Master Universitario en Software y Sistemas

Universidad Politécnica de Madrid

Facultad de Informática

TRABAJO FIN DE MASTER

The Innovation Sources in Software Engineering A Systematic Literature Review

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MADRID, JULIO DE 2012

"Dedicated to all those who have been and are
my sources of innovation"

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"Innovation can be systematically manage
if one knows where and how to look"
P.F. Drucker

1 Summary

During the last century many researches on the business, marketing and technology fields have developed the innovation research line and large amount of knowledge can be found in the literature. Currently, the importance of systematic and openness approaches to manage the available innovation sources is well established in many knowledge fields. Also in the software engineering sector, where the organizations need to absorb and to exploit as much innovative ideas as possible to get success in the current competitive environment.

This Master Thesis presents an study related with the innovation sources in the software engineering field. The main research goals of this work are the identification and the relevance assessment of the available innovation sources and the understanding of the trends on the innovation sources usage. Firstly, a general review of the literature have been conducted in order to define the research area and to identify research gaps. Secondly, the Systematic Literature Review (SLR) has been proposed as the research method in this work to report reliable conclusions collecting systematically quality evidences about the innovation sources in software engineering field.

This contribution provides resources, built-on empirical studies included in the SLR, to support a systematic identification and an adequate exploitation of the innovation sources most suitable in the software engineering field. Several artefacts such as lists, taxonomies and relevance assessments of the innovation sources most suitable for software engineering have been built, and their usage trends in the last decades and their particularities on some countries and knowledge fields, especially on the software engineering, have been researched.

This work can facilitate to researchers, managers and practitioners of innovative software organizations the systematization of critical activities on innovation processes like the identification and exploitation of the most suitable opportunities. Innovation researchers can use the results of this work to conduct research studies involving the innovation sources research area. Whereas, organization managers and software practitioners can use the provided outcomes in a systematic way to improve their innovation capability, increasing consequently the value creation in the processes that they run to provide products and services useful to their environment.

In summary, this Master Thesis has start to research the innovation sources in the software engineering field, providing useful resources to support an effective innovation sources management. Moreover, several aspects should be deeply study to increase the accuracy of the presented results and to obtain more resources built-on empirical knowledge. It can be supported by the INnovation SOurces MAnagement (InSoMa) framework, which is introduced in this work in order to encourage openness and systematic approaches to identify and to exploit the innovation sources in the software engineering field.

1.1 Spanish summary

Durante el último siglo muchos investigadores de diversos campos han contribuido al desarrollo de la innovación y hoy día se puede encontrar una gran cantidad información en la literatura. En la actualidad, los enfoques abiertos y sistemáticos usados para gestionar las fuentes de innovación resultan fundamentales en muchos campos del conocimiento. También en el sector de la ingeniería de software, donde las organizaciones necesitan absorber y aprovechar tantas ideas innovadoras como sean posibles para alcanzar el éxito en este entorno sumamente competitivo.

Esta Tesis de Master presenta un estudio sobre las fuentes de innovación en el campo de la ingeniería del software. Los objetivos principales son la identificación y la ponderación de las fuentes de innovación disponibles, y la comprensión de las tendencias de uso de dichas fuentes. Primeramente, se ha realizado una revisión general de la literatura con el fin de definir el área de investigación y de identificar posibles lagunas de conocimiento. Tras esto, se ha propuesto la *Systematic Literature Review (SLR)* como método de investigación para construir de forma sistemática unos conocimientos fiables basados en evidencias acerca de las fuentes de innovacin en el campo de ingeniería de software. Los resultados de la SLR proporcionan recursos para facilitar una identificación sistemática y una explotación adecuada de las fuentes de innovación más adecuadas. Se han construido varios artefactos potencialmente útiles como por ejemplo listas, taxonomías y valoraciones de las fuentes de innovación más adecuadas en la ingeniería del software. Además, se han investigado las tendencias de uso en las últimas décadas de las fuentes de innovación, así como sus particularidades en algunos países y áreas de conocimiento.

Este trabajo facilitará a investigadores, gerentes y *practitioners* del campo de la ingeniería del software la sistematización de actividades crticas en los procesos de innovación, como la identificación y explotación de las oportunidades más adecuadas. Por un lado, los investigadores en innovación pueden utilizar los resultados de este trabajo para llevar a cabo estudios relacionados con la gestión de las fuentes de innovación. Por otro lado, los gerentes y *practitioners* de organizaciones relacionadas con la ingeniería del software pueden utilizar los resultados obtenidos de una manera sistemática para mejorar su capacidad innovadora, aumentando en consecuencia la creación de valor en los procesos que llevan a cabo para proporcionar productos y servicios útiles a su entorno. Más allá, varios aspectos deben continuar estudiándose para aumentar la precisión de los resultados presentados y para obtener más recursos valiosos que esten construidos sobre conocimiento empírico. Para ello, se introduce un marco de trabajo (*INoovation SOurces MAnagement - InSoMa)* que tiene por objeto fomentar los enfoques de gestión abiertos y sistemáticos dirigidos a identificar y explotar las fuentes de innovación disponibles en la ingeniería de software.

2 Introduction

To introduce a research contribution is not an easy task because there a big set of complex questions to answer. To do that, some guides, like the Stanford method [82], can facilitate the introduction of a research issue. This chapter introduce this Master Thesis providing answers to the following questions.

2.1 What is the problem?

Nowadays, innovation plays an important role in software engineering field due to it enables to firms to create competitive advantages and to adapt to new market trends providing more value for the business and its customers [38]. In the current market, the increasing global competition has forced software firms to introduce constantly innovations that allows to differentiate of their competitors [38]. It is well established that the capacity of the firms to innovate successfully is a relevant component of the higher value creation [59].

But innovation is a complex and holistic multi-stage process [4] with large set of activities to cover. One of the most critical ingredients of an innovation is the sources of the ideas where these innovation is inspired [35], which can be originated from a wide set of actors [9]. The innovative ideas sources are the inputs to an innovation because they form the basis of the products or the services that a firm will offer to the market with the purpose of to achieve the satisfaction of its customers [81].

"All innovation begins with creative ideas" [14]

Currently, software organizations need to identify and integrate diverse pools of innovative knowledge, and it can be from inside or outside of the company [34]. In both case, to identify in a systematic way the innovative ideas could be useful for software organizations (i) to design effective work processes that facilitates the delivery of new products and services and (ii) to design products and services valuable for the customers [84]. In summary, software organizations need a deeper understanding of the innovation sources to achieve a best use of their resources and opportunities, and improve their results [81].

2.2 Why it is interesting and important?

One way to improve the hole innovation process is to find creative ideas with a potential value for the organization. This searching must be done in a systematic way, making a widely exploration of the new opportunities that could increase the business or customer value produced by an organization. So, the innovation sources identification is an interesting challenge in software engineering as it enables an effective innovation management considering as much innovative ideas as possible. As it was emphasized by Drucker [19]:

"Systematic innovation begins with
the analysis of the sources of new opportunities"

The sources of innovation have to be researched deeply to increase scientific knowledge for its own sake [68]. In the last decades, international organizations like the OECD [31] have contributed to the development of innovation field [56] and the innovation sources issue have been dealt by many researchers [18, 35, 43, 34, 52]. Studies about innovative ideas sources have been conducted in many knowledge fields [73, 26, 83], and some of them are focused in technology-based firms [9, 3] and software organizations [61, 40]. But, as most of these contributions are dispersed or they are not enough adapted to the software engineering field and its particularities, a deeply study about the innovation sources in the software engineering field is as necessary as promising.

2.3 Why it is difficult?

To get an useful identification of the innovative knowledge sources for software engineering field is a difficult activity due to the following reasons. First of all, every kind of industry have its special features and the detection process of useful innovation is different for each one [35]. Von Hippel, one of the *gurus* on innovation sources [35], asserts that the role and the activities of users, manufacturers, suppliers and others actors involved on the innovation process varied widely across different industries, and specific studies for each knowledge field are required [16]. As a token of that, empirical studies [51] reveals significant differences between the innovation modes in different sectors. The innovation sources issue has been studied generically from a business and technological perspective [73, 26, 83, 9, 3, 61, 40], but most of these contributions have not been done specifically for software engineering field and its particularities [79]. Apparently, there a lack of empirical and systematic studies of innovation sources tailored to software organizations. It seems that innovation sources management in software engineering field have not been enough researched.

