"Paraná's Innovation Index (IPrI)": an initiative for the development and evaluation of innovation in industry

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Abstract

The article describes the process of building a measurement system for innovation in industry – the Paraná's Innovation Index (IPrI). Conceived in 2009 by the Federation of Industries of the State of Paraná System (Fiep System) and developed by National Service for Industrial Apprenticeship of Paraná (Senai/PR), this metrics integrates a project that encourages innovation in the state's manufacturing industries. The IPrI's approach to innovation is developed under a complementary procedural understanding between three theoretical pillars: 'Efforts', 'Management' and 'Results'. Conceptually structured this way, the measurement system was developed through qualitative weight assignment to the indicators distributed in these pillars by experts. Application of weighted arithmetic mean led to the index. The index contributes to theoretical and practical advances in the subject, and its results enabled understandings regarding the innovative behavior of the participating industries of Paraná, the ranking of the most innovative industries and their georeferenced localization in the state.

Keywords: Evaluation system; innovation status; manufacturing industries; Paraná's Innovation Index (IPrI).

Resumo

O artigo relata o processo de construção de uma métrica para avaliação da inovação na indústria – o Índice Paranaense de Inovação (IPrI). Concebido em 2009 pela Federação das Indústrias do Estado do Paraná (Fiep) e desenvolvido pela Serviço Nacional de Aprendizagem Industrial no Paraná (Senai/PR), a métrica integra um projeto de incentivo a inovação nas indústrias de transformação do estado. O IPrI abordou a inovação sob um entendimento processual complementar entre 'Esforços', 'Gestão' e 'Resultados', enquanto pilares teóricos. Estruturada conceitualmente dessa forma, a métrica foi desenvolvida mediante atribuição qualitativa de pesos por especialistas à indicadores distribuídos nesses pilares, trabalhando com médias ponderadas, que gerava o valor do índice de inovação. O índice contribui para avanços teóricos e práticos no tema, e os resultados da sua aplicação possibilitaram compreensões acerca do comportamento inovativo das indústrias participantes do Paraná, identificação ranqueada dos setores industriais mais inovadores, e suas localizações georreferenciadas no estado.

Palavras-chave: Métrica de avaliação; status de inovação; indústrias de transformação; Índice Paranaense de Inovação (IPrI).

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1 Introduction

Innovation surveys are important for several factors, such as enabling the better understanding of the process and of its relation to economic growth, assisting policymakers, presenting indicators for comparisons with other countries, and for observing their evolution over the years (Organization for Economic Co-operation and Development [OECD], 2005). In order to direct and standardize concepts, methodologies and analyses to facilitate the comparison of researches throughout the world on the subject, the OECD – which is composed by about thirty countries –, produces since 1990 the Oslo Manual (3rd edition title). After each conference, the countries update this manual and the title is replaced by the name of the host city. Editions were launched in 1992 and 1997. The latest edition (3rd) was launched in 2005, incorporating the marketing and organizational innovations and adopting the following concept of innovation:

> An innovation is the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organisation or external relations (OECD, 2005, p. 46).

Aware that it is not easy to reach a consensus when dealing with innovation, which requires adopting conventions, the OECD recognizes the limitations of the Oslo Manual, but still considers it a great advance for countries to better understand the process of innovation:

> Finding consensus has sometimes meant reaching compromises and agreeing to conventions. Furthermore, the complexity of the innovation process itself makes it difficult to establish absolutely precise guidelines. Nevertheless, the goal of the Manual is to provide a robust set of guidelines that can be used to produce meaningful indicators of innovation (OECD, 2005, p. 25).

Even before the existence of the Oslo Manual, or of any directions on how to research on innovation, some countries, concerned with the identification of the reasons and of the forms of innovation in their territories, conducted researches on the subject. The main objectives of these researches were generally related to the need of establishing government policies to encourage enterprises, understand their work and their innovation process. Basically, surveys are identification tools that deal with varied information about companies, gathering data from the strategic, tactical and operational planning activities and also from the organizational environment profile. Countries such as Australia, Brazil, Canada, United States, Norway, New Zealand, Thailand, Zambia, the members of the European Union and others conduct or have conducted research on innovation in their companies or industries. Among these, the researches applied in Brazil, Canada, European Union and New Zealand are the most recent and also provide information about the methodology used, presenting the process of data collection and the questionnaire itself. Because of these characteristics, these researches will be the ones discussed in the next subsection; with the provided information, it will be possible to perform a systematic analysis regarding their content and their approach towards the subject 'innovation'.

1.1 Previous Studies on Innovation in Industries

In Brazil, the PINTEC research (Research on Technological Innovation) was conducted in 2010 by the Brazilian Institute of Geography and Statistics (IBGE), an agency within the Ministry of Planning, Budget and Management. According to this Institute, the research objective is to enable the creation of indicators on innovation activities of the industry in the country and in its regions. The results can be internationally compared, since the research is based on the Oslo Manual. Moreover, the evaluated industrial performance works as a source for companies and sectorial analysis, and it collaborates in the elaboration of policies for technology development (IBGE, 2010).

Internationally, there are other representative surveys regarding research on innovation in industries. In Canada, the Survey of Innovation and Business Strategy is conducted by Statistics Canada – the Canada's National Statistical Agency –with the objectives of identifying and providing information on strategic decisions, innovation activities and operational tactics used by Canadians enterprises. In this survey, the subject 'innovation' is mentioned in 37 of the 102 questions of the compulsory questionnaire (CANADA, 2012).

The Business Operations Survey which in 2005 substituted the Innovation Survey, applied since 2003, is a research conducted by the Statistics New Zealand and aims to understand how the organizations work and what the most important factors to their success are. This research contains a segment whose objective is to provide information about the private sector of New Zealand, helping in the development of policies and facilitating the understanding of the processes in the country. The measured items are: (a) innovation level of the organization; (b) how and why organizations collaborate with other organizations and institutes to innovate; (c) factors that affect the organization's ability to innovate; and (d) results of the organizations innovations (STATISTICS NEW ZEALAND, 2007, 2010).

