INNOVATION EVALUATION AND MEASUREMENT

MACRO LEVEL AND FIRM LEVEL PERSPECTIVES

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ABSTRACT

Innovation is recognised as a difficult domain to assess and to measure. Innovation indicators are necessary to characterise innovation dynamics and to assess the effects of public policies supporting innovation or, from a micro perspective, return on investment, including the creation of conditions conducive to RD&I activities. Moreover, it is also important to observe the role of the different actors, whether companies, the main drivers of innovation, or other entities in the innovation system.

At country level, research has highlighted the importance of analysing innovation performance. Also, several studies have focused approaches developed by international organisations, in particular the European Commission. Part I of this chapter relates to a macro level perspective applied to innovation measurement.

Companies are eager to develop and apply methodologies contributing to capture innovation results. A problem in innovation management is how to do it. A framework model was proposed and applied, considering three levels of evaluation of innovation activities and projects, following a Return on Investment (ROI) approach. Part II of this chapter aims to analyse how companies are managing innovation, which practices have been implemented and what framework could be designed to promote their capabilities to evaluate and measure innovation. It will contribute to the understanding of innovation measurement at firm level and to a more systematic approach for innovation management.

Keywords: Innovation Management; Innovation Measurement; Innovation Indicators; Performance; ROI

PART I - INNOVATION MEASUREMENT AT MACRO LEVEL

1. INTRODUCTION

Innovation indicators are necessary to characterise innovation dynamics and to assess the effects of public policies supporting innovation or, from a micro perspective, return on investment, including the creation of conditions conducive to RD&I activities. Moreover, it is also important to observe the role of the different actors, whether companies, the main drivers of innovation, or other entities in the innovation system.

The systemic approaches to innovation allow us to complement and enrich the theories focused on the innovative company since, as we saw before, based on the reference framework proposed by the OECD, they ensure the compiling of comparable data and indicators.

However, the fact that through measurement a company's position in different parameters of R&D and innovation is more visible may explain the current trend for developing practical application experiments by using complementary surveys (Baghai et al. 2008; Haanaes et al. 2009; Lay Tin, 2005; Radjou, 2004) and broadening the analysis beyond macro indicators.

However, despite their relevance being above all associated with a sectorial perspective, services have brought new challenges to measuring company innovation since the metrics used require the need for compatibility.

Abreu et al. (2010) note that none of the companies analysed in the study had a separate R&D budget and this fact seems to ensure a degree of "comfort". Amongst the reasons mentioned, the need, in the case of expenditure, to have to identify the "return" on sales stands out. Indeed, as one of the cited businessmen notes:

> ... on the finance side everything has to have a return on sales and this will be a potential problem for me in the next 3, 4, 5 years ... how do you justify an expenditure of several million on something that is going to give you little payback and all you are expecting is risk. (Abreu et al., 2010)

This argument to a certain extent helps to incorporate other less "enlightened" areas of innovation within companies, such as organisational innovation. Looking at thirteen main types of organizational innovation, Armbruster et al. (2008) see the need to apply a different approach. Innovation surveys, overly centred on product innovation, must be revised to address this diversity. The authors argue that all companies which develop organisational innovations, regardless of whether in the last three years, must be included in the group of innovative companies under the risk of seeking to benefit the "followers".

More recently, through the emergence of the concept of sustainable innovation, there has been a noticeable adoption of metrics more aligned to organisational development perspectives, incorporating new themes such as stakeholder links, eco-innovation (energy efficiency or efficient management of scarce resources are mandatory development axes in innovation) or measuring the effects of innovation on society. (Berkhout, 2014; Walker & Phillips, 2009)

Evaluating innovation processes becomes particularly relevant when moving from the national to the international sphere, seeking to frame regions, countries and geographical entities in joint assessment exercises that enable comparative analysis and benchmarking studies.

In recent decades, various initiatives have attempted to revise the criteria associated with the design, development and application of innovation indicators, such as the EU's high-level group on measuring innovation, whose results were published in September 2013.

This is an aim which other international organisations, such as the OECD, or private institutions, such as the COTEC organisations in Spain, Portugal and Italy, have also pursued.

2. LITERATURE REVIEW

Different authors have been studying the importance of assessing and measuring countries' technological capacities (Archibugi & Pianta, 1996; Archibugi & Coco, 2005; Archibugi et al., 2009; Freeman & Soete, 2009). Most of the studies have focused on analysing the most important indicators applied by international organisations, such as the European Commission, World Bank and the specialised agencies of the United Nations, UNIDO and UNCTAD in particular. A different line of research has confirmed the existence of various works of interpretation of the situation in different countries, such as Norway (Foyn, 2013), Japan (Ijichi, 2013 and Fujimoto, 2014), Germany (Peters & Rammer, 2013), Italy (Hall, Lotti, & Mairesse, 2013), China (Zhang, 2014), Sweden (Edquist & Zabala-Iturriagagoitia, 2015) and Portugal (Godinho, 2013), to mention just a few recent examples.

Archibugi et al. (2009) have focused on a number of approaches developed with a view to measuring countries' technological capacities.

The aim is to benefit from their proposed analysis, updating some of the approaches identified and introducing new benchmarks that are justified on two main grounds:

1. The fact that, unlike Archibugi et al. (2009), the purpose is to analyse innovation capacities as opposed to technological capacities;
2. The need to ensure closer alignment with the business perspective, raising the visibility of indicators that can contribute to the strategy and development of companies.

Besides the exercises carried out by the European Commission, World Bank and World Economic Forum, analysed in Archibugi et al. (2009), also identified are the approaches proposed by INSEAD, Cornell University and the World Intellectual Property Organisation consortium and by COTEC Portugal/Everis as part of the Innovation Barometer.

3. INNOVATION MEASUREMENT AT MACRO LEVEL: MAIN INSTRUMENTS

3. 1 Summary Innovation Index (SII - European Commission)

The Community Innovation Survey (CIS) is the main instrument for assessing innovation activities in the European Union. It is internationally divulged through the use of its indicators in various high-profile reports and assessment exercises, such as the Innovation Union Scoreboard (IUS) for example, whose structure is presented below:

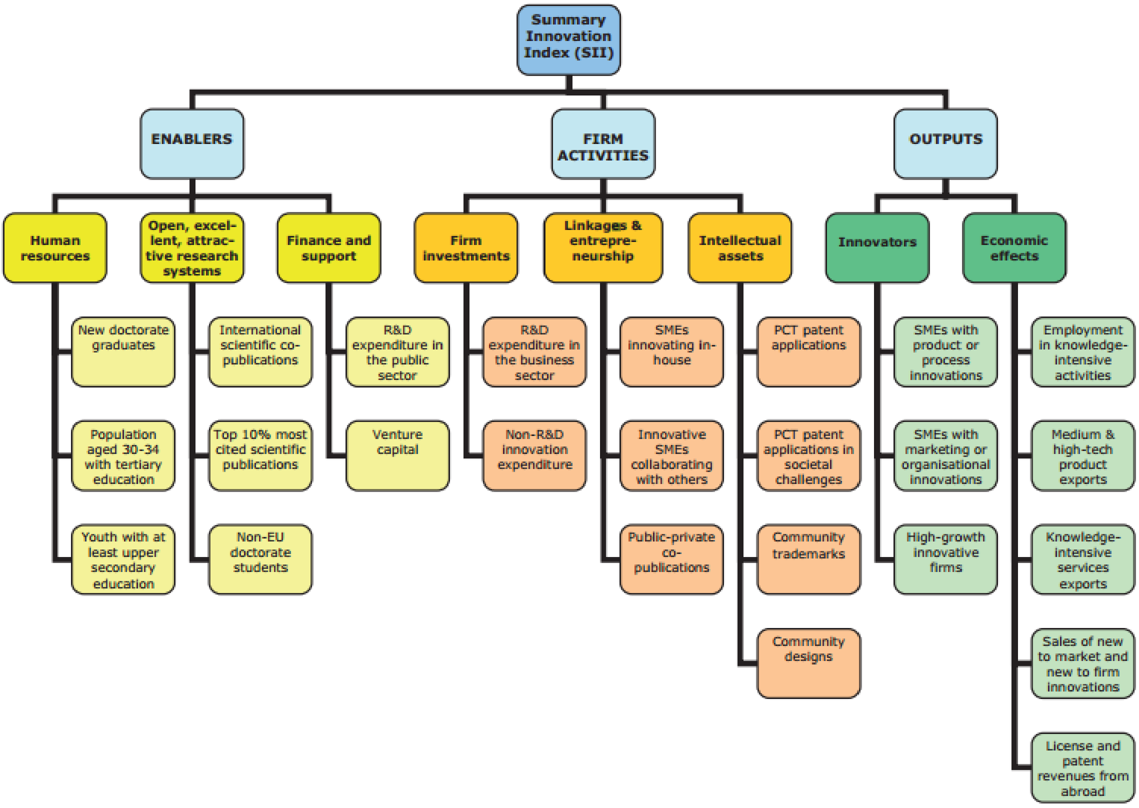

Figure 1 | Framework of the Innovation Union Scoreboard (IUS).
Source: http://europa.eu/rapid/press-release_MEMO-12-74_en.htm

