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Macro and Firm Level Innovation Measurements and Indicators



**Galway City and County Council
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Table of Contents

Executive Summary.....6

Macro Level Measures and Indicators.....7

1 Introduction7

2 Triple Helix Approach.....8

3 Innovation Union Scorecard and Community Innovation Survey.....10

4 Directorate-General for Research and Innovation13

5 Community Innovation Survey15

Firm-level Innovation Indicators17

Executive Summary

This White Paper focuses on innovation measures and indicators at two levels. Our first focus is on macro measures of innovation that are used for international comparisons and compiled by national statistical agencies. For the purposes of the White Paper we focus on the European Union Innovation Scorecard that is conducted on an annual basis. This is used for comparative purposes among the 27 EU Members States and to compare the EU 27 against other countries. In addition, we outline additional measures of innovation that the DG for Research and Innovation has used that captures both input and output measures of innovation. At a national level we focus on the Community Innovation Survey that examines innovation activities at a firm level. It focuses on such issues as product, process, and marketing innovation as well as barriers to innovation. In recent years innovation measures and indicators have broadened to capture more inputs and actors.

The latter focus of our White Paper is on firm level measures and indicators of innovation. There is a growing number of models and frameworks that are being developed by academics and consultancy firms to support and shape firm level innovation. In particular we focus on organisational innovation, innovation management and management innovation measures and indicators. Measuring innovation is a complex and difficult task. Creating environmental conditions with respect to inputs, supports and ease of sustaining linkages between different stakeholders can encourage firms to invest and adopt effective innovation practices. The indicators and measures in this White Paper are designed to give a sense of the different ways that innovation can be measured from inputs to outputs. These measures provide a barometer that ultimately feeds into decision making at firm level and provide policy makers with evidence of policy implementation progress.

Macro Level Measures and Indicators

1 Introduction

Innovation and entrepreneurship activities in an economy have positive economic benefits, particularly in employment, taxation revenue, and economic output. Creating the environmental conditions to support these activities is critical for any location. Some countries and regions have distinct advantages that enable these activities to occur without too much intervention. However, there is a growing interest among policy makers, Governments and firms to measure the success of innovation and entrepreneurship policies. These measurements provide a basis for international comparisons and provide data points that feed into firm level decision-making with respect to R&D investment. The market premium for knowledge, the rapid pace of scientific development, advances in ICT, the increasing numbers of highly skilled workers are driving the nature of innovation and entrepreneurship.

The measuring of innovation at a macro level has evolved since the 1950s where there was a focus on input indications such as R&D expenditure, capital and science and technology personnel. During the 1970s measurement of innovation focused on outputs indications such as patents, publications, products and quality change. The 1990s saw a growth of innovation surveys and benchmarking activities. The fourth generation of innovation measurement focuses on process indicators that can be applied at firm and sectoral levels (see Table 1). Because innovation can be achieved in many ways, measuring innovativeness is difficult to do well with a single measure. Smith (2005) argues that while it is impossible to measure and quantify some aspects of innovation, “its overall characteristics do not preclude measurement of key dimensions of processes and outputs.”¹

Recent research has identified several new indicators of innovation inputs and outputs, including economy-wide measures that have some degree of international comparability.

Table 1:
Evolution of Innovation Metrics by Generation

¹ Smith, M. (2005) The Balanced Scorecard. Financial Management February pp 27-28.

First Generation Input Indicators (1950s–60s)	Second Generation Output Indicators (1970s–80s)	Third Generation Innovation Indicators (1990s)	Fourth Generation Process Indicators (2000s plus emerging focus)
<ul style="list-style-type: none"> • R&D expenditures • S&T personnel • Capital • Tech intensity 	<ul style="list-style-type: none"> • Patents • Publications • Products • Quality change 	<ul style="list-style-type: none"> • Innovation surveys • Indexing • Benchmarking innovation capacity 	<ul style="list-style-type: none"> • Knowledge • Intangibles • Networks • Demand • Clusters • Management techniques • Risk/return • System dynamics

Source: Centre for Accelerating Innovation, George Washington University (2006)

2 Triple Helix Approach

In tandem with the evolution of different innovation measures the triple helix paradigm has shaped policy makers thinking and implementation of national innovation policy. It has also shaped the measurement of innovation to include such measures around activities from third level institutions and levels of entrepreneurial endeavours. Both EU and national innovation and entrepreneurship policies reflect core aspects of the triple helix². The triple helix approach attempts to understand the relationship and interaction between universities/public research organisations (PROs), industry and government and innovation.³ For national innovation systems to have an impact and be sustainable requires effective partnership between these actors. The dynamic interactions between these actors represent the true nature of innovation systems⁴. The triple helix approach incorporates three intertwined dynamics of institutional transformations, evolutionary mechanisms, and the enhanced position of the university. The concept of the triple helix emerged from a failure to concisely locate and define the processes of innovation.

