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# How Innovative are Companies? Exploring a new approach to characterize the innovation level

Marcelo Gaspar [1], Luís Serrano, [1] Jorge Julião [2] and Ana Sofia Silva [2]

[1] School of Management and Technology, Polytechnic Institute of Leiria, Leiria, Portugal

[2] Católica Porto Business School, Universidade Católica Portuguesa, Porto, Portugal

**Abstract.** This study aims to develop an innovative method that allows classifying and characterizing the degree of innovation in companies. As part of this investigation, a new methodology was developed to allow for characterizing and quantifying the innovation effort of a company without the need for its feedback through surveys or questionnaires. To such end, relevant data of 571 companies available on two official databases were analyzed and discussed. As a result, an innovative framework was presented based on a dedicated set of indicators, and an empirical parameter was derived to characterize and quantify the Innovation Level of companies.

**Keywords:** Innovation, Innovative Capacity, Incentive Programs, Financing, Innovation Level.

## 1. Introduction

Globalization and competitiveness are two of the main challenges that drive companies to seek new and improved ways to strive when facing the current market demands [1]. The ongoing search for new tools that allow organizations to identify and work on new opportunities, and reconfigure and protect their knowledge, competencies, and technologies to achieve sustainable competitive advantage should be based on a strategy focused on innovation [2]. In line with this, new product development and innovation are at the very core of value creation [3].

High innovativeness embedded in products, services and processes holds the potential for growth and profits [4]. However, the innovation capability of companies depends on several factors [5], of which the lack of external financial support is one of the most difficult barriers organizations must overcome. According to that, many countries, including Portugal, have been developing policies to stimulate business research, development, and innovation by promoting cooperation and research, like the current recovery and resilience plan to face the impact of the ongoing COVID-19 pandemic [6].

This study aims to develop an innovative method that allows classifying and characterizing the degree of innovation in companies, based on a dedicated framework with specific indicators. Current investigation is based on systemic approaches about innovation in which, the innovation concept is defined as a non-linear, evolutionary, complex, and interactive process, wherein relationships between the companies and their environment assume a significant role.

## 2. Background

It is acknowledged that innovation is key to improving economic performance and growth, whilst contributing to the nations' sustainable development [7]. In this sense, the companies that are aware of such facts are increasingly investing in innovation-based strategies by developing new products and processes, or by improving their existing portfolios, while at a governance level, several incentives are proposed to firms to build upon investing in innovation [8]. In this way, there has been a growing commitment of many countries, including most European Union member states, to public policies to stimulate business investment in R&D [9].

It is also important to acknowledge that financing, although not considered as a strategic factor, emerges as one of the main constraints to the survival and development of companies [10]. In this context, it can be

stated that it continues to be extremely important and urgent to design and implement public policies that stimulate and foster innovation.

Considering the importance related to the topic of innovation, there are several studies that seek to understand the factors that influence and limit the innovative business capacity, while seeking to establish criteria that allow classifying organizations as to their propensity to innovate [11]–[13]. Thus, both academically and corporately, it is significant to develop a study that focuses on companies that apply for public incentives and seeks to classify them, using differentiating indicators, to characterize their ability to innovate. Hence, it is aimed with the current research to develop and present an explorative approach to characterize innovation in organizations based on dedicated indicators to classify companies according to their level of innovativeness.

## 3. Business Innovation and Innovative Capacity

Innovation has always played a crucial role in predicting an organization's long-term survivability [14]. In an era of increasing globalization, the modus operandi of organizations has been heavily influenced by rapid and disruptive changes, increased variety of customer demands, the uncertainty of markets, and strong international competition [15]. Thereby forcing organizations to acquire new technological skills and promote cooperation networks to explore new processes and business models that allow maintaining long-term profitability [16], [17]. Consequently, the adoption of a strategy of business innovation that allows to keep up with the patterns of fast consumption, while meeting the needs of customers, is considered one of the most critical and important factors for the success of organizations [18], [19].

