# Eco-Innovation in Brazil. The Creation of an Index

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**Abstract**

*We have created an index that measures eco-innovation in Brazil at firm level. It is a first experience for the country and for this reason we have organized the survey with a qualitative and quantitative approach. The index was structured based on the experiences of the Eco-Innovation Index (EIO, 2013), on the Brazil Innovation Index (FURTADO and QUADROS, 2006) and on contributions of other surveys regarding the definition of the indicators. The next step is the development of multiple case studies to verify if the index proposed here (with modifications) can be calculated using data from the companies.*

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## 1. Introduction

The economic growth evidenced as of the Industrial Revolution in the 18th century had the abundance of natural resources, especially those listed as an energy source, as a truism. In addition, the disposal of waste from production processes and from the products generated by the new model of economic organization was not on society's agenda at the time (Freeman, 1996), (Barbieri, 2007), (Junqueira, Souto Maior and Pinheiro, 2011).

This wealth generation process was then called "brown economy" (United Nations Environment Programme, 2011), where the restrictions imposed by the supply or demand would be overcome from the facilitation of technological alternatives so as to perpetrate the unlimited material progress of society (Chapple, 2008).

However, the truism of the self-adjustment of this system began to be tested in the 19th century on the basis of the signs of finitude of natural resources due to the expansion of the demand for them and to the impact of greenhouse gases on the ozone layer. The following milestone events stand out in this reflection: the Stockholm Conference (1972), the Club of Rome "Limits to Growth" Report (1972), the Vienna Convention for the Protection of the Ozone Layer (1985), the "Our Common Future" report - Gro Brundland (1987), release of the first IFCC report (1988), Rio-92 Conference (UN) and its ramifications such as the Kyoto Protocol (1997) (Freeman, 1996), (Junqueira, Souto Maior and Pinheiro, 2011).

Faced with this scenario, topics relative to sustainable development gain scale and ramifications, one of which is the "green economy" (Sarkar, 2013), (United Nations Environment Programme, 2011). The green economy was defined by the United Nations environment programme (2011, p. 16) as "an improvement in social well-being and human equity, and at the same time the reduction of environmental risks and ecological scarcities".

The green economy delivers results through the efficient organization of resources on behalf of the appreciation of nature and of society. It also calls for the preservation of ecosystems and the promotion of social equality, having poverty eradication as its primary cause (United Nations Environment Programme, 2011).

The transition from the "brown economy" to the "green economy" is complex and involves all the sectors of society around the world, where the political borders must be overcome according to the principle of "shared responsibility" (Sarkar, 2013), (Unfccc, 2008). In this scenario, public and private institutions take on the role of catalysts of these change efforts with society, especially due to the power in investments in technologies that bring about positive impacts on the environment (Rennings and Wiggering, 1997), (Barbieri, et al., 2010), (United Nations Environment Programme, 2011), (Veugelers, 2012).

One of the vectors of these efforts in cleaner technologies is environmental innovation or eco-innovation (Barbieri et al., 2010), (Boken et al., 2012), (Sarkar, 2013). As an instrument of change, countries and companies are impelled to invest in innovations that result in products or processes which are more in line with their surrounding ecosystems (Barsoumian, Severin and Spek, 2011).

In this sense, developing and maintaining mechanisms to measure eco-innovation can help to identify progress in different dimensions of the sustainability concept and also allow public and business policies that overcome technological bottlenecks associated with environmental and social degradation (Arundel; Kemp, 2009), (Maçaneira and Cunha, 2010), (OECD, 2012). The literature on eco-innovation is undergoing a process of conformation, and specifically the measurement and control process based on indicators is still incipient (Rennings and Wiggering, 1997), (European Enviroment Agency, 2006); (Lázaro, et. al., 2008). the metrics used for environmental innovations are still generic and associated with the countries (Kemp; Horbach, 2008; Almeida, 2008; Oltra; Kemp; Vries, 2008; Huber, 2008; Kemp; Horbach, 2008; Kemp; Pearson, 2008; Reid; Miedzinski, 2008; organization for economic cooperation and development, 2009; Arundel; Kemp, 2009).

In this sense, as an eco-innovation management practice, special emphasis is placed on the "eco-innovation observatory - eio" in the European Union, which monitors the regional and national levels of efforts and results in eco-innovation (Eco-innovation observatory, 2013). However, the indicators used are still broad and associated with macroeconomic variables, so that there is not yet any formulated index at the company level. In the specific case of Brazil, the development and the application of ecological indicators is incipient. The technological innovation survey (Pintec/Ibge) is the only instrument of broad scope in the country that monitors innovation efforts based on companies. The survey with triennial systematicity has already published four editions (2000, 2003, 2005 and 2008), while the entire questionnaire contains six alternatives that involve the environment in the "impacts of innovations" section (Ibge, 2012).

The questionnaire features qualitative evaluations where the respondent indicates the importance of the impact as: "high", "medium", "low" and "not relevant" (Ibge, 2012). Hence there are no indicators related to the innovative activities or for results that clearly measure "eco-innovations" in the country.

Thus this survey seeks to create an index for eco-innovation, which we call the Brazil Eco-innovation Index. This objective seeks to span a theoretical and practical gap that has not yet been bridged which is the structure of indicators geared towards eco-innovation based on companies. Therefore, the expected outcome is to deliver a proposal to measure entrepreneurial efforts in environmental innovations and the resulting impacts on environmental and company performance.

For this purpose, the article was organized in 5 (five) sections in addition to this introduction. The second section addresses the theoretical benchmark of eco-innovation, establishing the definition, taxonomies and structure of the eco-indicators for the index. The third section presents the materials and methods used in empirical research that precede the analysis and discussion of results in the fourth section. The final considerations are presented last of all, with special emphasis on the advances made in this survey and the limitations that follow. The possibility of future surveys is also pointed out before the bibliographical references are listed.

