# DYNAMIC AND INNOVATIVE ENTERPRISES: IS IT POSSIBLE TO MEASURE THEIR CONTRIBUTION TO THE ECONOMY?

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## Abstract

A new family of indicators that aims at capturing the output of innovative and high growth firms was proposed in this paper. The DINNOV family of indicators was developed as an alternative to the Innovation Output Indicator (IOI) conceived for the Europe 2020 strategy (European Commission, 2013). Brazilian data were used to calculate the values of the new family of indicators for several years. and a methodology was proposed on how to explore the Eurostat´s Micro-Moments Dataset - MMD in order to compute them for several European economies as well. The paper argues that the proposed family of indicators provides a better way to gauge the impact of innovation and entrepreneurship in the economy than the IOI alternative.

**Keywords**: innovation, output, indicator, high-growth firm, Brazil, Europe, DINNOV.

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## 1. Introduction

The importance of Science, Technology and Innovation (ST&I) indicators is justified by their usefulness as an essential tool to better understand and monitor processes of production, diffusion and use of scientific knowledge, technologies and innovations (Viotti, 1993). Its importance is also in the scientific field, which aims at encouraging the acquisition of knowledge about the nature of the dynamics of ST&I processes. Also in politics, its focus is placed on the capacity to design and implement efficient public policies (Viotti, 1993).

It is important to take into account the choice of indicators that constitutes the ST&I system. This reflects a way of looking at the nature of phenomena in certain economic conditions. Viotti (1993) argues that "[…] the definition of indicators is usually preceded by the realization of certain choices related to the importance and the role of variables. Such choices usually reflect some model of implicit or explicit understanding of the nature of the processes of production, diffusion and use of ST&I". Therefore, according to the interpretative model of innovation, it is necessary to design a different basket of indicators."

For these reasons, the trajectory of indicators since the 1950s and 1960s accompanies the history of the influence of economic thinking on innovation since then. Archibulli and Sirili (2000) comment that, as in the 1950s and 1960s, the main indicator chosen to measure ST&I was related to Research and Development (R&D). Subsequently, with the development of the chained link model (in the 1980s) and the ascendancy of the systemic vision developed in the 1990s, new variables were added to the indicator basket. At the end of the 20th century, the portfolio of possibilities included variables such as patents, technological balances of payments, high technology products, and human resources, as well as innovation surveys, with the addition of indicators related to knowledge mapping, institutional mapping, intangible investments, opinion surveys, information and communication technologies (ICT) and to the economic analysis (Archibulli & Sirili, 2000). However, the measurement of innovation and of its economic impacts is not yet consolidated and still presents opportunities for the introduction of improvements.

The aim of this paper is to present a particular view about the dynamism of economies in terms of innovation and growth. It is argued that is possible to observe the pace of countries' economies in a

close view of a small subset of firms that innovate and grow simultaneously.[11] This hard core of innovation and growth in combination acts as an engine of economy in two different ways. The first one, by innovation, which, as intensively discussed by several authors, represents a "crucial source of effective competition, of economic development and the transformation of society" (Freeman, 2003). Nevertheless, the disruptive immanence of innovation can provoke rising of both productivity and unemployment rates. The second way, by growth, which would represent a compensation for the rising of unemployment by opening new frontiers (i.e., economic activities), gaps in the structure where is possible to sustain productivity and hire more people. These two ways are both connected and interdependent in the micro level (firm), generating virtuous cycles of product expansion in the macro level.

In order to follow the rhythm of the economy through these two components, this paper proposes a new family of indicators that combines innovative and high-growth firms. In this new family of indicators, called DINNOV ("dynamism and innovation"), surveys inspired in the Oslo Manual (OECD, 2005) are used, while high-growth is interpreted by high growth firms, concept adopted by OECD, that takes into account all firms with more than 20% of growth over a three-years period (OECD, 2016). [12] The proposed indicator is an alternative to the European Union 2020 innovation indicator (European Commission, 2013), DYN, which aims at capturing innovation outputs and outcomes and thereby "support policy makers in establishing new or reinforced actions to remove bottlenecks that prevent innovators from translating ideas into products and services that can be successful on the market" (European Commission, 2013). All calculation is based on Brazilian databases. The sources of data to calculate the proposed indicator for European countries is also presented in the paper.

Besides this introduction, this paper is divided into three major sections. Section 2 details the building of the European DYN in comparison of DINNOV Family and summarizes an innovation output indicator presented in Viotti et al (2015) using Brazilian micro data. Section 3 presents a proposal of calculating DINNOV Family with European countries data. The methodology reflects

[11] Growth, here, can be regarded in terms of the number of employees, but extensible to other variables, like revenue or value added. However, for the motivation of this paper, the concept of High Growth by number of employees sounds more likely once the idea is to compensate job loses provoked by productivity rising.

[12] The DINNOV indicator is calculated dividing the number of high-growth and innovative firms by the total number of firms. The indicator shows the relative weight in the economy, measured in terms of firms, the core of firms that are simultaneously innovative and of high-growth.

limitations of Eurostat´ Micro Moments Dataset (MMD) (Eurostat, 2016; Hagsten et al, 2013). Finally, the main conclusions of the paper are presented in section 4.

## 2. The DINNOV Family of Innovation Output Indicators

This section is splited out in four subsections. The first one sets the basis for the construction of a new indicator or a new family of indicators as proposed here. It begins by redeeming essential aspects of the directives for the creation of an innovation output indicator as presented from the workforce called High Level Panel that was created by the European Commission in 2010 (European Commission, 2010). It is shown that the "tortuous" paths that the innovation output indicator ends up, would lead essentially to the lack of adequate data in order to directly estimate the participation of the innovative firms of high-growth in the economy. This subsection also shows that such a problem is not affecting Brazil and indicates how the participation of those firms can, in the Brazilian case, be estimated on the basis of the census information of the Central Registry of Enterprises (CEMPRE) published by the of Brazilian Institute of Geography and Statistics (IBGE), the data from the Brazilian Innovation Surveys (PINTEC) and the IBGE Entrepreneurship Statistics.