Following the use of the CIS, several studies appeared that sought to analyse the effects of public innovation policies. Bearing in mind the scope of the concept of innovation and its effects, the studies generally focus on specific aspects such as the role of patents, the link between innovation and company performance, cooperation with R&D institutions, technological change, etc. However, at the heart of these surveys was also an attempt to understand innovation processes, a particularly key aspect for the purpose of this research.

As admitted by the European Commission, the CIS aims to harmonise information on innovation in companies, compiling data on the degree of innovation in different sectors by type of company, types of innovation and the various aspects of development of innovation activity, such as the goals, sources of information, financing and expenditure, for instance.

3.2 Knowledge Economy Index (World Bank)

The Knowledge Economy Index (KEI) comes from applying an assessment methodology – the Knowledge Assessment Methodology (KAM) – proposed by the World Bank and based on four pillars deemed crucial to the creation, adoption, adaptation and use of knowledge in the economy, generating high-value goods and services:

1. Economic incentives and institutional regime;
2. Innovation and adoption of technology;
3. Education and training; and
4. Information and communications technologies infrastructure.

In the latest publication, dated 2012, it can be seen that the pillar relating to innovation and adoption of technology uses three indicators which aim to reflect the efficiency of the innovation system and based on it to assimilate and adapt knowledge to local needs or creation of new technologies:

1. Payments and receipts of royalties;
2. Technical articles; and
3. Patents (granted by the USPTO).

3.3 Global Competitiveness Index (World Economic Forum)

The Global Competitiveness Index (GCI) is published annually by the World Economic Forum and analyses countries' competitive capacity alongside the microeconomic components of their growth capacities. This assessment tool uses data compiled from an annual survey (Executive

Opinion Survey) for a large number of indicators for which no available statistical data exist. In 2015, over 14,000 executives in 140 countries responded.

Based on 12 pillars of analysis, the GCI highlights the importance of innovation as a factor in economic growth and, in particular, technological innovation emerges as a defining factor in progress and quality of life. The link between innovation and competitiveness has characterised the approach developed, which is closely associated with the vision of Porter who inspired and contributed to its creation. Nevertheless, in its most recent publication (2016), GCI opens a new debate in order to update its model and to assimilate recent research results from different disciplines, including innovation.

The indicators identified also allow the different stages of development to be distinguished since for some countries the adoption and assimilation of technologies can be important while for others it is important to design, develop and market disruptive innovations that generate more value (Lev, 2001, Archibugi et al., 2009).

In the innovation-related pillar (12th pillar), countries are classified according to their performance in the following areas:

1. Capacity for innovation;
2. Quality of scientific research institutions;
3. Company spending on R&D;
4. University-industry collaboration in R&D;
5. Government procurement of advanced technology products;
6. Availability of scientists and engineers;
7. PCT Patents applications

3.4 Global Innovation Index (Cornell, INSEAD and OMPI)

The Global Innovation Index emerged in 2007 out of a partnership between the University of Cornell, INSEAD and a specialised United Nations agency. Through its annual report, the GII divulges the ranking of over 100 countries according to two main sub-indexes: an input sub-index (1 to 5) and an output sub-index (6 and 7) covering several pillars:

1. Institutions;
2. Human capital and research;
3. Infrastructure;

4. Market sophistication;
5. Business sophistication;
6. Knowledge and technology;
7. Creative outputs.

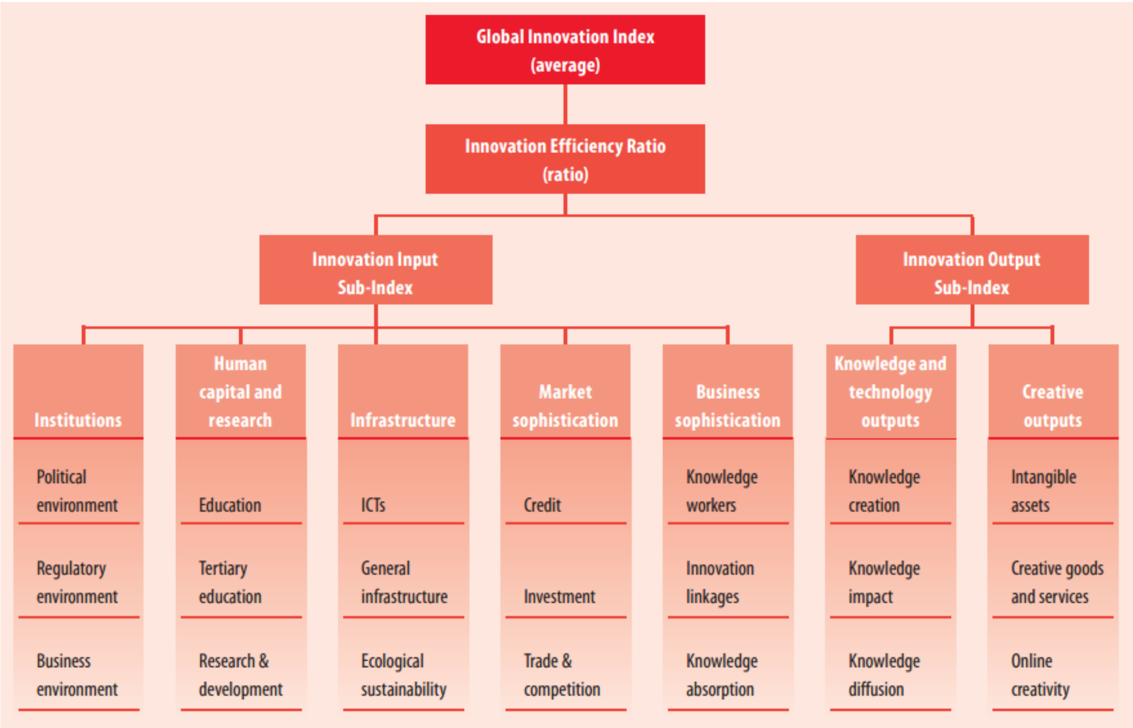

Figure 2 | Framework of the Global Innovation Index (GII).
Source: http://www.globalinnovationindex.org/content.aspx?page=gii-full-report-2014

The indicators proposed, as for example those included in the field of creative outputs, reveal a holistic vision of innovation since they especially highlight intangible aspects of nature frequently ignored by more traditional approaches (Dewangan & Godse, 2014).

4. INNOVATION MEASUREMENT AT MACRO LEVEL: A CASE STUDY FROM PORTUGAL - THE INNOVATION BAROMETER (COTEC PORTUGAL)

Since its creation in 2003, COTEC Portugal, a business association promoting in innovation, has been actively involved with its associated member companies in developing a framework capable to be used at firm level. A self assessment and measurement system concerning business innovation performance was launched, in 2007, labelled as innovation scoring, as a way to evaluate main dimensions of business innovation.