The UNU Intech – Policy Innovation, in its turn, is a research methodology applied to the understanding of innovation systems in different sectors of economic activities. The surveys conducted until today are based in an approach developed by the Institute for New Technologies of the United Nations University and were applied not only in European Union economies but also in emerging ones, like Asia, Africa, and South America (UNU-INTECH, 2004).

Developed by the Network for Science and Technology Indicators – Ibero-American and Inter-American (RICYT) –, The Bogota Manual is a tool for theoretical and methodological orientation directed to help understanding the innovation processes specificities in South America and Caribbean. This document aims to standardize the technologic innovation indicators which are measurable and comparable in regional and international levels due to the application of its guidelines in surveys conducted in different locations (JARAMILLO; LUGONES; SALAZAR, 2000).

Lastly, the Community Innovation Surveys (CIS) is a research on innovative activities of the European Union enterprises (as well as the enterprises from Norway and Iceland, EU candidate countries). The standard questionnaire for the data gathering (CIS3), which contains a set of definitions and methodological recommendations, was developed by the Eurostat (European Statistics) in cooperation with the EU member countries and aims to guarantee the comparability between the participating countries. The CIS was projected with the objective of obtaining information about the innovative activities in the enterprises as well as about the aspects inherent to this process, like the innovation effects, the information sources, the costs, etc. (BIS, 2010).

In the next subsection the content of four surveys will be comparatively analyzed and commented. Since the Bogota Manual and the UNU Intech – Policy Innovation are not actually researches, but documents for theoretical and methodological orientation, these will not be contemplated hereafter.

1.2 Analysis of Researches Focused on the Subject 'Innovation'

Performing a content analysis of the mentioned surveys' questionnaires, 20 subjects could be found and categorized (BARDIN, 2004). Generally, these subjects can be related to the kinds of innovation (product, process, marketing and organizational) according to the OECD (2005), finance (costs and incomes), objectives and obstacles, cooperation and questions related to the innovation activities developed. The Table 1 illustrates the number of questions that mentioned each of the categorized themes in the analyzed researches.

Table 1. Main themes mentioned in the questionnaires x quantity of questions

Identified themes	**PINTEC (2008)** ***Research on Technological Innovation***	***Business Operations Survey* (2009)**	***The Community Innovation Survey* (2008)**	***Survey of Innovation and Business Strategy* (2009)**
Governmental Support	1			2
Innovation Activities	10	2	1	
Sales Growth / Income	1	1		
Biotechnology	1			
Cooperation	2	5	2	
Difficulties		1	1	
Funding	1			
Information Sources	2	1		
Outlay	1	1	1	3
Innovation Impacts	1			
Marketing Innovation	1	2	2	3
Process Innovation	7	3	2	5
Product Innovation	6	3	2	11
Organizational Innovation	1	2	2	4
Innovations with environmental benefits			3	
Protection Methods	2	1		
Nanotechnology	1			
Innovation Objectives / Reasons for Innovation		1	1	
Obstacles	3			9
Abandoned or unfinished process	2	2	1	

Although the mentioned surveys informed that they used the guidelines from the Oslo Manual (OECD, 2005), it is possible to realize, through the analysis of the themes, that each one focuses and deepens certain aspects, which makes the questionnaires distinct from each other. Among their common characteristics, all of them mentioned the four kinds of innovation and the outlay of the organizations. They are distinct from each other mainly because they focus, in different proportions, other kinds of innovations – among the ones mentioned in the Oslo Manual (OECD, 2005) – or because they work specific themes using a different conceptual basis. In other words, these surveys are conceptually structured on different understandings of the themes identified in the Table 1, according to

the kind of information to be raised. This implies, also, knowing the target audience of the survey, conceiving guidelines regarding the way to gather data, and the adopted sample kind to these scopes, as shown in Table 2.

Table 2. Target audience, sample and gathering of innovation surveys

	Survey			
Factor	**PINTEC (2008)** ***Research on Technological Innovation***	***Business Operations Survey*** **(2009)**	***The Community Innovation Survey*** **(2008)**	***Survey of Innovation and Business Strategy*** **(2009)**
Target Audience	At least 10 workers	At least 6 workers GST * > $30 thousand operating + 1 year (36.348 enterprises)	At least 10 workers	At least 20 workers GST > $30 thousand operating + 1 year (36.348 enterprises)
Sample	Stratified by size, sector and innovation capacity (16.371 enterprises)	Stratified by size and sector (5.603 enterprises)	Stratified by size and sector (censuses taken in some countries)	Stratified by size and sector (census for large companies) (6.233 enterprises)
Gathering	Voluntary adhesion; Presential or by phone information gathering (both computer-assisted)	Compulsory adhesion; Gathering by mail.	Compulsory adhesion; Gathering by mail (some countries with distinguished gathering forms)	Compulsory adhesion; Gathering by mail.

*Note. *Goods and services tax*.

Again, generally the surveys follow the recommendations of the Oslo Manual (OECD, 2005), which suggests that the larger enterprises, due to their innovation capacity, are the target audiences of the researches. Despite this premise, all the researches keep their singularities in the process of gathering and, specially, of sampling, because the grouping characteristics and the enterprises classifications of each region follow different criteria, according to their area's industrial policies. However, the reports of all the consulted surveys indicate a concern on keeping their data in accordance with the Oslo Manual recommendations, enabling comparisons with other global researches.

As shown in Table 3, most of the researches on innovation are conducted under a three-year interval. Only the survey conducted in the European Union has annual frequency. In both situations the researches are aligned with the guidelines of the Oslo Manual, which suggests that such investigations should be conducted with a frequency ranging from one to four years.