## 2. Theoretical basis

### 2.1. Concepts and Taxonomies of Eco-Innovation

Eco-innovation is an abbreviated term for environmental innovation (Reid and Miedzinski, 2008), so that its use is aimed at associating the innovation process with matters inherent to the environment, on account of the generality of the innovation concept (Rennings, 2000).

Therefore, Eco-innovation is an extension of innovation (Sarkar, 2013), which is defined by grupp (1998) as a process oriented on results that can be expressed by new products, new production systems, transportation, management system, development of new sources of supply of raw material and new markets, so that these innovations provide financial results. According to Schumpeter (1985), innovation can occur upon the: i) introduction of a new product and\or service unknown to the consumer market; ii) introduction of a new production method; iii) creation of a new market for the company; iv) creation of new sources of inputs; and v) creation of a new organizational structure.

Grupp (1998) and Tigre (2005) stress that innovation, as the main axis of the *Schumpterian* thinking, is the "mainspring" of the capitalist system, due to the possibility of creating new markets. In spite of its possibility considered by classic authors, it is only in Schumpeter that innovation begins to be understood as a process induced by firms (Santos, Basso and Kimura, 2012). Nevertheless, starting from the ecological crisis, multiple investments in innovation are associated with environmental demands, i.e., in the development of products or processes whose environmental impact is minimized or eliminated (Agostini, 1996), (European Environment Agency, 2006). In view of the foregoing, different terminologies are used to cover innovations targeting the resolution or minimization of environmental impacts of human activity, such as: Environmental Innovation, Eco-innovation (Andersen, 2006), clean innovation

(Veugelers, 2012), green innovation (Dangelico and Pujari, 2010), (OECD, 2012) and sustainable innovation (Barbieri et al. 2010), ecological technology or green technology (Sarkar, 2013), (Kabayashi et al., 2011).

We will use the term eco-innovation as it is prominent in the literature and in technical reports, encompassing the whole scope provided for in the others. The terminology eco-innovation was proposed in the mid-1990s (Kemp; Horbach, 2008), and the first definition is attributed to James (1997) (Maçaneiro and Cunha, 2010).

Therefore, eco-innovation is associated with a new product and\or process that creates value for the organization and also presents a lesser environmental impact (Maçaneiro and Cunha, 2010) (James, 1997 Apud Kemp; Foxon, 2007) (Sarkar, 2013) .to Reid and Miedzinski (2008), eco-innovation is defined as:

Eco-Innovation means the creation of novel and competitively priced goods, processes, systems, services, and procedures that can satisfy human needs and bring quality of life to all people with a life-cycle-wide minimal use of natural resources (material including energy carriers, and surface area) per unit output, and a minimal release of toxic substances (REID; MIEDZINSKI, 2008, p.i).

Similarly, OECD defines Eco-innovation as:

"Activities which produce goods and services to measure, prevent, limit, minimize or correct environmental damage to water, air, soil as well as problems related to waste, noise and ecosystems. This includes technologies, products, and services that reduce environmental risks and minimize pollution" (OECD, 1999)

In both cases, eco-innovation is an "eco-efficient" innovation going from the use or development of technologies that minimize the "environmental footprint". This condition is prominent and the effects attain nonrenewable natural resources, preservation of the water, soil and atmosphere (Barbieri et al., 2010). therefore, the eco-innovation effort must cover the entire life cycle of products, from the primary source of raw material to the final destination (Kemp; Foxon, 2007), (Maçaneiro and Cunha, 2010). Eco-innovation has the necessary taxonomies for a better understanding and assistance in the evaluation process. Table 1 presents the main classifications found in the literature investigated.

**Table 1 –Eco-innovation Taxonomies**

| No... | Classification | Definition | Reference |
|---|---|---|---|
| 1 | Eco-innovation | Grounded both in a new product and in significant | (HUBER, 2008); |

| | | | |
|---|---|---|---|
| | in the Life Cycle | improvements in any stage of the life cycle of this product. This taxonomy envisages a reduction both in the use of raw materials, and in the levels of waste produced in any stage of the life cycle of the product, i.e., from the production phase up to consumption. | (REID and MIEDZINSKI, 2008) |
| 2 | Product Eco-innovation | Refers to the new and/or improvement of a respective product, in which the global environmental impact is minimized. | (HUBER, 2008); (REID and MIEDZINSKI, 2008) |
| 3 | Eco-innovation in Processes | Based on the new and/or improvement of the productive system, aiming to fulfill some sustainable principles such as reduction in the consumption of water, power, raw material, emission of gases and waste. | (HUBER, 2008); (REID and MIEDZINSKI, 2008) |
| 4 | Organizational Eco-innovation | Addresses the inclusion of specific environmental management tools, such as the incorporation of the standards from the ISO 14000family or voluntary agreements (e.g. Global Reporting Initiative). | (HUBER, 2008); (REID and MIEDZINSKI, 2008) |
| 5 | Eco-innovation in Marketing | Based on the implementation of new marketing methods, embodying significant changes in the product design, packaging, promotion of products, markets, education in product consumption, and others. | (HUBER, 2008); (REID and MIEDZINSKI, 2008) |
| 6 | Incremental Eco-innovation | Grounded in the catalysation of the existing technology in order to refine it, and make it more efficient in the use of resources. | (ARUNDEL; KEMP, 2009), (OECD, 2012) |
| 7 | Disruptive Eco-innovation | Refers to the alteration of the way in which processes or products are performed, without necessarily altering the technological paradigm, e.g. the substitution of incandescent bulbs by florescent bulbs. | (ARUNDEL; KEMP, 2009), (OECD, 2012) |
| 8 | Radical Eco-innovation | Established with an alteration in the technological paradigm, including economic changes, as it involves alteration or creation in the consumption patterns and supply chains. | (OECD, 2012) |

**Source: Prepared by the authors.**

Andersen (2008) further proposes five categories to classify eco-innovation: i) Add-on; ii) integrated; iii) alternative product; iv) macro-organizational; and v) general purpose. Add-on eco-innovation is geared towards products, so as to make them more eco-efficient with consumers and the final destination. Integrated eco-innovations involve joint efforts in the production process and products with less environmental impact; alternative products are innovations targeting the creation of new products, based on clean technology, which is a radical innovation. Macro-organizational eco-innovation is the same provided for in item 4 of Table 1. General-purpose innovations are those that modify the structure of the economy, such as the sugarcane-based ethanol program.