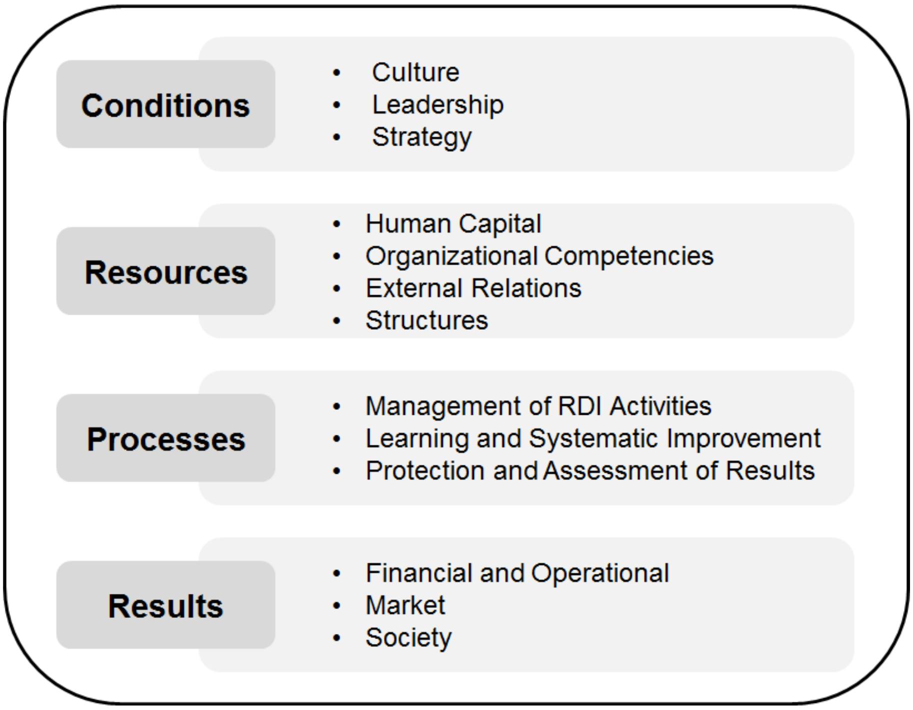

Figure 3 | Innovation Scoring system, dimensions and pillars.
Source: www.innovationscoring.org

More recently, in 2010, in cooperation with Everis, COTEC Portugal has created a macro level measurement instrument - the Innovation Barometer.

The Research, Development and Innovation (RD&I) indicators model consists of 4 dimensions, 10 pillars and 67 indicators. Annually, it is presented the Innovation Digest, a consolidated ranking for the 52 countries analysed.

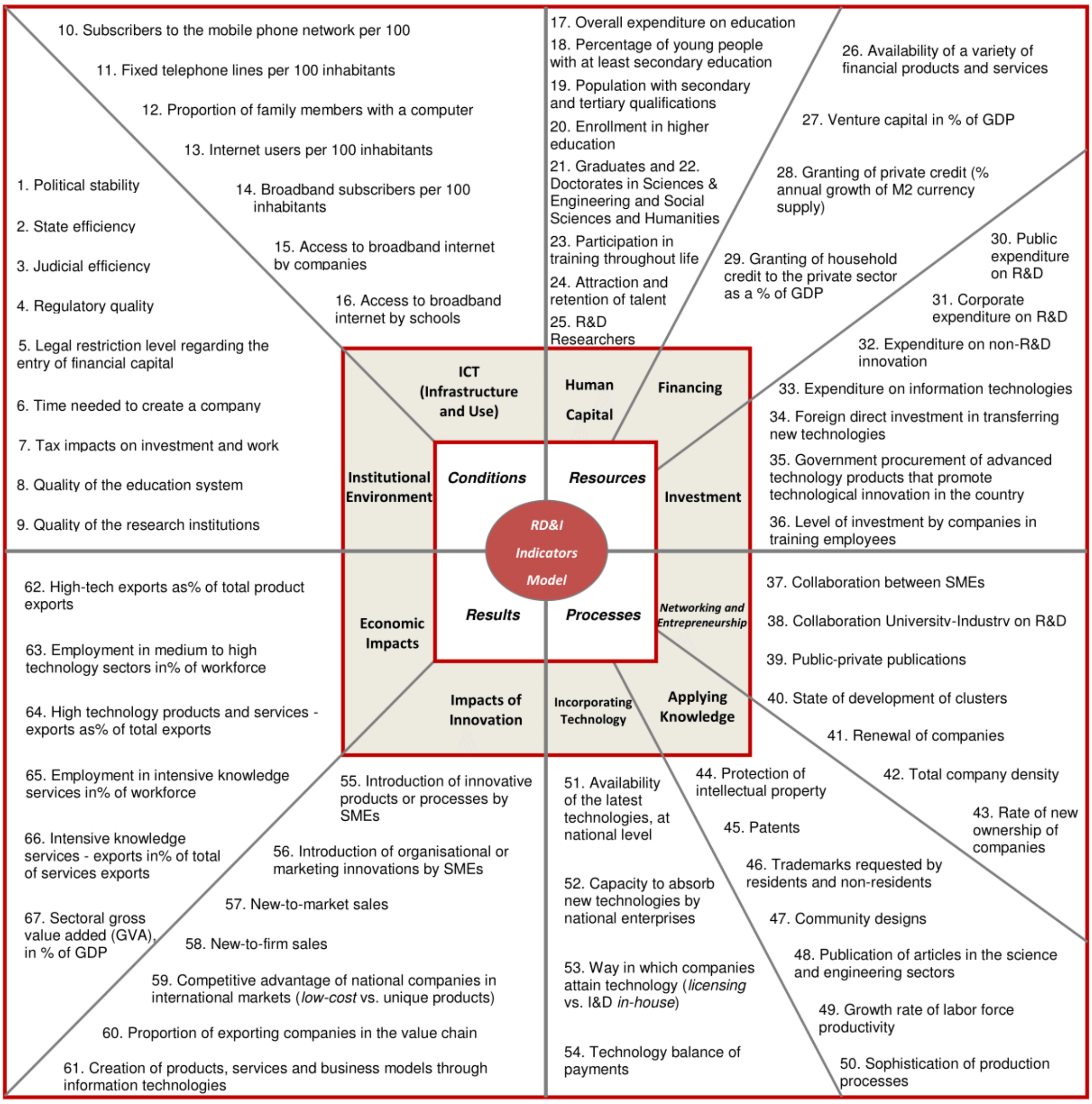

Figure 4 | RD&I indicators model: dimensions, pillars and indicators.

Source: http://www.barometro.cotecportugal.pt/website/statistics/index/c/statDimPilaresIndicadores

In the model presented, the indicators selected, from credible international sources, reveal that "Portugal's behaviour varies for each of these pillars between higher values for conditions and resources and lower values for processes and results" (Godinho, 2013: 35).

Apart from the possibility to analyse each of the 52 countries considered in the Innovation Barometer and comparing their innovation performances, facilitating benchmarking, foresight and competitive intelligence exercises, it is also original its framework, revealing the importance of innovation processes, those that guarantee R&D and technological absorption, so critical in today's digital challenges, as well as knowledge appropriation and transformation in innovations.

5. COMPARATIVE ANALYSIS OF MACRO LEVEL INSTRUMENTS

The comparative analysis of the five instruments mentioned (Table 1) shows that all focus on input indicators, in some cases designated “conditions”, and output indicators. To a certain extent, there exists an almost linear view of innovation. However, the adoption of a more systemic approach, as analysed previously, brings a set of new indicators that the instruments used up until now have yet to totally take on board, such as the quality and intensity of the interactions established between the actors in the innovation system, only present in the Summary Innovation Digest, from the European Commission, and Innovation Digest, from the Innovation Barometer, the valuing of knowledge and the economic and social effects and impacts. Various limitations have therefore been identified.

