The impact of a proposal for innovation measurement in the software industry

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Abstract

Measuring an organization's capability to innovate and assessing its innovation output and performance on the market is a challenging task. We proposed a comprehensive model and a suite of measurements to support this task. In the current paper, we have reflected on the impact of the work. We have mainly relied on quantitative and qualitative analysis of the citations of the paper.

CCS Concepts: • **Computer systems organization** → **Embedded systems**; *Redundancy*; Robotics; • **Networks** → Network reliability.

Keywords: innovation, impact, relevance, measurement

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1 Introduction

Innovation measurement in SE was a challenge—we contributed with a measurement framework in *Towards innovation measurement in the software industry* [4].

The paper is structured as follows: Section 2 summarizes the contribution of *Towards innovation measurement in the software industry*. In Section 4, we describe a content analysis of the articles citing *Towards innovation measurement in the software industry*. Section 5 discusses the research identified in Section 4 that has extended our work. In Section 6, we discuss the research which documents the use of our work in industrial settings. Section 7 concludes the paper with some suggested directions for future research.

2 Summary and main contributions of *Towards innovation measurement in the software industry*

Over the past, companies relied on cost and lead time reduction and quality improvement to strengthening their competitiveness. While quality is necessity, today it is not sufficient. Companies must continuously innovate; develop new processes and deliver new products to achieve and sustain a competitive advantage. Otherwise, they tend to lose their position to new and emerging startups that have innovative offerings. Such turnover signifies the importance of sustained innovation, thus the problem is not happen-stance innovation but rather doing it continuously on a regular basis. For sustained innovation to become a reality, a better understanding of innovation is required, which is possible only when innovation is measured.

The important of innovation measurement is well emphasised in industry. The Boston Consulting Group's survey [1] revealed that most executives believe that their companies should measure innovation as rigorously as core business operation, but less than half of companies actually do so. There is little consensus on how innovation measurement should be carried out. Each definition of innovation that is used signify a different aspect of innovation, e.g. perspectives, levels and types etc. This in turn determines what is considered as elements of innovation and how these are measured.

Organisations require means not only to measure their innovative output but also to assess their ability and capacity to innovate. Measurement helps to better understand and evaluate the consequences of the initiatives geared towards innovation. Furthermore, like any other measurements, these will allow organisations to specify realistic targets of innovation in the future and to identify and resolve problems hindering progress towards goals, making. decisions and continuously improve the abilities to innovate.

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The aims of this study were to establish the state of the art of innovation measurement and to capture the state of the practice of innovation measurement in the software industry. A systematic literature review (SLR) [6] was conducted to establish the state of the art of innovation measurement, followed by a web-based questionnaire [5] and face-to-face interviews [3] to collect the opinions of software industry practitioners and academics. In total, we retrieved 13,401 articles from seven digital libraries (Compendex, Scopus, IEEEXplore, ACM Digital Library, ScienceDirect and Business Source Premiere). After applying inclusion/exclusion criteria, 204 papers were accepted as the primary studies. We had 145 respondents out of which 94 completed the questionnaire - thus the completion rate was 54.83%. Four industry practitioners (middle managers) and three academics with close relationship with industry were interviewed in this study.

Our review shows that there are 41 definitions of innovation found in the literature which highlight 4 important attributes to measure:

- Impact of innovation on the market and technology, e.g. incremental or radical innovation, market or technological breakthrough.
- Types of innovation, e.g. product (new or significantly improved products), process (new or significantly improved design, analysis, or development method), market (new or significantly improved marketing methods, strategies, and concept in product design or packaging, placement, promotion, or pricing), and organisation innovation (new or significantly improved organisation methods, e.g. business practices, workplace organisation or external relations.
- Degree of novelty, e.g. new to the firm, new to the market, new to the world, and new to the industry.
- Nature of process: iterative process.

While twenty-eight determinants of innovation have been reported in literature, but only seven of them are studied in the software industry: internal collaboration, customer orientation, champions, human resources, strategy, networking, and leadership. Two-hundred and thirty-two metrics have been used to measure innovation in firm (88%), industry (1%), regional level (11%). However, only 37% of them have been statistically validated and 58% have never been used in practice. Our review also identifies 13 innovation measurement frameworks. Most of these framework focus on technological breakthrough (8 frameworks). Out of these frameworks, only one framework have been studied in software companies. asds

3 Methodology

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For understanding the impact of *Towards innovation measurement in the software industry*, we have relied on the classification schema for academic citations proposed by Teufel et al. [9]. We also considered the taxonomy proposed by Bornmann and Daniel [2]. However, based on a pilot application we found Teufel et al. [9] more straight forward and sufficient for our analysis. The decision is further supported by prior experience of using Bornmann and Daniel's taxonomy in software engineering literature [8].