Despite the actuality of the topic, the definition and classification of eco-innovation resort to the theoretical bases of the innovation theory (Sarkar, 2013). for this reason, as in traditional innovation, eco-innovation does not occur randomly in companies, as there is the need for investments in resources and a management system that incorporates in its requirements and guidelines an environmental innovation-oriented action program (Kobayashi et al., 2011), (Lazaro et al., 2008), (Pereira and Vence, 2012). Firm-level eco-innovation efforts should be associated with the typical stages of a process and the environmental impacts expected by companies that have sustainability as a business policy (Barbieri, 2007). figure 1 illustrates the stages considered in the evaluation of the environmental impact of companies based on the conceptual framework developed by Dangelico and Pujari (2010), besides other studies (OECD, 2012), (Barsoumian, Severin and Spek, 2011), (eco-innovation observatory, 2013) (Kobayashi et al., 2011).


**Figure 1 – Stages and environmental impacts of a business process**
**Source: Prepared by the authors**

The evolution of the eco-innovation efforts established in Figure 1 gains scale and scope as of the organizational learning that can be illustrated in Figure 2 proposed by Machiba (2010).

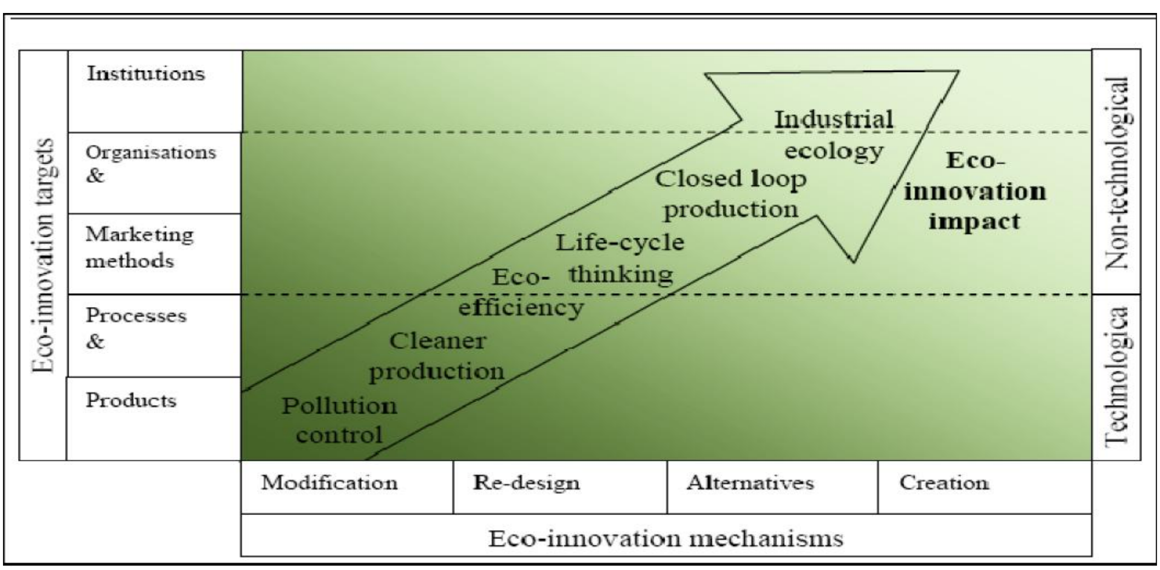



**Figure 2 – Eco-innovation targets and mechanisms.**
**Source: Machiba (2010, p.)**

Note that the first stages of eco-innovation are associated with modifications in products and processes with the introduction of cleaner technologies. The impacts of eco-innovation are first perceived when there is efficiency arising from eco-innovations and assumption of alternative strategies for management of the product life cycle and for the entire production cycle. Nonetheless, this more advanced stage requires more managerial competencies than the first based on technological development.

The introduction of green ecological manufacturers with the experiences reported in the Nordic countries, Luxembourg and Belgium demand a stage of maturity from all the institutions from society (BARSOUMIAN, SEVERIN and SPEK, 2011), (EIO, 2013), (SARKAR, 2013).

## 2.2. Eco-Innovation Indicators

As an extension of innovation, eco-innovation presents the same difficulty similar or in addition to its measurement and control instruments. Besides the absence of consolidated indices the conceptual field that serves as the foundations of eco-innovation is controversial with regards to the economic perspective, such as, for example, the dichotomy between the neoclassical and Marxist schools for the measurement of value creation.

Besides the theoretical apparatus, the metrics and methods of quantification of environmental impacts are not unique, which makes the task of establishing the relation between innovation and aspects associated with the environment an arduous one. Moreover, the measurement of eco-innovation is a complex task, when this is understood as a process and that its effectiveness as concerns the environment only occurs when the life cycle of the product is comprehended (Bocken et al., 2012) (Kemp; Arundel, 1998), (Kobayashi et al., 2011).