The second subsection presents the first indicator of the DINNOV family, which measures the proportion of the number of firms that are simultaneously high-growth and innovative in the total number of the firms. This high-growth and innovation rate measures the relevant weight in the economy, calculated in terms of the number of the firms, of the core firms that associate these two phenomena of great interest for the economy. This subsection presents the calculation formulas of this indicator both for the years when PINTEC data are available, and for the years when it is not the case. In addition, the values of the indicator DINNOV-Employment estimated for Brazil for the period between 2008 and 2012 are presented, as those data are detailed for all the divisions of the manufacturing industry, the total of the extraction industry, and selected services.

The third and fourth subsections present respectively two new indicators of the DINNOV family. As their names suggest, they calculate the participation of high-growth innovative firms in the economy in terms of employment and the value added as well. In the third subsection, the respective forms of calculation of the values of those indicators are described, and the results of their estimations for Brazil are presented. Apart from the aggregated data for Brazil, detailed data for selected economic activities are also presented. The period covered from those statistics correspond to the years from 2008 to 2012. The last part ends up with a presentation of a simplified version of indicator, a proxy of DINNOV. The form that the DINNOV indicator assumes permits its

calculation for cases of countries where databases required for the direct calculation of the weight of the innovative high-growth firms in the economy are available. As in the case of those countries, it was not possible to find the innovation rate of the firms, it is assumed that that the innovation rate of the firms in general also keeps constant among the high-growth firms. The values of the DINNOV-Simplex calculated for Brazil and some other countries are presented and compared in this subsection.

### *2.1. The original proposal: the European Commission output indicator*

In the wake of political interests in encouraging innovation, the European Commission has created, at the end of the 2000s, a high-level panel, whose objective was to identify internationally comparable indicators that best reflected the intensity of the innovation and focused on results and impacts (European Commission, 2010, Section 7.2, p. 29-30). The Panel, at that point, explored two options. The first one was to use three indicators already available, based on patent applications, on the contribution to the balance of payments of high and medium high intensities and on employment in knowledge-intensive activities. The second would be to use a single indicator that would specifically reflect the development and dynamism of innovative business activities. The European Commission has decided on the second option, which is an indicator that measures innovative rapid growth, even if it were necessary to invest more labor and time to generate their first results.

The choice, at that point, was based on basic assumptions that Hollanders (2011) calls desirable properties of the new indicator. In practice, it means an ideal list of ten characteristics that should be observed to construct a new index. The "perfect" indicator should be simple and easy to understand, comprehensive and direct, objective, rapidly computable, stable, internationally comparable, decomposable, poorly susceptible to manipulation, technically easy to compute, and sensitive to stakeholder perceptions. The high-level panel also pointed a series of problems associated to the use of data from the Community Innovation Survey (CIS). The following points stand out:

- CIS does not cover all the sectors of the economy, having information only for sections B, C, D, E, G46, H, J58, J61, J62, J63, K, M71 from ISIC rev. 4, violating the criterion of being comprehensive and direct;
- Problems regarding the size of the samples, which would decompose in sectors of the economy;

- Comparability between the surveys due to the differences between firms and their perceptions about the degree of innovation of their competitors, violating the principle of being internationally comparable;
- CIS data are not available on an annual basis, violating the view that it should be sensitive to stakeholders; and
- Subsequent scientific validation of the indicator would require microdata, which are not available to all countries.

The proposal presented in September 2013 by the European Commission (European Commission 2013a; 2013b and 2013c) had the ambition to develop an indicator of the result of the innovation process, which may play a similar role, or complementary to, that nowadays carried out by the established input indicators, in by R & D indicators.

The innovation outcome indicator (IOI) is a composite indicator obtained by the combination of 5 other indicators as follows:

- Patent applications as a proportion of GDP (PCT);
- Jobs in knowledge-intensive activities (KIA);
- Contribution of exports of high and medium-high intensity products for the commercial payment balance (GOOD);
- Participation of knowledge-intensive services in total exports of services (SERV); and
- Employment in high growth companies in innovative sectors (DYN).

The possible comparison of DINNOV Family is specifically with the employment in high growth firms in innovative sectors (DYN). The fifth and last component of the composite indicator of innovation outcome is an indicator that seeks to measure the contribution that employment in innovative high growth in all high-growth firms (innovative or not). Therefore, this indicator can be interpreted as the dynamism of innovation among high-growth, a way of measure the contribution of innovation to dynamism of the economy of a given country (European Commission, 2013b, pp. 5 and 10).

Calculation of the contribution to employment of high-growth innovative enterprises is, however, done indirectly, using for this purpose “sector coefficients which reflect the degree of innovation of each sector and serve as a proxy to distinguish innovative firms” (European Commission, 2013b, p.9). As already indicated, the indicator considers only the high growth rates that belong to activities included in the sectors called “business industries”, excluding the financial sector. As a

result, there are disregarded activities belonging to sections A - Agriculture; K – Activities Financial institutions; O - Public administration; P - Education; Q - Health; R - Arts; T - Domestic and U - International agencies, and sections 94 and 96 of section S - Other activities and services (European Commission, 2013b, p.20). All other activities are considered in the calculation of the indicator.

The original intention of directly measuring the contribution of innovative and high-growth companies was abandoned because of two reasons, both related to the innovation surveys carried out by the countries of the Community Innovation Surveys (CIS). The first is related to the fact that the understanding of the concept of innovation can vary between countries, which would partially compromise its use for comparison countries. The second reason is associated with the fact that innovation surveys are not available for every year and are published only two or more years after the reference year. This would prevent the calculation and publication of the results of the DYN indicator periodicity and limit the promptness required for its use in policy formulation and evaluation.

As a way to overcome this difficulty, the alternative of measuring the contribution to employment of activities that would come to be classified as innovative sectors. In passing, it is worth noting here that the reference that the title of the DYN indicator makes to "innovative sectors" can be interpreted as a sort of archaeological testimony of this intermediate step in the evolution of the indicator. The intention of this alternative was to base the calculation of the DYN indicator on a new classification of innovative sectors, which would play a role similar to that played by the classification of intensive sectors knowledge in the calculation of the indicator of knowledge - intensive activities - KIA.