Table 3. Main differences between the surveys

Data	**PINTEC (2008)** ***Research on Technological Innovation***	***Business Operations Survey*** **(2009)**	***The Community Innovation Survey*** **(2008)**	***Survey of Innovation and Business Strategy*** **(2009)**
Local	Brazil	New Zealand	European Union countries and candidate countries.	Canada
Observation Period	3 years	2 years	1 year	3 year
Specific questions about innovation	30 questions	27 questions about innovation (from 111)	16 questions about innovation (from 18)	37 questions about innovation (from 102)

In summary, the mentioned researches show the general phenomenon of innovation in enterprises. The differences identified in the investigative tools are justified by the particular organizational characteristics of each location and by the specific diagnosis intention of each research. Moreover, even dating back to 2005, the Oslo Manual (OECD, 2005) is still used as a reference for innovation surveys. Countries from different parts of the world use it as guidance, which demonstrates that the Manual fulfills its function. Even so, it is important to note that the innovative performance assessment initiatives are, since the 90's, criticized by their pretended scope and validity, as they generally sustain claims of universally valid indicators for evaluating innovation – which must be understood as according to economic sector, location, organization, etc. (MARINS; ZAWISLAK, 2010).

So it is important to emphasize that the **understanding of innovation in organizations as a process** – which includes a constant effort and the need of supporting practices and management activities in order to obtain real results – seems to be a core element to the way the innovation is treated in these analyzed surveys, especially in the Oslo Manual (OECD, 2005). This broad understanding is the central theme of the IPrI regarding the comprehension of innovation and of its raised, measured and analyzed variables.

1.3 Paraná's Innovation Index (IPrI)

Developed from a pioneer initiative in Paraná, the project "Paraná's Innovation Index" (IPrI), conceived in 2009 by the Federation of Industries of the State of Paraná System (Fiep System) and developed by the National Service of Industrial Apprenticeship of Paraná (Senai/PR), aimed to promote the innovation process in the manufacturing industries of Paraná through guidance and awareness of the sector's entrepreneurs regarding the main variables related to innovation, as tools and management practices for the competitiveness increase. Among the three years and several phases of the project, an innovation index was proposed for the comparison of the innovation status between the manufacturing industries of Paraná.

Aiming to gather necessary data and information for the index generation, giving practical orientations to the participants, a rigorous and scientific research was realized between April and October 2012. It was supported by the National Council for Scientific and Technological Development (CNPq), federal universities, local productive arrangements (ALP), commercial associations, union entities, and partnership with contracted organizations. The research population was composed by all the manufacturing industries

of Paraná, grouped according to the National Classification of Economic Activities – CNAE 2.0[10] (IBGE, 2004). From this population, 1.098 enterprises answered to the structured questionnaire, during the research.

Considering this initial overview, which aimed to present the context of Paraná's Innovation Index conception and use, this article has the objective to expose, in an explanatory way, the construction, validation and utilization process of this Index, presenting its methodological conception, consequences and contributions for evaluation of innovation in industries.

So, mobilized for a research question that inquires which are the scientific and technologic contributions for the evaluation of innovation in industry by metrics such as the one developed and sustained by the IPrI, the article is organized as follows: after this introductory section (i), which aimed to contextualize the text initiative, comes the discussion about the methodological procedures adopted during the elaboration (ii), the validation and the improvement of the index system; then, an analysis of results achieved (iii) by the use of the index in the sample of participants is undertaken, covering its reach and potentials; finally, the last section discusses the employment and the use of the index (iv), extending the analysis to examine its effective scientific and technological contributions in comparison with existing ones.

2 Methods

In order to design the data collection instrument, a research on world's key reference documents on innovation was undertaken and the variables addressed in them were crossed aiming to define the potential components of the index. National and international researches on innovation undertaken since 2005 have been employed in indexed databases, and a set of criteria was employed for their selection, gathering about 5.000 documents. From this survey, filtering procedures based on criteria that focused on the variables' identification, conceptual definitions, and ways to measure it, resulted in 652 documents, which were then classified according to the level of adherence to each variable of the innovation index as well as to the importance of the periodic, totaling 218 documents – articles in national and international scientific peer-reviewed journals, and theses and dissertations databases on innovation in Brazilian relevant federal universities. The final set of variables was grouped into 10 dimensions of innovation and compiled according to categorization criteria established in the research, namely: (i) the results of innovation, (ii) fundraising, (iii) investments, (iv) innovation activities, (v) external interaction, (vi) protection methods, (vii) internal environment, (viii) R&D, (ix) information and knowledge, and (x) innovation management. Discussion and validation sessions with scholars and market-experts on the subjects legitimated the project, based on the established criteria for acceptable methodological rigor which also validated the proposal.

Given the Oslo Manual (OECD, 2005) research guidelines, and based on the consulted literature, the project investigated the phenomenon of innovation focusing not only on the efforts required for its accomplishment or results sprung from it, but also on its understanding as a process conducted in business, given a set of conditions, activities and different practices, explaining it more fully. By addressing innovation in this rather more integrated fashion, search results enabled a broader understanding not only about

[10] The Brazil's National Classification of Economic Activities 2nd version (CNAE 2.0) is identical to the International Standard Industrial Classification Revision 4 (ISIC Rev.4) at the level used in this research, called "division" (UNITED NATIONS, 2008).

innovation, but above all more feasible with its nature, given that in everyday business reality, activities relevant to the three spheres (see below) of the phenomenon in question are to be found.

2.1 Efforts

Efforts were understood as investments in financial, human, technical and infrastructural areas, allocated by the company in order to achieve product, process or service innovation. The 'Efforts' indicators are used in the evaluation of how the company is dedicated to innovation and how these indicators are related to investments, allocated resources and structure that the company provides for it. These 'Efforts' indicators (detailed in terms of investments, people, structure, etc.) were evaluated based on their existence and proportionality in regard to the size of the company. In short, the following criteria were taken as indicators for 'Efforts': i) the presence of innovation in routine or mission of the company; ii) efforts to develop innovative actions, including R&D; iii) quantity and profile of human resources involved in R&D; iv) quantity and types of activities; v) internal structure to innovate; and vi) investments to achieve innovations.