**Huger (2008) demonstrates this complexity in Figure 3:**

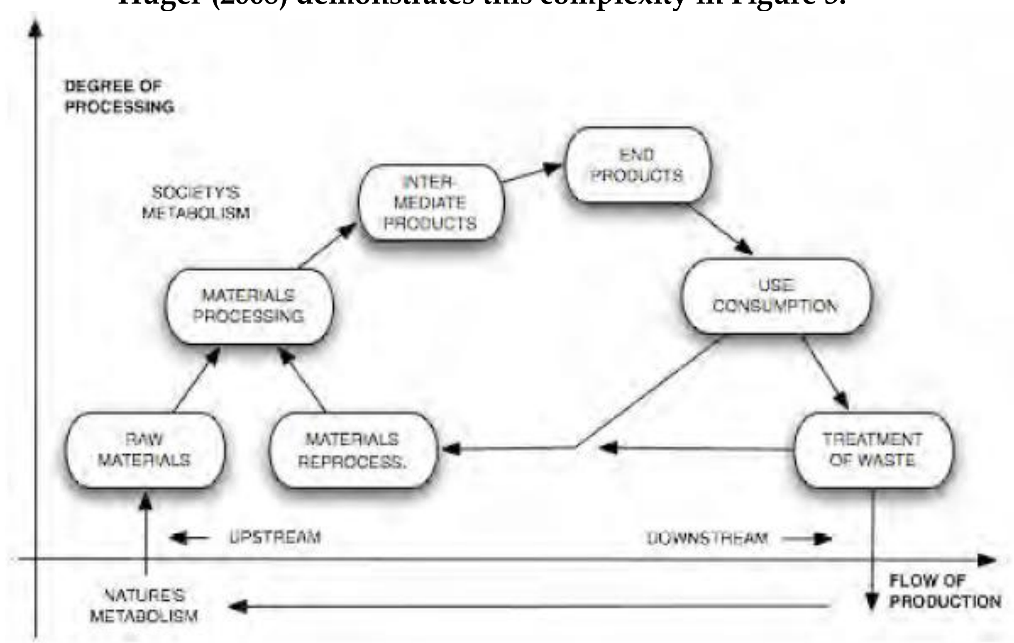



**Figure 1 – Product Chain**
**Source: Huber (2008)**

Thus, the development of eco-indicators is undergoing a process of conformation (European Environment Agency, 2006), and some experiences already demonstrate analyzable results (Echo-Innovation Observatory, 2013).

Andersen (2006) proposes that indicators geared towards eco-innovation contemplate topics related to technological, economic and social matters. However, the proposal submitted

By the author involves indicators to evaluate the Eco-innovation System, where the business segment is one of the elements to be evaluated together with the availability of capital for project funding, incentive to entrepreneurship in green technologies, public policies, knowledge and involvement of universities and structure for monitoring information and knowledge.

EIO involves a set of sixteen indicators in five categories, whose data are extracted from eight different databases. Table 2 presents the indicators.

**Table 2 – EIO 2011 and 2012 version Eco-Innovation Indicators**

| 1. Eco-Innovation Inputs | 2. Eco-Innovation Activities | 3.Eco-Innovations Outputs | 4. Environmental Outcomes | 5.Social-economic Outcomes |
|---|---|---|---|---|
| 1.1. Governments environmental and energy R&D appropriations and outlays (% of GDP | 2.1. Firms having implemented innovation activities aiming at a reduction of material input per unit output (% of total firms) | 3.1.Eco-innovation related patents (per mln population) | 4.1 Material productivity (GDP/Domestic Material Consumption | 5.1. Exports of products from eco-industries (% of total exports) |
| 1.2. Total R&D personnel and researchers (% of total employment) | 2.2. Firms having implemented innovation activities aiming at a reduction of energy input per unit output (% of total firms | 3.2. Eco-innovation related academic publications (per mln population) | 4.2. Water productivity (GDP/Water Footprint | 5.2. Employment in eco-industries (% of total workforce). |
| 1.3. Total value of green early stage investments | 2.3. ISO 14001 registered organizations (per mln population) | 3.3. Eco-innovation related media coverage (per numbers of electronic media | 4.3. Energy productivity (GDP/gross inland energy consumption | 5.3. Turnover in eco-industries |
| | | | 4.4. GHG emissions intensity (CO2e/GDP | |

**Source: Adapted from the Eco-Innovation Observatory (2013, P. 44)**

To calculate the indicators from Table 2, EIO makes use of a structure of correlated sub-indicators (Eco-Innovation Observatory, 2013). It can be seen that the EIO structure is made up of four dimensions: i) investments in eco-innovation (inputs); ii) Activities associated with the effort of innovating; iii) results of investments and management in eco-innovation; and iv) impact of results on the social environment. This view forms a contrast among some traditional eco-innovation indicators focused exclusively on business investments related to the reduction of pollution from their processes. In the wake of creating an index for eco-innovation in Brazil, the Brazil Innovation Index (IBI) drawn up in the Department of Scientific and Technological Policy of the Geoscience Institute of Universidade Estadual de Campinas is observed as a first initiative for broader innovation (Furtado and Quadros, 2006). The preparation of IBI encompasses two dimensions, namely: i) the innovative effort undertaken by companies; and ii) the impact of innovation on technological and economic perspectives. Therefore two aggregate indicators are proposed: the Aggregate Indicator of Effort (AIE) and the Aggregate Indicator of Result (AIR). Both the AIE and the AIR are broken up into two indicators each: i) AIE is composed of the Index of Innovative Activities (IIA) and Index of Human Resources (IHR); and ii) AIR is formed by the Patent Index (PI) and by the Economic Impact Index (EII). IBI is calculated using formula (01):

$$(01)\ \mathrm{IBI} = (\mathrm{IIA} \times 0.75 + \mathrm{IHR} \times 0.25) + (\mathrm{PI} \times 0.40 + \mathrm{SRI} \times 0.6)$$

