology-based companies. According to these scholars, "the strategically critical character that technology has for this group of companies indicates that their innovative effort should be guided not exactly to the technological modernization of the production process, but essentially to the product characteristics: technology-based company introduces new products that reflect new technologies developed by the company, whether or not in partnership with other companies or research centers" (Fernandes et al, 2004). Moreover, the authors add that this product must be in the market and be economically viable, or is it just an invention, an applied scientific knowledge.

Pinho (2006), in its report on EBT industry, confirms this view by holding that "in the EBT, innovation can not be a central tenet of competitive strategies. In its characterization should be included the presence of significant results in terms of product technology". The author also argues that activities can be distinguished between innovative and "modernized". It means that companies with significant technology efforts but aimed at the modernization of operations are not geared to generation of product innovations. With this, the author states that in this way, it is possible to separate the companies whose dynamics is given by technological innovation and those whose dynamics is defined by activities in areas where the movement of the boundaries is slower, even though the technology in these areas is dense and sophisticated.

In a perspective that seeks to differentiate the EBT of the companies those operating purely modern or technologically dense but not necessarily dynamic processes, EBT would be defined, according to Fernandes et al (2004), as those companies that: (i) carry out significant technological efforts and (ii) focus its operations in the manufacture of new products. Table 2.3 below, seeks to highlight this difference.

Table 2.3 - Identification of technology-based companies

	Highest rate of product innovation	**Lowest rate of product innovation**
Highest technological effort	**EBT** (or high technological intensity and dynamism companies)	Modernized but not dynamic companies
Lowest technological effort	Productive companies (companies that produce, for example, light immature consumer goods)	Traditional companies in mature sectors

Source: Department of Technology Management / UFSCar in Fernandes et al (2004)

According to these scholars, one additional aspect that must come out for the purpose of this work is the fact that the activities of R&D and technological efforts of firms are relatively more concentrated in those sectors of greatest intensity and technological opportunities[7].

The literature on technological development of industry has long recognized that industrial sectors differ in terms of their use of technological resources (Pavitt, 1984). According to Cassiolato and Lastres (2000), the difficulties of establishing clear boundaries between economic activities that increasingly intermingle and classify them within strictly "sector" limits have been increasingly recognized. But the relative intensity of innovative efforts by the various "sectors" of the economy is fundamental to the formulation of industrial policy and innovation. Therefore, it is necessary a vision based on the spending on R&D on sales (or any other performance variable) indicator, which involves intensive technological dynamism with this variable.

The Organization for Economic Cooperation and Development (OECD) developed a taxonomy[8] of technological intensity in classifying industrial activities based on set of indicators: (i) expenditure on R & D / value added, (ii) expenditure on R & D / production; (iii) expenditure on R & D plus technology embodied in intermediate goods and capital / output (Hatzichronoglou, 1997)[9]. Based on this methodology were established four main groups of technological intensity[10]:

- high-technology: aerospace, pharmaceutical, computer, electronic and telecommunications instruments;
- medium-high technological intensity: areas of electrical equipment, motor vehicles, chemicals (excluding pharmaceuticals), and rail transportation equipment, machinery and equipment;
- medium-low technological intensity: naval construction, rubber and plastic products, coke, refined petroleum products and nuclear fuel, other non-metallic products, basic metal and metal products;
- low technology: other industries and recycling, wood, pulp and paper, publishing and printing, food, beverages and tobacco, textiles and clothing, leather and footwear.

7 According to Valério Netto (2006), the segment of technology-based companies are scattered in various sectors such as aerospace and defense, new materials, electronics and technological information, telecommunications, fine chemicals, precision engineering, optics and instrumentation, and industrial automation.

8 An alternative perspective to the OECD taxonomy was developed by Pavitt (1984). The taxonomy of companies built by Pavitt used innovative patterns in industries to distinguish them in four sectors: 1) dominated by suppliers, 2) with large-scale production, 3) with specialized suppliers and 4) based on scientific knowledge.

9 It is important to highlight that there is a great variability in the national behavior in terms of R&D efforts. The numbers that led to the construction of the OECD taxonomy relied on the aggregate spending of a number of countries belonging to the organization. Often, however, national behaviors are out of this average.