Universities:

Universities have three core missions - teaching, research and what is now termed technology and knowledge transfer. At the heart of university activities is scientific excellence to create national or international leadership positions. These areas of excellence can be complimented by technology and knowledge transfer activities, which seek to take some of the outputs from research to be exploited for outcomes of public and private good. Etzkowitz (2003)⁵ describes this as: “Just as the university trains individual students and sends them out into the world, the

² Etzkowitz, H. and Leydesdorff, L. (Ed) (1997) *Universities in the Global Economy: A Triple Helix of University-Industry-Government Relations*. Cassell Academic, London

³ Godin, B. (2005) *The Linear Model of Innovation: The Historical Construction of an Analytical Framework*, *Science, Technology, and Human Values*, 31 (6), November 2006: 639-667.

⁴ Piekarski, A.E.T. & Torkomian, A.L.V. (2005) *How R&D Public Financing incites the Academy-Industry Cooperation: an assessment of the effects of a public policy in Brazil*. In: Triple Helix 5.

⁵ Etzkowitz, H. (2003) Research groups as ‘quasi firms’: the invention of the entrepreneurial university, *Research Policy*, 32:109-21.

Entrepreneurial University is a natural incubator, providing support structures for teachers and students to initiate new ventures: intellectual, commercial and conjoint.” Universities are at the forefront of new technological and scientific developments and are core actors in global knowledge production systems. Their international research teams create environments that attract the best talent to undertake doctoral and post-doctoral research.

Industry:

Within this context industry can benefit from university engagement through exploiting research, hiring new talent and having access to international research networks. Moreover, industry can shape the research fields that national governments prioritise that is aligned with their near or long terms business needs. Most EU Member States have gone through a research prioritisation exercise designed to align research with industry needs so they can compete more effectively in international markets. For example, Galway is the fourth sub-critical location in the world for manufacturing of medical devices and an international cluster has developed over the last decade in medical technologies⁶. Local third level institutions have supported the growth of this sector, with new programmes, establishment of international research programmes and recruitment of faculty. Also, industry, through their interaction with national and local governments, put pressure on these bodies to ensure that they create environmental - economic, social and educational - conditions to enhance firm competitive positioning in international markets.

Government:

National governments, in terms of their economic and social policies, create the environmental conditions that make it attractive for new venture creation, for entrepreneurs and for supporting services such as venture capitalists, to invest capital in the most efficient way possible. Mowery et al. (2004)⁷ argue that this is pivotal in supporting innovation and entrepreneurship and Etzkowitz (2002)⁸ suggests the role of government is expanding, not only in relation to macro factors but increasingly to encompass the micro conditions of innovation. Corporate and personal taxation, levels of government administration, house prices, provisions of suitable office locations, public investment in education, access to transport linkages and a myriad of other macro and micro factors create these general environmental conditions. For Governments, the level of entrepreneurship and new business creation is one of the measures of economic vibrancy. Governments also play a role in providing public investment in system-wide education – pre-school to third level. Educational policies and national curriculums are usually set by national governments. Another role that governments play within the triple helix is through public investment in research - through public research laboratories and higher level institutions. This public funding supports infrastructure, basic and applied research, human capital, doctoral students and senior researchers etc. In the case of the Human Genome Project for a US Government investment of \$3.6 Billion, 3.8 million jobs were created from 1998 to 2003, 310,000 jobs in 2010 and \$796 Billion generated in economic output.⁹

⁶ Giblin, M. and Ryan, P. (2012) "Tight Clusters or Loose Networks? The Critical Role of Inward Foreign Direct Investment in Cluster Creation", *Regional Studies*, 46(2), pp.245-258.

⁷ Mowery, D. C., Nelson, R. R., Sampat, B. N. and Ziedonis, A. A. (2004) *Ivory Tower and Industrial Innovation. University-Industry Technology Transfer Before and After the Bayh-Dole Act*. Stanford University Press: Palo Alto, CA

⁸ Etzkowitz, H. (2002). *MIT and the Rise of Entrepreneurial Science*. London: Routledge.

⁹ Science Programme, (2011) *Investing in Innovation Pays Off*, Science Progress, <http://www.doingbusiness.org/data/exploretopics/entrepreneurship#sub-menu-item-link>

In summary, aspects of the triple helix has manifested in national policy. For example, through five cycles of the Programme for Research in Third Level Institutions the co-funding by the Higher Education Authority and the European Research Development Fund has increased the physical and human research capacity in third level institutions. Recent large-scale centre programmes co-funded by Science Foundation Ireland and industry are further enhancing the university industry collaborations. At a national level a research prioritisation exercise has been completed that is shaping the public funding programmes through the various national funding bodies. Furthermore, third level institutions have enhanced and developed their Technology Transfer Offices with the support of Enterprise Ireland, through Knowledge Transfer Ireland.