Table 1 | Synopsis of assessment and innovation measurement exercises

	No. of Countries	Dimensions	Pillars	Indicators
Summary Innovation Index (SII - European Commission)	28	3 (a) Enablers, (b) Firm activities and (c) Outputs	8 (a) (1) Human Resources, (2) Open, excellent and attractive research systems and (3) Finance and support; (b) (4) Firm investments, (5) Linkages & entrepreneurship and (6) Intellectual assets; (c) (7) Innovators and (8) Economic effects	25
Knowledge Economy Index (World Bank)	146	-	4 (a) Economic Incentive and Institutional Regime, (b) Education, (c) Innovation and (d) Information and Communications Technologies	109
Global Competitiveness Index (World Economic Forum)	144	3 (a) Basic requirements subindex, (b) Efficiency enhancers subindex and (c) Innovation and sophistication factors subindex	12 (a) (1) Institutions, (2) Infrastructure, (3) Macroeconomic environment and (4) Health and primary education; (b) (5) Higher education and training, (6) Goods market efficiency, (7) Labour market efficiency, (8) Financial market development, (9) Technological readiness and (10) Market size; (c) (11) Business sophistication and (12) Innovation	114
Global Innovation Index (Cornell, INSEAD and OMPI)	143	2 (a) Innovation Input Sub-Index and (b) Innovation Output Sub-Index	7 (a) (1) Institutions, (2) Human capital and research, (3) Infrastructure, (4) Market sophistication and (5) Business sophistication; (b) (6) Knowledge and technology	81

			outputs and (7) Creative outputs	
Innovation Digest – Innovation Barometer (COTEC Portugal/ Everis)	52	4 (a) Conditions, (b) Resources, (c) Processes and (d) Results	10 (a) (1) Institutional surroundings (2) ICT (infrastructure and use); (b) (3) Human capital, (4) Financing and (5) Investment; (c) (6) Networking and entrepreneurship, (7) Application of knowledge and (8) Incorporation of technology; (d) (9) Innovation impacts and (10) Economic impacts	67

6. INNOVATION MEASUREMENT AT MACRO LEVEL: CHALLENGES AND LIMITATIONS

Examples all around the world reveal the diversity, originality and reach that innovation achieves. To attempt to find a single approach that captures the results of innovation is a challenge considered by many an impossibility. The systemic nature of innovation requires the use of diverse indicators able to reflect this reality and allow more margin for experimentation (Simões, 2008; Pereira, 2007), one of the reasons behind the emergence of various assessment exercises. Therefore, alongside the development of the Innovation Union Scoreboard, innovation surveys and other assessment tools have been used that use various methodologies in an attempt to apply new indicators, especially those related to output.

Despite the progress verified, the approach used in Europe, above all centred on the IUS, reveals several limitations, one of the most important of which is its difficulty in adjusting to a systemic model and its effects and measuring the dynamics of the actors, interactions and differences in the various countries. The European Commission itself recognises that new situations exist to which it is unable to respond using the existing assessment tools, such as for example the need to analyse rapidly growing companies and the need for greater international coverage, bolstering the link to the OECD.

Both Archibugi (2009) and Edquist & Zabala-Iturriagagoitia (2015) also stress that the use and "abuse" of the indicators related to technological capacities, despite the merit stemming from the possibility to swiftly identify each country's "place" in a ranking, complicate a more comprehensive analysis of the innovation process, including the main knowledge production, assimilation and dissemination mechanisms.

Table 2 | Leading countries in the approaches analysed (1st to 10th place)

Summary Innovation Index (SII - European Commission)	Knowledge Economy Index (World Bank)	Global Competitiveness Index (World Economic Forum)	Global Innovation Index (Cornell, INSEAD and OMPI)	Innovation Digest – Innovation Barometer (COTEC Portugal/ Everis)
The Innovation Union Scoreboard 2015	Knowledge Economy Index 2012 *Innovation Pillar*	The Global Competitiveness Report 2015-2016 *Innovation Pillar*	Global Innovation Index 2015	Innovation Digest 2015
Sweden	Switzerland	Switzerland	Switzerland	Switzerland
Denmark	Sweden	Finland	United Kingdom	Denmark
Finland	Finland	Israel	Sweden	Finland
Germany	Singapore	United States	Netherlands	U.S.A.
Netherlands	Denmark	Japan	USA	Ireland
Luxembourg	USA	Germany	Finland	United Kingdom
UK	Netherlands	Sweden	Singapore	Sweden
Ireland	Israel	Netherlands	Ireland	Germany
Belgium	China (Taiwan)	Singapore	Luxembourg	Luxembourg
France	Canada	Denmark	Denmark	Korea

On the subject of the place occupied by Sweden in the SII, Edquist & Zabala-Iturriagagoitia, (2015) note the following:

> We argue that the Summary Innovation Index provided by the Innovation Union Scoreboard is highly misleading. Instead of merely calculating this Summary Innovation Index, the individual indicators that constitute this composite innovation indicator need to be analyzed in much greater depth in order to reach a correct measure of the performance of innovation systems. We argue that input and output indicators need to be considered as two separate types of indicators and each type should then be measured individually. Thereafter the input and output indicators should be compared to one another, as is normally done in productivity and efficiency measurement.

A comparative analysis of the 10 leading countries in the 5 innovation indices selected allows use however, to find major convergence in terms of the countries' positioning, suggesting a similar methodological approach. In 2005, Archibugi & Coco noted the importance of basing measurement, via the selection of indicators, on a theory able to link technological capacities with economic and social performance. Observing the various exercises, it can be seen, as Edquist & Zabala-Iturriagagoitia (2015) note, that in the SII approach, in most of the innovation indices, no analysis of the efficiency and productivity of the innovation systems exists. Moreover, all the indicators considered were often given the same weight and no distinctions are made about which indicators measure various innovation components, such as inputs, processes and results, beside innovations per se. In Portugal's case, with the inclusion of differentiated weighting for the various analysis dimensions in the Innovation Barometer, a larger focus was seen on results, in an attempt to centre the analysis on the efficiency of the system.

As far as the challenges are concerned, the systematisation of the main innovation models, as well as the innovation indicators, allowed a first view of their scope to be established. Indeed, based on the analysis of the different innovation typologies, it was possible to verify that no set of assessment metrics exists in the literature associated with them. There are few metrics which resist the various innovation typologies presented and allow the full effects of innovation to be assessed. In fact, as can be observed at the business scale, organisational innovation is one of these examples since there are various particularities inherent to its effects, such as the temporal effect stemming from its lifecycle being different from other types of innovation (Armbruster et al., 2008).

Edquist & Zabala-Iturriagagoitia (2015) admit that the measurement of the performance of innovation systems must reflect both the characteristics of the innovation, in terms of input, and the results of innovation, often assumed as outputs.

Also when considering GCI challenge to update its model, it is still difficult to observe how it is proposed a new measurement model capturing competitiveness, independently of a "input - output" model or a resources based approach. Focusing on a innovative sustainability approach could require a more diverse and multidisciplinary effort in order to capture innovation intangible effects and externalities. In spite of admitting the need to apply a broader notion of innovation, as it is evident since the Oslo Manual edition from 2005, GCI still misses a holistic view of innovation. Ideas generation and implementation, being relevant to innovation culture and dynamics, are drivers of innovation together with other critical determinants that cannot be neglected.

Furthermore, as we can analyse at firm level, other results may be valued such as social impact, the influence of reputation and image, or the contribution of innovation to organizational efficiency or to scientific and technological progress.

From the limitations identified, as well as the challenges they present, the opportunity exists to develop an approach capable of ensuring, at least in business terms, progress in the assessment and measurement of return on innovation. Financial metrics, such as NVA or ROI, are already being used in different situations, including the assessment of social innovation projects. However, the link between the various analysis perspectives – macro, sectoral and business – may illuminate other "measurement" areas that are difficult to identify in isolation.

Another important challenge has to do with the purpose of measurement, with the literature suggesting that the answer to this may require the need for adaptation to suit the company's market sector and its strategic objectives. Therefore, proposals have been put forward for the selection of metrics that can be adapted to the various needs of the companies and sectors to which they belong. With regard to services, it is accepted that a huge group of activities are not covered by the more traditional metrics, such as the use of ICT and their impact on creating innovation. New metrics must emerge that respect four main criteria: accuracy, longevity, comparability and ease of data gathering (Abreu et al. 2010).