The option of defining the DYN indicator from the so-called sectorial innovation coefficients was fatalistically justified on the grounds that "unfortunately, the lack of data for some countries and / or sectors, the limited sizes of some samples, comparability problems in the certain details do not allow the production of country-specific coefficients that are suitable for cross-country comparisons" (European Commission, 2013b, p. 50). On the other hand, it cannot be disregarded the fact that this methodological option has serious consequences for the indicator.

One of the most important consequences of this methodological option is the fact that the coefficients have been established from European Union data as a single standard to be applied to any country. With this, the coefficients obviously disregard the different sectorial dynamics of the process of innovation and intensity of knowledge that occur in each country and replace it with an

average of these dynamics that was found for the set of countries of the European Union at a given moment.

The innovation performance indicator proposed by the European Commission is a composite indicator consisting of the combination of four other indicators, one of these four being in turn the combination of two others. As defined, the value of the composite indicator of innovation for each country and year depends on the choices made in terms of "... selection of components, unavailability of unavailable data, normalization, weights, aggregation method, among others "(European Commission, 2013b, p.40). It is true that such choices "... were made on the basis of expert opinion (e.g., component selection), or in standard practice (eg. normalization) and guided by statistical analysis (e.g. weights of the components)" (European Commission, 2013b, p. XXX). It is also true that such choices were intended to take into account various measures related to innovation, to combine them in a way to seek a certain statistical balance of the influence of each of the four components on the final indicator, to make it more convenient or easy to compare their values, by means of a process of normalization and transformation of the values of its components, as well as the indexation of the values of the composite indicator, taking as reference the value found for the European Union in the year of 2010. However, all these manipulations serve to move away the indicator of their most intuitive understanding and of their eventual use as a policy instrument or goal.

The analysis of the meaning and evolution of the new indicator is very complex and not intuitive because it is the result of the aggregation of several components, which are previously normalized, transformed, weighted by specific weights or coefficients and, at the end, the result Of its aggregation to be indexed. The fact that it is difficult to explain or understand the evolution of the indicator certainly limits the potential of using this new indicator as a tool for analysis and policy formulation. As Freudenberg (2000) states "composite indicators are valuable because of their ability to integrate a large amount of information into formats easily understood by the general public". However, composite indicators can be misinterpreted, particularly when they are used to rank the performance of countries under complex economic phenomena and even more so when these rankings are compared over time. "It seems that this is the main purpose of the new European Union indicator."

Another point that deserves attention is the combination of Indicators of input and output achieved by the new European indicator. The proposed indicator mixes input components of innovation, as in the case of PCT and KIA indexes, with result, such as COMP and DYN. The combination of

elements of this nature, as a rule, may not represent any evolution of the general indicator, since it occurs in the equilibrium of conflicting variables. Freeman & Soete (2009) warn of the difficulty of combining input and output indicators: "In fact, input measures are often used as substitutes for outcome measures. This does not mean that all measures of economic activity are useless, but it certainly does not mean that they should be used with great care and full attention to their limitations and the stage of evolution of particular economies and societies being considered and compared." In addition, the introduction of a new indicator, which in its explicit title is an indicator of results, but which mixes input indicators in its formulation, sounds at least somewhat contradictory.

### *2.2. The DINNOV Family of Innovation Output Indicators: a New Proposal*

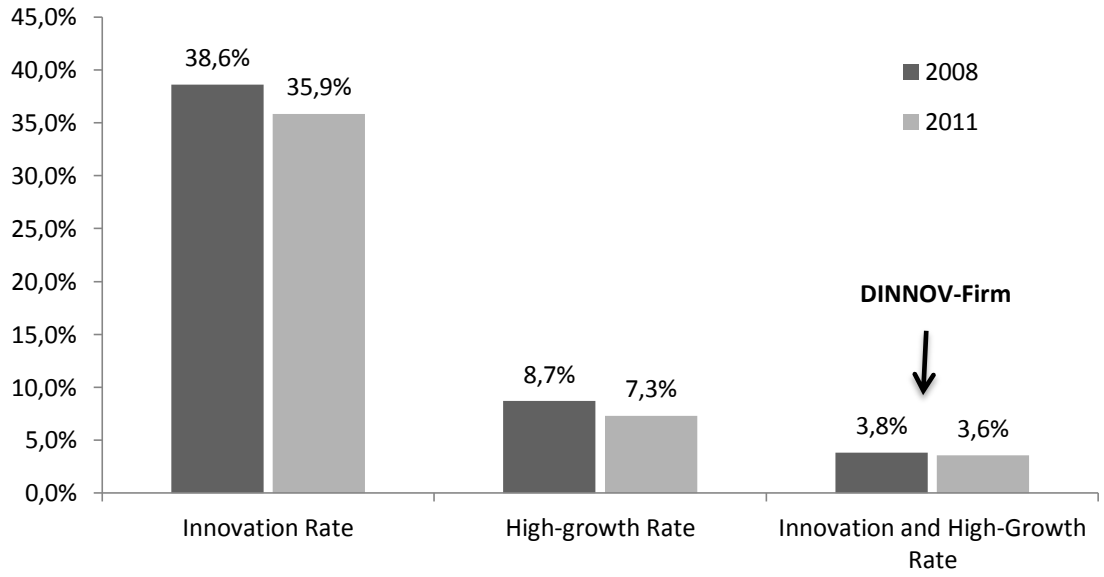
A first and important information on the high-growth and innovative firms can be obtained by counting the number of those firms in comparison with the total number of firms. The share or ratio obtained by the division of the number of the innovative high-growth firms by the total number of firms has characteristics and/or present the potential to become an indicator that approximates the original objectives proposed by the High Level Panel.[13] This indicator, which was attributed the name DINNOV- Firm, measures the share of the firms that connects two phenomena of great interest to the economy and to the economic and ST&I policies.[14] The dynamism (or high growth) and the innovation[15]. Figure 1 presents the rates of innovation, high-growth and innovation+high growth (DINNOV-Firm Indicator) for Brazil, years of 2008 and 2011.