3 Innovation Union Scorecard and Community Innovation Survey

*A good KPI should be definable and quantifiable.*¹⁰

One of the greatest challenges for Governments and policy makers is to evaluate whether their policy interventions and supports do make a difference to firms and entrepreneurs. Lundstrom et al (2008)¹¹ best described the challenges as: “One of the challenges for Governments is to determine what actions or combination of actions will most appropriately address the salient direct and indirect barriers to achieving higher levels of entrepreneurship and/or innovation, given their idiosyncratic set of county contextual and structural circumstances.” For the impact of innovation and entrepreneurship policies, it can take a number of years to see tangible outcomes. When it comes to measuring innovation many national government agencies are involved using commonly agreed measures and data collection protocols. The measurement of innovation involves measuring the activities of triple helix actors, government, industry and third level institutions and public research organisations.

Innovation Union Scorecard

Each year the European Commission publishes an Innovation Scorecard for each Member State based on a set of indicators and data supplied by national statistical agencies. Innovation Union Scorecard details the innovation leaders, followers, moderate innovators and modest innovators in Europe. (See Table 2 for the 2013 Innovation Union Scorecard indicators). It currently uses 29 indicator statistics, 19 of them tracking various measures of investment and the remaining 10 being measures of output or impact. These are then assembled into a composite index that broadly represents the state of development in science and technology in each country. The Innovation Union Scorecard uses a range of indicators in a national economy in relation to research and innovation performance for the 27 Member States. The dimensions of innovation are broken down into enablers (human resources; open, excellent and attractive research systems; finance and support); firm activities (firm investments; linkages and entrepreneurship; intellectual assets) and outputs (innovators and economic effects).

¹⁰ Reh, J. (2006). Key Performance Indicators.

¹¹ Lundstorm, A., Almerud, M. and Stevenson, L. (2008) Entrepreneurship and Innovation Policies: Analysing measures in European countries, Innovative Policy Research for Economic Growth, Swedish Foundation for Small Business Research.

Table 2:

Innovation Union Scorecard Indicators

Table 1: Innovation Union Scoreboard indicators		
Main type / innovation dimension / indicator	Data source	Years covered
ENABLERS		
Human resources		
1.1.1 New doctorate graduates (ISCED 6) per 1000 population aged 25-34	Eurostat	2006 – <u>2010</u>
1.1.2 Percentage population aged 30-34 having completed tertiary education	Eurostat	2007 – <u>2011</u>
1.1.3 Percentage youth aged 20-24 having attained at least upper secondary level education	Eurostat	2007 – <u>2011</u>
Open, excellent and attractive research systems		
1.2.1 International scientific co-publications per million population	Science-Metrix (Scopus)	2007 – <u>2011</u>
1.2.2 Scientific publications among the top 10% most cited publications worldwide as % of total scientific publications of the country	Science-Metrix (Scopus)	2004 – <u>2008</u>
1.2.3 Non-EU doctorate students ^a as a % of all doctorate students	Eurostat	2006 – <u>2010</u>
Finance and support		
1.3.1 R&D expenditure in the public sector as % of GDP	Eurostat	2007 – <u>2011</u>
1.3.2 Venture capital investment as % of GDP	Eurostat	2007 – <u>2011</u>
FIRM ACTIVITIES		
Firm investments		
2.1.1 R&D expenditure in the business sector as % of GDP	Eurostat	2007 – <u>2011</u>
2.1.2 Non-R&D innovation expenditures as % of turnover	Eurostat	2006, 2008, <u>2010</u>
Linkages & entrepreneurship		
2.2.1 SMEs innovating in-house as % of SMEs	Eurostat	2006, 2008, <u>2010</u>
2.2.2 Innovative SMEs collaborating with others as % of SMEs	Eurostat	2006, 2008, <u>2010</u>
2.2.3 Public-private co-publications per million population	CWTS (Thomson Reuters)	2007, <u>2011</u>
Intellectual assets		
2.3.1 PCT patents applications per billion GDP (in PPSE)	Eurostat	2005, <u>2009</u>
2.3.2 PCT patent applications in societal challenges per billion GDP (in PPSE) (environment-related technologies; health)	OECD / Eurostat	2005, <u>2009</u>
2.3.3 Community trademarks per billion GDP (in PPSE)	OHIM ² / Eurostat	2007, <u>2011</u>
2.3.4 Community designs per billion GDP (in PPSE)	OHIM / Eurostat	2007, <u>2011</u>
OUTPUTS		
Innovators		
3.1.1 SMEs introducing product or process innovations as % of SMEs	Eurostat	2006, 2008, <u>2010</u>
3.1.2 SMEs introducing marketing or organisational innovations as % of SMEs	Eurostat	2006, 2008, <u>2010</u>
3.1.3 <i>High-growth innovative firms</i>	N/A	N/A
Economic effects		
3.2.1 Employment in knowledge-intensive activities (manufacturing and services) as % of total employment	Eurostat	2007, <u>2011</u>
3.2.2 Contribution of medium and high-tech product exports to the trade balance	UN	2007, <u>2011</u>
3.2.3 Knowledge-intensive services exports as % total service exports	UN / Eurostat	2006, <u>2010</u>
3.2.4 Sales of new to market and new to firm innovations as % of turnover	Eurostat	2006, 2008, <u>2010</u>
3.2.5 License and patent revenues from abroad as % of GDP	Eurostat	2007, <u>2011</u>

As well as measuring innovation in each member state the EU details the innovation leaders, followers, moderate innovators and modest innovators in Europe. An analysis is presented for each Member State against EU average and a categorisation is given for each Member State.