In addition, the metrics described illustrate another of the challenges that need highlighting. The difficulties intrinsic to gathering data of this nature illustrate the lack of response, even in the proposed metrics just mentioned, such as VAL and ROI, to the measurement of intangibles such as knowledge or social and human capital (Lev, 2001).

PART II - INNOVATION MEASUREMENT AT FIRM LEVEL[1]

1. INTRODUCTION

Innovation is generally accepted to be linked to differentiation, competitiveness and value creation. Nevertheless, it is widely recognized as a difficult domain to assess and to measure. At firm level, most companies are eager to develop and apply specific methodologies contributing to capture innovation results effects. A major problem in innovation management is how to do it.

Different contributions resulting from academic research and empirical work justify the need for a deeper understanding of innovation evaluation and measurement, in some cases resulting from a systematic analysis of innovation indicators through different lenses at a macro, sectorial or business levels.

In spite of progress achieved, mainly through management practices based on innovation indicators, as it is the case for decision making processes (e.g. at ideas or project selection in innovation management), it is needed an harmonization that can be applied at business level. Seminal research focusing on econometric approaches (Mansfield et al., 1971; Leonard, 1971; Griliches, 1979; Cordero, 1990; Hall, 1996; David et al., 1999) identified this problem and its relevance. Several studies developed a review of research previously dedicated to innovation measurement, mostly devoted to R&D results (Hall, Mairesse & Mohnen, 2010; Hall, Lotti & Mairesse, 2013; Chiesa & Frattini, 2009) and also to innovation determinants and related indicators influencing results (Carayannis & Provance, 2008; Adams et al., 2006; Milbergs & Vonortas, 2005). Also, as demonstrated by case studies concerning innovation management relevance (Dewangan & Godse, 2014; Gama et al., 2007), companies experience difficulties to capture innovation outputs, especially intangibles, even when applying management tools as the Balance Scorecard. In the field of strategic management, research examines different appropriability mechanisms (patents, secrecy, lead time and complementary assets), contextual conditions and outcomes (Teece, 1986 and 2009; Al-Aali & Teece, 2013; James et al., 2013).

As admitted by Adams et al. (2006), there is a lack of clarity in the use of indicators and metrics by researchers and business managers. It is also experienced a main difficulty in developing a framework through which those indicators and metrics can be applied as innovation

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management tools, facilitating comparability and bench learning. The absence of such framework, together with risk, uncertainty and complexity that characterizes innovation (Salter & Alexy, 2014), opens a research avenue requiring a systematic literature review and a syncretised approach, requiring an integration of different perspectives that combined can give an overall encompassing framework for innovation management measurement.

2. A SYNCRETISED APPROACH TOWARDS INNOVATION MANAGEMENT MEASUREMENT

Relevant contributions from different theories and management and economic thought schools more than alternatives are complementary views that contain hypotheses that can be explored and integrated into a measurement framework.

Consensual stylized facts about innovation, based on results from empirical research, include the uncontroversial statement that capturing return on innovation is a complex goal (Salter & Alexy, 2014).

Innovation indicators, as well as metrics, have also been substantially studied when considering a macro level perspective and analysing regions and countries performance (Archibugi & Pianta, 1996; Archibugi & Coco, 2005; Milbergs & Vonortas, 2005; Archibugi et al., 2009; Freeman & Soete, 2009). At country level, several studies followed this research strand, focusing innovation performance from Norway (Foyn, 2013), Japan (Ijichi, 2013 and Fujimoto, 2014), Germany (Peters & Rammer, 2013), Italy (Hall, Lotti & Mairesse, 2013), China (Zhang, 2014), Sweden (Edquist & Zabala-Iturriagoitia, 2015) or Portugal (Godinho, 2013) just to illustrate some examples.

The idea that it does not exist a unique theory capable to explain such a complex phenomenon as innovation is the motto for our assumption that there is a need for a syncretised approach towards innovation management measurement.

Importance attributed to institutions (Dosi & Orsenigo, 1988; Nelson, 1991), to evolutionist approaches (Nelson & Winter, 1982) or to systemic perspectives (Freeman, 1987; Lundvall, 1992; Edquist, 1997; Teece, 2010), in spite of being explored according to specific research problems, can be used as theoretical contributions for this innovation management approach.

On the other hand, the influence of open innovation perspective on management (Chesbrough, 2003) emphasized the need to analyse innovation results in strategic terms, highlighting its effects on reputation, image and other intangible assets, apart from contribution to firms performance, as well as the importance of generating a new innovation model adapted to recent challenges and transformations.

A simplified input-output approach cannot capture anymore the diversity, permeability, due to openness and interdependence resulting from collaboration, and complexity of innovation activities. Open innovation induces a real impulse for improving a better connection with theories of management, emphasizing changes in the way firms own, control and leverage their resources to create competitive and transient advantages (Barney, 1991; Grant, 1991; McGrath, 2013; Alexy & Dahlander, 2014). In parallel, digital transformation generates disruptions that companies must consider and embrace in its innovation management model (Westerman et al., 2014).

Main instruments targeted to assess and to measure innovation, designed by international organizations (OECD, European Commission, World Bank, etc) must evolve to assume these shifts. Academy has already adopted several business cases revealing business practices aligned with those influences, as P&G, IDEO, GORE-TEX, ARUP and LEGO are examples. A common characteristic of those business cases results from the fact that companies analysed inserted innovation in business strategy, supported by the development of a creative, relational and open model.

Companies, remaining the most relevant innovation actors, mainly deriving from their market and value creation orientation, are effectively absorbing major changes in the innovation life cycle and the role different actors can play in a more open and dispersed context. New opportunities, market, technological, societal, put pressure on innovation management due to multiple sources, actors and influences (Dodgson et al., 2014). Since 2008, a Multi Channel Interactive Learning Model (Caraça et al., 2006) has been adopted by almost 200 companies in Portugal following its application as a basis for an innovation management system for audit certification by third parties.

Our research aims to analyse how companies are managing innovation, which practices and processes have been implemented and what framework could be designed to promote their capabilities to evaluate and measure innovation.

3. METHODS

In a first stage, in order to better understand how companies manage innovation and which practices have been used, a questionnaire was emailed to firms operating in Portugal, members of a Portuguese business association promoting innovation, as a proxy for Portuguese most innovative companies, and a total of 136 valid responses were obtained, approximately 50% of the sample.

The questionnaire targeted three main axes:

1. Business strategy and innovation;

2. Management practices connected with innovation activities and projects;
3. Accounting methods applied.

Both Cluster and MCA developed, showed that the selected variables (10 in total) have convergent validity, all measuring the index innovation itself. These variables apply to the principal object of measurement, and the initial exploration developed under this research, using statistical techniques previously presented, proved the validity of the survey conducted by its suitability for the purpose of study, complemented with the application of focus group exercises under the pilot group, and interviews in the companies, mainly Innovation Managers and Financial Managers, considered in previous studies as key informants (Gatignon et al., 2002), that led to the formation of aggregates considered in terms of maturity of the companies in the field of innovation management.

Assuming Porter's concept (1998) that a cluster can translate an aggregation of companies of similar characteristics, in spite of its diverse geographical origin, our cluster analysis, as an exploratory technique that can be used to detect homogeneous data groupings based on differences from selected variables, could permit, as theory suggests, to explain distances, correlations and associations observed, maximizing not only cases homogeneity in the same group but also heterogeneity between groups.

Nevertheless, as variables selection determine clusters characteristics, our analysis, based in variables showing a high multicollinearity, due to its measurement object being "innovation", was complemented with a multiple correspondence analysis (MCA). Through this analysis, it was studied relations between dichotomised variables associating optimal quantifications that maximize categories separation, facilitating its representation in few dimensions.

The index innovation verifies unidimensionality, through dimension 1 showing a Cronbach's alpha =0,753, and convergent validity due to the fact that all variables represent the same concept, quantified by eigenvalue > 1.