Secondly, the identification of the most useful innovation sources for a software firm is a difficult task because the innovation sources have not a fixed value for all organizations, it depends of the situation and the context of every organization [63]. Differences between enterprises on the innovation sources management can be founded depending of their situation [57]. The value of each source depends of the stock of knowledge of the organization and their ability to find, absorb and exploit new ideas [63]. This fact adds variability to the identification and assessment of the innovation sources in software engineering field.

Thirdly, the last key element that increase the difficulty of this research topic is the organizational and human factor because it has a relevant impact on the ability of a software firm to found, absorb and exploit new ideas. To innovate successfully in software engineering field is necessary to design useful resources, but it is not enough. To get benefits of a set of innovation sources is required an organizational climate which encourages ideas generation and promotes access to various sources of innovation [9]. To achieve that climate, an adequate enterprise´ s management systems that also consider the intangible factors (not only the traditional financial statements) could influence in the improvement of the knowledge, capacities and motivation of the personnel. Therefore, the knowledge plays a leading role these days, a first order source in the creation of the value and the generation of competitive advantages [45]. The social nature of organizational and human factors, that should be adequately managed to generate an innovative climate, add more difficulties to the identification process of innovation sources in software engineering field.

2.4 Why has not been solved before?

These difficulties have been taken into account, and since the 80s several attempts to understand which are the sources of successful ideas have been made. In the last decade, academic studies about innovation sources specific for technology field have been done [9, 3] and the main ideas about innovation provided by "gurus" like Von Hipel [35] and Chesbrough [34] are being widely taken in account in large technological firms [33].

But despite this increasing interest and the benefits of ideas sharing pointed out by open innovation paradigm [34], some organizations continue being very cautious with the external knowledge management. Despite being recognized as a critical aspect for the competitiveness of the company, the systematic and openness approaches designed to manage the innovation sources are still in their initial phases in almost all companies [42].

2.5 Which are the components of the contribution?

This Master Thesis is focused particularly on the internal and external innovation sources identification and exploitation providing reliable knowledge, obtained through the SLR method, that can be useful for the organization´ s success and competitiveness [47]. Research studies like this, focused on the innovation sources, can improve the business processes of the software organizations, transforming ideas into new valuable products and guaranteeing new market niches and new business models [42].

We have provided several resources in order to encourage systematic and holistic processes for the innovation management, facilitating to researchers and managers of innovative software organizations the systematization of critical activities on innovation processes like the identification and exploitation of the available innovation sources. These resources are lists, taxonomies and assessments of the innovation sources, as well as trend analysis on the innovation sources usage. The remainder of this work is as follows: Firstly, the related literature about innovation and innovation sources (chapter 3) is reviewed. Then, a Systematic Literature Review (SLR) is rigorously planned and conducted (chapter 4), and its results are properly reported to provide useful knowledge related to innovation sources in software engineering field (chapter 5). Finally, the results and the conclusions of this contribution, as well as the arisen future works are presented (chapter 6). Moreover, another supporting information are provided in the appendixes.

3 Innovation Background

This section provides an overview about the innovation field. Several definitions, taxonomies and models of innovation are review in the following chapters. Some examples related to software development are provided too.

3.1 Definitions of innovation

Since the earlies of the twenty century, many researches of different knowledge fields (economics, management, technology, science, engineering, etc) have been working on innovation from different points of view. Some definitions of innovation, stated by the most relevant authors, are collected for this work.

The first author to reference is **Schumpeter**. Reviewing the available literature, it can be said that he laid the foundations of innovation field. In the first decades of twenty century he started to develop an original approach to the study of economic and social changes, focusing in particular on the critical role played by innovation and the factors influencing it. But the Schumpeter' s contribution was really taken in account after he died, in 1950. When the technological changes started to arise, many economists, scientists and engineers took up again Schumpeter' s ideas and studied in deep the innovation field. In fact, recently relevant authors like Freeman point out to a "Schumpeter' s Renaissance" [32] in the last decades. Currently, many innovation studies uses concepts proposed originally in books like *The Theory of Economic Development* [71], written in 1912 and translated to English in 1934. In that contribution innovation is defined as follows:

"The introduction of new goods, new methods of production, the opening of new markets, the conquest of new sources of supply and the carrying out of a new organization of any industry"

The frame proposed by these definition is so general, but it is easy to adapt the innovation concept provided by Schumpeter to the software development field. For example, *new goods* could be refereed to new tools, technologies or infrastructures that could improve the performance of the team like an Integrated Development Environment (for example, Eclipse [22]) or a Continuous Integration Environments (for example, Hudson [37]); *new methods of production* could be refereed to new methodologies to organize the development process that could improve the coordination of the team like an agile approach (for example, Scrum [72]); *the opening of new markets* could be refereed to conquer new targets to extend the technological business, at least there are a marketing component (for example, a market strategy to improve the results [27]) and a technological component (for example, to use a Service Oriented Architecture approach [44]); *the conquest of new sources of supply and the carrying out of a new organization of any industry* could be refereed to strategical collaborations, commonly used by software and technological organizations in these currently

Table 1: Schumpeter innovation definition tailored to software engineering

Schumpeter innovation definition	**Software engineering adaptation**	**Examples**
New goods	New tools, technologies or infrastructures that could improve the performance	An integrated Development Environment (Eclipse [22]) or a Continuous Integration Environments (Hudson [37])
New methods of production	New methodologies to organize the development process	Agile approaches, like Scrum [72]
The opening of new markets	New targets to extend the technological business, at least there are a marketing component and a technological component	Market strategies to improve the results of a software firm [27] An Service Oriented Architecture approach [44]
The conquest of new sources of supply and the carrying out of a new organization of any industry	Practices commonly used in these currently global market based in collaborations between different organizations	Off shoring [8, 11], peer collaborations between different organizations [29] and universities [66, 67, 65])

global market, like the offshoring [8, 11], the relationships between different firms [29] and between firms and universities or research institutes [66, 67, 65].

The innovation definition proposed by Schumpeter could be general, but it is easy to tailored to software engineering field. The table 1 summarize the previous adaptation.

Once a widespread definition of innovation and its adaptation to software development was proposed, another innovation definitions are provided for our work. Schumpeter had many remarkable followers, a good example is **Drucker** who was an important economist involved in the innovation field in the second part of twenty century. Its life and contribution to innovation field will be deeply studied in the next sections. By now, we can keep one of the most referenced innovation definition provided in 1985 [18] in a simple and useful way:

"An innovation is a change that creates a new dimension of performance"

These definition has a large reach and it could be applied to any knowledge field. In software development, any of the previous examples proposed to tailor the Schumpeter' s definition could be a *change that create a new dimension of performance.*

Another good definition is provided by **Schumann**, who has worked in the innovation field as professor and as consultant in large companies like IBM and many others [70]. He has written a book in 1994, named *Innovate!: Straight Path to Quality, Customer Satisfaction and Competitive Advantage* [69], where the following definition of innovation is provided:

"Innovation is the way of transforming the resources of an enterprise through the creativity of people into new resources and wealth"

Like in other definitions, these innovation concepts are very general and it could be easily applied to software development. *The resources of a software enterprise* could be identified like its technologies and infrastructures, its employees and their time, its networking and its capital, etc. *The new resources and wealth* could be identified like something new created *through the creativity of people* and valuable for the business and its customers.