2.2 Management

Activities performed to facilitate efforts such as fundraising, external interactions, practices for creating innovation-conductive environments, administrative actions to overcome obstacles, use of management tools and organized execution of the different phases of the innovation process. Management indicators are used to evaluate how the company has, practices and formalizes innovation management activities. These indicators were evaluated according to the degree of formality and existence of activities. In short, the following criteria were taken as indicators for 'Management': i) stimulating innovation practices; ii) partnerships; iii) obstacles; iv) actions to innovate; v) search for resources; vi) practices of knowledge management; vii) process of innovation management; and viii) management tools of innovation.

2.3 Results

The set of benefits that the company gets from its efforts and the management of these efforts, such as increased income from innovative products or services, cost savings due to innovation in internal processes, number of completed projects, market-share extension, etc. Result indicators (sales, marketing, etc.) assess how much is being obtained by a company from the effort, the process and the stimuli on innovation. In short, the following criteria were taken as indicators for 'Results': i) types of innovation results; ii) partnerships (organizational innovation); iii) scope of innovation; iv) benefits obtained; v) ongoing projects; vi) revenues from innovations vii) protection of innovation; and viii) number of patents (applied for and obtained).

For the usage of the various indicators raised in the IPrI questionnaire, scores from 0 to 10 were assigned for each item to be checked in each question. The responses given to these items composed the score obtained by the question, which also ranged from 0 to 10, and each of the grades awarded to every question was multiplied by the respective weight of that question in the context of its importance to each of the three pillars explained above,

called "Efforts", "Management", and "Results". Some weights and values question differed according to the size of the company, which were defined and grouped based on the Sebrae (2012) classification by number of employees; therefore, the following ranges have been grouped: i) micro (up to 19 employees) and small (from 20 to 99 employees) companies; and ii) medium (from 100 to 499 employees) and large (over 500 employees) companies. The level of each pillar was given by the weighted mean of the weights of scores for each question, ranging from 0 to 10.

Thus, the level of each pillar was composed by the mathematical sum involving the obtained grade in a specific question (depending on the qualitatively given weight), multiplied by the weight attributed to it, and divided by the sum of the weights of the questions that composed the pillars, varying according to the size of the enterprise (micro, small, medium and large). For example, for one of the pillars, the formula for calculating the "Efforts" level for micro and small enterprises was represented by the Equation 1:

$$EL = \frac{[(a \times 7) + (b \times 5) + (c \times 7) + \cdots + (i \times 10)]}{\sum EP} \quad (1)$$

In which:

EL = Efforts Level for micro and small enterprises
a,b,c[...] = Obtained grade in the *a,b,c[...]* question of the survey questionnaire
$\sum EP$ = Sum of the weights of the "Efforts" pillar for micro and small enterprises = 70

The expanded IPrI formula is presented by the Equation 2. It was composed by specific calculations of each of the three pillars multiplied by the qualitatively given weight to the relevance of each of the pillars in a measurement of innovation process in enterprises and divided by 10 – due to the index range from 0 to 10.

$$IPrI = \frac{(Efforts\ Level) \times 3) + (Management\ Level \times 3) + (Results\ Level \times Level \times 4)}{10} \quad (2) \quad (2)$$

The grades and weights assigned for each question was based on an analysis of the theoretical contribution of the question for the research elaboration, the internal validations involving a team of researchers of the project, and external validations with national expert researchers on innovation. These procedures were guided by two fundamental criteria that guide the elaboration of every good data gathering tool: reliability and validity. In the area of innovation, several authors have already used similar methodology (CAVALCANTE, 2010; CORAL; OGLIARI; ABREU, 2008; FAYET, 2010; FURTADO et al., 2007; REIS; CARVALHO; CAVALCANTE, 2009, 2011; SCHERER; CARLOMAGNO, 2009; SILVA NETO; TEIXEIRA, 2011).

Considering the literature adopted for the IPrI, several variables were identified and gathered in order to explain the innovation construct in enterprises. These variables were distributed according to the thematic grouping of the pillars. The 10 dimensions were conceived not only because they conceptually explain the innovation construct, but also because of the audience of the survey – industrial managers in Paraná. The set of identified and grouped variables was distributed in these 10 dimensions, being some of them allocated in more than one dimension, due to its theoretical relevance as in the literature, and to the identified conceptual relations. This arrangement had, above all, a didactic aim

to explain the research's theme to its audience, facilitating their comprehension on the survey's topics.

The 10 dimensions conceived were:

(a) innovation results;

(b) fundraising;

(c) investments;

(d) innovation activities;

(e) external interaction;

(f) protection methods;

(g) internal environment;

(h) R&D;

(i) information and knowledge;

(j) innovation management.

From the 55 questions that compose the data gathering tool, 44 were allocated in one or more of the pillars that consolidate the IPrI, not only because of their specific content, but also because of their common presence in several items of the research. When calculating the index from a final sample of the participating enterprises, it was possible to visualize the most innovative enterprises in the state, their corresponding economic sectors, and their sizes, due to a georeferenced work.

3 Data Analysis

The 1.082 sampled cases were evaluated in terms of missing values and minimal lack of variation (HAIR et al., 2009).. Such analysis indicated the need to exclude 15 entries, remaining 1.067 valid cases. The exploratory data analysis identified 20 outliers and no extreme value. Analysis with or without outliers didn't show difference in the results, so that it was possible to preserve the observations in the basis. Then the assumptions to do the parametric tests were verified.

Dependent variables normality assumption was verified through Kolmogorov-Smirnov tests with Lilliefors ($n>50$) and Shapiro-Wilk ($n<50$) ($p <0,05$) correction (MAROCO, 2007), and the results indicated absence of normality in some variables, but the histogram evaluation haven't indicated significant deviation in the data distribution. After that, kurtosis and asymmetry index were examined. Asymmetry varied from 0,21 to -0,784, and kurtosis varied between 0,006 and -1,50. Schumacker & Lomax (2004) claim that asymmetry and kurtosis respectively between ±1,0 and ±1,5 do not preclude the application of statistical techniques that assume normality. The variance homogeneity assumption was evaluated through the Levene test ($p < 0,05$).