The main intervening variables that compose the aggregate indicators of the IBI model present a conceptual structure based on the Oslo Manual. Formulas (02), (03), (04) and (05) present the detailed calculation of each indicator.

$$(02)\ \mathrm{IIA} = [(\mathrm{IR} \times 0.30) + (\mathrm{ER} \times 0.15) + (\mathrm{OK} \times 0.10) + (\mathrm{ME} \times 0.15) + (\mathrm{TR} \times 0.05) + (\mathrm{PL} \times 0.10) + (\mathrm{PR} \times 0.15)]$$

The structure of the innovative activities brings together Internal R&D (IR) as the most preponderant factor, followed by External R&D (ER), Machinery and Equipment (ME) and Industrial Projects (PR); The variables acquisition of Other Knowledge (OK) and Product Launch (PL) have a weight of 10%, while the variable Training (TR) received the lowest importance with 5% of the weight of the indicator. Each variable of this index is measured through the outlays incurred in each item and relativized by net revenue as a means of standardizing the differences of size of the organizations. After this the result of each company is divided by the mean value of the sector in which the company is included. This quotient will then be multiplied by the weightings presented in formula (02), so as to allow a ranking of the more innovative companies.

$$(03)\ \mathrm{IHR} = [(\mathrm{UGR} \times 0.15) + (\mathrm{MT} \times 0.35) + (\mathrm{DR} \times 0.50)]$$

In the Index of Human Resources IBI segregated capital human by the level of education with dedication in R&D at companies. Thus Doctors (DR) received the highest weight, followed by Masters (MT) and Graduates (GR). In these indices the calculation occurs at two separate times, as does the IIA. Initially the quantity of each variable is related to the total employee headcount of the company and afterwards this quotient is divided by the industry standard.

$$(04)\ \mathrm{PI} = [(\mathrm{PD} \times 0.50) + (\mathrm{PG} \times 0.50)]$$

In the Patent Index the variables used are Patents Deposited (PD) and Patents Granted (PG), with equal weight. The variables are calculated with the division of the patents by the employee headcount then each quotient is related to the industry standard.

$$(05)\ \mathrm{SRI} = [(\mathrm{RE} \times 0.10) + (\mathrm{RN} \times 0.40) + (\mathrm{RM} \times 0.50)]$$

The Sales Revenue Index involves Total revenues with new products (RE), Revenues in the national market with new products (RN) and national revenues in the global market with new products (RM). The calculation proposal is the same as the other indicators; first of all the revenues of each variable are related to the company's total revenue then the quotients are divided by the industry. Furtado and Quadros (2006) do not explain the decision criterion of the weights for each variable, but only the calculation methodology that was applied with the data from the first edition of PNTEC with companies that agreed to take part in the IBI.

Santos, Basso and Kimura (2012), when analyzing the variables that define the capacity to innovate of Brazilian companies with data from the 2000, 2003 and 2005 editions of PINTEC, extended the AIR concept by using the metrics traditionally used in corporate finance, substituting the revenue indicator with the performance variables ROA, ROE, ROS and Profit Margin. Moreover, the authors suggested that the indicator innovative activity should be segregated in internal capital and relational capital (external).This situation combines with the studies of (Malerba, 2005) and ratifies the importance of the relationship chain for the diffusion and creation of technology between companies and research centers (universities, institutes, laboratories, and others) (Arbaciauskas et al., 2010). Pereira and Vence (2012) investigated empirical studies on eco-innovation at the firm level, aiming to verify the determinants of these investments. The authors found fourteen empirical studies between the years 2006 and 2011 and identified four determinant categories of eco-innovation presented in

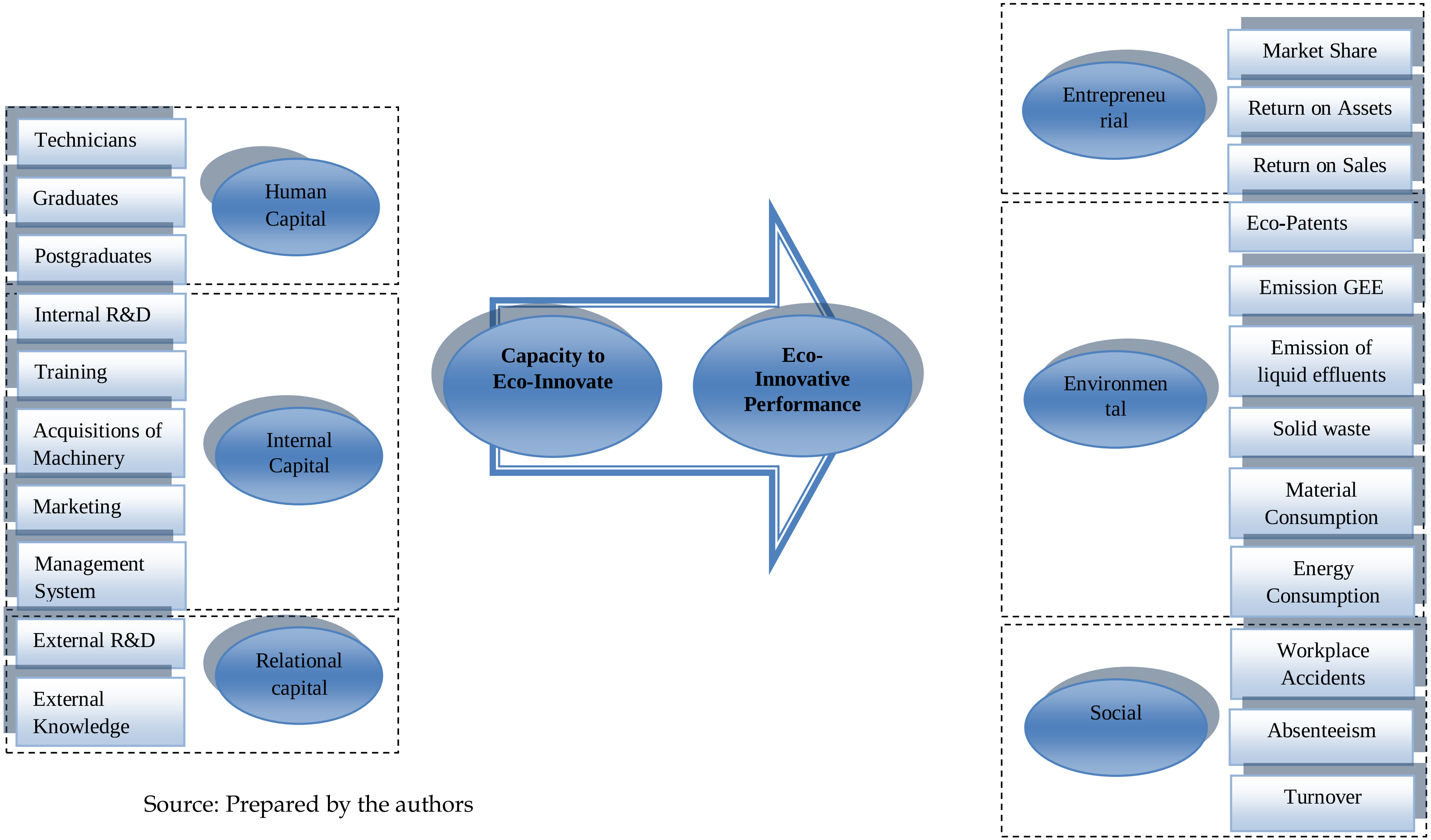
**Table 3 – Determinants of Eco-innovation**