Previous definitions establish a good ground for our work, but it was provided many years ago. Currently, innovation still playing an essential role in the economic and technological development and other authors still working to improve innovation field. For example, in 2003 **Luecke** et al have written a book, named *Managing Creativity and Innovation* [46], where innovation is defined as follows:

"Innovation is generally understood as the successful introduction of a better thing or method. It is the embodiment, combination, or synthesis of knowledge in original, relevant, valued new products, processes, or services"

One more time, any of the examples previously mentioned related to software development could be framed in these definition. *The successful introduction of a better thing or method* could generate an *valuable improvement of the products, processes or services* used or offered by an organization. Like it can be seen, these definition are easily adapted to software engineering.

Besides the definitions of relevant authors, there are international organizations where innovation field is notably developed. One good example is the **Organisation for Economic Co-operation and Development (OECD)** [31], who provides useful guidelines for innovation activities, used in next sections, like the Oslo manual[56] or the Frascati manual[30]. OECD defined in 2005 innovation as follows:

"An innovation is the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relation. The minimum requirement for an innovation is that the product, process, marketing method or organisational method must be new, or significantly improved, to the firm"

Like it can be seen, currently there are several definitions of innovation and

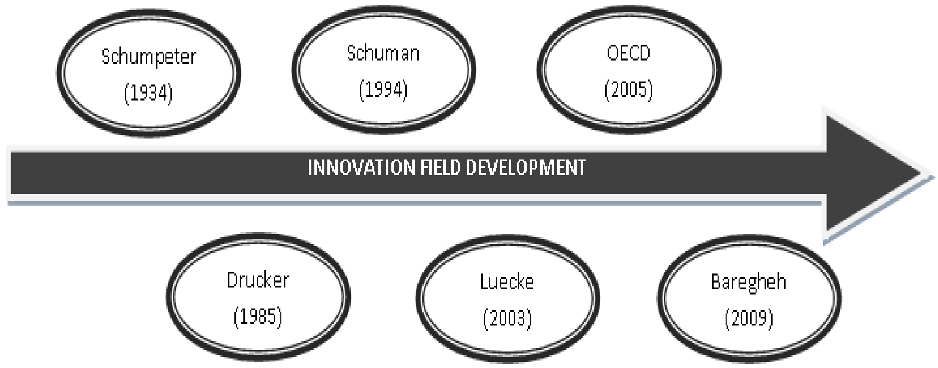


Figure 1: Authors providers of innovations definitions

it could be difficult to give an unique meaning. Due to, recently an interesting contribution have been made by **Baregheh** et al [4] to provide an integrative definition of organizational innovation. A content analysis of the most extended definitions was conducted in order to keep the key attributes of the innovation meaning and build the following definition:

"Innovation is the multi-stage process whereby organizations transform ideas into improved products, service or processes, in order to advance, compete and differentiate themselves successfully in their marketplace"

Once some definitions provided by relevant authors or organizations have been reviewed, it could be useful to summarize in a graphical and temporally way the previous contributions, like the figure 1 represents. Previous definitions can facilitate the understanding of the innovation meaning and its adaptation or use in the software engineering field. Once it became more clearly, the types of innovation are exposed in the next section.

3.2 Types of innovation

Several classifications of innovation are available in the literature due to there are different criteria to classify an innovation. In this section, the most mentioned classifications are presented.

One criteria used in the technological field [41] was mentioned by Schumpeter [71] and developed in the last decades of twenty century by Freeman [32]. The criteria to classify innovations is the innovative degree of these innovation, and the resulting classification is as follows:

- **Radical innovation**, when the new product or service provides new features and benefits to the customer. For Schumpeter, radical innovations shape big changes in the world.

- **Incremental innovations**, when the current product or service is updated with minor changes. For Schumpeter, incremental innovations fill in the process of change continuously.
- **Platform innovation**, when the new product or service enables possibilities of innovation.

A big set of examples related to software engineering can be framed in the previous classification. In our case, an example of innovation types related to agile methods are exposed as follows: In 2001, the agile manifesto [6] point out to a paradigm change in software development providing new benefits to customers (it supposes a radical innovation). In the following years many increments to this knowledge field was done, like the introduction of LEAN concepts into agile software development [49] (it supposes a incremental innovation). Currently, many electronic tools are being widely used to enable new possibilities in agile software development, like the use of video systems and collaborative tools to facilitate the use of agile methods in distributed developments (it supposes a platform innovation).

Recently, more criteria to provide innovation taxonomies have been emphasized in the Oslo manual [56]. The first of these criteria is related to the novelty degree of the innovation, the resulting classification is as follows:

- **Worldwide innovation**, when these innovation is new in the hole World.
- **Firm-only innovation**, when these innovation is new in a concrete context however it is not new in another contexts.
- **Intermediate**, when these innovation is new in the country or the industry but not in the hole World.

These taxonomy could be enlightening in the following issue. Sometimes, innovation can be only understood like something totally new and genuine in the hole World. But it is not totally true, innovation involves too the use of existing ideas (paradigms, practices, tools, etc.) in contexts where these ideas are totally new and genuine. For example, the first tablet pc supposes an innovation (concretely, a worldwide innovation) and its use on learning context with young students supposes an innovation too (concretely, a firm-only innovation).

The second criteria established in the Oslo manual [56] to classify an innovation introduced in an organization uses the target of the innovation to build the following classification:

- **Process innovation** is the implementation or adoption of new or significantly improved production or delivery methods. It may involve changes in equipment, human resources, working methods or a combination of these.

- **Product innovation** is the implementation or commercialisation of a product with improved performance characteristics such as to deliver objectively new or improved services to the consumer.
- **Organizational innovation** is the introduction of significantly changed organisational structures, the implementation of advanced management techniques and the implementation of new or substantially changed corporate strategic orientations.
- **Marketing innovation** is the introduction of a commercialisation method not used before with the scope of a sales increasing. This innovation should be involve significant changes in product design or packaging, product placement, product promotion or pricing.

Finally, based on the criteria of openness degree in innovation sources exploitation, another classification can be presented. Types of innovation can be seen like **closed innovation** (where the innovation is developed only with the internal resources of an organization) or **open innovation** (where innovation is developed using resources internal and external to an organization). The open innovation model [34] will more deeply studied in next sections.

3.3 Innovation models: an historic perspective

Like it said before, since 50s many researches and companies have been paying attention on innovation activities. This section provides an historic perspective of the innovation models used and developed by researchers and innovative organizations in the last 50 years.

The linear models, conceptually very simple, were the first approaches used by innovative organizations and they are framed in the first two generations of innovation processes. These models have an interesting history [7] to explain their origins, where different knowledge fields (mainly scientists, business researchers and economics) collaborated in an holistic way adding innovation sources and activities into a common framework. From 70s to 90s, new hybrid and more complex models have been developed to achieve an effective adaptation of the organizations to the competitive markets. In the last decade open innovation model [34] have been successfully introduced in academic and industrial fields.

As Rothwell established in 1993 [64] and different researchers on technology innovation and management field exposed too in 2005 and 2006 [77, 76], different innovation processes could be analysed in the second half of the twenty century. These models can be grouped in five generations of innovation process, that will be studied in the following subsections.

3.3.1 First generation (50s, 60s)

Due to the rapid industrial expansion and the new technological opportunities, the **technology push model** was widely used. In this simple and linear approach the innovation sources are scientific discoveries and the life cycle are driven by the new available technologies. The following activities represents the workflow of this model.