[13] Note that the values of the estimated variables for Brazil which were mentioned in this study refer to firms considered within the scope of PINTEC, as defined in defined in Board 2.02 of the previous section. For instance, when mentioned the total number of the firms, is in reference to the total number of the entrepreneurial entities with 10 or more employees , active in the Brazilian territory, which are classified in the activities of the CNAE 2.0 contemplated in the Brazilian innovation surveys in 2008 and 2011.

[14] A study on high-growth Austrian firms, which covered a period of 20 years (Hölzl, 2014) identified the existence of persistent problems among the HGF, that it is, the verification of a small share of the firms that continue presenting the characteristics of high growth for long periods. A possible confirmation of this characteristic of the HGF would certainly decrease the advantage of using them as a policy target. An interesting line of research would be to try to assess whether this issue of persistence would be higher or lower for innovative high-growing firms.

[15] The formula of the first indicator is $\mathrm{DINNOV}_{\mathrm{Firm}} = \frac{\mathrm{F}^{\mathrm{IHG}}}{\mathrm{F}^{\mathrm{T}}}$.

*Figure 1. Rates of Innovation, High-Growth and Innovation + High Growth (DINNOV-Firm Indicator), Brazil, 2008 and 2011*

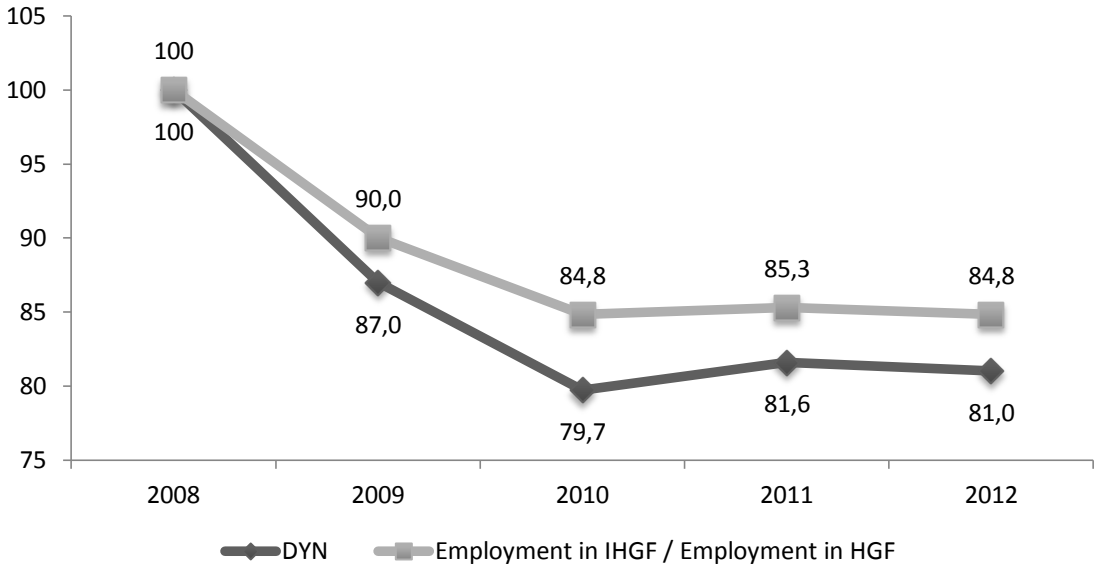



Source: CEMPRE, PINTEC 2008 e 2011 (IBGE, 2010 e 2013a) and Entrepreneurship Statistics 2008, 2010, 2011 e 2012 (IBGE 2011, 2012, 2013b e 2014a).

In order to anticipate the trends of the DINNOV-Firm Indicator in the years for which no result from the innovation surveys are available, it is proposed to estimate the values of the DINNOV-Firm Indicator based on the assumption that the rate of the innovative firms among high-growth firms has remained unchanged since the most recent year for which it is possible to rely on the results from the innovation survey. The *Cadastro Central de Empresas* (*CEMPRE*) registry allows the calculation of the number of high-growth firms in the scope of PINTEC for each and every year. By dividing this number by the total number of the firms, it is possible to calculate the rate of the high-growth firms for each and every year. By multiplying the latter by the rate of innovation of high-growth firms for the year of the latest innovation survey, the value of DINNOV-Firm is estimated for each year.[16] Figure 2 represents the Brazilian data with the adjustments described above.

[16] This transformation is equivalent to the multiplication of the original formula by one, which is not alternating the value of the fraction. Thus, the formula DINNOV-Firm, reordered as shown below, is transformed by the multiplication of the rate of innovation of the high-growth firms by the high growth rate: $DINNOV_{\mathrm{Firm}} = \left(\frac{F^{IHG}}{F^{HG}}\right)\left(\frac{F^{HG}}{F^{T}}\right)$ where $DINNOV_{Firm}$, $F^{IHG}$, $F^{HG}$, $F^{T}$, $\left(\frac{F^{IHG}}{F^{HG}}\right)$ and $\left(\frac{\mathrm{F^{HG}}}{\mathrm{F^{T}}}\right)$ correspond, respectively to high-growth and innovation rate, number of innovative high-growth firms, number of high-growth firms, total number of firms, innovation rate of the high-growth firms and high-growth rate.

*Figure 2. The evolution of the DYN indicator and the ratio between the employment in the high-growing and innovative firms and the employment in high-growing firms for the whole manufacturing industry, Brazil, 2008-2012 (2008 = 100)*




Sources: CEMPRE, PINTEC 2008 and 2011 (IBGE, 2010 and 2013a), and Entrepreneurship Statistics 2008, 2010, 2011 and 2012 (IBGE 2011, 2012, 2013b and 2014a. (Elaborated by the authors).