The growing recognition of this reality, as well as the challenges in stimulating sustainable innovation and entrepreneurial spirit within companies, have generated numerous studies and investigations. Porter [20] commented that innovation, continuous improvement, and change were the three pillars of global competitiveness. This idea is also corroborated by Schumpeter [21] who, in his publications, highlights the role of innovation and entrepreneurship in economic growth. Nowadays, innovation strategies are mainly market-driven, with innovation capacity being a key driver to strive in a disruptive and rapidly changing business environment [22].

Business innovation is seen as an evolutionary, non-linear, complex, and dynamic process that requires great levels of integration both intra- and inter-organizational. This concept assumes that innovation is influenced and stimulated by multiple actors, who interact with each other, and sources of information, both inside and outside the company [23]. Interactivity plays a central role in promoting a company's innovative capacity, involving both internal collaboration between departments of an organization (R&D, production, marketing, distribution, etc.), as well as external cooperation with other companies (customers and suppliers), knowledge-related entities (universities and technology centers), banking, trainers, and public administration [24].

Innovation capacity can be defined as the continuous improvement of capabilities for organizations to generate innovation with a view to developing new products, processes, practices, and organizational models that are able to meet the market needs [25], [26]. In conclusion, today, companies no longer face the paradigm between "innovate or not innovate" and have instead become concerned about "how to innovate successfully". This issue, as described above is affected by multiple factors that contextualize the organization in its surroundings. However, it is certain that companies that exploit their strategies and acquire the ability to innovate successfully benefit from competitive advantages and increases in profitability and market share [27].

## 4. Innovation Classification Systems

The innovation classification systems are interactive tools that allow for custom comparisons of performance scores. These frameworks present different drivers and dimensions to characterize the innovation level of companies and nations. Considering the exploratory nature of current research, three different classification systems were selected to better understand their main dimensions and parameters.

## 4.1. Innovation Union Scoreboard

The Innovation Union Scoreboard (IUS) is a referential to measure company innovation, as the IUS annual report provides a comparative assessment of the EU Member States performance at their level of research and innovation systems [28]. As such, the IUS helps the Member States to focus on areas in which they need to concentrate their innovation performance. This classification model (Table 1) distinguishes between three types of main dimensions and eight innovation dimensions, capturing a total of 25 indicators.

Table 1: Dimensions and criteria of the Innovation Union Scoreboard [28].

| Dimension | Criteria |
|---|---|
| *Enablers* | Human Resources |
| | Research Systems |
| | Finance & Support |
| *Company Activities* | Company Investments |
| | Linkages & Entrepreneurship |
| | Intellectual Assets |
| *Outputs* | Innovators |
| | Economic Effects |

The first dimension, the Enablers, concerns the main innovative performance drivers that are external to the company and include three large groups: human resources; open, excellent, and attractive research systems and funding & support. The second dimension, the Company Activities, integrates criteria that capture innovative efforts at the organization level, i.e.: company investments in R&D and non-R&D to generate innovations; 'Linkages & Entrepreneurship', which measure innovative capabilities, looking at in-house SMEs and business-to-business collaborative efforts and public-private research efforts; and, finally, the 'intellectual heritage', which concerns the different forms of intellectual property rights generated as a result of the innovation process.

Finally, the third dimension, the Outputs, refers to the effects of an organization's innovative activities that are categorized into two indicators: innovators that measure the share of companies that have introduced innovations, in the market or within the organizations themselves, and the ability to absorb employment in fast-growing companies in innovative sectors; and the 'economic effects' that capture the economic success of innovation in the labour market, exports and sales resulting from innovative activities.