Table 3 | Summary Model - Mean Cronbach's Alpha is based on the mean Eigenvalue

SUMMARY MODEL

Dimension	*Cronbach's alpha*	*Explained Variance*	
		Total (Eigenvalue)	*Inertia*
1	,753	3,102	,310
2	,232	1,264	,126
3	,093	1,091	,109
4	,022	1,020	,102
5	-,135	,891	,089
6	-,238	,824	,082
7	-,400	,735	,074
8	-,705	,612	,061
9	-,956	,537	,054
10	-1,137	,494	,049
Total		10,571	1,057
Mean	,060[a]	1,057	,106

Due to the high multicollinearity between variables (variance inflation factor >3, correlations between variables > 0.85), the small differences among companies in the 10 variables (see Appendix A) are explained by others variables which belong to the questionnaire but are not included in this latent factor, allowing us to consider 5 aggregates:

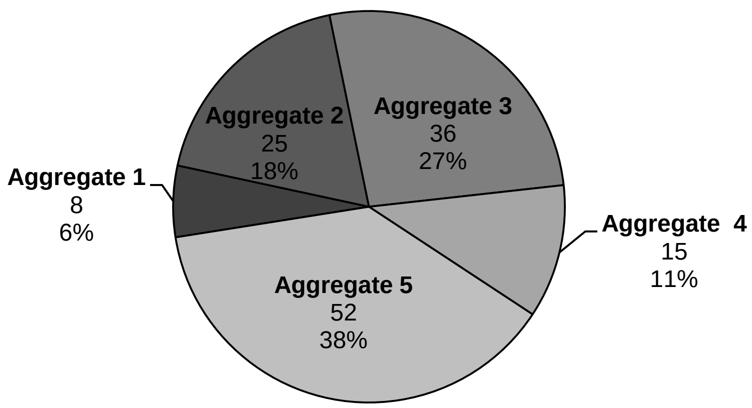

Figure 5 | Sample distribution by aggregates.

Absorbing insights from the Capability Maturity Model Integration (CMMI) methodology, as presented in Figure 6, developed by Carnegie Mellon University and initially applied mainly in engineering sectors, it was possible to identify, through variables considered and respondents data, different maturity levels concerning innovation management.

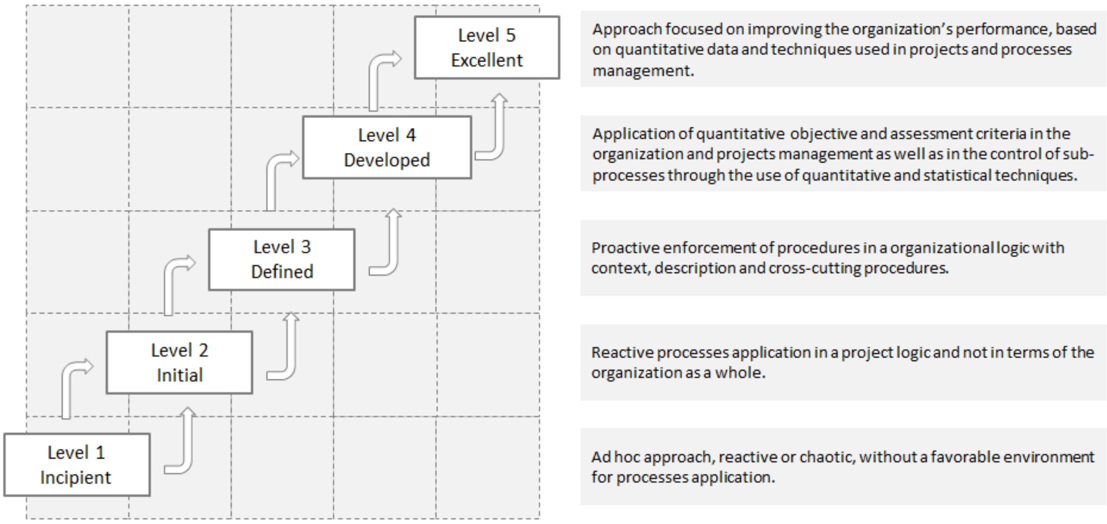

Figure 6 | CMMI Methodology - Maturity Levels in Innovation Management. (Software Engineering Institute, 2010).

Following the assumption that companies from each cluster are as much as possible similar between them and differentiate from others, in what concerns objectives and maturity in managing Research, Development and Innovation (RDI) activities, our analysis used the aggregates already indicated in Figure 5.

An examination of each aggregate, corresponding to companies showing a similar profile, maturity level and strategic support to innovation, was developed. Each aggregate was constructed through the combination of 10, in a total of 18, different closed answers (Yes/No). Those 10 structured answers, from the survey applied, included in the three axes above mentioned, were considered as variables for this analysis.

A pilot group of companies was formed in order to guarantee a facilitation network that enabled not only the focus group exercises but also the interviews and the validation and test of a preliminary evaluation measurement framework. This procedure previously used in the design of business performance measurement (Neely et al., 2000; Gatignon et al., 2002) permitted a participatory process through which companies from different sectors could share their processes and practices.

Table 4 Summary of the characterization of the Pilot Group

Pilot Company	Type of Innovation	Tools of R&DI Management	Indicators	Project Selection	Transversal Risk Analysis	Accounting
Company 1	Service / Process	■	■■	■■	■■	■
Company 2	Service	■■	■■	■	■	■
Company 3	Product	■	■	■■	□	■■
Company 4	Process	■■	■■	■	■■■	■■
Company 5	Organisational	■■	■	■	■■	■■
Company 6	Organisational	■■	■■	■	■	■
Company 7	Organisational Service Marketing	■■	■■	■■	■■■	■■

Maturity Level

Incipient / Not developed	□
Initial	■
Defined	■■
Developed	■■■

4. FINDINGS

4.1 Maturity levels in innovation management

The first finding is that companies show different innovation management maturity levels, characterised by their strategic, operational and financial approaches. Through survey results, it was possible to aggregate respondent companies, in total 136, in five different groupings, business "clusters", and to identify their specific innovation management practices and proficiency. The identification of maturity levels followed the CCMI methodology and guidelines concerning product development as a proxy for a broader application in innovation management, taking profit from the fact that it envisages the development and sustainability of a measurement capability supporting specific processes and information needs (CMMI Institute, 2015).

Different maturity levels in innovation management capture a broad range of practices and processes. Through our analysis, we cannot conclude that less developed companies, in terms of innovation measurement, are less innovative. Nevertheless, those companies revealing more structured approaches have already in place seeds for RDI performance evaluation and measurement. As identified in the pilot group cases, most of companies use innovation management tools and apply RDI indicators. In terms of accounting, some companies have identified and defined the relevance of implementing accounting analytical procedures but have still a long way to achieve a mature and developed framework capable to capture innovation impact and its value. A group of companies was designated as a "hybrid" group as they don't fit to the previous standardized groups already characterized, as they are not incipient but they are neither mature, demonstrating a confused innovation management profile.

Table 5 | Maturity Levels in Innovation Management

Business "clusters"	*Stage*	*Maturity level*
Cluster 1	Incipient	1
Cluster 2	Initial	2
Cluster 3	Defined	3
Cluster 4	Developed	4
Cluster 5	Hybrid	-

Our analysis has also shown that the five different business clusters reflect distinctive approaches towards innovation management. At a first level, an incipient stage gathered those companies that don´t include innovation as a key driver for global business and strategic management.

At next level, another group of companies was formed by those companies in which analytical accounting is not yet applied to RDI activities and projects, thus creating difficulties to a measurement exercise.

Under level 3, a group of companies having in place more developed innovation management practices, differentiates as they apply also several measurement indicators and metrics, directly linked to their accountancy guidelines and financial department. Innovation is assumed as a strategic driver for the organization and that implies an alignment of management practices as routine operations, ensuring a more fertile environment for assessing and measuring innovation results.

At level 4, a small group of companies, about 11% of those inquired, revealed that there are cases in which a holistic measurement exercise is tried, as those companies demonstrate that innovation is embedded in its culture, embracing and stimulating innovation as a transversal value for all the organization.