(See Table 3 for example of categorisation for 2013). The Innovation Union Scoreboard 2013 found that Sweden is the leading innovation performer. Signs are emerging that an innovation performance gap is widening between member states. The danger is that over the coming years this gap could widen further and it will be difficult for countries to close the gap, with more innovative countries accelerating and consolidating their performance. The Innovation Union Scoreboard (2013, p.7) noted that: “The most innovative countries in the EU share a number of strengths in their national research and innovation systems, with a key role played by business activity and the higher education sector. The business sectors of all innovation leaders perform very well as measured by Business R&D expenditures and PCT patent applications. They also share a well-developed higher education sector as demonstrated by very high results of new doctorates graduates, international scientific co-publications and public-private co-publications with the latter also signaling strong linkages between industry and science.”

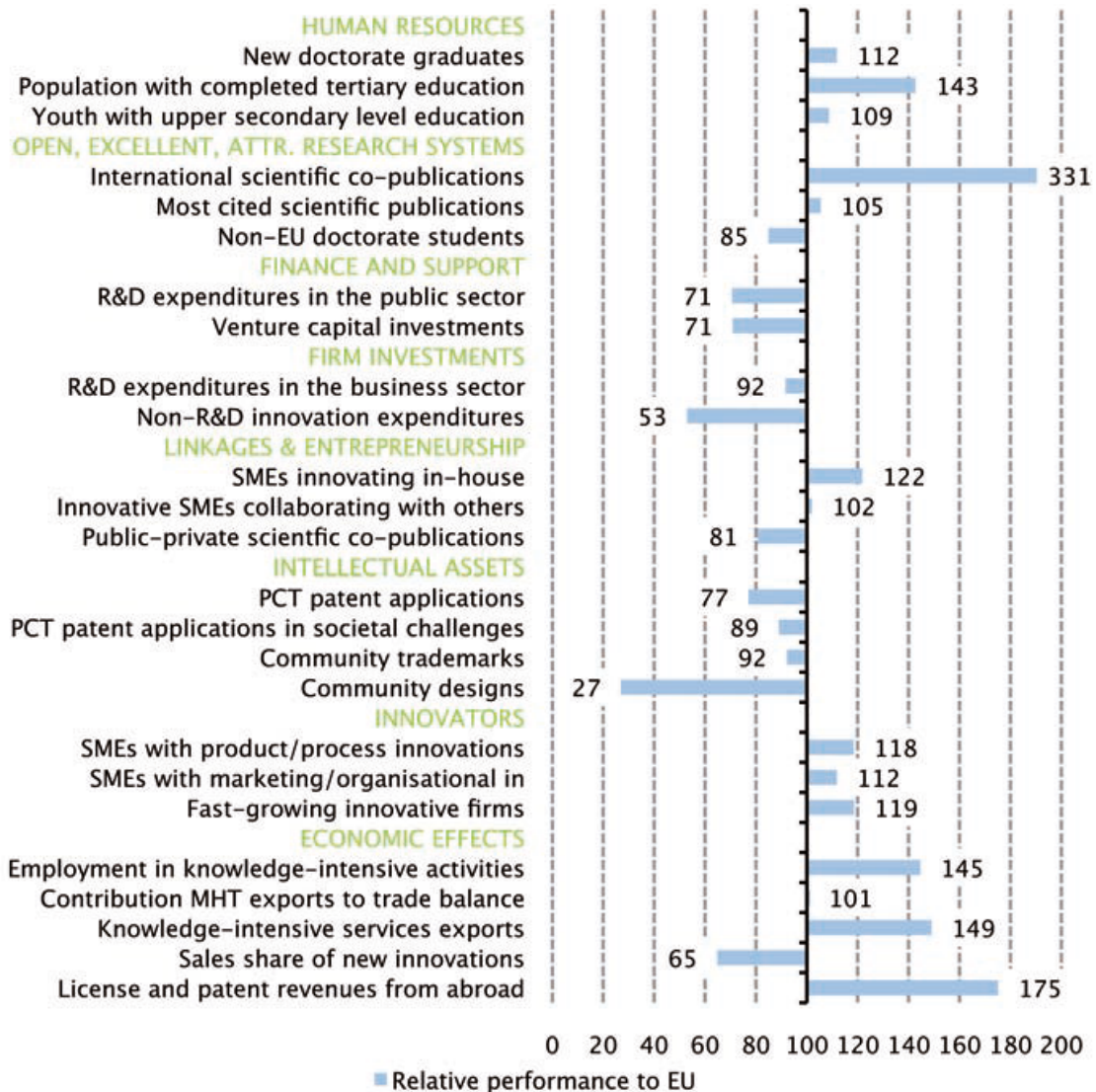
Table 3:
[Summary Innovation Union Scoreboard 2013](#)