### *2.3. DINNOV Employment*

The DINNOV-Firm is an indicator that measures the share of the firms, which, within the reference period, show elevated dynamism (i.e. high growth) and introduced product and process innovations. Despite the significant contribution that this indicator may give for the understanding and the monitoring of those phenomena, in its format proposed in the previous section, still cannot sufficiently include the original objective pursued by the High Level Panel, the European Commission, and the survey though which it is possible to rely on the satisfactory output or impact indicator on the economics of innovation associated with high growth. However, it is possible to approximate significantly an indicator of the pursued objective. In order to do this, it is sufficient to add the dimension of the impact of those dynamic and innovative firms in the economy, in terms of employment and the value added. There two new dimensions can be added to the indicator by enriching its original formulation. The aggregation of these two dimensions will be treated in the form of DINNOV-Employment and DINNOV- Value Added, which become part of the so-called DINNOV indicators family. The first of these two indicators, that it be the DINNOV-Employment, will be developed in this section, while the second, that it be the DINNOV- Value Added, will be addressed in the next section of this report.

In the same way that occurs in the case of DINNOV-Firm, the formula presented above only allows the calculation of the DINNOV-Employment, for those years for which it is possible to rely on the results of PINTEC. It is proposed to adopt a similar procedure as adopted in the case of DINNOV-Firm to calculate the values of DINNOV-Employment for the years that there are no available results from innovation surveys. In this case, it is proposed to project the value of this indicator on the basis of the assumption that the ratio of the employment in high-growing innovative firms to the employment in the high-growth firms as calculated by the most recent year of PINTEC, remains constant in the immediately following years, until it is possible to rely on the results of a new PINTEC wave[17].

### *2.4. DINNOV Value Added*

Another important dimension of the impact on the economy of the innovative high-growth firms is its contribution on the value added. The indicator DINNOV- Value Added or DINOV-VA measures this distribution as a share of the value added of all firms.

The calculation consists of building the value added of innovative high-growth firms as a proportion of the value added of all firms. Numerator brings the value added of the innovative high-growth firms. Denominator presents de value added of all firms. The interpretation is the indicator shows the relative weight in the economy, calculated in terms of the value added of the core of the firms that are simultaneously innovative and high-growth.

The PINTEC data merging of 2008 and 2011 with the entrepreneurship statistics of the same reference years allow computing the values of DINNOV-VA indicator for the years 2008 and 2011 for Brazil. The ASIs and PINTECs (the latter, when referred to the manufacturing and mining industries) do not estimate the value added of the firms, but instead the Value of the Manufacturing Industry-VMI- (difference between the gross value of the industrial production and the cost of industrial operations), which is a very similar concept to the added value and specifically refers to the manufacturing and mining activities.

[17] The formula of the indicator presented above may undergo a transformation, which also does not affect the result, through the simultaneous multiplication of its numerator and its denominator by the employment generated by high-growth firms: $L^{HG}$. The formula is $\text{DINNOV}_{\text{Employment}} = \left(\frac{L^{IHG}}{L^{HG}}\right)\left(\frac{L^{HG}}{L^{T}}\right)$, where $L^{IHG}$, $L^{HG}$ and $L^{T}$ are, respectively, the employment in innovative high-growth firms, employment in high growth firms and total employment of the economy.

For this reason, the estimated results for the DINOV-VA refer, strictly speaking, to the Industrial Manufacturing Value. Moreover, it is also important to note that the population of the firms under consideration refers to firms with 10 or more employees classified in the sections of CNAE 2.0 which correspond to the extractive and manufacturing industries. Due to reasons that will be presented later on, it was not possible to include in those estimates activities that refer to selected services, in accordance with the scope of IS´ wave.

The relative share of IF, HGF and IHGF in the added value of the total of the firms, fell between the years 2008 and 2011.The DINNOV-VA dropped from 10.5% in 2008 to 8.8% in 2011. This decrease was accelerated more by the drop in the share of high-growth firms in the total value added (23.4%), rather than the drop in the share of the innovative firms in the total value added (8.8%).

In the calculation of the DINNOV-VA for the years without PINTEC information, it is assumed that the share of the value added of the high-growth innovative firms in relation to the value added in high-growth firms as identified for the year of a certain PINTEC wave remain as a coefficient gamma , $\gamma$, constant for the following years. In this way, the computed values of the indicator remain constant until their re-estimation based on the results of a new innovation survey.[18]

In the calculation of the DINNOV-Firm and DINNOV-Employment indicators, it was possible to consider the selected services activities in conjunction with the extractive and manufacturing industries which are all included in the scope of PINTEC. Nevertheless, there were no conditions to include the service sector in the calculation of the DINOV- Value Added in this research project. This is attributed to the fact that the variables necessary to estimate the values of the first two indicators, for the years without PINTEC information, are available in the census data base of the Business Demography / CEMPRE. Unfortunately, all in all, these data do not include information on the value added of the firms. To calculate the values of DINNOV-VA for the extractive and the manufacturing industries for the years without PINTEC information, it was necessary to consult the data of the Annual Survey of Industry -ASI. If the project had also granted access to data from the Annual Survey of Services – ASS, it would have been possible to include in DINNOV-VA service activities within the scope of PINTEC. During the period of 2008-2012 the indicator dropped from 10.5% to 8.7%.

[18] Explicitly, the same formula can be therefore written as:

$$DINNOV_{VA(Year\ without\ wave)} = \gamma_{Year\ with\ wave} \left(\frac{V^{HG}}{V^{T}}\right)_{Year\ without\ wave}$$

### *2.5. DINNOV Simplex: a simpler alternative*

The three DINNOV family indicators as presented in the previous sections, that it be DINNOV-Firm, DINNOV-Employment, and DINNOV- Value Added, could be only estimated because, in the Brazilian case, the identification of the hard-core dynamic and innovative firms is possible. Like Brazil, many countries have the possibility and could be encouraged to estimate equally those three indicators of the DINNOV family. However, many countries still do not have databases that would permit such identification. For this reason, we propose a method to calculate a proxy for the DINNOV-Firm without the need for access to micro-data on innovative high-growth firms. This alternative uses data that are computed and published regularly by a relatively considerable number of countries. This indicator called DINNOV-Simplex, is based on the simple multiplication of the innovation rates with the rates of high-growth firms. In the absence of accurate information on the rate of innovation of the high-growth firms, it is assumed, in the case of this indicator, that the best possible estimation of this rate is the rate of innovation that prevails for all the firms in the economy under analysis, that it be for the high and low growth firms.