10 Source: OECD: ANBERD and STAN databases, May 2003.

More recently, Brazilian scholars, for example Quadros and Furtado (2005), argue that the classification of sectors according to the intensity of R&D has different meanings in a developed country from those assumed in developing nations. The classification used by OECD is supporting the behavior of the industry average, representing the overall dynamics of the global technological frontier. In the case of a developing country, these authors suggest that a lower average level of technological effort and a much more homogeneous behavior across sectors would be expected. However, so far, official studies on the subject and the data available for research, such as those presented and analyzed in PINTEC 2005 (IBGE, 2007), use the taxonomy developed by the OECD. This taxonomy will be used in sequence to configure the technology-based companies that are the object of this study.

A recent survey carried out by Fernandes et al (2004) in technology-based companies in the State of São Paulo found a high concentration of companies surveyed in two sectors of the CNAE[11] classification: (i) manufacturing of medical equipment and precision instruments and industrial automation (CNAE 33, with 41.4%), and (ii) computer-related activities (CNAE 72, with 20.7%). Together, these two sectors account for almost two thirds (62.1%) of the sample, thus indicating a high concentration of industry in which the CNAE 33 sector is, prominently, the most responsible.

Additionally, the results of a survey on EBT in Brazil (Pinho, 2006) converge with the results mentioned above. In this survey, the two sectors with the largest weight in the sample are arguably the manufacture of medical equipment, precision instruments and industrial automation equipment (division CNAE 33), and computer-related activities (division CNAE 72). Each of these sectors account for about one third of the sample in number of companies, slightly more than that in terms of workforce and a little less when it comes to revenue.

Those sectors, which in the results of the researches above mentioned constitute together the majority of EBT (Division CNAE 33 and Division CNAE 72), are classified as high and medium - high technological intensity in the taxonomy of the OECD.

Based on this discussion, for the purposes of this research, the EBT are defined as companies in the high and medium-high technological intensity sectors, according to the taxonomy of the OECD (OECD, 2003).

3. Technological innovation

3.1. Analytic framework

The literature has emphasized the central role of innovation in knowledge-based economy. At

11 National Classification of Economic Activities

the macro level, reports a significant body of evidence that innovation is the dominant factor in national economic growth and patterns of international trade. At company level, experts point out that research and development (R&D) are perceived as the factor of greatest capacity to absorb and use new knowledge of all kinds, making innovative companies more productive and more successful than those that do not invest in the generation of innovations (OECD, 2004).

Although the role of innovation in the development has reached consensus on a global level, the processes that generate innovation and its economic and social impacts are not yet sufficiently studied and understood. The term innovation has different meanings in different contexts and its definition should be developed according to the particular objectives of the analysis or measurement to be achieved (OECD, 1997).

A summary of the main conceptual approaches to technological innovation, developed from reviews carried out by Brazilian researchers (Meirelles, 2008, Conde & Araújo-Jorge, 2003, and Alves, 2003) and the Oslo Manual (OECD, 2004) is presented as follows. Based on this framework, the concept of innovation that will be adopted in this study is defined.

According to Schumpeter (1934), the concept of innovation encompasses five distinct types: (i) introduction of new products that may be new to consumers, or new items to match the quality of an existing product, (ii) introduction of new production methods, which have not been tested in the company's field of business, that is not necessarily a scientific discovery, (iii) opening new markets, where other companies in the same line of business have not yet entered, and such markets have existed before or not, (iv) development of new sources providers of raw materials and other inputs, (v) establishment of a new industrial organization, either by creating a monopoly or by fragmentation of a monopoly.

From the early 80's, the evolutionary approach (Nelson & Winter, 1982) consider the "innovation as a process" through which knowledge and technology are developed based on the interaction between various actors and factors. According to these authors, the market demand and marketing opportunities have an influence in the products to be developed and the technologies that will be successful (Meirelles, 2008).