<p>Innovation Leaders: Sweden, Germany, Denmark and Finland all show a performance well above that of the EU average.</p> <p>Innovation Followers: Netherlands, Luxembourg, Belgium, the UK, Austria, <u>Ireland</u>, France, Slovenia, Cyprus and Estonia all show a performance close to that of the EU average.</p> <p>Moderate Innovators: The performances of Italy, Spain, Portugal, Czech Republic, Greece, Slovakia, Hungary, Malta and Lithuania are below that of the EU average.</p> <p>Modest Innovators: The performances of Poland, Latvia, Romania and Bulgaria are well below that of the EU average.</p>

Source: European Union [c.europa.eu/enterprise/policies/innovation/facts-figures-analysis/innovation-scoreboard/](http://ec.europa.eu/enterprise/policies/innovation/facts-figures-analysis/innovation-scoreboard/)

Ireland’s performance for the 2014 Innovation Union Scorecard is well above EU average despite the challenging economic climate. The measurement indications show that Ireland does well with respect to scientific co-publications, licences and patent revenues from abroad as well as population at tertiary education and employment in knowledge intensive services (see Table 4).

Table 4:
Ireland's Innovation Union Scorecard 2014



Source: European Commission, (2014) Innovation Union Scorecard, p.49.

4 Directorate-General for Research and Innovation

A more extensive list of key indicators has been used by the DG for Research and innovation and are listed in Table 5. The indicator set that is used covers many aspects of the innovation and entrepreneurship eco-systems from financial investment, human capital, intellectual capital,

venture capital investment to knowledge intensive services. This data is collected by national statistical agencies using standardised and harmonised data collection protocols.

Table 5:
DG Research and Innovation Indicator List

Gross domestic expenditure on R&D (GERD) millions of euro
R&D intensity
Business expenditure on R&D (BERD) millions of euro
Business expenditure on R&D (BERD) as % of GDP ⁽¹⁵⁾
Business expenditure by SMEs (0-249 employees), millions of euro ⁽¹⁵⁾
Business expenditure by SMEs (0-249 employees) as % of GDP
Inward R&D expenditure by foreign affiliates, millions of euro ⁽¹⁶⁾
Inward R&D expenditure as % of R&D expenditure by business enterprise ⁽¹⁶⁾
Public expenditure on R&D (GOVERD + HERD) millions of euro
Public expenditure on R&D (GOVERD + HERD) as % of GDP
Investment in knowledge (R&D and Education), millions of euro
Investment in knowledge (R&D and Education) as % of GDP
New doctoral graduates (ISCED 6), total
New doctoral graduates (ISCED 6) per thousand population aged 25-34
Number of researchers (FTE)
Number of researchers (FTE), per thousand labour force
Number of researchers (FTE) working in the private sector
Number of researchers (FTE) working in the public sector
Human Resources in Science and Technology aged 25-64
Human Resources in Science and Technology aged 25-64 as % of labour force
New S&T graduates (ISCED 5A) with S&E orientation)
License and patent revenues from abroad, millions of euro ⁽¹⁷⁾
License and patent revenues from abroad as % GDP ⁽¹⁷⁾
Community trademarks
Community trademarks per billion GDP (PPS€)
Total number of scientific publications (fractional counting method)
Scientific publications in the 10% most cited scientific publications worldwide
Scientific publications in the 10% most cited scientific publications worldwide as % of total scientific publications of the country
PCT patent applications, total number
PCT patent applications per billion GDP (PPS€)
Female PhD / doctoral graduates, total number
Share (%) of female PhD / doctoral graduates in total PhD / doctoral graduates
International scientific co-publications, total number
International co-publications as % of total publications
PCT patent applications with co-inventor(s) located abroad
PCT applications with co-inventors located abroad, as % of total PCT patent applications
Public-private co-publications per million population

Venture capital (early stage, expansion and replacement), millions of euro ⁽¹⁸⁾
 Venture capital (early stage, expansion and replacement) as % of GDP ⁽¹⁸⁾
 Cost of patent application and maintenance for SMEs, PPS€
 Cost of patent application and maintenance for SMEs, per billion GDP (PPS€)
 Health technology patents (PCT)
 Health technology patents (PCT) per billion GDP (PPS€)
 Climate change mitigation patents (PCT)
 Climate change mitigation patents (PCT) per billion GDP (PPS€)
 Employment in knowledge intensive economic activities ⁽¹⁹⁾ as % of total employment
 Medium and high-tech manufacturing exports, millions of euro ⁽²⁰⁾
 Medium and high-tech manufacturing exports as % of total product exports ⁽²⁰⁾
 Knowledge intensive service exports, millions of euro ⁽²⁰⁾
 Knowledge intensive service exports as % of total service exports ⁽²⁰⁾
 Contribution of medium-high and high-tech exports to the manufacturing trade balance as % of total manufacturing ⁽²¹⁾

Source http://ec.europa.eu/research/innovation-union/pdf/competitiveness-report/2011/data-and-statistics/key_indicators_summary_table.xls

5 Community Innovation Survey

This survey is carried out on a national basis and covers a range of topics relating to innovation, which focuses on technological, organisational, and marketing innovations and creative skills. This survey is carried out jointly between Forfas and the Central Statistics Office. The key measurement variables that CIS use are outlined in Table 6. The focus of this survey is at firm level.