It is necessary to recognize that one of the factors that contributed to the decision of the European Commission to compute the indicator that introduced in September 2013 were the issues related to the international comparison of the results of the European innovation surveys (CIS). Such difficulties were mainly arising from the different perspectives on what is "new to the market " (European Commission, 2010b, pp.5). The criterion of the CIS to consider an innovative firm is generally the introduction of a new product or service (or even a method of organization or marketing) into the market in which the firm operates. This concept of novelty is obviously affected by the structure and the degree of internationalization of the firms in each country. By proposing the use of the innovation rate to calculate the DINNOV-Simplex, it was understood that the advantages of ignoring this issue are bigger than those incurred by using DYN. This stands true, because, on the one hand, it is believed to be possible to overcome the problem in the mid-term with the improvement of the CIS questionnaires. Briefly, the criteria of the "new" for a firm, the domestic and international market as adopted from PINTEC present a valuable alternative in order to overcome, at least partially, the issues related with the international comparability of CIS. On the other hand, it should be admitted that the adopted solution for the calculation of the indicator on the innovation output proposed by the European Commission seems to involve higher costs. Indicatively, the variables used in the calculation of the sectorial innovativeness rates, which feed the DYN component indicator, offer information about the innovative firms from various countries, neglecting the potential comparability issues. Moreover, by proposing that the standardization of the

use of such coefficients for all countries, this indicator ignores entirely the differences in the innovation processes among countries. The national differences, in this case, end up stemming entirely from the different weights of the productive sectors in the structure of each country.

Similarly to the method used in the cases of the previous indicators, it is possible to calculate the value of the DINNOV-Simplex for the years that the innovation surveys were not carried out. A large number of countries from the European Community and the OECD publish annually statistics on entrepreneurship, but none of them includes annual innovation surveys. Most European Community countries held their innovation surveys, the so-called Community Innovation Surveys – CIS, every two years, generally in even years. By using the high-growth rates provided annually by statistics on entrepreneurship, it is possible to estimate the values of the indicator DINNOV-Simplex assuming that the rate of innovation achieved in the last innovation survey prevails the ones from the previous years for which is not available any new rate. Also, as in the previous cases, the values of the DINNOV-Simplex indicator projected for the years without innovation surveys can be reviewed when it is possible to rely on the results of a new innovation survey.

*Table 1. DINNOV-Simplex and DYN indicators, selected European countries and Brazil, 2008-2011*

| | 2008 | | 2009 | | 2010 | | 2011 | |
|---|---|---|---|---|---|---|---|---|
| | Simplex | DYN | Simplex | DYN | Simplex | DYN | Simplex | DYN |
| Brazil | 3,3 | | 3,1 | | 3,1 | 12,7 | 2,5 | 12,5 |
| Spain | 0,9 | | 0,5 | | 0,4 | 15,2 | - | 15,5 |
| Estonia | 2,5 | | 1,7 | | 1,4 | 14,1 | - | 14,1 |
| France | - | | 2,2 | | - | 19,2 | - | 19,2 |
| Nether-lands | 1,0 | | - | | - | 17,2 | - | 16,4 |
| Hungary | 0,8 | | 0,6 | | 0,5 | 15,9 | - | 17,8 |
| Italy | 0,9 | | 0,8 | | 0,7 | 14,3 | 0,7 | 14,4 |
| Latvia | 2,7 | | - | | - | 12,7 | 1,3 | 12,6 |
| Lithuania | - | | - | | 0,4 | 11,7 | - | 12,7 |
| Luxem-bourg | 1,7 | | 0,8 | | 1,1 | 18,1 | 1,1 | 18,1 |
| Portugal | 1,5 | | 1,0 | | 0,8 | 13,6 | 0,8 | 13,3 |
| Czech Rep | 2,0 | | 1,3 | | 1,0 | 15,2 | - | 15,6 |
| Romenia | 0,2 | | 0,1 | | 0,1 | 14,0 | - | 15,2 |
| Sweden | 1,6 | | - | | - | 20,6 | - | 20,4 |

Sources: DINOV-Simplex: Eurostat Database <http://ec.europa.eu/eurostat/data/database>, Entrepreneurship at a Glance (OECD, 2011, 2012, 2013, 2014), PINTEC (IBGE, 2010 e 2013a) e Estatísticas de Empreendedorismo (IBGE, 2011, 2012, 2013b e 2014). DYN: European Commission (2014a e 2014b) and Viotti et al. (2014). (Elaborated by author.)

Table 1 presents the values of the innovation rate, the high-growth rate and the DINNOV-Simplex indicator, which is the result of the multiplication of the two rates, for a set of selected countries[19] in the period 2008-2012. In the calculation of the innovation rate were considered as innovative only the firms that introduced new products and services during the reference period. Both rates refer only to the manufacturing industry, which is included in all national innovation surveys. As can be observed in the Table 1, Brazil presents at the indicated DINNOV-Simplex, a leader position of among the considered countries. This leadership in mainly due to the exceptional high-growth rates observed in the country in the time-frame of the analysis, during which period the Brazilian economy, in comparison with the European countries, was much less affected by the international crisis that began in late 2007. The Brazilian leadership would be likely disputed by other emerging countries, especially China, in case that the data were available in those countries.

## 3. DINNOV Family and European Data

This section explores the methodology of building DINNOV Family Indicators, as close as the ideal, using European countries information. The first subsection brings a discussion on how to calculate DINNOV family in the case of European countries. This approach identifies in the Eurostat´s Micro-Moments Dataset, MMD, a promising database to perform the calculations, once it contains information of innovation and high-growth firms for a considerable part of the European countries. This database would turn possible to present a table of DINNOV family indicators with data of 14 European countries, providing a comparison among countries. Table 1, presented above, represents the calculation of DINNOV Simplex, that is the only indicator possible to be calculated with the information available on Internet.