## 4.2. COTEC Portugal Innovation Barometer

The COTEC Portugal [29] is a business association for innovation with the mission to promote the competitiveness of Portuguese companies through the development and dissemination of a culture and practice of innovation. This association has created a dedicated classification system to work as an innovation barometer of Portuguese companies. The COTEC Portugal produces reports with information on R&D and Innovation that are made available on its platform [29]. Based on such a barometer, it is possible to measure the Portuguese innovation index, when compared with a set of reference countries. Table 2 summarizes the dimensions and the criteria used in this system.

Table 2: Dimensions and criteria of the COTEC Portugal Innovation Barometer [29].

| Dimension | Criteria |
|---|---|
| *Conditions* | Institutional Environment |
| | ICT (Infrastructure and Use) |
| *Resources* | Human Capital |
| | Financing |
| | Investment |
| *Processes* | Networking and Entrepreneurship |
| | Knowledge Application |
| | Technology Incorporation |
| *Results* | Impacts of Innovation |
| | Economic Impacts |

## 4.3. Innovation and Knowledge Mission Unit

The Innovation and Knowledge Mission Unit (IKMU) proposes a system of indicators to be used in the mapping of innovation and knowledge [30]. Such mapping is based essentially on five dimensions: performance, investment, incentives, capabilities, and environmental context (Table 3).

Table 3: Dimensions and criteria of the IKMU [30].

| Dimension | Criteria |
|---|---|
| *Performance* | Sales of new innovative products |
| | Productivity |
| | Number of new doctorates |
| | % of innovative companies |
| *Investment* | Corporate expenditure in R&D |
| | Non-banking fraction of total investment |
| *Incentives* | Main location of international markets |
| | Barriers to Innovation |
| *Capabilities* | % of graduated population |
| | Flow of graduates |
| | Cooperation in R&D projects with others |
| | % of companies involved in the innovation |
| | Expenditure on IT as a percentage of GDP |
| | Number of computers per 100 inhabitants |
| | % of companies with access to the Internet |
| | % of families with access to the Internet |
| *Environmental Context* | Demography |
| | Sustainability |
| | Economic Reform |

This Innovation classification system is based on 68 indicators, which allow representing the dynamics of the main aspects associated with performance and investment of companies in innovation and knowledge, as well as incentives for innovation and capacities to innovate (including individual, collective, organizational and IT capabilities).

# 5. Methodology

The objective of this study is to explore the development of a set of indicators to classify companies according to their level of innovation. The literature review shows that many of the existing innovation classification systems are developed with empirical data collected through interviews and/or questionnaires. This research aims to propose a different approach that is less complex, time-consuming, and resource-based, and not dependent on the availability of companies to provide information.

Considering the need to work with non-company dependent empirical information, data were collected from two main databases that keep a record of the applications for innovation projects submitted by companies that applied for public funding in European programs, namely the Seventh Framework Programme of the European Community for research and technological development (FP7) [31] and the Portuguese National Strategic Reference Framework (QREN) [32]. To such end, only the data from projects related to R&D or innovation investments were selected. Table 4 presents the sample size of this study.

Table 4: Sample size.

| Database / Project type | # Projects |
|---|---|
| FP7 | 170 |
| QREN | |
| - R&DT Co-promotion | 120 |
| - Individual R&DT | 161 |
| - Innovation & Entrepreneurship | 072 |
| - Productive Innovation | 364 |
| Total # of companies: | 751 |

From these projects it was possible to extract the following information: project data (e.g., name, start and end date, topic, call and funding scheme, instruments); investment and financing data (e.g., total project

cost, eligible investment and the incentive received); company data (e.g., name, country, region, activity sector, information about the promoter).

A secondary public database (SABI) [33], containing complementary information about these companies, was also used. From this database it was possible to extract financial and non-financial data of the companies, such as the number of employees, operating income, turnover, net income, and EBITDA (Earnings before interest, taxes, depreciation, and amortization), using the tax number of each company. The extracted data were compiled and classified into a global database for further analysis.