(i)Basic science, (ii)Design and engineering, (iii)Manufacturing, (iv)Marketing, (v)Sales

3.3.2 Second generation (60s, 70s)

Due to the industrial concentration and the firms competitiveness was increasing, the **market pull model** was widely used. In this simple and linear approach the innovation sources are the market needs and life cycle are driven by these market needs. Comparing with the first generation, the R & D staffs has a more reactive role in this process. The following activities represents the workflow of this model:

(i)Market need, (ii)Development, (iii)Manufacturing, (iv)Sales

3.3.3 Third generation (70s, 80s)

Due to the high rates of inflation and demand saturation, companies were forced to adopt different strategies and the **coupling model** was widely used. In this approach, the innovation sources used in previous generations (the market needs and the scientific discoveries) are both the drivers of the hole innovation process, playing a proactive role. The following activities represents the process of this model (that are not sequentially), that is feed by the market needs and the scientific discoveries:

(i)Idea Generation, (ii)Research & Design & Development, (iii)Prototype production, (iv)Manufacturing, (v)Marketing & Sales

3.3.4 Fourth generation (80s,90s)

Due to the concentration of the companies on core business or core technologies, the manufacturing strategy required more importance. *Time to market* become a key element and strategic alliances between organizations was used to reduce it. Then, the **integrated model** was extended because the involved activities in the innovation process can be developed parallel in a "pipeline schema" with frequents joint group meetings, where dependencies and synergies can be stayed clearly. The following activities represents the workflow of this model, that is not sequentially:

(i)Marketing, (ii)Research & Development, (iii)Product development, (iv)Production engineering, (v)Parts manufacture (suppliers), (vi)Manufacture

3.3.5 Fifth generation (90s)

Due to time to market and strategic alliances continued being a critical element in the innovation process, the companies focused in the improvement of capabilities like flexibility and adaptability to improve its development speed. *Fast innovation* become one of the most important elements in the organizations competitiveness, then **networking model** was extended because it provides some useful factors and guides to increase the innovation development speed.

However this model will not be deeply studied, its key concepts are presented to end its understanding. The life cycle is based on the integrated model and the innovative elements introduced by networking model are integration, flexibility, networking and parallel information processing.

3.4 Open innovation model

The open innovation model [34] is introduced in this chapter like one of the most popular innovation models currently, that is very suitable for our contribution about the innovation sources in software engineering.

Open Innovation model was introduced in 2006 by Henry Chesbrough [34]. Its ideas has caused a great impact in the following years, and recently this phenomenon is being deeply studied by many researchers [23]. Besides, currently large organizations are taking in account the open innovation model [33, 36, 54, 12] to improve its business results.

Firstly, in the following paragraphs the differences between closed (or traditional) innovation and open innovation are presented. Secondly, the principles of Open innovation model are provided and its innovation definition is emphasized. Finally, to introduce successfully this model some challenges must be identified and solved. This work will try to deal with one of this challenges in software engineering field.

3.4.1 Closed Innovation vs Open Innovation

Two approaches to work on the innovation field are analysed. The first one is the traditional way and the second one is the most innovative way. The first workflow has been the classic model up to now and it is defined like **Closed innovation** in the Chesbrough book [34]. It allows to an organization to use its own researches or technologies to developed new process, products and services to introduce in their current market or in new markets.

The second workflow, that includes the first one, is the main and differential element of the **Open Innovation** paradigm. It allows to an organization to use researches or technologies generated by another organizations (probably, they haven´ t got the capability or the intention to exploit adequately alone) to developed new process, products and services to introduce in their current market

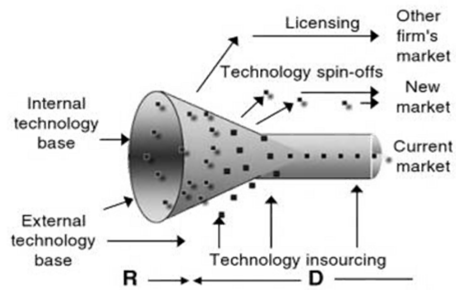


Figure 2: Open Innovation model. Extracted from [34]

or in new markets. With the appropriate policies and the necessary intellectual property protection mechanism, these collaborative workflow facilitates enriching synergies and productive alliances between different organizations, creating more and more value for the customers. Recently, many large organizations are introducing and dealing with these ideas and open innovation units have being created [36, 54] to improve its innovation capabilities.

The figure 2, extracted from [34], represents graphically the Open Innovation model:

3.4.2 The definition and the principles of Open Innovation

To make this model run much more smoothly, a set of **principles** have to drive the open innovation paradigm:

- Not all the smart people work for the same organization. A firm needs to work with smart people, who can stay inside and outside of the organization.
- R & D processes, outside and inside of a organization, can create significant value. Internal R & D is needed to claim some portion of that significant value.
- Not is necessary to originate a research to profit from it.
- To generate a good business model is better than to get the market first.
- Using effectively the internal and external ideas, an organization will win.
- An organization can profit from its own IP and from IPs of another firms, if it makes to improve the business model.

Taking in account these principles, innovation process is defined as follows [34]:

"Systematically encouraging and exploring a wide range of internal and external sources for innovation opportunities, consciously integrating that exploration with firm capabilities and resources, and broadly exploiting those opportunities through multiple channels."

Probably the most relevant contribution of this innovation approach, at least for our work about innovation sources, is related to the open character of the innovation sources, that is emphasize in previous definition.

"Systematically encouraging and ***exploring a wide range of internal and external sources for innovation opportunities****, consciously integrating that exploration with firm capabilities and resources, and broadly exploiting those opportunities through multiple channels."*

Like it can be seen, Chesbrough proposes an open model where the innovative knowledge produced in the researching phase of an environment can supply its own development phase or the development phase of another environments, even if the receiver environments are competitors of the producer environment. In practice, it is not an easy task and the following challenges must to be solved.

3.4.3 Challenges to solve

Chesbrough identified [34] three challenges to introduce successfully in the industry the Open Innovation model, enabling organizations to get as much benefits as possible. Currently, researchers [23] and technological companies [36, 54] are still working in the following challenges, that are strongly connected with the innovation sources management.

- **Maximization**
  Firms need a wide range of approaches to maximize the returns to internal innovation. One innovation generated by an organization could be useful for the own organization because they can develop and exploit, getting benefits in their market. Besides, others internal innovations are not used by the organization who produce it, could be exploited by another organization making the most of these innovations and getting benefits for both organizations.

- **Incorporation**
  If an organization cannot identify relevant knowledge for itself and incorporate it into its innovation activities faster than its rivals, the existence of external knowledge do not provides benefits to the firm. To take advantage, an organization should do the following activities: (i) to scan available opportunities, (ii) to recognize the best for the firm, (iii) to absorb and perform the selected opportunities, and (iv) to get the political willingness to enable this model. Summing up, to solve this challenge is necessary to identify the best opportunities and to integrate these knowledge with the firm.

- **Motivation**
  Open Innovation assumes as ongoing stream of external innovation, but without efforts it will not exist for ever. To continue using external knowledge as a source of innovation, organizations must cultivate ways to assure continued supply of relevant external technologies and IP useful for the organization.

Like it can be observed, the target of our contribution are specially lined up with the second challenge. For software engineering field, it is critical to incorporate relevant and innovative knowledge into the development process and its resulting products. To do that, the innovation sources in software engineering must be identified and properly assessed and used.

3.5 Innovation sources background

During the last century many researches on the business, marketing and technology fields have developed the innovation management research line. Thanks to the studies conducted in the last decades, there are a well set of general findings related to the innovative ideas sources, that should be taken into account to get the background knowledge about the innovation sources. Despite many of the following contributions are not focused in the software engineering field and some of them have more than 20 years, these contributions are being used in current models like Open Innovation and they could very useful for the purpose of our work.

In this section a previous analysis of some innovation sources taxonomies, which have been built from a general perspective in the last decades by innovation *gurus*, are presented chronologically:

3.5.1 Linear models

Like it is exposed previously, the linear models were developed from 50s to 70s by professionals of different fields of knowledge like scientists, engineers, economists, etc. Nowadays, these models are taken in account on the innovation field and they are included in current innovation strategies due to the effectiveness of their innovation sources to develop valuable products, processes and services.

The first linear approach is the technology push model and it proposes **new technologies and scientific advances**, that mainly are produced by R & D activities, like an useful innovation source. The second linear approach is the market pull model and it proposes the **social needs and market requirements**, that mainly are discovered by market studies, like another useful innovation source. Both sources are the first ones to take in account to define a software innovation sources taxonomy.

3.5.2 Drucker and the discipline of innovation

Drucker was one of the most important authors in the last century on the management field, he worked as professor in business schools and as consultant for technology firms like IBM and Intel. In his career he provided many innovative ideas in his 39 books about how to manage the organizations and their workers, these ideas were summarized in the book *"The Essential Drucker. The Best of Sixty Years of Peter Drucker´ s Writings on Management"* [20].