In this context, emerged in the 90's the concept of innovation systems (Lundvall, 1992, Nelson, 1993), that studies the influence of external institutions, defined broadly, about the innovative activities of enterprises and other actors. In considering the "innovation as a system" the authors emphasize the importance of the transfer and dissemination of ideas, experiences, knowledge, information and signs of various kinds. Innovation is seen as a dynamic system in which knowledge is accumulated through learning and interactions between the institutions

involved. Also emphasize the importance of the conditions, regulations and policies in which the markets operate and the role of governments, particularly the regulatory agencies, to monitor and seek to harmonize the functions of the overall structure. These concepts, introduced as the national systems of innovation, can also be applied to regional and international systems.

The concept of "technological innovation" by the Oslo Manual, in its third edition, is "the implementation of a product (or service) new or significantly improved, or a process or a new marketing method, or a new organizational method in business practices, the organization of the workplace or external relations" (OECD, 2004, p.55). Regarding to this concept, there are four types of innovation: product, process, marketing and organizational. This classification has the highest possible degree of continuity with the previous definition of product and process innovation used in the second edition of the Oslo Manual: "technological product or process (TPP - Technological Product and Process) will cover deployments of products or processes technologically new and substantial technological improvements in products and processes "(OECD, 1997). In order to consider a TPP innovation implemented it is necessary that this have entered the market (product innovation) or used in the production process (process innovation).

The general concept of innovation used in the second edition of the Oslo Manual refers to product or process that is new or substantially improved for the company, not necessarily new to the market or industry in which it operates. Within a more rigorous analytical perspective, Schumpeterian, should not be considered as such innovations the products and processes that are only new for the companies in which they were introduced. These products and processes should be classified as technological diffusion and absorption of innovations.

Having as a research object the technology-based MSMEs, this work adopts the more stringent concept of innovation: “the product (or service) technologically new or significantly improved for the domestic market and / or processes that are technologically new or significantly improved for a particular industry." When compared to the generic concept, this definition has a higher meaning in their impact in terms of gains in competitiveness and accumulation of technological capabilities for technology-based MSMEs that introduced them.

3.2. Innovation Models

The complexity of the processes that integrate the activities of C, T & I and the multiplicity of connections between its different elements have stimulated proposals for simplified models of these processes that are able to identify causal relationships between science, technology, economy and society. In this context, partial theoretical schemes that link the innovation to the economy have been used as models (Sirilli, 1998).

The linear model, which emerged from the end of the 2nd World War, dominated the

thinking about innovation in S & T for about three decades (Bush, 1945, quoted in Earl and Araújo-Jorge, 2003). In this model, development, production and commercialization of new technologies are seen as a sequence of stages: (i) scientific research that could lead to processes of invention, (ii) applied research, (iii) experimental development, (iv) production, (v) introduction of marketable products and processes (OECD, 1992).

The linear innovation approaches rely on two theoretical frameworks: (i) the classical theories, which treat innovation mechanistically from endogenous variables to businesses and as a product of internal processes, (ii) the neoclassical theories, which try to incorporate the external forces and assign technical change to external factors (Ebner, 2000, Jackson, 1999 cited in Earl and Araújo-Jorge, 2003).

The limitations of the linear model were perceived by the fact that investments in R&D does not automatically lead to technological development or the economic success of the use of technology. This perception reinforced the emergence of non-linear or interactive approaches.

From the 1980s, the interactive model (chain-link model) proposed by Kline & Rosenberg (1986) became the model that was opposed to the linear model. Its design combines the interactions in the internal environment of business and those between the individual companies and the system of science and technology more generally, in which they operate.

In recent decades, the analysis of interactions between the different actors of innovation processes has become the focal point of many theoretical and empirical studies of the area of economics of innovation (Nelson & Winter, 1982; Dosi, 1988, Lundvall, 1988). These approaches (evolutionary or neo-Schumpeterian) recognize the importance of R&D in the innovation process and emphasize the central position occupied by companies in developing new technologies. From this perspective, organizational and learning factors (learning-by-doing) have great prominence. Innovation process involves a series of scientific, technological, organizational, financial and commercial activities. The central feature of the innovation process in interactive models is the existence of cycles of learning between research activities, production and marketing businesses.