# 6. New Innovation Level Parameter & Indicators

Analyzing the selected Innovation Classification Systems (ICS) presented in a previous section, it was possible to find several similarities between them. These interactive tools showed that a set of similar dimensions and parameters are usually considered when comparing the companies' innovation performance scores.

As most ICS require companies' feedback to convey empirical data collected through interviews and/or questionnaires, the current study aimed at using exclusively information collected from official databases that keep a record of the applications for innovation projects submitted by companies that applied for public funding in European programs. To such end, only the data from projects related to R&D or innovation investments were selected. In this study, a sample of 751 companies was considered, according to the distribution presented in Table 4.

After performing the data analysis, a set of indicators were selected to characterize companies' level of innovation, as presented in Table 5. These are aligned with the existing innovation classification systems and comply with the information that it is possible to extract from the public databases.

Table 5: Dimensions and criteria of the proposed Innovation Level Parameter and Indicators.

| Dimension | Weight | Criteria |
|---|---|---|
| *Investment* | *16,77%* | LI - Level of Investment |
| *Incentives* | *16,15%* | IR - Incentives Received |
| *Performance* | *16,36%* | AP - Approved Projects |
| | *12,42%* | CR - Coordination Role |
| *Project Type* | *15,11%* | MS - Multi-National Projects |
| | *12,22%* | IDT - ID&T Projects |
| | *10,97%* | CP - Co-Promotion Projects |

To validate the selected indicators, an exploratory pilot study was conducted to discuss the relative importance of each parameter. For this study, a group of 26 experts working in innovation consultancy and with experience in designing funding proposals were asked to discuss and rank the proposed criteria. As a result, based on the relative weights presented on Table 5, an empirical parameter named *Innovation Level* (*IL*) was derived according to the following equation:

$$\boldsymbol{IL} = 0{,}1677\,\boldsymbol{LI} + 0{,}1615\,\boldsymbol{IR} + 0{,}1636\,\boldsymbol{AP} + 0{,}1242\,\boldsymbol{CR} + 0{,}1511\,\boldsymbol{MS} + 0{,}1222\,\boldsymbol{IDT} + 0{,}1097\,\boldsymbol{CP}$$

To obtain the final *IL* parameter value to characterize and rank the company's *Innovation Level*, each of the criteria presented in Table 5 must be quantified between 0 and 100%, according to the data available on the above-mentioned public databases.

Each of the Innovation Level related dimension and criteria will be briefly discussed and the related averaged weigh resulting from the pilot study will be presented next.

## 6.1. Investment

The *Level of Investment* in projects by a company allows quantifying the effort carried-out by that organization in previous research projects. Just as R&D expenditure is an indicator present in almost all studies that intend to classify companies as to their degree of innovation, also the investment made for the execution of the projects for funding was considered for this study as a strong indicator of the innovative capacity of companies. As such, it was attributed by the panel of experts a relative weight of 16,77% to this dimension on the Innovation Level parameter, IL.

## 6.2. Incentives

The number of *Incentives Received* illustrates and quantifies how much of the eligible expenditure was considered for R&D and/or Innovation and therefore resulted in effective funding. Thus, it was considered appropriate to consider the financial incentive as an indicator of the innovative capacity of organizations, since this type of public support meets strict criteria for assessing the degree of innovation of companies by competent external entities in this area. The panel of experts proposed a relative weight of 16,15% to this dimension on the IL parameter.

## 6.3. Performance

The number of Approved Projects criterion is based on the premise that the more projects a company develops, the more processes it will be able to improve, or to acquire new technological and scientific knowledge, thus increasing its innovative capacity. With this, the goal is to classify companies with more approved projects as more innovative, compared to those that have developed fewer projects. The panel of experts attributed to this criterion a relative weight of 16,36% on the IL parameter.