To assess if size and sector of the enterprises significantly affect the innovation variables (Efforts, Management, Results, and the IPrI itself) an ANOVA procedure was undertaken, additionally to a Welch test (for inhomogeneous variance), followed by post-hoc Tukey HSD tests (for homogeneous variance) and Games-Howell (for inhomogeneous variance)

(MAROCO, 2007). Statistically significant considered effects were the ones with ≤ 0,05 p-value, and marginally significant the ones where 0,05 < p ≤ 0,05 (HAIR et al., 2009; MAROCO, 2007).

The ANOVA was performed to four variables: Innovation Efforts, Innovation Management, Innovation Results, and IPrI itself. To each variable, the analyses were undertaken considering case grouping by enterprise's size and economic sector.

3.1 Variance Analysis by Size

3.1.1 Efforts

An ANOVA test was done in order to verify possible differences in the Innovation's Effort Level in the manufacturing industries, considering the four sizes categorized. The Levene test was significant (F (3, 1063) = 2,84, p = 0,04), indicating inhomogeneous variance between the dependent variable and the size groups. The ANOVA indicated the existence of statistically significant difference (p < 0,05) between the Innovation's Effort Level and the four sizes categorized (F (3, 1063) = 28,10, p < 0,001, ηp2 = 0,07). These results were corroborated by Welch test, which is more robust to equality between means with inhomogeneous variance (F (3, 1603) = 29,50, p < 0,001). Multiple comparisons between pairs of groups using the Games-Howell indicated no significant difference of the Innovation's Effort Level between medium size enterprises (M = 6,56; SD = 2,05) and large size (M = 6,85; SD = 1,95), as well as between micro size enterprises (M = 4,99; SD = 2,06) and small size (M = 5,36; SD = 2,18). The other comparisons between pairs of groups indicated significant differences (p < 0,001) of the means.

3.1.2 Management

Regarding the Innovation Management pillar, the Levene test confirmed the homogeneity variance hypothesis (F (3, 1063) = 0,05, p = 0,65) between the dependent variable and the enterprise's size groups. The ANOVA indicated statistically significant difference (p < 0,05) to the Innovation Management Level between the four size groups (F (3, 1063) = 26,17, p < 0,001, η_p^2 = 0,07). Multiple comparisons between the pairs of groups using Tukey HSD test indicated no significant difference in the mean of the Innovation Management Level between micro size enterprises (M = 5,88; SD = 0,88) and small size enterprises (M = 5,96; SD = 0,93), as well as no significant difference between the medium size enterprises (M = 6,50; SD = 0,95) and large size enterprises (M = 6,74; SD = 0,93). The other comparisons between pairs of groups indicated significant differences (p < 0,001 of the means.

3.1.3 Results

For the Innovation Results pillar, a Levene test also confirmed the homogeneity variance hypothesis (F (3, 1063) = 1,96, p = 0,12) between the dependent variable and the enterprise's size groups. An ANOVA indicated statistically significant difference (p < 0,05) in the Innovation Results between the four size groups (F (3, 1063) = 5,88, p = 0,001, η_p^2 = 0,02). The Tukey HSD test indicated significant difference in the mean of Innovation

Results between micro size enterprises (M = 5,84; SD = 1,23) and small size enterprises (M = 6,20; SD = 1,15). The other comparisons between pairs of groups that included medium size enterprises (M = 6,02; SD = 1,14) and large size enterprises (M = 5,96; SD = 1,38), didn't show significant differences ($p < 0,05$).

3.1.4 IPrI

Regarding the IPrI and the enterprise's size, the Levene test performed was not significant (F (3, 1063) = 0,17, p = 0,92), indicating that the homogeneity variance hypothesis was not violated. The ANOVA indicated statistically significant differences ($p < 0,05$) in the means of the IPrI to the four enterprises size groups (F (3, 1063) = 19,93, $p < 0,001$, $\eta_p^2 = 0,05$). Multiple comparisons between pairs of groups using the Tukey HSD test didn't indicate significant difference in the IPrI mean between medium size enterprises (M = 6,33; SD = 1,14) and large size enterprises (M = 6,46; SD = 1,21). The other comparisons between pairs of groups that included micro size enterprises (M = 5,50; SD = 1,17) and small size enterprises (M = 5,87; SD = 1,19) suggest significant differences in the means ($p < 0,05$).

3.2 Variance Analysis by Economic Sector

3.2.1 Efforts

The Levene test wasn't significant (F (18, 1048) = 1,44, p = 0,10), indicating homogeneous variances. The ANOVA indicated statistically significant differences ($p < 0,05$) in the Innovation Efforts mean between eighteen economic sectors (F (18, 1048) = 2,82, $p < 0,001$, $\eta_p^2 = 0,05$). The Tukey HSD test indicated significant difference in the Innovation Efforts mean between Fabricated Metal Products (Except Machinery and Equipment) economic sector (M = 4,77; SD = 1,99) and other three: Computer, Electronic and Optical Products (M = 6,84; SD = 2,11), Electrical Equipment (M = 6,66; SD = 2,14) and Chemicals and Chemical Products (M = 6,23; SD = 2,10). The test also indicated significant difference between Wearing Apparel (M = 5,00; SD = 2,05) and Computer, Electronic and Optical Products, and marginally significant difference between Wearing Apparel and Chemicals and Chemical Products. There was still significant difference between the Printing and Reproduction of Recorded Media (M = 4,85; SD = 2,15) and Computer, Electronic and Optical Products, and marginally significant difference between the Printing and Reproduction of Recorded Media and Electric Equipment. The other comparisons between pairs of groups didn't show significant differences between the means ($p < 0,05$).

3.2.2 Management

The Levene test was not significant to the comparison between Management and economic sectors (F (18, 1048) = 0,69, p = 0,83), indicating variance homogeneity. The ANOVA didn't show statistically significant difference ($p < 0,05$) in the means (F (18, 1048) = 1,50, $p = 0,08$, $\eta_p^2 = 0,03$). This result was corroborated by the Tukey HSD test ($p < 0,05$).