Table 6:
Measurement Items Used for Community Innovation Survey

<p><u>Technological Innovation</u></p> <p>Types of Innovation expenditure:</p> <ul style="list-style-type: none"> • In-house Research and Development • Purchase of external Research and Development • Acquisition of machinery, equipment and software • Acquisition of other external knowledge • All other innovation activities <p>Product Innovations</p> <ul style="list-style-type: none"> • New or significantly improved goods • New or significantly improved services <p>Process Innovations</p> <ul style="list-style-type: none"> • New or significantly improved methods of manufacturing or producing goods or services • New or significantly improved logistics, delivery or distribution methods • New or significantly improved supporting activities for processes

Cooperation Partners for Innovative Enterprises:

- Other enterprises within own enterprise group
- Suppliers of equipment, materials, components or software
- Clients/customers
- Competitors/other enterprises in same sector
- Consultants, commercial labs or private R&D institutes
- Universities or other higher education institutes
- Government or public research institutes

Barriers to Innovation Activities

- Lack of funds
- Lack of external finance
- Innovation costs too high
- Lack of qualified personnel
- Lack of information on technology
- Lack of information on markets
- Difficulty in finding co-operation partners
- Market dominated by established enterprises
- Uncertain demand for innovative goods or services

Organisational Innovation Activities

An organisational innovation is a new organisational method in the enterprise's business practices, workplace organisation or external relations that had not been previously used by enterprises.

- Introduction of new business practices
- New methods of organising work responsibilities and decision-making
- New methods of organising external relations

Objectives of introducing organisational innovations:

- Reduced time to respond to customer or supplier needs
- Improved ability to develop new products or processes
- Improved quality of goods or services
- Reduced costs per unit output
- Improved communication or information sharing within enterprise or with other enterprises or institutions

Marketing Innovation Activities

- Introduction of new media or techniques for product promotion
- Introduced significant changes to the aesthetic design or packaging of a good or service.
- New methods for product placement or sales channels
- New method for pricing goods or services

Objectives for Marketing Innovation:

- Increase or maintain market share
- Introduce products to new customer groups
- Introduce products to new geographic markets

Creative Skills employed In-house

- Graphic arts / layout / advertising

- Design of objects or services
- Multimedia
- Web design
- Software development
- Market research
- Engineering / applied sciences
- Mathematics / statistics / database management

Type of creativity and skills employed by innovative enterprises:

- Brainstorming sessions
- Multidisciplinary or cross-functional work teams
- Job rotation of staff to different departments or other parts of your enterprise group
- Financial incentives for employees to develop new ideas
- Non-financial incentives for employees to develop new ideas, such as free time, public recognition, more interesting work, etc
- Training employees on how to develop new ideas or creativity

Other Innovation Indicators

- Gross value added
- Labour costs
- Capital acquisitions
- Exports
- E-commerce

Key findings from the latest CIS survey 2008 to 2010 conducted by the CSO (2012)¹² in Ireland found that:

- 60% of all enterprises were technological or non-technological innovation active
- Almost 50% of all enterprises were technological innovation active
- Almost 28% of enterprises were engaged in product innovations
- Almost 33% were engaged in process innovations
- Over 9% of turnover in the industrial and selected services sectors in 2010 resulted from new to market product innovations.
- Almost 30% of all technological innovation active enterprises were engaged in innovation co-operation.

Firm-level Innovation Indicators

Innovation matters and several different indicators have been developed over the last number of decades in relation to measuring firm level innovation. Empirical studies that have been conducted have focused on aspect of innovation and firm level performance. Day (2007)¹³

¹² Central Statistic Office (2012) Community Innovation Survey 2008-2010.

¹³ Day, G. (2007). Is it real? Can we win? Is it worth doing? Managing risk and reward in an innovation portfolio, Harvard Business Review, 85(12): 110-120.

found that ‘minor innovations make up 85% to 90% of companies’ development portfolio, but they rarely generate the growth that companies seek.’ When it comes to innovation and performance in a single business unit setting, Tsai (2001)¹⁴ found that if single business units occupy a central network position, they are likely to have access to useful knowledge from other business units, which provides them opportunities to share ideas, information and learning coupled with higher absorptive capacity levels and that: ‘internal social processes within organisations affect innovation at the organizational unit level.’