The group of indicators called the DINNOV Family is the result of the search for the basic precepts present in the usual nomenclature about the "good precepts" of an innovation outcome indicator. The so-called Decalogue of an indicator like this establishes desirable premises for a good indicator, among them, clarity of results, being easily computable, decomposable, preserving and establishing international comparisons, among others (Viotti et al., 2014). Therefore, DINNOV Family is a series of indicators with the same structure, establishing a certain "north" for the interpretation of the results, besides being a considerable simplification of the calculations necessary for the

[19] Several European countries were not included in the table due to the lack of high-growth data. Other countries, as was the case of the United Kingdom, could not harmonize their public data for considering also as innovative the firms that have abandoned or suspended innovative activities. An eventual exploration of the CIS microdata could expand the number of the countries included in the table.

tabulation of the results of the indicator proposed by the European Commission (European Commission, 2013)

Another good reason for the adoption of the DINNOV Family as an indicator of international comparisons is the fact that it preserves the original idea, elaborated and discussed within Eurostat and the European Commission: to represent the evolution of high growth innovative enterprises. This concept is totally preserved in the formulation of the DINNOV Family, putting the discussion of why the attempt to measure the induction process that high growth does in innovation and vice versa.

In conceptual terms, the DINNOV Family consists of a series of indicators, part of a more precise formulation of the phenomenon of high growth innovative firms, which, in the Brazilian case, represents a cross-referencing of CEMPRE census information, with the PINTEC sample, in the same base-year expand the result to the sub-domain of high growth within PINTEC. These results gives us a measure, the rate of innovative high-growth firms, compared with the active enterprises in the economy in the same year, which is the best possible approximation of the phenomenon to be measured.

However, such a phenomenon can only be measured in this way only in PINTEC years. In the others, a fixed parameter is estimated over three years, which represents the rate of evolution of innovation fixed in time.

### *3.1. Micro Moments Dataset*

Micro Moments Dataset is a database that serves as a hub of information from different sources, like Community Innovation Survey or Business Registers from 14 countries in Europe: Austria, Germany, Denmark, Finland, France, Ireland, Italy, Luxembourg, Netherlands, Norway, Poland, Sweden, Slovenia and United Kingdom. Hence, there is no information from a considerable part of European countries: Albania, Andorra, Armenia, Belarus, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czech Republic, Estonia, Hungary, Iceland, Kosovo, Latvia, Liechtenstein, Lithuania, Macedonia, Malta, Moldova, Monaco, Montenegro, Portugal, Romania, Russia, San Marino, Serbia, Slovakia, Slovenia, Spain, Switzerland, Turkey and Ukraine.

The two main variables needed to calculation of DINNOV Family are the information if enterprise is a high growth firm (from BR) and if it innovated in last period (from CIS). Both information are available in MMD.

Variables available for exploration include: the year to which data pertain; industry classification; Size class; number of firms (from Business Register); number of firms (from CIS Survey); number of firms (merged BR,IS); number of employees (from Business Register); number of employees (merged BR,IS); aggregate of positive firm-level employment change; aggregate of negative firm-level employment change; age category; sample used among others

### *3.2. European Innovation and High-Growth Firms data: methodological challenges*

This part of methodology aims to explain the procedures used for the integration of Brazilian bases, which have different domains and weights, for the creation of a single base to study the firms classified as of high growth. In addition, it seems the same methodology could be applied for MMD, which contains European information.

In order to carry out this integration it was proposed the use of a post-stratification model. Post-stratification techniques are usually used in an after-sampling scenario when stratification factors are uncorrelated with secondary variables (Holt and Smith, 1979)[20].

Based on statistical premises[21] is possible to describe the process of simple random sampling without reposition in order to calculate the new weights for the post strata:

1. Determine the weights to add each individual:
2. Post-stratify the sample, obtaining $L$ post-strata with $n_i$ sampling dimensions for $i = 1, \dots, n$.
3. Calculate the weights $\frac{N_i}{\hat{N}_l}$ for each individual in the sample.
4. Calculate the adjusted weights $\frac{N_i}{\hat{n}_l}$
5. Calculate the post-stratification estimators $\tau$ and $\mu$.

[20] The model consists of stratifying a sample using auxiliary information that is available in the estimation phase. The total population estimator can be calculated as $\hat{\tau}_{PS} = \sum_{i=1}^{L} \frac{\hat{\tau}_l}{\hat{N}_l} N_i$ where $L$ is the number of post strata, $\hat{\tau}_{PS}$ is the $i$-th post stratum total centered estimator and $\widehat{N}_l$ is $i$-th post stratum regular dimension estimator. The total estimator $\hat{\tau}_l$ can be described by the Horvitz-Thompson definition (Overton and Stehman, 1995) is $\hat{\tau}_i = \hat{\tau}_{\pi_i} = \sum_{k \in S_i} \frac{y_k}{\pi_k}$, where $y_k$ is the observed value in the sample and $\pi_k$ is the probability of selection of an element of the sample. In the same way, for $\widehat{N}_i$ we have: $\widehat{N}_i = \sum_{k \in S_i} \frac{1}{\pi_k}$. We can use $\mu$ as the mean post stratification estimator $\hat{\mu}_{PS} = \frac{1}{N} \hat{\tau}_{PS}$

[21] The content of footnotes is the statistical guide to reach to the steps

Sample sizes are calculated in each final stratum in order to assure that estimator of total employees (or persons engaged) in each natural stratum with $CV < 10\%$. The sample was obtained by simple random sampling without reposition for each sampled stratum by adding enterprises belonged to specific final strata. It was chosen a minimum of five elements for each stratum, granting all enterprises in the sample in strata with five elements in the population.