Anyway, the most important contributions of Drucker for our work about innovation sources was the book *"Innovation and Entrepreneurship* [18] written in 1985 and the article *"The discipline of innovation"* [19] published in 1998, both widely extended on innovation field. There are two key concepts to innovate successfully, showed in the following Drucker´ s quote:

*"**Systematic innovation** begins with*
*the analysis of the **sources of new opportunities**"*

The first one is about the discipline and the systematization of the innovation activities. May be some ideas are created by a flash of a genius, but normally good innovations require hard work driven by the following steps: (i) analyse opportunities, (ii) stay perceptive, (iii) be simple and focused, (iv) start small, and (v) aim at leadership.

The second one is about the innovation sources. Drucker pointed out the sources where a innovative opportunity could be found: **(i) unexpected successes of failures of the organizations, (ii) incongruities between the industry´ s assumptions and its reality, (iii) process needs, (iv) changes on the market or the industry, (v) changes in demographics, (vi) changes in meaning and perception and (vii) new scientific and non-scientific knowledge**.

Previous ideas are interesting for our work. A systemic approach to deal with the innovation activities and the importance of the localization of the innovation sources are critical challenges to solve nowadays. But the Drucker´ s contribution are not focused on software engineering and, like Von Hippel pointed out, the innovation sources can change across different industries and more specialized studies are required in each knowledge field [35].

3.5.3 Von Hippel and the sources of innovation

The book *"The sources of innovation"* was written by Von Hippel in 1988 [35], and it is one of the most referenced books on innovation field. He provided an innovative idea about the role of the users on the innovation process, that is the differential point of his work, and a taxonomy for innovation sources.

Two functional sources in an innovation process are identified in a high level

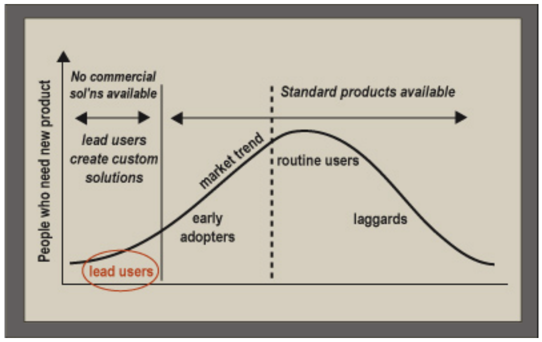


Figure 3: Lead User concept. Extracted from [35]

of abstraction. The first one are the **users or customers** because they need to use a new product, process or service or they need an improvement in the current products, processes and services. The second one are **other organizations** which can provide value to the firm.

Focusing on the first innovation source: the users, Von Hippel pointed out to the importance of customers in the innovation process because they could have very innovative ideas or they could even develop it. In this line, an important contribution for our work is the concept of *lead users* like an innovation source. These users identified before anybody a market need and they have the capability to build a innovative solution for their need. If the innovation is really valuable, in the next years more users will start to use it and probably similar products, process or services will appear in the market. The figure 3, extracted from [35], represents graphically the lead user concept.

Normally, time between the creation of the new solution by the lead users and the expansion of these innovation to general users are very large, around 6 years. But nowadays, the increasing number of solutions generated by lead users and the available tools for self-marketing and ideas sharing are changing it. Probably, in next years these time could be significantly reduced [33].

Focusing on the second innovation source: the organization, Von Hippel pointed out to the responsibility of an innovative firm to scan a big collection of innovation sources. These sources collection are presented as follows: **suppliers, customers, universities, governments, laboratories, competitors and other nations**.

3.5.4 Leonard and the wellspring of knowledge

A complete book about innovation sources named *"Wellsprings of knowledge: building and sustaining the sources of innovation"* was written by Leonard in 1995 [43]. She tried to find reasons cause some firms managed better the innovation than others. To do that, some examples of successes and failures in innovative developments were analysed, and relationship between the success of a firm and its capability to explore, discover and exploit innovative ideas were found.

These innovative ideas can be provided from external sources like **(i)Competing companies, (ii)Non-competing companies, (iii)Vendors, (iv)National labs, (v)Customers, (vi)Consultants and (vii)Universities**. Normally, these sources can provide different types of innovation and probably there are differences too in parameters like the access costs and the intellectual property protection policies. It is important to take in account these ideas to build a complete taxonomy for innovation sources in software engineering.

Like many others contributions, its findings are extracted from a general business perspective and it is not enough focus in the software engineering domain. Anyway, the provided classification can be helpful to create a sources taxonomy for software development field.

3.5.5 OECD and the Oslo manual

The Oslo manual [56] is a guide about innovation and the methods to measure it, highly influenced by the Frascati manual [30]. The Oslo manual has been developed and extended in several editions (1992, 1997 and 2005) by the Organisation for Economic Co-operation and Development Statistical Office of the European Communities. These guide is useful to clarify several concepts related to innovation field, and it is mainly used to elaborate methodologically surveys and statistics about innovation processes in European Union [74] and other localizations [28] using models like the Community Innovation Survey.

The Oslo manual is useful to provide a classification of innovation sources. The following list shows innovation sources which have been found relevant.

- **Internal sources within the firm or business group**: in-house R & D; marketing; production; other internal sources.
- **External market/commercial sources**: competitors; acquisition of embodied technology; acquisition of disembodied technology; clients or customers; consultancy firms; suppliers of equipment, materials, components and software.
- **Educational/research institutions**: higher education institutions; government research institutes; private research institutes.
- **Generally available information**: patent disclosures; professional conferences, meetings and journals; fairs and exhibitions.

For the purpose of our contribution, these innovation sources taxonomy could be very general and it could be difficult to apply directly to software engineering

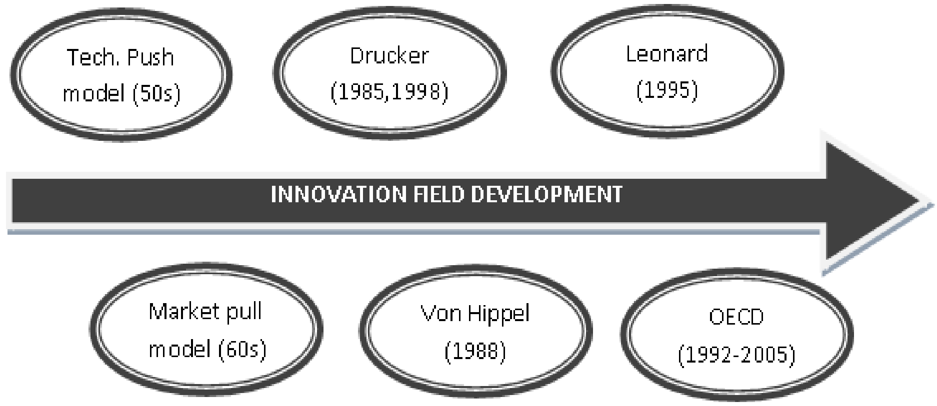


Figure 4: An overview of theoretical taxonomies for innovation sources

field. Probably, an adaptation is required. To facilitate it, the flexibility of the previous taxonomy is explicit in Oslo manual in several aspects: The fist one is about the classification criteria, previous innovation sources could be classified too in domestic and foreign sources; The second one is about the country particularities, previous innovation sources could be adapted to national requirements; The third one is about the industry particularities, previous innovation sources plays different roles across the current knowledge fields.

So, to build an innovation sources taxonomy for software development the taxonomy provided by the manual will be taken in account and it will be adapted to software engineering field.

3.5.6 Conclusions

Some general contributions of relevant authors or institutions have been studied in this chapter. The figure 4 represents in a graphical and chronological way these contributions related to theoretical taxonomies to classify innovation sources.