Within firms the interaction of different functions and teams is an enabling process for innovation. Creating mechanisms within firms to allow social interaction between different parts of the firms helps drive innovation activities. Taylor and Greve’s (2006)¹⁵ study of the comic book industry revealed that: ‘multimember teams and teams with experience working together produced innovations with greater variation in value, but individuals were able to combine knowledge diversity more effectively than teams.’ Organisations that are open to external sources of innovation or search channels can have higher levels of innovation performance. This is particularly the situation with radical innovation in the early stages of product life cycles, and, when the technology matures, increased searching activities take place in order to improve and broaden the product or service appeal. However the danger is that organisations can overly search which can impede innovation performance¹⁶.

Collaborative innovation is becoming a key feature for firms as they partner with university research, public bodies and other firms in realising their innovation strategy. In some sectors collaborative innovation is the norm. When examining innovation and performance in collaborative contexts Stuart (2002)¹⁷ found that older and larger organisations benefited less from large and innovative strategic alliance partners than smaller younger organisations. Interestingly, innovation performance is greater in situations where alliance partners have an equity joint venture, when technological diversity between partners is higher and that the organisational form shapes incentives such as information sharing ultimately affects innovative performance. In a collaborative context firms should actively manage the sharing of knowledge in their own innovation system and global firms should actively develop strategies to participate in global innovation systems (Spencer, 2003)¹⁸. Spencer (2003) in this study of the flat panel display industry found that: ‘firms that shared relevant knowledge with their innovation system earned higher innovative performance than firms that did not share knowledge.’

Organisational Innovation Measures

Organisational innovations can be understood as the non-technical part of process innovations. While the effects of product and service innovations can be directly measured by monetary indicators (share of sales), the effects of process innovations are not directly visible in shares of

¹⁴ Tsai, W. (2001) Knowledge transfer in intraorganizational networks: effects of network position and absorptive capacity on business unit innovation and performance. *Academy of Management Journal*, 44(5): 996-1004.

¹⁵ Taylor, A. and Greve, H. (2006) Superman or the fantastic four? Knowledge combination and experience in innovation teams. *Academy of Management Journal*, 49(4): 723-740.

¹⁶ Katila, R. and Ahuja, G. (2002) Something old, something new: a longitudinal study of search behavior and new product introductions. *Academy of Management Journal*, 45(6):1183-1194.

¹⁷ Stuart, T.E. (2000) Inter-organizational alliances and the performance of firms: a study of growth and innovation rates in a high technology industry. *Strategic Management Journal*, 21(8) 791-811.

¹⁸ Spencer, J.W. (2003) Firms’ knowledge sharing strategies in the global innovation system: empirical evidence from the flat panel display industry. *Strategic Management Journal*, 24(3):217-233.

sales and are therefore more difficult to measure. According to Kirner et al (2008) organisational innovations can be understood in different ways:

1. Enablers for other types of innovations: implementation and use of other forms of innovations (e.g. material product, service or technical process innovations) might be linked to organisational innovations
2. Distinct form of innovation - direct source of competitive advantage: organisational innovations can directly improve performance
3. Prerequisites for knowledge development in firms: Firms' ability to acquire, create and make the best use of competencies, skills and knowledge is closely linked to organisational and managerial practices¹⁹

There is no "one best indicator" to measure the effect/outcome of organisational innovation, given that organisational innovation itself is a multidimensional phenomenon. Some measures of organisational innovation are outlined in Table 7:

Table 7:
Some Measures of Organisational Innovation

Potential firm level outcomes of organisational innovations:

- Improved quality of goods or services
- Reduced costs
- Reduced time to respond to customers or suppliers
- Increased flexibility (product, process flexibility)
- Increased productivity
- More product or service innovations

Potential employee level outcomes of organisational innovations:

- Improved employee satisfaction
- Improved work-life balance
- Increased autonomy at work
- Increased motivation

Lofsten (2014) suggests that the innovation strategy should be aligned with organizational strategy, thus stimulating the conditions necessary for sustained growth.²⁰

Innovation Management and Management innovation Indicators

According to Bessant (2003), innovation management indicators are proposed to report organizational behaviour and not economic variables.²¹ Tadeu and Silva (2014) posit that innovation management indicators are "a function of the market context, the innovation

¹⁹ Kirner, E., Som, O., Armbruster, H., Lay, G and Zhou, W. (2008) "Measuring organisational innovation – concepts, indicators and outcomes" Fraunhofer Institute for Systems and Innovation Research (ISI) - 6 CP Workshop

²⁰ Lofsten, H. (2014). "Product innovation processes and the trade-off between product innovation performance and business performance." European Journal of Innovation Management 17(1): 61-84.

²¹ Bessant, J. R. (2003). High-involvement innovation: building and sustaining competitive advantage through continuous change, Wiley.

strategies and the operational processes.”²² Innovation management is analysed as a consequence of the market context and of the organizational strategy, being broken down into indicators.