As indicated previously, the questionnaire targeted three main axes, business strategy, innovation activities and projects and accounting methods applied by the companies surveyed. The variables considered, linked to specific questions introduced in the questionnaire, permitted to elaborate an analysis, as presented in Table 6, of the innovation management processes those companies apply.

Table 6 | Innovation Management Processes: clusters analysis

Innovation Management Processes	*Cluster 1*	*Cluster 2*	*Cluster 3*	*Cluster 4*	
Strategic approach to innovation	x	√	√	√	Business strategy
Innovation plan	x	√	√	√	
Innovation management indicators	x	√	√	√	
Other management indicators or metrics to assess innovation impact	x	x	x	√	
RDI projects - quantitative evaluation	x	√	√	√	Innovation activities and projects
RDI activities (apart from projects) - quantitative evaluation	x	x	x	√	
Technologies and tools supporting innovation management	x	x	x	√	
R&D accounting (cost accounting in analytic terms)	x	x	√	√	Accounting
R&D accounting process applied to provide investment, cost and profit analysis associated with R&D projects	x	x	x	√	
RDI accounting (apart from R&D) - specific financial analysis	x	x	x	√	

4.2 CMMI application main lessons

The application of maturity models in the domain of innovation enabled to develop and analyse a framework, combining maturity levels at firm level with capabilities to develop a ROI approach. Designed as a matrix, the framework helps to identify companies positioning in five different levels according to their innovation management proficiency and their assessment and measurement capacities, especially when considering a ROI approach to Research, Development and Innovation (RDI) activities.

Initially applied in information technologies, namely in software development processes, CMMI enables a maturity assessment in different management domains, extending its original focus. Business practitioners and consultants have already assimilated this possibility (Planview, 2014), highlighting its potential to improve performance monitoring and measurement. It facilitates evaluation through the identification of business areas that can be considered more critical. Levels used in CMMI facilitate the analysis of trajectories for organizations willing to improve their products or services acquisition, development or commercialization.

RDI activities reveal normally high complexity and the need to manage it, facilitating to reduce uncertainty and risk as well as to support better and evidence based decisions, led to the application of different management models.

The appropriation of CMMI and its application in business innovation enabled the development of a framework, presented in Figure 7 that combines: 1.The maturity levels in innovation management and 2. The capability levels in innovation evaluation and measurement. In a simplified tool, companies and organizations can position themselves and identify its proficiency according to these two main lenses.

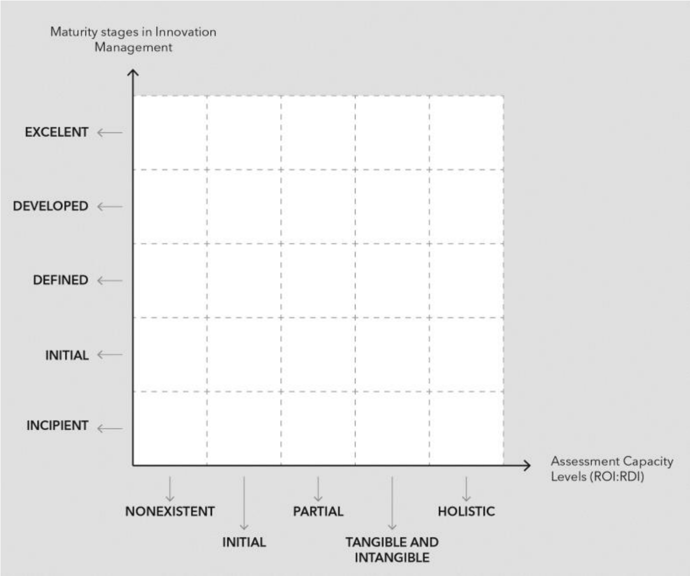

Figure 7 | Innovation Measurement at firm level – Maturity and ROI assessment capacity levels.

4.3 Innovation activities: focus on projects

Measuring innovation results requires then an adequate accountancy process and respective methods for assessing costs and profits associated with innovation activities. As recently assumed by Perani (2015), Oslo Manual revision must capture users needs for a better measurement of innovation outcomes, matching and integrating different approaches towards a multi-stage mechanism.

Under this "umbrella" of Oslo Manual revision, intangibles are emerging as a new dimension, complementary to innovation costs. Also, relevance of a more holistic perspective, as proposed in our model, highlights open innovation effects as a phenomenon that must be evaluated and measured.

Projects have been identified, in literature as well as in practice, as "measurable entities" that can more easily accommodate a formal and systematic evaluation procedure, frequently associated with its funding rules and its management standards (as required by International Projects Management Association or Project Management Institute organizations).

A ROI approach to innovation, based on the conventional ROI formula[2], could then be applied to innovation projects, representing most of innovation activities at firm level, including at an open innovation mode.

Nevertheless, it was observed that evaluation "time" is not consensual. Post project evaluation, generally up to three years after project conclusion, is considered adequate as most project results will be already disseminated and its measurement will be easier. Specificities from R&D

[2] ROI (%) = ((Gain from investment – Cost from Investment) / Cost from Investment) x 100

and Innovation activities developed in some domains, as pharma or biotech, could require a different evaluation time. Contributions from several authors, as Shenhar & Dvir (2007) and Chiesa & Frattini (2009), emphasize that business goals and sectors influence projects characteristics and there is a need to maintain several evaluation methods in order to address diversity, complexity, implementation, costs and other decision criteria when facing project evaluation.

Apart from a posteriori measurement, firms can also apply an a priori ROI approach, before projects launch. Firms tend to absorb tools and methodologies which can contribute to reduce uncertainty, to assess risk and define strategies to maximize project success, to improve knowledge concerning potential projects results and to enable better decision making in order to guarantee minimum rates of return.

4.4 Innovation indicators

Innovation dynamics raised the need to have indicators and metrics contributing to analyse, evaluate and compare its different expressions and impact on performance and competitiveness.

According to the research problem identified, management practices from companies analysed have shown that they apply several indicators, being the most common the weight of new or significantly improved products (measured by the ratio: Sales of new or significantly improved products / Turnover).

In line with previous research developed at COTEC Portugal (Caetano, 2010), many companies having implemented a formal innovation management system, audited and certified by external parties, absorbed and applied several indicators and metrics described in literature. In some cases, surveys and qualitative methods complement and enrich evaluation initially based on indicators. In specific innovation types, as organizational or services innovation, it is also assumed that generalized survey are not adapted.

Nevertheless, apart from its nature being more linked to conditions, as input indicators, to processes, as throughput indicators, or to results, as outputs indicators, companies don't have in place a systematic process to evaluate and measure, regularly, its innovation effects.

5. TOWARDS AN EVALUATION AND MEASUREMENT FRAMEWORK: EXTRACTING LESSONS FROM PRACTICES

Following the application of the interactive innovation management model in Portugal (Caraça et al., 2006), our evaluation and measurement approach captures its main contributions, highlighting not only the importance of "context" in which firms operate but also the innovation determinants and the innovation process cycle which can be considered as its main building blocks.

Companies surveyed and pilot group cases studies have shown the possibility to implement an evaluation and measurement framework concerning innovation activities. Nevertheless, it was clear that those companies that have not in place solid management processes, including its linkages with accounting guidelines, demonstrate less developed capabilities to implement that type of framework, namely if it is foreseen to analyse tangible and intangible effects as proposed in levels 2 and 3 from our model, as described in Figure 8, considering an application of a ROI approach to innovation activities and projects.

Many companies, approximately 60% of respondent companies, already use a self assessment generalised in Portugal, the innovation scoring system promoted by COTEC Portugal and IAPMEI. Nevertheless, in spite of supporting innovation management and guiding an internal diagnosis concerning innovation determinants (Smith et al., 2008; van der Panne et al., 2003), this tool doesn´t capture value created by innovation.