Some conclusions of these contributions can be extracted to build a complete innovation sources taxonomy for software engineering:

- The taxonomy of innovation sources provided by the innovation linear models are simple and useful. On one hand, new technologies and scientific advances are considered as an innovation source. On the other hand, social needs and market requirements are considered too as an innovation source. Normally, these sources are exploited by different units of a business: the first one involves R & D departments, the second one involves marketing departments.
- Drucker proposed a taxonomy of innovation sources focused in the mo-

ments when an innovation could be generated. This is an important aspect to taken in account, but for our scope, an approach based on the sources where the innovation could be found (not when the innovation could be found) will be used.

- Von Hippel pointed out the important role of users on the innovation process. Besides, he proposed the following innovation source taxonomy: suppliers, customers, universities, governments, laboratories, competitors and other nations.
- Leonard provided the following classification for innovation sources: competing companies, non-competing companies, vendors, national labs, customers, consultants and universities.
- The Oslo manual proposed the following elements as innovation sources: in-house R & D; marketing; production; other internal sources; competitors; acquisition of embodied technology; acquisition of disembodied technology; clients or customers; consultancy firms; suppliers of equipment, materials, components and software; higher education institutions; government research institutes; private research institutes; patent disclosures; professional conferences, meetings and journals; fairs and exhibitions.

This knowledge have not been systematically collected and it is not focused specifically on software engineering field, but they enables the required exploration of the research area previous to a deeper analysis.

3.6 Systemic Innovation Capability

Finally, a holistic and systemic approach could be used to integrate useful knowledge from many sources into valuable innovations applied to the process of an organization or the products and services provided to its customers [47]. In fact, recently the concept of *Systemic Innovation Capability* has born to support this approach.

There are two contemporary publications that defines these concept. Due to the similar dates of publication and the lack of references between these contributions, it is difficult to identify who are the first authors. In one side, the book *"Innovation on the core"* [58] provides a chapter, named *"Building a Systemic Innovation Capability"*, that points out the use of this kind of strategy. In other side, an article named *"Systemic Innovation Capability"* [47] points out too the use of these concept. It seems that the last publication is more focused on technological point of view, so it will be the main source for our work. The following definition was provided in [47]:

"Systemic innovation capability is proposed as the ability to effectively ***combine knowledge from a variety of sources*** *(internal and external to the company) into disruptive innovations that lead to the development of competitive*

products and services, efficient business processes, and valuable new combinations of knowledge, ***holistically*** *taking into consideration business, marketing, operations, and technological aspects."*

In line with Open Innovation paradigm [34], these ideas points out to use internal and external innovation sources to get success on innovative projects. In the open innovation era, the advantages of cooperation are increasing [23]. In fact, nowadays collaborations between organizations are a critical point in the industry and everyone who decides do not participate will get serious risk and competitive disadvantages [23]. The previous collaborative approach with other organizations is not enough, an integrative and holistic vision of every component of hole organization is considered too to get success on innovative projects. Both aspects are emphasized on previous definition. To implement these concepts, intra-collaboration (between different units of an organization) and inter-collaboration (between different organizations) should be adequately managed. [34, 23]

"The ability to collaborate is a meta-capacity for innovation" [50]

Currently, many organizations where innovation and knowledge management are important elements of the business are considering this kind of collaborative and systemic approaches. In fact, Machado analyses in [47] a case study with one organization, named *Empresa Brasileira de Aeronautica*, that implements the concept of Systemic Innovation Capability.

To measure its impact, the author uses the idea of *New Product Development Effectiveness*, that is defined in [10, 80] like the conjunction of efficacy (better product concepts and better targeted products), efficiency (shorter development cycles and lower R & D expenditures) and productivity (more successful per R & D personnel and more successful projects per R & D investments).

The findings of Machado´ s contribution are not definitive and he assumes that more researches are required to validate the concept of Systemic Innovation Capability. Anyway, the obtained conclusions in these case study could be useful for our work, they are as follows:

- A Systemic Innovation Capability can improve New Product Development effectiveness and therefore a organization´ s performance.
- Systemic Innovation Capability is an essential enabling condition of a fruitful partnership.
- The most important thing is to create an environment, intra-organizational and inter-organizational, where people feel free to share knowledge.

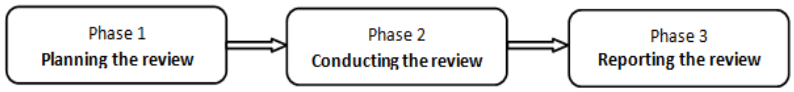


Figure 5: Phases of the SLR method, proposed by Kitchenham [39]

4 Research method: Systematic Literature Review

The Systematic Literature Review (SLR) has been proposed in software engineering research by Kitchenham [39] as a method to report reliable conclusions about a research area collecting systematically quality evidences. As it can be seen in figure 5, the process has three main phases:

- Planning the review, to develop a review protocol
- Conducting the review, to execute the previous protocol
- Reporting the review, to provide the obtained results to the community

The whole process includes several iterations to get valuable feedback, improving the overall research.

4.1 Phase 1: Planning the review

The target of this phase is to develop a systematic review protocol. It must define the methods and the mechanism to find valuable contributions where our research questions can be dealt. As it can be seen in figure 6, this phase has a set of steps.

4.1.1 Step 1.1 Review objective and research questions

Like it has been said in the introduction, the objective of this review is to identify studies where knowledge about innovation sources taxonomies in software engineering field could be extracted. Concretely, the research questions that have been addressed to achieve the research goals are as follows:

- RQ1: Which are the innovation sources in the software engineering field?
- RQ2: What is the order of relevance of the identified innovation sources?
- RQ3: Which is the trend on the usage of the identified innovation sources?

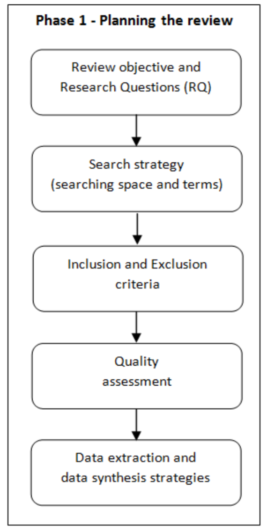


Figure 6: Steps of the phase 1 of SLR method, proposed by Kitchenham [39]

Table 2: Search resources

Electronic databases
IEEE Xplore (ieeexplore.ieee.org)
ACM Digital Library (dl.acm.org)
ISI Web of Knowledge (www.webofknowledge.com)
Science Direct (www.sciencedirect.com)
EI Compendex (www.engineeringvillage2.org)

4.1.2 Step 1.2: Search strategy

To conduct a systematic literature review, it is completely necessary to use a formal search strategy. It facilitates in a more reliable way the localization of the scientific contributions that could provide relevant answers to the arisen research question. Besides, to follow a formal search strategy enables recommendable practices in research contexts like the repeatability and the external reviews of this contribution.

Firstly, a searching space should be defined. The electronic databases consulted in this SLR are presented in table 2. The categories to be considered in this SLR are related to engineering, computer science and management. Secondly, the search terms should be defined to get a collection of candidate contributions. The search terms are defined generically to cover widely the contributions that could be related to innovation sources in software engineering field. The follow-

Table 3: Quality assessment form

Quality assessment form
Does the contribution define clearly its aims and objectives?
Does the contribution use empirical methods to get evidences?
Is the context of the study adequately described?
Is the context of the study connected with software engineering field?
Does the contribution provide reliable findings for software engineering field?

ing searching chain has been designed:

[In Full Text:] software and ("innovation source" or "source* of innovation")*

It is mentionable that due to differences on the search mechanism of some electronic databases and its constraints, some changes have been introduced in the previous searching chain. For example, in ISI Web of Knowledge searchers in full text are not supported and searchers in the title, abstract and keywords have been executed.

4.1.3 Step 1.3: Inclusion and Exclusion criteria

A review protocol must provide criteria to include or to exclude on the final selection of relevant studies the candidate contributions, considering its potential value for this systematic literature review. The following filter insures to get studies suitable for the software engineering field providing empirical lists or taxonomies of innovation sources:

- Inclusion criteria: Scientific material (papers, experience reports, summaries of workshops, etc.) written in English and accessible digitally. The included contributions should provide relevant and suitable knowledge for software engineering field about empirical lists or taxonomies, preferably ordered by relevance degree, of innovation sources.