| **Determinant Categories** | | **Factors** |
|---|---|---|
| Conventional Factors | Structural characteristics of the firm | Size |
| | | Industry |
| | | Age |
| | Business Logic | Cost cutting |
| | | Consumer needs |
| | | Consumer benefits |
| | | Consumer satisfaction |
| | | Expectation of demand |
| | | Export-oriented strategy |
| | Technological competency | R&D activities |
| | | Path dependencies of innovations in the past. |
| | | Qualification of the employees |
| | | Cooperation and networked activities |
| | | Relationship with companies from the industry |
| Environmental strategy of the company / Innovation Management and Marketing | | Environmental Management System (ISO, EMAS) |
| | | Environmental criteria in product planning and development |
| | | Company product life cycle evaluation activities |
| | | Waste disposal and reverse logistics |
| | | Environmental labeling |
| | | Market research on green products |
| | | Information from consumers |

**Source: Pereira and Vence (2012, p. 80)**

Having brought up this theoretical discussion, the theoretical model proposed as a hypothesis to identify the variables and degrees of influence for an Eco-Innovation Index structure is presented in Figure 3.

Figure 3 – Conceptual Model for the Brazil Eco-Innovation Index




Source: Prepared by the authors

The variables in a circle are latent variables or not directly observable. This is a case of constructs established by the structure (quantitative or qualitative) of the variables observed directly beside the phenomenon. Thus the firm's capacity to generate eco-innovations is organized on the resources associated with human, internal and relational capital. This structure accompanies the model proposed by Santos, Basso and Kimura (2012) which is based on the structure of the Oslo Manual (2002) that serves as a basis for the research of Pintec/Ibge (2007) and the IBI (Furtado and QuadroS, 2006).

As already observed, we did not find an Eco-innovation Index structure in the databases searched, except for the structure already presented of the Eco-Innovation Observatory (Table 2). Nevertheless, the indicators proposed in Figure 3 are supported by research already undertaken on the topic. Table 3 presents the results of the research.

**Table 3 – Eco-indicators associated with the Capacity to Eco-Innovate Used in the literature**

| Category | Indicator | Description | Reference |
|---|---|---|---|
| Human Capital | R&D staff | Based on the number of people who work at least 50% of the time on R&D projects | (LÁZARO et al., 2008) |
| | Investment in Machinery and Equipment | Outlays in machinery and equipment. | (SEGARRA-OÑA et al., 2011) |
| Internal. Capital | Total investments in R&D | Expenses with Internal R&D | (ANDERSEN, 2006), (LÁZARO et al., 2008) (CAINELLI, MAZZANTI and ZOBOLI, 2010) |
| | Number of R&Dprojects executed | R&Dprojects in processes, products and services executed over a period of time. | (LÁZARO et al., 2008) |
| | Training expenses | Based on the total expenses related to innovative processes, products and services. | (LÁZARO et al., 2008) |
| | Organizational changes | Environmental certifications; Internal and external environmental audits; Formalized environmental policies; Environmental reports available to the public; Environmental programs for the employees. | (BLUM-KUSTERER and HUSSAIM, 2001), (LÁZARO et al., 2008), (CAINELLI, MAZZANTI and ZOBOLI, 2010) |
| Relational Capital | External R&D and Other knowledge | Relationship between companies and technological centers or universities. | (SCARPELLINI et al. 2012), (CAINELLI, MAZZANTI and ZOBOLI, 2010) |