The model proposed addresses those limitations and includes the business innovation cycle in its context as firms are not isolated units. A systemic approach facilitates then our understanding of the different components represented and its linkages, influences and interdependences with micro and macro environment elements:

1. Innovation Business Determinants: innovation evaluation and measurement at firm level, as previously suggested by researchers (Adams et al., 2006; Dervitsiotis, 2010; Muller et al., 2005), must include a regular and systematic process addressing innovation determinants included in a broad spectrum of areas, for example culture, strategy, governance, processes and innovation results.

2. Innovation Process Cycle: transformation of ideas and knowledge into innovative results (product, process, organizational, marketing, social, business model innovations...) requires a formalised process, normally associated with new product development methodologies that reflects also evaluation and measurement in order to check the agility, speed, flexibility and capabilities in maintaining a healthy innovation portfolio, in an ambidextrous perspective, as a relevant axis of business sustainability.

3. Innovation Activities and Projects: Innovation activities and projects are at the core of innovative firms. In our model, a ROI approach can be applied to this building block as it is possible to link to accounting procedures in order to evaluate and measure innovation effects in different levels, including the

possibility of associating direct costs and profits to the activity or project that is subject to analysis.

Research developed has contributed to identify, through a systematic analysis of literature, survey answers, focus group interviews and its linkages to the innovation scoring main dimensions and pillars (COTEC Portugal, 2007), innovation determinants to be evaluated and measured. It was then developed a framework, reflected in Figure 8 that apart from the application of a ROI approach to innovation activities and projects can encompass broader measurement areas contributing to characterise an innovative performance at firm level as well as the innovation process life cycle.

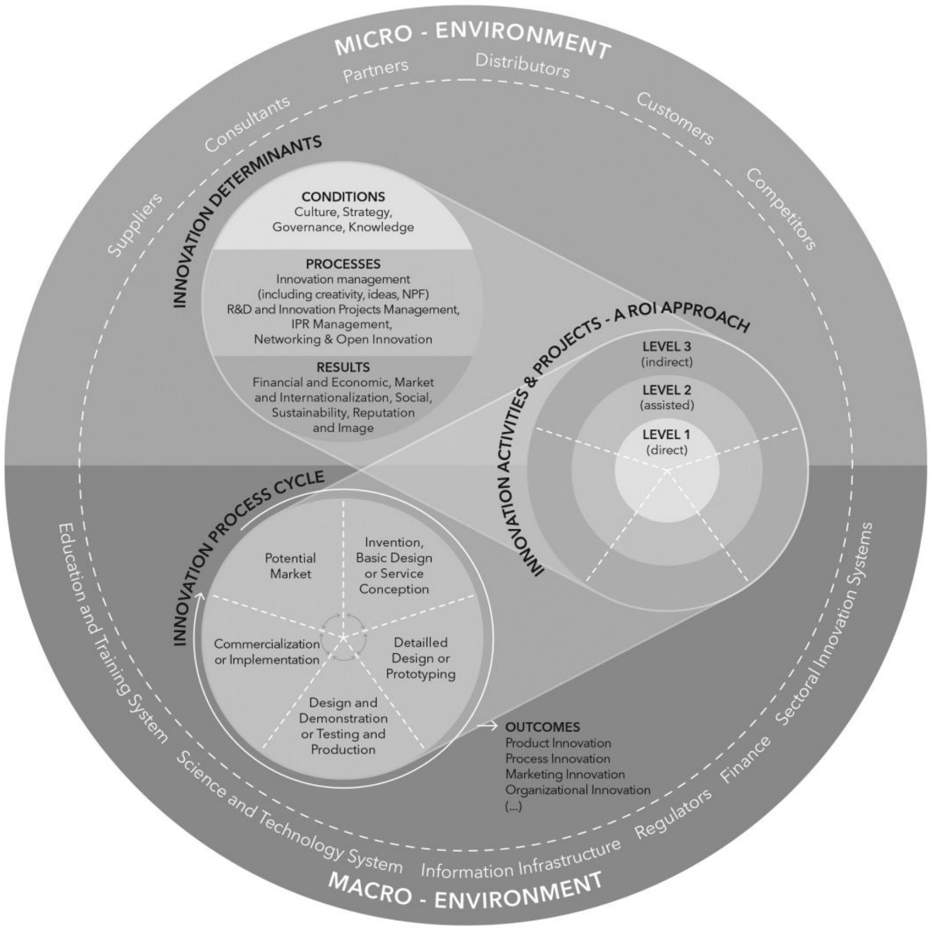

Figure 8 | Innovation Measurement at firm level – A return on Innovation Approach.

6. CONCLUSIONS

This research contributes to the understanding of innovation measurement at business level and its relevance to a more systematic approach towards innovation management, identifying specific innovation indicators and generating knowledge on how companies can apply an evaluation methodology. Considering innovation as a critical resource contributing to a sustainable competitive advantage, its influence on business performance, namely in value creation, puts pressure on managers to apply an evidence based methodology to evaluate and to measure innovation results.

Innovation management is challenged by the power of demonstrating its value, showing return on investment and giving evidence based information and data supporting business decisions and options concerning innovation activities.

Cases from the pilot group have highlighted that innovation measurement is a difficult and extremely complex task, requiring different competences and processes in order to pursue that goal. Some of these difficulties are related with the need to find and to apply innovation indicators that can be transversal. In fact, the nature and the type of projects or other innovation activities could require specific indicators but in order to achieve a common and holistic framework, innovation indicators must be independent regarding diversity, at least at macro level. By that reason, in spite of most companies effort to apply some general innovation indicators, innovation projects are identified as the most appropriate units to implement specific innovation indicators targeting outcomes and impact as well as to apply a ROI approach.

Our research also identified that isolating innovation impacts from the global business activities is not easy due to several aspects. First of all, time is a key ingredient to be considered in the measurement exercise and RDI activities are frequently developed in a long term perspective. The time range to assess and measure RDI impact should be defined and aligned with the measurement process, which is not consensual between companies, sectors and innovation types (product, service, process, organizational, marketing, social, etc). Also, information systems and technologies applied at firm level, mostly as decision support systems, enable to get a picture of the moment but hardly achieve to facilitate a prospective view concerning future impact of RDI activities and projects.

In what concerns innovation measurement and its linkage to accountancy guiding principles, it was noted that companies are aware that RDI costs should be identified and clearly specified in financial terms. In fact, public policies concerning tax incentives for R&D favored this procedure. Nevertheless, it was observed that RDI profits are not, as costs, so clearly stated in close connection with the activity or project that originated it. Most companies reveal serious problems when trying to differentiate and measure tangible and intangible profits. Issues as costs reduction or business growth due to customers loyalty related to innovation results are practically ignored in most companies. Indicators measuring intangibles are almost inexistent in innovation management measurement practices from the companies analyzed, as it is the case concerning trademarks, brands or reputation.

Through a better understanding of the innovation management maturity levels, and specific processes linked to different proficiency stages, managers can absorb and apply practices and processes as enablers for a more robust and systematic innovation management. Also, for those organizations adopting a specific ROI: RDI methodology, a formal coordination between different departments or functions, as it is the case of HR, Marketing, RDI, Financial, etc, will be stimulated in order to evaluate, in its broader context, innovation results and effects.

In sum, the results obtained confirm that there is a need to further develop research exploring connections between innovation determinants, innovation life cycle dynamics and innovation performance measurement in terms of a ROI approach. The presented framework could also be further applied in order to be revised and validated in terms of its practical usefulness and acceptability. Return on investment indicators linked to innovation activities and projects should be systematized and tested, detailing costs and profits that could be associated with the three levels of evaluation and measurement (direct, assisted and indirect) and a portfolio of possible indicators and metrics could be provided.

When admitting a 'Mode 3' systems approach (Carayannis and Campbell, 2009), even if departing from firm level, innovation can be analyzed and measured in a broader context in which *soft power* determinants, including culture and values, are crucial, as the 'quadruple helix' advocates. A new innovation measurement model as presented in Figure 8 covers not only those 'modes', in which actors assume different roles, but also a non linear representation of the innovation dynamics, illuminating interactions and linkages between different systems.

Further research should be dedicated to develop a digital tool facilitating integration of the innovation measurement framework in business management processes and systems, improving evidence based decision.

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