- Exclusion criteria: Non-scientific material (articles based in opinions); Material non written in English; Studies framed in contexts so far-away to software engineering field; Studies without considerations about the whole innovation sources, that are focused in a concrete innovation source. In general, contributions that do not fulfil the inclusion criteria are excluded.

4.1.4 Step 1.4: Quality assessment

Following the Kitchenhams guidelines [39], a quality assessment of every included study is recommended. Despite there is no universal criteria for the quality in this sense, different approaches have been proposed and used in other

Table 4: Suitability assessment form

Suitability assessment form
The study describes the purpose and the context of the researching
The study provides an empirical taxonomy of innovation sources
The study provides evidences about the relevance of innovation sources
The study and its evidences are reliable and suitable in software engineering field

SLR [21, 17]. The table 3 presents the designed quality assessment form, composed by five questions. The quality of the each included study in the SLR can be assessed through this form, every question could be response with "yes" (1), "no" (0) or "partially" (0.5). Using systematically this form, a subjective and quantitative measure (from 0 to 5) of the quality of each included study can be provided.

Moreover, a suitability indicator of each contribution included in the SLR can be obtained using a suitability assessment form. The table 4 presents the designed form, composed by four items that can be answered with "yes" (1), "no" (0) or "partially" (0.5). Using systematically this form, a subjective and quantitative measure (from 0 to 4) of the suitability of each included study can be provided.

4.1.5 Step 1.5: Data extraction and data synthesis strategies

In a systematic literature review [39], it is critical to identify, to extract and to synthesize correctly the information of the included studies to provide reliable answers to the arisen research questions. To do that, the previous quality and suitability forms can enable the design of a template to extract valuable information of each included contribution. The template has been created to keep (i) the context of a study, (ii) the findings related with our research questions, and (iii) the reliability and suitability of the study for our purposes. Summaries of the included contributions and data like their geographic zone, the number of involved firms, and the identified innovation sources have been managed in spreadsheets where these information have been extracted and grouped.

Once the data of the whole studies have been properly extracted, they should be synthesised in order to provide new knowledge in a research area. As it is established in a tertiary study about the current state of the SLR development [15], the lack usage of synthesis approaches and synthesis methods in a SLR decrease its reliability as synthesis strategies are necessary to build robust findings answering the arisen research questions. As it will be seen in the next phases of this SLR, mainly an integrative approach [53] and the narrative method [62] have been adopted, however an interpretative approach and features of other methods can been lightly utilized.

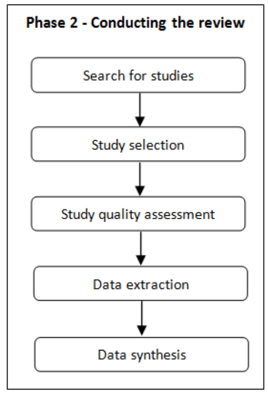


Figure 7: Steps of the phase 2 of SLR method, proposed by Kitchenham [39]

Table 5: Studies search

Search resources	**Retrieved**	**Excluded**	**Included**
IEEE Xplore	436	429	7
ACM Digital Library	66	64	2
ISI Web of Knowledge	57	53	4[-1]
Science Direct	899	880	19[-3]
EI Compendex	10	7	3[-3]
Secondary studies	7	0	7
Total	1475	1433	42[-7]= **35**

4.2 Phase 2: Conducting the review

The target of this phase is to execute the systematic review protocol planned previously. It must provide information of the selected studies about their quality and relevant knowledge for the SLR purposes. As it can be seen in figure 7, this phase has a set of steps.

4.2.1 Step 2.1: Search for studies

The searching process have been executed following the guidelines described in the step 1.2. 1468 primary studies (identified through the mentioned electronic databases) and 7 secondary studies (identified through by citations) have been retrieved in the SLR. A summary is presented in the table 5.

4.2.2 Step 2.2: Study selection

The retrieved contributions have been filtered using the inclusion criteria described in the step 1.3. Firstly, evaluating the title and the abstract of the

Table 6: Studies selection

Search resources	**Retrieved**	**Pre-included**	**Included**
IEEE Xplore	436	40	7
ACM Digital Library	66	7	2
ISI Web of Knowledge	57	8	4[-1]
Science Direct	899	85	19[-3]
EI Compendex	10	5	3[-3]
Secondary studies	7	7	7
Total	1475	152	42[-7]= **35**

Table 7: Publication channels overview

Type	**Name**	**Occurrences**
Inproceedings	IEEE International Conference	5
Inproceedings	PICMET	3
Inproceedings	Management and Service Science	1
Journal	Research Policy	11
Journal	Technovation	6
Journal	International Journal of Technology Management	2
Journal	Journal of Product Innovation Management	2
Journal	Communications ACM	1
Journal	IEEE Transactions on Engineering Management	1
Journal	Technological forecasting and social change	1
Journal	Computers and Industrial Engineering	1
Journal	Engineering Management Journal	1

retrieved studies a first filter have been applied, excluding the 1323 of the 1475 of the retrieved contributions. Secondly, evaluating the abstract, the title and the conclusions of the studies and scanning the whole body of the pre-included studies a second filter have been applied, excluding 110 of the 152 pre-included contributions. Finally, 42 contributions have been identified in the SLR, but as 7 of the included studies appears in different electronic databases, the final set of included contributions in the SLR is 35. These results are summarized in the table 6.

Moreover, the 35 included contributions have been published in international journals and conferences proceedings. The table 7 provide an overview of the publication channels of the included contributions.

Table 8: Quality assessment overview

	Poor (0-2]	**Medium (2-3'5]**	**High (3'5-5]**
Number of studies	0/35	17/35	18/35
Percentage of studies	0%	48%	52%

Table 9: Suitability assessment overview

	Poor (0-2]	**Medium (2-3]**	**High (3-4]**
Number of studies	1/35	15/35	19/35
Percentage of studies	3%	42 %	55%

4.2.3 Step 2.3: Study quality and suitability assessment

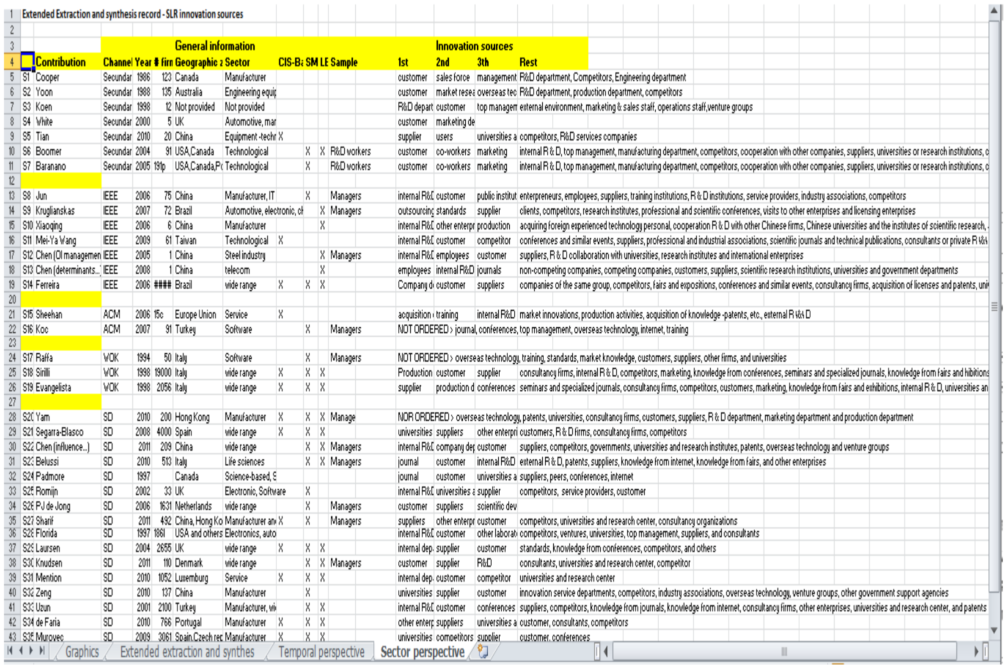
The quality and the suitability of the included contributions have been assessed following the forms described in the step 1.4 of the SLR. Subjective and quantitative measures to evaluate the quality and the suitability of the included studies have been calculated as it has been exposed previously. The results are summarized in tables 8 and 9.