The categories in the schema we used are listed and briefly described in Table 1. To separate any industrial application of our work we added a separate category.

On February 24, 2020, the *Towards innovation measurement in the software industry*had over 72 citations in Science Direct and Scopus, 61 in Web of Science Core Collection, and 234 in Google Scholar. To get a relatively complete picture of how this work has impacted further research, we decided to analyse the 234 citations on Google Scholar.

In a pilot, the first two authors classified ten randomly selected articles and discussed the use of categories. Thereafter, they divided the 234 articles among them and independently classified them. The procedure followed is briefly summarized below:

- Exclude citations where the full-text is not available.
- Exclude articles which are not written in English.
- Exclude articles that do not cite *Towards innovation measurement in the software industry*in the full-text.
- From the title, abstract and the publication venue judge the discipline of the publication (e.g. software industry, manufacturing, farming or automotive).
- Only for conference papers and journal article, search for the citation to *Towards innovation measurement in the software industry*in the full text, for each citation in the paper read the entire paragraph containing it to understand the context, then classify the citation based on categories in Table 1.

4 Overview of the papers citing *Towards innovation measurement in the software industry*

Nauman

The 234 citations to*Towards innovation measurement in the software industry*were analysed using the process described in the Section 3. 64 Exclude papers 64 (52 were not written in English, 6 were inaccessible in full-text, 5 did not cite *Towards innovation measurement in the software industry*in the body of the paper and 1 was a duplicate citation).

Grey literature: 53 citations are from what we have classified as grey literature. Of these 53, 2 are technical reports, 10 are book chapters and 41 are theses.

In total there are 108 conference papers and 76 journal articles citing *Towards innovation measurement in the software industry*. The analysis of their use of *Towards innovation measurement in the software industry*is summarized in Table 2.

The paper has nine self citations (including one from a thesis).

Table 1. Categories of citing papers from Teufel et al. [9]

Category	Sub-category	Description
Weakness	Weak	Weakness of the approach pursued in *Towards innovation measurement in the software industry*, Weakness in the definition, model, entities, attributes, or measurements of innovation as proposed in *Towards innovation measurement in the software industry*
Contrast/Comparison	CoCoGM	Contrast/Comparison in Goals or Methods (neutral)
	CoCoR0	Contrast/Comparison in Results (neutral)
	CoCo-	Unfavourable Contrast/Comparison (current work is better than the work in *Towards innovation measurement in the software industry*)
	CoCoXY	Contrast between a cited method and the method in *Towards innovation measurement in the software industry*
Positive sentiment	PBas	author uses the work in *Towards innovation measurement in the software industry*as a starting point
	PUse	author uses definitions/models/measures
	PIUse[1]	author uses the work in *Towards innovation measurement in the software industry*in industrial settings
	PModi	author adapts or modifies definition/model/measurements presented in *Towards innovation measurement in the software industry*
	PMot	this citation is positive about approach or problem addressed in *Towards innovation measurement in the software industry*(used to motivate work in current paper)
	PSim	author's work and the work in *Towards innovation measurement in the software industry*are similar
	PSup	author's work and the work in *Towards innovation measurement in the software industry*are compatible/provide support for each other
Neutral	Neut	Neutral description of cited work, or not enough textual evidence for above categories.

When looking at the literature, where there is no stated connection to the context of software industry we see that the literature encompasses several diverse fields including the following: automotive, banking, economics, farming, forestry, health sector, human resources, logistics, manufacturing, mechatronics, NGOs, oil industry, politics , restaurants and transportation.

While discussing the citations the following reference will be useful [7] We can use this to also articulate why we have relied on citations as a way to reflect on the paper.

5 Positioning in consideration of the recent state of the art and practice

Henry

What has been done after this (partly we'll get it from the previous section). Open innovation seems to be the area in SE that has been a follow-up of our work.

6 Expected impact

Here it would be nice to show cases in industry not counting Ericsson. Perhaps we can get it from Section 4?

7 New emerging ideas and current vision

Possibly Richard? What will be done, possibly

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Table 2. Results of an analysis of the citing papers

	Total	Weak	Comparison / Contrast	Positive	Neutral	Jrnl.	Conf.
Self citations	9	0	0	2 (PBas:1, PMot:1, PModi:1)	6	5	1
From software related fields	44	0	0	17 (PBas:4, PModi:2,PUse:7,PMoti:4, PSup:1)	27	24	20
Others	72	0	2	21 (PBas:2, PModi:2,PUse:14,PMoti:2,PSim:1, PSup:2)	48	57	15
Total	116	0	2	38 (PBas:6, PModi:2,PUse:21,PMoti:6,PSim:1, PSup:3)	75	81	35

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