3.2.3 Results

The Levene test results confirmed the variances homogeneity (F (18, 1048) = 1,05, p = 0,41), and the ANOVA indicated statistically significant difference ($p < 0,05$) in the means (F (18, 1048) = 2,87, $p < 0,001$, $\eta_p^2 = 0,05$). The Tukey HSD test indicated significant difference in the Innovation Efforts mean between Wearing Apparel (M = 5,65; SD = 1,09) and Machinery and Equipment n.e.c. (M = 6,39; SD = 1,25) and Chemicals and Chemical Products (M = 6,43; SD = 1,00). The other comparisons between pairs of groups didn't show significant differences between the means ($p < 0,05$).

3.2.4 IPrI

The Levene test didn't show itself as significant (F (18, 1048) = 0,64, p = 0,87), indicating that variances homogeneity. The ANOVA indicated statistically significant difference ($p < 0,05$) between the means (F (18, 1048) = 2,83, $p < 0,001$, $\eta_p^2 = 0,05$). The Tukey HSD test for multiple comparison between pairs of groups indicated significant difference in the IPrI mean between Chemicals and Chemical Products (M = 6,34; SD = 1,10) and Fabricated Metal Products (Except Machinery and Equipment) (M = 5,55; SD = 1,15), as well as relating to Products of Wood and Cork (Except Furniture) (M = 5,56; SD = 1,19). There were also significant differences between the Computer, Electronic and Optical Products (M = 6,60; SD = 1,21) and Wearing Apparel (M = 5,55; SD = 1,10), and Fabricated Metal Products (Except Machinery and Equipment). There was also marginally significant difference between the Computer, Electronic and Optical Products and the Printing and Reproduction of Recorded Media (M = 5,53; SD = 1,30), and Products of Wood and Cork (Except Furniture). Lastly, there was still marginally significant difference between Printing and Reproduction of Recorded Media and Chemicals and Chemical Products. The other comparisons between pairs of groups didn't show significant differences between the means ($p < 0,05$).

4 Results and Discussion

The Paraná Index of Innovation was generated from the answers obtained in the 1.067 questionnaires. It aims at the 18 sectors of the transformation industry that were focused along the research, such as can be seen in Table 4, along with the ANOVA results.

Table 4. IPrI according to Sector (2012)

	Efforts L.	Management L.	Results L.	IPrI	
	Mean (SD) $^{sig.}$	Mean (SD) $^{sig.}$	Mean (SD) $^{sig.}$	Mean (SD) $^{sig.}$	Quantity
Computer, Electronic and Optical Products	6.84 (2.11)^{a,b,c}	6.42 (0.97)	6.56 (1.18)	6.60 (1.21)^{a,b,f*,h*}	20
Electrical Equipment	6.66 (2.14)^{d,e}	6.33 (0.87)	6.34 (1.15)	6.43 (1.15)	25
Chemicals and Chemical Products	6.23 (2.10)^{f,h*}	6.33 (0.81)	6.43 (1.00)^{b}	6.34 (1.10)^{c,d,e,g*}	51
Machinery and Equipment n.e.c.	5.61 (2.36)	6.00 (1.04)	6.39 (1.25)^{a}	6.04 (1.27)	73
Furniture	5.66 (2.00)	6.01 (0.90)	6.00 (1.18)	5.90 (1.07)	94
Other Manufacturing	5.39 (2.01)	6.05 (0.87)	6.16 (1.17)	5.90 (1.15)	61

	Efforts L.	Management L.	Results L.	IPrI	
	Mean (SD) sig.	Mean (SD) sig.	Mean (SD) sig.	Mean (SD) sig.	Quantity
Rubber and Plastics Products	5.47 (2.32)	6.02 (0.89)	6.14 (1.26)	5.90 (1.26)	64
Paper and Paper Products	5.81 (2.05)	6.27 (0.96)	5.65 (0.99)	5.89 (1.12)	30
Motor Vehicles, Trailers and Semi-Trailers	5.03 (2.07)	6.11 (0.91)	6.33 (1.33)	5.88 (1.20)	31
Repair and Installation of Machinery and Equipment	5.60 (2.17)	6.14 (1.12)	5.81 (1.02)	5.85 (1.23)	39
Food Products	5.39 (2.30)	6.08 (1.04)	5.96 (1.24)	5.83 (1.29)	106
Basic Metals	5.42 (1.99)	6.02 (1.11)	5.79 (1.17)	5.74 (1.18)	39
Beverages	5.42 (2.06)	6.06 (0.79)	5.51 (1.24)	5.65 (1.11)	11
Other Non-Metallic Mineral Products	5.04 (2.15)	5.93 (0.90)	5.73 (1.04)	5.58 (1.14)	38
Products of Wood and Cork (Except Furniture)	5.07 (2.11)	5.81 (0.94)	5.74 (1.14)	5.56 (1.19)^{c,h*}	69
Wearing Apparel	5.00 (2.05)^{c,e,h*}	5.95 (0.89)	5.65 (1.09)^{a,b}	5.55 (1.10)^{b,e}	125
Fabricated Metal Products (Except Machinery and Equipment)	4.77 (1.99)^{b,d,f,g*}	5.81 (0.86)	5.93 (1.32)	5.55 (1.15)^{a,d}	106
Printing and Reproduction of Recorded Media	4.85 (2.15)^{a,g*}	5.86 (0.92)	5.80 (1.41)	5.53 (1.30)^{f*,g*}	52
Textiles	4.96 (2.36)	5.99 (0.86)	5.59 (1.22)	5.52 (1.27)	33
Total	*5.36 (2.17)*	*6.01 (0.94)*	*5.96 (1.21)*	*5.80 (1.20)*	*1067*

Note. Efforts L., Management L., and Results L. are the different-weighted levels that compose the IPrI.
a, b, c, d, e, f, g, h refer to significant differences groups' means verified by Tukey HSD multiple comparisons test, ANOVA test, utilized here as there was no violation to the variances homogeneity assumption.
* refer to marginally significant values.