Following the development of evolutionary approaches, due to the resilience of the linear model of innovation, emerges the concept of "national system of innovation" (Lundvall, 1988). Widely adopted in the documents and studies by the OECD and the Brazilian government proposals, this concept has been used on two levels: (i) as proposed analysis, to identify the networks of interrelationship between the institutions of public and private sectors involved in the generation and dissemination of innovations and (ii) as a policy instrument to promote such relations.

A review of the literature on innovation systems driven by Senker et al. (1999) indicates that this concept does not qualify as a formal theory, but as a conceptual framework for analysis of factors influencing the innovation capacity of enterprises. In its most simplified version, it focuses on the institutional actors involved in the production and dissemination of new knowledge. In the wider version, it includes the system of R & D, the role of the public sector, including public policies, the national technological infrastructure, the relationships between businesses, the financial system, the education and training of human resources and organization of domestic firms.

The literature also provides some non-linear approaches or models of the innovation process that dialogue among themselves and with the previous ones. Among them are: (i) the Triple Helix model, designed by Etzkowitz & Leydesdorff (2000). (ii) the "Mode 2" of knowledge production (Gibbons et al., 1994), (iii) the "the post-modern research systems" (Rip and Van der Meullen, 1996) and the "research systems in transition" (Cozzens et al. 1990; Ziman, 1994).

It is noteworthy that these models form the basis of a framework for measuring innovation used in the Oslo Manual and, therefore, in the Technological Innovation Survey (PINTEC) - the primary source of data for this study.

The measurement framework proposed in the Oslo Manual (OECD, 2005, p.42) includes views of various theories of innovation-based company (Nelson & Winter, 1982; Rosenberg 1982; Dosi, 1988) with approaches that take innovation as a system (Lundvall, 1988) The main features of this structure are: (i) innovation in the enterprise, (ii) interactions with other firms and research institutions, (iii) the institutional framework in which companies operate and (iv) the role of demand (OECD, 2005).

3.3. Measurement

According to Viotti (2003), the measurement of Science, Technology and Innovation (S, T & I) is essential for better understanding and monitoring the production processes, dissemination and use of scientific knowledge, technologies and innovations. The author highlights in three dimensions the reasons for the importance of measurement of S, T & I, namely: (i) scientific - search for and understanding of factors determining the processes evaluated, particularly the possibility of establishing relations between technical change, growth and development; (ii) policy - the use of indicators of S, T & I as tools for the formulation, monitoring and evaluation of public policies; (iii) business - support the definition and evaluation of technology strategies, such as the ability to identify technological opportunities and support investment decisions based on these indicators.

From the 90's, international instruments for measuring and analyzing the R&D and innovation activities have been created, reviewed and updated as a result of new approaches and models for the analysis of innovation (Conde and Araújo-Jorge , 2003). Among these instruments,

the manuals of the "Frascati family" and those belonging to the series "The Measurement of Scientific and Technological Activities", OECD: the Canberra Manual (1995) and the Oslo Manual (1997) can be highlighted. For the purposes of this work, the Oslo Manual, which formes the conceptual basis of the primary source of research data, is presented in more detail.

Dedicated to the measurement and interpretation of innovation, the Oslo Manual[12] was originally published in 1992, had a second edition in 1997 and most recently, the third edition published in 2005. This manual aims to "provide guidelines for the collection and interpretation of data on innovation. Data on innovation may have many uses and the Handbook is designed to accommodate these uses. One reason for the collection of innovation data is to better understand these activities and their relationship with economic growth. This requires expertise in innovation activities that have direct impact on company performance (for example, increased demand or reduced costs), and the factors that affect its ability to innovate. Another purpose is to provide indicators to collate national performance with best practices" (OECD, 2005, p 19). Based on the neo-Schumpeterian and the systemic approach of innovation, the Oslo Manual focuses on innovation processes at company level. Innovation is assessed on the interactions between market opportunities and the knowledge base and skills of companies.

According to the Oslo Manual (OECD, 1997), the main reason for conducting research on innovation in developing countries is the provision of grants for the design of public policies and the formulation of business strategies, with the main focus of the generation, dissemination, appropriation and use of new knowledge in business.