**Source: Prepared by the authors**

**Table 4 – Eco-indicators associated with the Eco-Innovator Performance used in the literature**

| Category | Indicator | Description | Reference |
|---|---|---|---|
| Entrepreneurial | Revenues as a result of innovation | Aims to obtain the percentage of revenue reached after the innovation. There is segregation between revenues from new products for the national and international market | (Lazaroet al., 2008); (Segarra-Oña et al., 2011) |
| Environmental | Intellectual Property | Number of patents granted. It is a means of measuring the intellectual property of innovation and of new ideas. | (Andersen, 2006), (Lazaro et al., 2008), (Segarra-Oña et al., 2011) |
| | Material Input Per Service Unit (MIPS) | Measures the quantity of inputs used during the manufacture of a product and/or service | (Reid and Miedzinsk, 2008) |
| | Domestic Extraction Used – (DEU) | Measures the flow of materials extracted from the environment, which have physically entered the economic system via production and/or consumption. | (Reid and Miedzinsk, 2008) |
| | Direct Material Input – (DMI) | Measures the input of materials for use by an economy. All the materials that have an economic value, and are used in the production and consumption activities. | (Reid and Miedzinsk, 2008) |
| | Domestic Material Consumption – (DMC) | Measures the total quantity of materials used directly in an economy. The DMC may use generic measurements, such as consumption of energy, water and others. | (Reid and Miedzinsk, 2008) |
| | Total Material Consumption – (TMC) | Measures the total quantity of materials used in domestic production and consumption. Includes the indirect flow of imports. | (Reid and Miedzinsk, 2008) |
| | Physical Trade Balance – (PTB) | Reflects the trade deficit and/or surplus. This is defined by the expression imports minus exports. | (Reid and Miedzinsk, 2008) |
| | Total Domestic Output – (TOD) | Refers to the environmental burden of the use of materials. And the quantity of materials that have left the environment, in response to economic activities. | (Reid and Miedzinsk, 2008) |

**Source: Prepared by the authors**

**References**

Agostini, N. A (1996). crise ecológica: o ser humano em questão. In: Moreira, A. D. S. Herança franciscana: Festschrift para Simão Voigt. Petrópolis: Vozes, p. 223-255.

Andersen, M. M. (2006). Eco-innovation indicators. Report for Risö National Laboratory. European Environment Agency: Copenhagen.

Almeida, J. A. J. P&D no setor elétrico brasileiro:um estudo de caso na Companhia Hidro Elétrica do São Francisco. 2008. 97 f. Dissertation (Master's degree in Economics) - Universidade Federal de Pernambuco, Recife, 2008.

Arbaciauskas, V.; Gaiziuniene, J.; Laurinkeviciute, A.; Zidoniene, S. Sustainable Production through Innovation in Small and Medium Sized Enterprises in the Baltic Sea Region. Environmental Research, Engineering and Management, v. 51, n. 1, p 57–65, 2010.

Arundel, A.; Kemp, R. Measuring eco-innovation. Working Paper Series, 2009.

Barsoumian, S.; Severin, A.; Spek, T. V. Eco-innovation and national cluster policies in Europe.A Qualitative Review. European Cluster Observatory. Brussels: Europe Innova, 2011.

Barbieri, J. C. Gestão ambiental empresarial: Conceitos, modelos e instrumentos. 2. ed. São Paulo: Saraiva, 2007.

Barbieri, J. C.; et al. Inovação e Sustentabilidade: Novos modelos e proposições. Revista de Administração de Empresas, São Paulo, v. 50, n. 2, p. 146-154, Apr./Jun. 2010.

Blum-Kusterer, M.; Hussaim, S. S. Innovation and corporate sustainability: an investigation into the process of change in the pharmaceuticals industry. Business Strategy and the Environment, v. 10, n. 5, p. 300–316, 2001.

Bocken, N. M. P.; Allwood, J. M.; Willey, A. R.; King, J. M. H. Development of a tool for rapidly assessing the implementation difficulty and emissions benefits of innovations. Technovation, v. 32, n. 1, p. 19-31, Jan., 2012.

Cainelli, G.; Mazzanti, M.; Zoboli, R. Complementarity in eco-innovation: concepts and empirical measurement. In: Annual International Sustainable Development Research Conference, 16, 2010, Utrecht-Netherlands, Proceedings, ISDR, 2010.

Chapple, K. Defining the Green Economy: A Primer on Green Economic Development. In: . The Center for Community Innovation, Nov.2008.

Conselho Nacional De Desenvolvimento Científico E Tecnológico – CNPq. Projeto CNPq-MIT nº 29\2012. Available at: < http://www.cnpq.br/web/guest/chamadas-publicas?p_p_id=resultadosportlet_WAR_resultadoscnpqportlet_INSTANCE_0ZaM&idDivulgacao=1781&filtro=encerradas&detalha=chamadaDetalhada&id=413-2-1695>. Access on: August 25, 2012.

Dangelico, R. M.; Pujari, D. Mainstreaming Green Product Innovation: Why and How Companies Integrate Environmental Sustainability. Journal of Business Ethics, v. 95, n. 3, p. 471–486, 2010.

Eco-Innovation Observatory (EIO). Europe in transition. Paving the way to a green economy through eco-innovation. European Commission, DG Environment, Brussels, 2013.

European Environment Agency - EEA. Eco-Innovation Indicators. Copenhagen, 2006.

Freeman, C. The greening of technology and models of innovation. Technological forecasting and social change, v. 53, n. 1, p. 27-39, 1996.

Furtado, André; Quadros, Ruy. Construindo o IBI. Revista Uniemp Inovação, Campinas, v. 2, n. 3, p. 26-27, 2006.

Grupp, Hariolf. Foundations of the economics of innovation. Theory, measurement and practice. Massachusetts: Edward Elgar Publishing, 1998.

HUBER, J. Technological environmental innovations (TEIs) in a chain-analytical and life-cycle-analytical perspective, The Journal of Cleaner Production XX. p. 1-7, 2008.

Instituto Brasileiro De Geografia E Estatística (IBGE). Pesquisa de Inovação (PINTEC) Available at: <http://www.pintec.ibge.gov.br//>. Access on: August 25, 2012.