The results of the variances analysis by sector (Table 4) showed that there was significant difference between the 18 economic sectors regarding the variables Efforts, Results and IPrI ($p < 0,001$). However, to the variable Management there was no difference between the sectors' means ($p = 0,41$). Still, to all the variables, the effects founded are of low dimension ($\eta_p^2 \leq 0,05$) (MAROCO, 2007). It is possible that the absence of significant difference between the means of the Management pillar is associated to a socially desirable answer bias, as the questionnaires were mostly answered by enterprises' owners, managers and/or CEOs – in other words, by people directly related to the enterprises' managing activity.

The research's results show similarity to the OECD (2011) most innovative industrial sectors ranking, as five of the ten best positioned sectors in the IPrI are directly related to those indicated by OECD. The results also corroborate other studies where economic sectors such as Computer, Electronic and Optical Products; Electrical Equipment; and Chemicals and Chemical Products are recognized as of being from medium to highly intensive in innovation and/or technology (FEIJO; CARVALHO; RODRIGUEZ, 2003; HATZICHRONOGLOU, 1997; O'REGAN; SIMS, 2008; PAVITT, 1984).

The other well positioned sectors in the IPrI that differ from the innovation degree advocated by the OECD (2011) classification have their score partially explained by the regional particularities of each sector, despite the fact that they are not traditionally connected to high or medium/high technological intensity – such as Furniture, Other

Manufacturing and the Paper and Paper Products, which occupy, respectively, the fifth, sixth and seventh positions in the Table 4.

It is due to the very fact that these sectors support a nonlinear conception of the innovation process that this kind of sectorial particularity could be perceived in the IPrI research, which reinforces the need to understand the particularities of the innovation process according to the structural reality – in a national and, especially here, regional – faced by industries (GARCIA, 2001; STAL; CAMPANÁRIO, 2010).

Besides the industrial sector, another categorization variable employed in the research was the size of the responding companies. Because of that, as well as the IPrI calculation of the business sector (as presented on Table 4), the IPrI was also generated according to the size classification contemplated in the study, which makes it possible to associate the categorical variable to the respondents' performance in innovation, such as presented in Table 5.

Table 5. IPrI according to Size (2012)

	Efforts L.	Management L.	Results L.	*IPrI*	
	Mean (SD) [sig.]	Mean (SD) [sig.]	Mean (SD) [sig.]	Mean (SD) [sig.]	Quantity.
Micro	4.99 (2.06) [b,c]	5.88 (0.88) [f,g]	5.84 (1.23) [f]	*5.50 (1.17) [f,g,h]*	605
Small	5.36 (2.18) [d,e]	5.96 (0.93) [h,i]	6.20 (1.15) [f]	*5.87 (1.19) [f,i,j]*	285
Medium	6.56 (2.05) [b,d]	6.50 (0.95) [f,h]	6.02 (1.14)	*6.33 (1.14) [g,i]*	137
Large	6.85 (1.95) [c,e]	6.74 (0.93) [g,i]	5.96 (1.38)	*6.46 (1.21) [h,j]*	40
F	*28.10*	*26.17*	*5.88*	*19.93*	
p-value	*p < 0,001**	*p < 0,001*	*p = 0,001*	*p < 0,001*	
Total	*5.36 (2.17)*	*6.01 (0.94)*	*5.96 (1.21)*	*5.78 (1.20)*	*1067*

Source: IPrI's data gathered.
Note. Efforts L., Management L., and Results L. are the different-weighted levels that compose the IPrI.
b, c, d, e refer to the significant differences in the means' of the groups verified by the Games-Howell test in the ANOVA, due to the violation of the variances homogeneity assumption showed in the Levene test in the ANOVA.
f, g, h, i, j refer to the significant differences in the means' of the groups verified by the Tukey HSD test in the ANOVA.
* *p* value identical results both in the ANOVA as well as in the means equality Welch test performed due to the violation of the variances homogeneity assumption.

The ANOVA results showed statistically significant differences ($p \leq 0,001$) between the means, in the four innovation variables (Efforts, Management, Results, and IPrI), between the four enterprises' size groups. The results showed medium dimension effect to Efforts and Management ($\eta_p^2 = 0,07$ to both), and low dimension effect to Results and IPrI ($\eta_p^2 = 0,02$ e 0,05 respectively) (MAROCO, 2007). Considering only the groups with statistically significant difference ($p \leq 0,001$) between the means, the results to the enterprises size groups suggest the existence of a positive relation between size and innovation status in Paraná's manufacturing industries, since the highest index scores occurred in large size enterprises (e.g., large, small and micro in the Efforts, Management and IPrI dimensions). Such findings suggest the situation of better innovative capability in large enterprises, in relation to small and micro enterprises.

Thus, it was also possible to verify the connection between the innovation status in Paraná's industry according to size distribution, which showed a presumed escalating relation suggesting that, in the state, the medium and large-sized companies present a

significantly higher innovative capacity compared to micro and small companies. However, it is noteworthy that this difference – based upon the average of the index calculation – is not necessarily expressive, floating up to 1,0 (one) point.

5 Conclusions

By addressing innovation in a highly integrated search, the results enabled a broader understanding not only about innovation, but also more feasible with its nature, given that in everyday business reality, activities take place in all three spheres of the phenomena here considered. Thus, the proposed index, conceptually structured as described, contributes to theoretical and practical advances in the subject, addressing it more vigorously. With the qualitative weight-assignment done by experts distributing the indicators in the three pillars, and working with weighted means of the weights of the grades for each question, an equation that generated the index value of innovation was created. Due to data analysis, it was possible to obtain results about the innovative behavior of Paraná's industries, as well as to determine the highest ranked players, the most innovative industries, and their georeferenced location in the state. Replicating this research in the future will make it possible to think of a comparative assessment of index in "tracks" (or "labels"), which already have a serial number of edits made as categorical variables such as company size, area of expertise, and technological intensity of the sector, allowing researchers to establish medium increasingly parameterized for each studied group. Therefore, companies may be located in relation to companies of the same industry and size in order to receive ratings by categorizing tracks or labels. Another possibility is to come up with analyses based on ranking companies by sector and size, according to the value of their index, allowing ways to elucidate which of the pillars of innovation justify best its performances. The results of the project will assist Fiep System and particularly the National Service for Industrial Apprenticeship of Paraná (Senai/PR), in promoting the development and improvement of products and services (specific consulting, laboratories, courses and training), as well as set standards for public policy actions regarding the investment for the development of industrial innovation in the State of Paraná.