Because of the possibility to know and follow the development of indicators, the results of research on innovation can be used by various actors, namely: (i) companies - to serve the purpose of market analysis and development of their technology strategies; (ii) associations - for longitudinal studies on sector performance and other characteristics of the investigated sectors, (iii) government - to formulate and evaluate national and regional policies to support innovation in enterprises, universities and scientific and technological institutions (STIs) .

In Brazil, the main survey on innovation with national coverage is the *Pesquisa de Inovação Tecnológica* (PINTEC) undertaken by the Brazilian Institute of Geography and Statistics (IBGE), with the support of the Studies and Projects (FINEP) and the Ministry Science and Technology (MCT). Following the conceptual framework of the Oslo Manual, the information available at

12 Translated in 2004 under the responsibility of FINEP, the original editions were published in English and French, respectively under the titles: The Measurement of Scientific and Technological Activities - Proposed Guidelines for Collecting and Interpreting Technological Innovation Data: Oslo Manual / La mesure des activités scientifiques et technologiques - Princes directeurs proposés pour le recueil et l'interprétation des données sur l'innovation technologique: Manuel d'Oslo (the third edition of the 2005 updated edition 1997).

PINTEC focus on technological innovation of products and processes and adopted the approach of "subject". It means that the information obtained is related to the companies' behavior and the undertaken activities, the impacts and the factors that influence the company as a whole (IBGE, 2007).

4. Technological innovation in Brazilian technology-based MSMEs

4.1. Technological Innovation Survey (PINTEC): primary data source

PINTEC is a satellite survey of the System of Economic Statistics from IBGE. Its main goal is to gather information of technological innovation in Brazilian companies on different aspects. Such information enables the development of sector indicators with international comparability. These indicators are based on tools that help companies in defining their strategies and contribute to the development and implementation of government policies (IBGE, 2006).

This survey covers all enterprises employing 10 or more persons, holding registration in the National Register of Legal Entities of the Ministry of Finance (CNPJ) and that are classified as industrial companies at IBGE, according to the National Classification of Economic Activities (CNAE)[13]. Within the other IBGE surveys covering the mining and processing (PIA)[14] and the telecommunications and technology information services (PAS)[15], PINTEC has broad analytical potential.

In its structure, PINTEC part of a conceptual basis, consistent with international recommendations, which allows information comparability with internationally accepted references. Its conceptual and methodological reference is the Oslo Manual (OECD, 2005) that provides specific guidelines and procedures for registration and interpretation of data related to technological innovation.[16] More specifically, PINTEC was inspired by the harmonized[17] model proposed by Eurostat[18]: the third and fourth version of the Community Innovation Survey (CIS). Regarding to the analysis of technological intensity, PINTEC uses the taxonomy of the Organization for Economic Cooperation and Development (OECD).

13 The PINTEC's reference of activities classification is CNAE 1.0 sections Extractive Industries and Processing Industries (C and D, respectively), Telecommunications group (64.2) and divisions of Computer-related Services and R&D (72 and 73, respectively).

14 PIA, Annual Survey of Industry, aims to identify the basic structural characteristics of the business segment of industrial activity in the country and its changes over time. Available at: http://www.ibge.gov.br/home/estatistica/economia/industria/pia/empresas/default.shtm.

15 PAS, Annual Survey of Services, aims to identify the basic structure of the non-financial business services in the country, their spatial distribution and monitoring of its changes over time. Available at: http://www.ibge.gov.br/home/estatistica/economia/comercioeservico/pas/pas2006/default.shtm

16 The latest version of the Oslo Manual is its 3rd edition, 2005.

17 Standard questionnaire for all countries, with set of definitions and methodological recommendations, respecting the Oslo Manual, basically with degrees of freedom for other questions / populations.

18 Statistical Office of the European Commission, site: www.ec.europa.eu/eurostat.

Up until now, IBGE performed three studies: PINTEC 2000, PINTEC 2003 and PINTEC 2005. The first covered the triennium 1998-2000, the second the period 2001-2003 and the third 2003-2005. From the PINTEC 2005, the universe of research of the survey was expanded to include, in addition to the activities of mining and processing, the named high-technology services: research and development (R&D), telecommunications and computer-related services.