The number of enterprises $n_k$ contained in each natural stratum depends on the type of final stratum $h$:

1. Managerial census strata $M1$ and $M2$ ($h = 1$ and $h = 2$, respectively) $n_h = N_h$, where $N_h$ is the $h$-th final stratum population size and $n_k$ is the number of enterprises in the sample that was selected from the stratum.
2. Sample strata $A1$, $A2$ and $A3$ ($h = 3$, $h = 4$ and $h = 5$, respectively). The size of these strata are determined following Neyman allocation criteria, which can be divided into two parts:
    a. Calculation of the number of enterprises in the sampled stratum to be selected[22].
    b. Determine, for each sampled stratum $h$, the number of respondent enterprises in the selected sample[23].

Once the post-stratification model was presented, it is possible to investigate the economic rates associated to the sample[24].

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[22] The formula used in this calculation is given by Silva et. al (1996), $n_a = \frac{N_a^2[\sum_h(w_h S_h)]^2}{CV^2(Y_c+Y_g+Y_a)+N_a\sum_h(w_h S_h)}$, where $Y_c$ is the total population of persons engaged in the census stratum; $Y_g$ is the total population of persons engaged in the managerial stratum; $Y_a$ is the total population of persons engaged in the sampled stratum; ${S_h}^2$ is the variance of persons engaged in the sampled stratum; $w_h = \frac{N_h}{N_a}$ is the population fraction of final sampled stratum $h$; $N_a$ is the population number of enterprises in the total sampled stratum $a$; and $CV$ is the coefficient of variation (pre determined in 10%) for the total persons engaged estimator in each natural stratum. It is important to stress that $Y_c + Y_g + Y_a = Y$ is the total of persons engaged in the corresponding the natural stratum.

[23] According to Cochran (1977), this number is given by $n_h = n_a \frac{N_h S_h}{\sum_{j=3}^{5} N_j S_j}$ where $N_{h(j)}$ and $S_{h(j)}$ are, respectively, the number of enterprises and the standard deviation of persons engaged variable in the sampled stratum $h(j)$.

[24] Following the same nomenclature used in the previous section, the number of enterprises in a final stratum can be represented by $n_h = \sum_{i=1}^{N} w_i\, e_i = \sum_{i=1}^{N} E_i$, hence, $E_i = w_i e_i$ where $e_i(0,1)$, is a categorical variable indicating the presence of the enterprise in the sample, $w_i$ the weights and $E_i$ a binary operator representing the presence of the firm in the final stratum.

Therefore, the rate of innovation of high-growth enterprises is given by the number of innovative high-growth enterprises in the total of active enterprises under the Innovation Survey[25].

However, such measure can be described as a combination of two coefficients: the rate of innovation of high growth firms in relation to the total of high growth firms and the rate of high growth of firms in the scope of Innovation Survey in the total of active enterprises with 10 or more employees[26].

Then, the coefficient of innovation of high growth, $\propto$, represents the total of innovative high growth firms in the total of high growth firms and it is fixed in a two year period, or when a new wave of Innovation Survey is available[27].

## 4. Conclusions

In this paper, a new family of indicators that aims at capturing the output of innovative and high-growth firms was proposed. The DINNOV family of indicators was developed as an alternative to the Innovation Output Indicator (IOI) conceived for the Europe 2020 strategy (European Commission, 2013). The new family of indicators were calculated using Brazilian data and a methodology was proposed on how to explore the Eurostat´s Micro-Moments Dataset - MMD in order to compute them for several European economies as well.

Based on ideas of National Innovation Systems and following the principles spread out by European Commission (Hollanders and Tarantola, 2011), it was possible to observe how difficult is to measure a complex system simply using only one indicator as a tool. However, it is also argued that the proposed indicators could provide a more comprehensive base of data to understand the evolution of innovation output trough countries than DYN, once DINNOV possesses more

[25] $I_{E_i^{HGF},E_i} = \frac{\sum_{i=1}^{N} E_i^{IHGF}}{\sum_{i=1}^{N} E_i}$ where $E_i^{HGF}$ is the mark for a high growth firm $i$ (0,1); $E_i^{IHGF}$ is the mark for an innovative high growth firm $i$ (0,1); $E_i$ is a mark for active firm $i$ (0,1) under the scope of Innovation Survey; $I_{a,b}$ is the innovation rate of $a$ in relation to $b$; and $HG_{a,b}$ is the high growth rate of $a$ in relation to $b$.

[26] $\mathrm{I}_{\mathrm{E_i^{HGF}},\mathrm{E_i}} = \frac{\sum_{i=1}^{N} \mathrm{E_i^{IHGF}}}{\sum_{i=1}^{N} \mathrm{E_i^{HGF}}} \frac{\sum_{i=1}^{N} \mathrm{E_i^{HGF}}}{\sum_{i=1}^{N} \mathrm{E_i}}$, $\mathrm{I}_{\mathrm{E_i^{HGF}},\mathrm{E_i}} = \propto \mathrm{HG}_{\mathrm{E_i^{HGF}},\mathrm{E_i}}$, where $\propto = \mathrm{I}_{\mathrm{E_i^{IHGF}},\mathrm{E_i^{HGF}}}$.

[27] As an example, one could imagine: the number of innovative high-growth firms in the base year of 2008 as 5,000; the number of high-growth firms under Innovation Survey is 10,000; and the number of active enterprises with 10 or more employees in the scope of Innovation Survey is 128,000. So, $\propto \equiv \propto_{2008} = 0{,}5$, $\mathrm{HG}_{\mathrm{E_i^{HGF}},\mathrm{E_i}} = 0{,}078$ e $\mathrm{I}_{\mathrm{E_i^{HGF}},\mathrm{E_i}} = 0{,}039$. Given that the group of high-growth enterprises varies with the growth threshold, the behavior of curves over the years for two distinct high growth rates is analyzed for a given base year of PINTEC: $th = 10\%$ e $th = 20\%$.

desirable properties than DYN. The difficulties of DYN to reach the own proposal of ideal properties are discussed in recent papers (Janger et al, 2017). Then, the main contribution of this paper was to present a way to overcome the barrier of access of a reliable data to build up a simpler and measurable indicator, to European countries, than DYN. DINNOV emerges as a good candidate to describe the dynamics of the economy through innovation and entrepreneurship. However, the consistency of the proposed methodology still need be tested.

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