Junqueira, L. A. P.; Souto Maior, J.; Pinheiro, F. P. Sustentabilidade: A produção científica brasileira entre os anos de 2000 a 2009. Revista de Gestão Social e Ambiental, São Paulo, v. 5, n. 3, p. 36-52, Sep./Dec. 2011.

Lazaro, E. J.; Dorronsoro, I. C.; Casas, S. H.; Rodríguez, D. G.; Sedano, J. A. G. Indirect measurement of eco-innovation based on company environmental performance data.In: MEI Project. Mar. 2008.

Lovins, L. H. Rethinking Production, in: World Watch Institute, State of the World 2008: innovations for a sustainable economy. Available at: <http://www.worldwatch.org/> Access on: September 5, 2012.

Kemp, R.; Arundel, A. Survey indicators for environmental innovation. Idea Paper Series, 1998.

Kemp, R.; Foxon, T. J. Typology of Eco-Innovation. In: MEI project: Measuring Eco- Innovation. European Commission, Aug. 2007.

Kemp, R.; Horbach, J. Measuring of Competitiveness Eco-Innovation, In: MEI project: Measuring Eco- Innovation. European Commission, Mar. 2008.

Kemp, R.; Pearson, P. Policy brief about measuring eco-innovation and Magazine/Newsletter articles. In: MEI project: Measuring eco-innovation. European Commission, Mar. 2008.

Kobayashi, H.; Kato, M.; Maezawa, Y.; Sano, K. An R&D Management Framework for Eco-Technology. Sustainability, v. 3, n. 8, p. 1282-1301, 2011.

Maçaneiro, M. B.; Cunha, S. K. Eco-Inovação: um Quadro de Referência para Pesquisas Futuras. In: Simpósio De Gestão Da Inovação Tecnológica, 26, 2010, Vitória-ES, Anals..., Vitória: ANPAD, 2010.

Organisation for Economic Co-Operation and development - OECD. Oslo Manual: diretrizes para coleta e interpretação de dados sobre inovação. 3rded. Trad. FINEP. Rio de Janeiro: OECD; Eurostat; FINEP, 2006. Available at: <http: //www. finep.gov.br /imprensa /sala_imprensa/oslo2.pdf> .

Access on: September 5, 2012.

Organisation for Economic Co-Operation and Development - OECD. Measuring material flows and resource productivity, Synthesis Report, Paris: OECD, 2008.

Organization for Economic Cooperation and Development - OECD. Sustainable manufacturing and eco-innovation: Framework, practices and measurement. Synthesis Report. Paris: OECD, 2009. Available at: <http:// www.oecd.org /dataoecd/ 15/58/ 43423689.pdf > Access on: October 4, 2012.

Organization for Economic Cooperation and Development - OECD. The future of eco-innovation: The Role of Business Models in Green Transformation. OECD Background Paper. Copenhagen, 2012.

Pereira, A.; Vence, X. D.Key business factors for eco-innovation: an overview of recent firm-level empirical studies. Cuadernos de Gestión, v. 12, Especial Innovación, p. 73-103, 2012.

Reid, A.; Miedzinski, M. Eco-Innovación, Final Report for Sectoral Innovación

Watch. Brussels: Technopolis Group, 2008. Available at: <http://www.technopolis-group.com /resources/downloads/661_report_final.pdf>. Accesson: September 8,2012.

Rennings, K. Redefining Innovation – Eco-Innovation Research and the Rennings, K.; Wiggering, H. Steps towards indicators of sustainable development: Linking economic and ecological concepts. Ecological Economics, v. 20, p. 25-36, 1997.

Contribution from Ecological Economics. Ecological Economics, 32, p. 319 – 332, 2000.
Santos, D. F. L.; Basso, L; F. C; Kimura, H. A estrutura na capacidade de inovar das empresas brasileiras: uma proposta de constructo. Revista de Administração e Inovação.São Paulo, v. 9, n.3, p. 103-128, Jul-Sept. 2012.
Sarkar, A. N. Promoting Eco-innovations to Leverage Sustainable Development of Eco-industry and Green Growth. European Journal of Sustainable Development, Rome, v. 2, n. 1, p. 171-224, 2013.
Scarperllini, S.; Aranda, A.; Aranda, J.; Llera, E.; Marco, M. R&D and eco-innovation: opportunities for closer collaboration between universities and companies through technology centers. Clean Technologies and Environmental Policy, v. 14, n. 6, p. 1047-1058, 2012.
Schumpeter, J. A. Capitalism, socialism and democracy. New York: Harper Brothers, 1942.
Segarra-Oña, M.; Peiró-Signes, A.; Miret-Pastor, L.; Albors-Garrigós, J. ¿Eco-innovación, una evolución de la innovación? Análisis empírico en la industria cerámica española. Boletín de la Sociedad Española de Cerámica y Vidrio, v. 50, n. 5, p. 253-260, Sept. /Oct., 2011.
Tigre, Paulo Bastos. Paradigmas tecnológicos e teorias econômicas da firma. Revista Brasileira de Inovação, Campinas-SP, v. 4, n. 1, p. 187-223, Jan./Jun., 2005.
United Nations Environment Programme – UNEP.Towards a Green Economy: Pathways to Sustainable Development and Poverty Eradication. Available at: <www.unep.org/greeneconomy>. Access on: August 7, 2012.
United Nations Framework Convention On Climate Change – Unfccc. Kyoto Protocol Reference Manual on Accounting of Emissions and Assigned Amount.UNFCCC: Bonn, 2008.
Verfaillie, H. A.; Bidwell, R. Medir a eco-eficiência: um guia para comunicar o desempenho da empresa. World Business Council for Sustainable Development. Jun, 2000.
Veugelers, R. (2012). Which policy instruments to induce clean innovating? Research Policy, 41, p. 1770 - 1778.
World Business Council for Sustainable Development – Wbcsd (2000).Eco-efficiency: creating more value with less impact.