PINTEC has great scope covering a group of 100,657 industrial, telecommunications, computer-related services and R&D companies between 2003 and 2005. In this period, the industry sample size was approximately 12 thousand companies, a fraction of about 12% of the population of the Brazilian registered industrial companies. For groups of telecommunications companies (Division CNAE 64.2) and companies operating in IT and related services (division CNAE 72), the sample covered 704 companies, representing a fraction of 17% of the population of registered companies. For groups of firms in the R & D division (CNAE 73), the survey covered 89 companies.

The data, information and indicators of PINTEC cover more than 150 items, including qualitative and quantitative variables. Overall, the questionnaire includes 196 questions that cover various dimensions of the innovation process. The information requested are relate to the following attributes: (i) characteristics of the company, (ii) product innovations and / or implemented process (incomplete or abandoned), (iii) innovative activities undertaken, (iv) expenses for these activities, (v) financing of these expenditures, (vi) the character of internal R & D (vii) number and skill of people involved in innovation activities, (viii) time of the dedication of those involved with innovation activities, (ix) impact of innovations in business performance, (x) sources of information, (xi) cooperative arrangements established with other organizations, (xii) the role of government incentives, (xiii) patents and other protection methods, (xiv) obstacles to innovation activities, and (xv) strategic and organizational changes undertaken during the study.

4.2. Research Object

According to PINTEC, two factors significantly interfere with the rate of innovation and investment in technological activities: the size of companies and the sector of activity in which they are included.

Taking these factors into consideration and based on the theoretical framework, the following considerations were made in order to compose the desired object of study:

i) To separate the firms according to their size, the base of definition IBGE/Sebrae was adopted. This proposed classification, according to the benefits explained in Chapter 2, is particularly useful for the purpose of carrying out studies and researches which aim to produce results that can support mechanisms and instruments of public policies in Brazil. In

addition to other studies that also use the IBGE/Sebrae definition, this work aims to contribute with the formation of a body of knowledge about MSMEs in Brazil.

Regarding to this company size classification, the limitation of the database (PINTEC) for the purpose of this study must be highlighted: the survey conducted by PINTEC does not include companies with fewer than 10 employees[19].

ii) regarding to the sector of activity, according to the concepts presented in Chapter 2, to compose the object of study were considered those sectors classified as high and medium-high technological intensity sectors in the OCDE taxonomy. For the purposes of this study, the companies included in these sectors are considered the technology-based companies. In the context of PINTEC, companies included in the high and medium-high technological intensity sectors have high innovation rates (IBGE, 2005 and 2007).

Additionally, in order to obtain the innovation rate of the technology-based MSMEs, was necessary creating two distinct groups:

Group 1: technology-based MSMEs that implemented technological innovation;

Group 2: technology-based MSMEs that did not implement technological innovation.

According to the criteria adopted by PINTEC, to consider that a company implemented technological innovation in the period of analysis, it must have carried out at least one innovative activity in this period.

The innovative activities are defined by PINTEC as the effort done by companies in order to develop and implement product (or service) technologically new or significantly improved. These activities hold all the scientific, technological, organizing and commercial steps, including the investment in new knowledge that target product or process innovation. This means that innovative activities are those necessary activities to the development and implementation of product (or service) technologically new or significantly improved (IBGE, 2006). According to PINTEC, the innovative activities are: research and development; acquisition of external R&D; acquisition of external knowledge, software, machines and equipments; industrial project and other technical preparation for the production and distribution; training and introduction of technological innovation into the market.

The criterion adopted to separate the technology-based MSMEs according to the two groups mentioned above ignored the activities of machinery and equipment acquisition, training and software acquisition as innovative activities. This is related to the understanding about the lower

19 PINTEC strictly follows the Oslo Manual recommendation for the classification of statistical units by size, which means to take in consideration companies from 10 employees.

technological dynamism of the developing countries economy. At this point, the study would have to reflect the understanding that innovation activities in these countries are more related to the dissemination, adaptation and improvement of existing technologies, as proposed by Bell & Pavitt (1993). However, this study should be able to distinguish the modernized company to the technology-based company (EBT), as presented in Chapter 2. Thus, to emphasize the EBT, the activities of software and machinery and equipment acquisition were not considered as innovative activities carried out by companies.