6 References

BARDIN, L. **Análise de conteúdo**. 3. ed. Lisboa: Edições 70, 2004.

BIS. **The Community Innovation Survey**. Disponível em: <http://www.bis.gov.uk/policies/science/science-innovation-analysis/cis>. Acesso em: 1 mar. 2012.

CANADA. **Survey of Innovation and Business Strategy**. Disponível em: <http://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&SDDS=5171&lang=en&db=imdb&adm=8&dis=2#a4>. Acesso em: 15 mar. 2012.

CAVALCANTE, M. Gestão da Inovação. In: FAYET, E. (Ed.). **Gerenciar a inovação**. Curitiba: IEL/PR, 2010. p. 53–63.

CORAL, E.; OGLIARI, A.; ABREU, A. **Gestão integrada da inovação estratégia, organização e desenvolvimento de produtos**. São Paulo: Atlas, 2008.

FAYET, E. **Gerenciar a inovação: um desafio para as empresa**. Curitiba: IEL/PR, 2010.

FEIJO, C. A.; CARVALHO, P. G.; RODRIGUEZ, M. S. Concentração industrial e produtividade do trabalho na indústria de transformação nos anos 90: evidências empíricas. **Economia**, v. 4, n. 1, p. 19–52, jun. 2003.

FURTADO, A. et al. **Índice Brasil de Inovação: manual informativo sobre o procedimento de adesão de empresas**. Campinas: Universidade Estadual de Campinas, 2007.

GARCIA, R. A importância da dimensão local da inovação e a formação de "clusters" em setores de alta tecnologia. **Ensaios FEE**, v. 22, n. 1, p. 143–160, 2001.

HAIR, J. F. et al. **Analise Multivariada de Dados**. 6. ed. Porto Alegre: Bookman, 2009.

HATZICHRONOGLOU, T. Revision of the high-technology sector and product classification. **OECD Science, Technology and Industry Working Papers**, n. 2, 1997.

IBGE. **Classificação nacional de atividades econômicas**. Brasília: Instituto Brasileiro de Geografia e Estatística - Comissão Nacional de Classificação, 2004.

IBGE. **Pesquisa de inovação tecnológica: 2008**. Brasília: Instituto Brasileiro de Geografia e Estatística - Coordenação da Indústria, 2010. p. 164

JARAMILLO, H.; LUGONES, G.; SALAZAR, M. **Normalización de indicadores de innovación tecnológica en América Latina y el Caribe: Manual de Bogotá**. Bogotá: OEA - COLCIENCIAS, 2000.

MARINS, L.; ZAWISLAK, P. A. **O desempenho inovativo de sete firmas brasileiras à luz de um conjunto de novos indicadores de inovação**. In: ENCONTRO NACIONAL DA ASSOCIAÇÃO NACIONAL DE PÓS-GRADUAÇÃO E PESQUISA EM ADMINISTRAÇÃO. **Anais**...Rio de Janeiro: ANPAD, 2010

MAROCO, J. **Análise Estatística com utilização do SPSS**. 3. ed. Lisboa: Sílabo, 2007.

O'REGAN, N.; SIMS, M. A. Identifying high technology small firms: a sectoral analysis. **Technovation**, v. 28, p. 408–423, 2008.

OECD. **Oslo Manual**. 3. ed. Paris: OECD Publishing, 2005. p. 162

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

REIS, D. R.; CARVALHO, H. G.; CAVALCANTE, M. B. **Gestão da inovação: inovar para competir**. Brasília: Sebrae, 2009.

REIS, D. R.; CARVALHO, H. G.; CAVALCANTE, M. B. **Gestão da inovação**. Curitiba: Aymará, 2011.

SCHERER, F.; CARLOMAGNO, M. **Gestão da inovação na prática: como aplicar conceitos e ferramentas para alavancar a inovação**. São Paulo: Atlas, 2009.

SCHUMACKER, R.; LOMAX, R. **A beginner's guide to structural equation modeling**. 2. ed. New York: Psychology Press, 2004.

SEBRAE. **Critérios e conceitos para classificação de empresas**. Disponível em: <http://www.sebrae.com.br/uf/goias/indicadores-das-mpe/classificacao-empresarial>. Acesso em: 5 out. 2012.

SILVA NETO, A.; TEIXEIRA, R. M. **Mensuração do grau de inovação de micro e pequenas empresas: estudo em empresas da cadeia têxtil de confecção em Sergipe**. In: ENCONTRO NACIONAL DA ASSOCIAÇÃO NACIONAL DE PÓS-GRADUAÇÃO E PESQUISA EM ADMINISTRAÇÃO. **Anais**...Rio de Janeiro: ANPAD, 2011

STAL, E.; CAMPANÁRIO, M. A. **Indicadores de inovação tecnológica em empresas brasileiras internacionalizadas**. In: SIMPÓSIO DE GESTÃO DA INOVAÇÃO TECNOLÓGICA DA ASSOCIAÇÃO NACIONAL DE PÓS-GRADUAÇÃO E PESQUISA EM ADMINISTRAÇÃO. **Anais**...Vitória: ANPAD, 2010

STATISTICS NEW ZEALAND. **Innovation in New Zealand: 2005**. Wellington: Statistics New Zealand, 2007.

STATISTICS NEW ZEALAND. **Business Operations Survey: 2009**. Wellington: Statistics New Zealand, 2010.

UNITED NATIONS. **International Standard Industrial Classification of All Economic Activities, Rev.4**. Disponível em: <http://unstats.un.org/unsd/cr/registry/regcst.asp?Cl=27>. Acesso em: 1 out. 2012.

UNU-INTECH. **Designing a policy-relevant innovation survey for Nepad**. Maastricht: UNU-Intech, 2004.