A review of existing literature by Tadeu and Silva (2014) suggests that “rates of innovation are greatest when the innovation strategy is well understood and the alignment with other business areas more effective, being something more relevant than solely technological innovation.” Management innovation typically occurs in a number of recognizable stages. The key central phase, invention, is preceded by a combination of dissatisfaction with the status quo (inside the company) and inspiration from others (typically outside the company). Invention is then followed by a process of validation both inside and outside the company²³. Innovation indicators should be associated with the following factors: established strategy, favourable environment for creative practices, organizational culture and constant investments in new products, processes and technology²⁴. Table 8 provides some examples of innovation key performance indicators that firms can use to measure innovation.

Table 8:
Some Example Innovation KPIs

<p>Conversion Ratios for each step in the Innovation process / value stream</p> <ul style="list-style-type: none"> • Ideas : Ideation campaigns • Ideas that reach concept design : Ideas • Implemented designs : Concept designs • Ideas that sell : Implemented ideas • Ideas that make a profit : Ideas that sell • Sales leads : Target customer base • Sales : Sales leads <p>Financial & market measures</p> <ul style="list-style-type: none"> • Revenue from new products or services • Profit from new products or services • New customers from new products or services • New segments and sector entry from new products and services <p>Holistic ratios for the rate of renewal of the organisation</p> <ul style="list-style-type: none"> • Sales from new products & services : sales from existing products & services • Profit from new products & services : profit from existing products & services • Customers on the new products : customers on the old products • Rate of transfer of capital investment to new capabilities <p>Balancing the desire to innovate with risk management</p> <ul style="list-style-type: none"> • Verified knowledge : Unverified assumptions • Effort spent on implementations : Effort spent on concept development

²² Tadeu, H. and Silva, J. (2014). "Management Indicators and Measurement of Innovation: Review of the Literature." Management 3(10): 52-58.

²³ Birkinshaw, J., & Mol, M. (2006). "How management innovation happens." Sloan Management Review, 47(4): 81–88

²⁴ Bowers, J., Knorakian, A. (2014). "Integrating Risk Management in the Innovation Project". European Journal of innovation management, Vol. 17, pp. 25-40.

Innovation Competency / Effectiveness / Discipline / Repeatability

- Use of formal creativity tools & techniques
- Use of formal idea management tools & techniques
- Use of formal problem solving tools & techniques

Growth and sustainability measures

- Revenue from new products & services; Profit from new products & services
- How much have your customers increased their success(quality/sales/revenue/...) or reduced their cost due to use of your products and services
- Rate of return on Innovation Investment (how sustainable is your Innovation)
- Market share growth from new products & services
- Brand awareness and Stickiness (those who stay on new product : those who leave)
- Patents created per year; Markets hare protected by patents
- Revenue protected by patents; Revenue generated from licencing patents

Source: Bearing Point

Knoke and Eschenbaceher (2012) have developed ways to measure innovation in a systematic way at a firm level.²⁵ This is designed in a way that allows firms to manage their innovation process from ideas to implementation and to quantify organisation and individual effort required (see Table 9). This list may be extended by KPIs measuring the estimated risk of the innovation due to technical and market uncertainty.

Table 9:

KPIs adapted from the Value Reference Model (VRM) for systematic business innovation

Number of new ideas	Number of new ideas	UoM
Idea Yield	The percentage of ideas accepted into concept development	%
R&D Investment Ratio	Percent R&D resources/investment devoted to new products	%
Expected Commercial Value	This equals the net present value of product cash flows multiplied by the probability of commercial success minus the commercialization cost. This is multiplied by the probability of technical success minus the development costs	\$
Number of Ideas in Pipeline	Number of ideas/proposed products in the pipeline or the investigation stage (prior to formal approval)	#
Product Innovation Index	Number of new, innovative, or upgraded product features distinguishable from the previous product.	#
Design Effort	Average number of engineering man-months for each design released to production. This ratio shows the resources required	time

Source: Knoke and Eschenbaeher, (2012) KPIs to Manage Innovation Processes in VEEs

²⁵ Knoke, B. and Eschenbaeher, J (2012). KPIs to Manage Innovation Processes in VEEs Initial Thoughts and Results. NGEBIS.

Andrews et al, (2009) has divided measurement of innovation activities into inputs, processes and output (see Table 10). The output measures are hard financial ones²⁶.

Table 10:

A technology company chooses metrics to optimise its performance

Inputs	Processes	Outputs
Number of new ideas	Idea to decision time	Patents granted
Business-unit investments by type of innovation	Decision to launch time	Launches by business segment
R&D as a percentage of sales	Projects by type and launch date	Percentage of sales and profit from new products
Full-time technical staff and how (and where) it is used	Sum of projected net present values	Innovation ROI

Source: Andrew et al, (2009) *Measuring Innovation 2009*.

²⁶ Andrew, J.P., Haanæs, K., Michaels, D., Sirkin, H. and Taylor, A. (2009). "Measuring Innovation 2009: The Need for Action." A BCG Senior Management Survey: 1-23.



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