Thus, in the context of this work, technology-based MSMEs included in the Group 1 (technology-based MSMEs that implemented technological innovation) are those that fit the following criteria in the period of analysis:

1) introduced product (or service) technologically new or significantly improved to the domestic market or to a certain sector in Brazil; and

2) developed at least one of the following innovative activities:

- research & development (R & D);
- acquisition of external R & D;
- acquisition of external knowledge;
- introduction of technological innovations into the market;
- industrial project and other technical preparations for the production and distribution.

After the study object has been set, a request for special tabulations was carried out to the Industry Coordination of the IBGE, responsible for PINTEC.

4.3. Brazilian technology-based MSMEs innovation rate

According to the definition of the object of study, data were lifted from the three PINTEC editions (2000, 2003 and 2005). Table below shows the profile of Brazilian technology-based MSMEs.

Table 4.1 - Brazilian technology-based MSMEs identified in the universe of companies participating in PINTEC

	1998-2000		2001-2003		2003-2005	
industrial EBT	Group 1	Group 2	Group 1	Group 2	Group 1	Group 2
Micro	505	3841	341	5154	502	5416
Small	848	4012	432	5956	653	6402
Medium	378	1122	199	1383	300	1410
MSMEs	**1731**	**8975**	**972**	**12493**	**1455**	**13228**
	10706		**13465**		**14683**	

Services EBT	Group 1	Group 2
Micro	-	-
Small	338	3265
Medium	78	227
MSMEs	**416**	**3492**
	3908	

Source: Own elaboration from special tabulations based on PINTEC 2000, 2003 and 2005 editions.

The data in the table 4.1 lead to the following observations:

- increasing in the number of industrial technology-based MSMEs in the period 1998-2005: an evolution from 10,706 (1998-2000) to 13,465 (2001-2003) and 14,683 (2003-2005);
- inclusion of some service sectors in the PINTEC 2005: 3,908 service technology-based MSMEs were registered in the period 2003-2005;
- growing number of companies that did not implemented innovation: evolution from 8,975 (1998-2000) to 12,493 (2001-2003) and 13,228 (2003-2005).

For all periods can be observed that micro and small businesses[20] account for the majority of the technology-based MSMEs. It is worth remembering that, as discussed in before, PINTEC does not cover services technology-based micro enterprises, characterized by having up to 09 employees.

Table 4.2 shows the innovation rates (number of companies that implemented innovation on the total business) of Brazilian technology-based MSMEs for the period 1998-2005.

Table 4.2 - Technology-based MSMEs innovation rate

EBT	1998-2000	2001-2003	2003-2005	2003-2005 (services)
Micro	11,6 %	6,2 %	8,4 %	_
Small	17,5 %	6,8 %	9,3 %	9,4 %
Medium	25,2 %	12,6 %	17,5 %	25,6 %
MSMEs	16,2 %	7,2 %	9,9 %	11,9 %

Source: Own elaboration from special tabulations based on PINTEC 2000, 2003 and 2005 editions.

20 According to the basic definition used in this study, micro and small industrial enterprises are up to 99 employees and service companies up to 49 employees.

The analysis of table 4.2 reveals that in the period 1998-2000 the percentage of industrial firms that implemented innovation was 16.2%, falling to 7.2% from 2001 to 2003 and experiencing a slight recovery to 9.9% from 2003 to 2005. It is important to highlight the sharp decline in the period 2001-2003. Compared to the previous period, a reduction to almost half in number and less than half in the percentage of companies that implemented innovation[21]. With regard to service companies, 11.9% implemented innovation in the period 2003-2005, a percentage slightly higher than in industrial firms in the same period.

In order to contextualize the Brazilian technology-based MSMEs, the results presented in the table 4.2 were compared, for the periods 2001-2003 and 2003-2005, with the equivalent results of PINTEC (new product for the domestic market and new process for the sector in Brazil), presented in the table 4.3.