The role of a company in the coordination of funded R&D and/or Innovation projects showcases the effort that such a company has put in the past towards attaining its innovation goals. The responsibilities of a project coordinator are increased when compared to the other consortium participants. Given this increased responsibility, it was clear that the Coordination Role on a project requires more of the company's resources, which must have the capacity and guidance to manage larger contact networks. Thus, it was appropriate to highlight the Coordination Role of the companies, considering that they have or end up acquiring a greater propensity to innovate. The proposed relative weight of this criterion on the IL parameter was 12,42%.

## 6.4. Project Type

The number of Multi-National (e.g., European-sized) projects of which a company may have previously been part is a key innovation criterion, as according to the literature, market orientation can be an important factor towards innovative business capacity. This is mainly because companies nowadays must work in an environment marked by internationalization and globalization. Thus, companies oriented to the external market will be more efficient and therefore should be the ones that innovate the most and best. Silva [10] in his study concludes that companies that produce for the foreign market are more likely to innovate than the companies that produce for the domestic market. The panel of experts attributed to this criterion a relative weight of 15,11% on the IL parameter.

Another criterion, related to the number of ID&T Projects that a company has been part of in the past, also allows contributing to characterize its Innovation Level. In this perspective, organizations that apply for ID&T incentive systems often have projects that result in more innovative solutions than those that apply just for innovation incentive systems, as the latter do not always materialize in new products or process improvement. Given this evidence, it was considered that companies that apply to different types of incentives should be differentiated, pleading those that apply for ID&T projects. The proposed relative weight for this criterion was 12,22%.

The number of projects in co-promotion that a company may have part of in the past is the final criterion to contribute to characterize its Innovation Level. In this light, innovation can be seen as the result of an interactive learning process, involving various companies, knowledge-provider institutions and partners [34]–[36], which can stimulate innovation activities. This flow of information becomes especially important in the exchange of tacit knowledge, which is not easy to encode. Therefore, it is expected that companies that apply for projects in co-promotion have higher innovative capacity than those just applying for individual projects. To this latter criterion, the panel of experts attributed a relative weight of 10,97% on the Innovation Level parameter, IL.

# 7. Discussion & Conclusions

This research aimed to develop a methodology that should allow for characterizing and quantifying the Level of Innovation of a company without the need for its feedback through surveys or questionnaires to obtain empirical innovation-related data. One of the goals of this study was to create a method that favored

simplicity and ease of access to compile information, while also proposing an innovative analysis that focuses mainly on companies that have applied for public funding.

The study allowed identifying relevant innovation classification systems that use theoretical indicators to classify companies according to their innovation capabilities. With this research, a set of indicators were proposed, that may be considered innovative since these are different from those found in the literature. Nonetheless, the addressed dimensions and criteria can be used to establish a bridge with the parameters also used in other studies that seek to characterize companies as to their degree of innovation. These indicators were compared with the information available in two public databases, where data from companies that applied for innovation public funding. From this research, an empirical equation was derived to propose characterizing and quantifying the Level of Innovation of a company.

Although the sample of current research may not be fully representative, considering the exploratory nature of the pilot study it can be suggested that criteria like the investment level in innovation projects, the number of previously approved projects and the incentives received by the company, should have a higher weight when classifying the company's innovation capabilities.

This study used data from 751 companies available on two European funding programs, where information about the companies that applied for public funding, was available. To further validate the indicators found in this research, additional incentive programs should be considered. Moreover, it is suggested to conduct a comprehensive survey among the stakeholders in the innovation system to improve on the quantification of each of the IL indicator weights.

Finally, for future investigations, it is suggested that, in continuity with the work done so far, the following steps include the standardization of the different variables inherent to each indicator. Since each dimension represents very different scales and values, it is imperative to find criteria that allow them to be comparable, either through binary or categorical variables, for example. This will allow the figures to be included in the IL equation to be demonstrated consistently, producing at the end an indicative value of the innovative capacity of each company This step will allow refining the presented method to characterize and quantify the Innovation Level of companies.

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