Table 4.3 - Percentage of Brazilian industrial firms that implemented innovations, according to groups of employed persons[22]

Employed persons	Innovation rate		Product		**Product new to the domestic market**		Process		**Process new to a sector in Brazil**	
	2001-2003	2003-2005	2001-2003	2003-2005	**2001-2003**	**2003-2005**	2001-2003	2003-2005	**2001-2003**	**2003-2005**
Total	33.3	33.4	20.3	19.5	**2.7**	**3.2**	26.9	26.9	**1.2**	**1.7**
10 to 49	31.1	28.9	19.3	17.0	**2.1**	**2.1**	24.8	23.1	**0.7**	**0.9**
50 to 99	34.9	40.6	19.1	22.8	**2.3**	**3.7**	28.6	33.2	**0.8**	**1.2**
100 to 249	43.8	55.5	25.3	31.1	**3.9**	**6.5**	37.7	44.8	**1.7**	**3.8**
250 to 499	48.0	65.2	28.4	35.9	**5.8**	**9.4**	38.8	56.0	**3.4**	**6.1**
500 and more	72.5	79.2	54.3	58.1	**26.7**	**33.4**	64.4	68.4	**24.1**	**27.1**

Source: IBGE, PINTEC 2003 and PINTEC 2005

The comparison reveals that the innovation rate of industrial technology-based MSMEs (7.2% in 2001-2003 and 9.9% in 2003-2005) is almost the double of the "equivalent innovation rate" for all companies taking part in PINTEC (3.9% in 2001-2003 and 4.9% in 2003-2005). This "equivalent innovation rate" correspond to "new product for the domestic market or new process for the sector in Brazil." This finding is even more significant when we pay attention to the universe of

21 This study does not address aspects of macro-economic nature, which could explain the significant reduction in the innovation rate in the period 2001-2003.

22 PINTEC classification of firms by size employed by the presentation and analysis of results differs from the classification adopted in this work. For PINTEC favors comparability with the results of other national surveys of innovation that adopt a different classification.

analysis PINTEC, which includes companies with more than 500 employees.

5. Conclusions

The aim of this work was to contribute to the knowledge about the Brazilian technology-based MSMEs presenting a profile of Brazilian technology-based MSMEs in relation to their innovation rate. In order to reach this goal the research made several methodological and analytic choices which constitute significant contributions to the analytic literature on the topic.

In order to achieve this goal, first, the research proposed a division of the firms according to their size, and the definition of IBGE/Sebrae was adopted. Here is important to highlight that this criteria is particularly useful for the purpose of carrying out studies and researches which aim to produce results that can support mechanisms and instruments of public policies in Brazil. Next, the research considered as technology-based MSMEs those included in the high and medium-high technological intensity sectors, according to the OECD taxonomy. Fourth, a strong concept of innovation was adopted: “the product (or service) technologically new or significantly improved for the domestic market and / or processes that are technologically new or significantly improved for a particular industry". When compared to the generic concept, this definition has a higher meaning in their impact in terms of gains in competitiveness and accumulation of technological capabilities for technology-based MSMEs that introduced them. Finally, the criteria for defining a technology-based MSMEs that implemented innovation in the period was those that introduced product (or service) technologically new or significantly improved to the domestic market or to a certain sector in Brazil; and developed at least one of the following innovative activities: research & development (R & D); acquisition of external R & D; acquisition of external knowledge; introduction of technological innovations into the market; industrial project and other technical preparations for the production and distribution.

On the basis of these, the research produced with on data from a special tabulation of PINTEC data, a pioneering profile of Brazilian technology-based MSMEs was set. Further, a comparative analysis between the innovation rates of the technology-based MSMEs and those of the universe of industrial companies PINTEC "New product for the domestic market or process new to the sector in Brazil demonstrated the suitability of the criteria adopted for defining the object of study: rates of innovation displayed by the technology-based MSMEs are almost twice (7.2% and 9.9% respectively in the periods 2001-2003 and 2003-2005) displayed by the universe of companies PINTEC.

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