4.2.4 Step 2.4: Data extraction

The identification and extraction of useful data in the included contributions is critical to collect the necessary data to build reliable answers to the arisen research questions [15]. The information provided in each contribution valuable for our purposes have been extracted and synthesized following the guidelines provided in the step 1.5. As it is depicted in the figure 8, these information have been gathered using a set of spreadsheets as electronic support. Information from each included contributions related to the publication year, number of involved firms, geographic zone, industrial sector, type of involved firms (SME-LE), type of sample (Managers, R & D workers) and the provided innovation sources, in relevance order when it is possible, have been extracted systematically. Furthermore, a brief summary of the included contributions can be found in the appendix.

4.2.5 Step 2.5: Data synthesis

The synthesis of the information extracted of the included contributions is critical to build reliable answers to the arisen research questions [15]. As it was exposed in the step 1.5 of this SLR, an integrative approach [53] and the narrative method [62] have been mainly adopted, however an integrative approach and features of other methods have been lightly utilized.



1	Extended Extraction and synthesis record - SLR innovation sources														
2															
3			General information									Innovation sources			
4		Contribution	Channel	Year	# firn	Geographic z	Sector	CIS-B	SM	LE	Sample	1st	2nd	3th	Rest
5	S1	Cooper	Secundar	1986	123	Canada	Manufacturer					customer	sales force	management	R&D department, Competitors, Engineering department
6	S2	Yoon	Secundar	1988	135	Australia	Engineering equip					customer	market resea	overseas tec	R&D department, production department, competitors
7	S3	Koen	Secundar	1998	12	Not provided	Not provided					R&D depart	customer	top managem	external environment, marketing & sales staff, operations staff,venture groups
8	S4	White	Secundar	2000	5	UK	Automotive, mar					customer	marketing de		
9	S5	Tian	Secundar	2010	20	China	Equipment -techr	X				supplier	users	universities a	competitors, R&D services companies
10	S6	Boomer	Secundar	2004	91	USA,Canada	Technological		X	X	R&D workers	customer	co-workers	marketing	internal R & D, top management, manufacturing department, competitors, cooperation with other companies, suppliers, universities or research institutions, c
11	S7	Baranano	Secundar	2005	191p	USA,Canada,P	Technological		X		R&D workers	customer	co-workers	marketing	internal R & D, top management, manufacturing department, competitors, cooperation with other companies, suppliers, universities or research institutions, c
12															
13	S8	Jun	IEEE	2006	75	China	Manufacturer, IT		X		Managers	internal R&D	customer	public institut	enterpreneurs, employees, suppliers, training institutions, R & D institutions, service providers, industry associations, competitors
14	S9	Kruglianskas	IEEE	2007	72	Brazil	Automotive, electronic, ch			X	Managers	outsourcing	standards	supplier	clients, competitors, research institutes, professional and scientific conferences, visits to other enterprises and licensing enterprises
15	S10	Xiaoqing	IEEE	2006	6	China	Manufacturer			X		internal R&D	other enterpr	production	acquiring foreign experienced technology personal, cooperation R & D with other Chinese firms, Chinese universities and the institutes of scientific research,
16	S11	Mei-Ya Wang	IEEE	2009	61	Taiwan	Technological	X				internal R&D	customer	competitor	conferences and similar events, suppliers, professional and industrial associations, scientific journals and technical publications, consultants or private R \&\
17	S12	Chen (OI managemen	IEEE	2005	1	China	Steel industry			X	Managers	internal R&D	employees	customer	suppliers, R & D collaboration with universities, research institutes and international enterprises
18	S13	Chen (determinants...)	IEEE	2008	1	China	telecom			X		employees	internal R&D	journals	non-competing companies, competing companies, customers, suppliers, scientific research institutions, universities and government departments
19	S14	Ferreira	IEEE	2006	####	Brazil	wide range	X	X	X		Company d	customer	suppliers	companies of the same group, competitors, fairs and expositions, conferences and similar events, consultancy firms, acquisition of licenses and patents, uni
20															
21	S15	Sheehan	ACM	2006	15c	Europe Union	Service	X				acquisition	training	internal R&D	market innovations, production activities, acquisition of knowledge -patents, etc., external R \&\ D
22	S16	Koc	ACM	2007	91	Turkey	Software		X		Managers	NOT ORDERED > journal, conferences, top management, overseas technology, internet, training			
23															
24	S17	Raffa	WOK	1994	50	Italy	Software		X		Managers	NOT ORDERED > overseas technology, training, standards, market knowledge, customers, suppliers, other firms, and universities			
25	S18	Sirilli	WOK	1998	19000	Italy	wide range	X	X	X		Production	customer	supplier	consultancy firms, internal R & D, competitors, marketing, knowledge from conferences, seminars and specialized journals, knowledge from fairs and hibitions
26	S19	Evangelista	WOK	1998	2056	Italy	wide range	X	X	X		supplier	production d	conferences	seminars and specialized journals, consultancy firms, competitors, customers, marketing, knowledge from fairs and exhibitions, internal R & D, universities an
27															
28	S20	Yam	SD	2010	200	Hong Kong	Manufacturer	X	X	X	Manage	NOR ORDERED > overseas technology, patents, universities, consultancy firms, customers, suppliers, R & D department, marketing department and production department			
29	S21	Segarra-Blasco	SD	2008	4000	Spain	wide range	X	X	X		universities	suppliers	other enterpri	customers, R & D firms, consultancy firms, competitors
30	S22	Chen (influence...)	SD	2011	209	China	wide range		X	X	Managers	internal R&D	company dep	customer	suppliers, competitors, governments, universities and research institutes, patents, overseas technology and venture groups
31	S23	Belussi	SD	2010	513	Italy	Life sciences		X	X	Managers	journal	customer	internal R&D	external R & D, patents, suppliers, knowledge from internet, knowledge from fairs, and other enterprises
32	S24	Padmore	SD	1997		Canada	Science-based, S					journal	customer	universities a	suppliers, peers, conferences, internet
33	S25	Romijn	SD	2002	33	UK	Electronic, Software		X			internal R&D	universities a	supplier	competitors, service providers, customer
34	S26	PJ de Jong	SD	2006	1631	Netherlands	wide range		X		Managers	customer	suppliers	scientific dev	
35	S27	Sharif	SD	2011	492	China, Hong Ko	Manufacturer an	X	X		Managers	suppliers	other enterpr	customer	competitors, universities and research center, consultancy organizations
36	S28	Florida	SD	1997	1861	USA and others	Electronics, auto					internal R&D	customer	other laborat	competitors, ventures, universities, top management, suppliers, and consultants
37	S29	Laursen	SD	2004	2655	UK	wide range	X	X	X		internal dep.	supplier	customer	standards, knowledge from conferences, competitors, and others
38	S30	Knudsen	SD	2011	110	Denmark	wide range		X	X	Managers	customer	supplier	R&D	consultants, universities and research center, competitor
39	S31	Mention	SD	2010	1052	Luxemburg	Service	X	X	X		internal dep.	customer	competitor	universities and research center
40	S32	Zeng	SD	2010	137	China	Manufacturer		X			universities	supplier	customer	innovation service departments, competitors, industry associations, overseas technology, venture groups, other government support agencies
41	S33	Uzun	SD	2001	2100	Turkey	Manufacturer, wi		X	X		internal R&D	customer	conferences	suppliers, competitors, knowledge from journals, knowledge from internet, consultancy firms, other enterprises, universities and research center, and patents
42	S34	de Faria	SD	2010	766	Portugal	Manufacturer	X	X	X		other enterp	suppliers	universities a	customer, consultants, competitors
43	S35	Murovec	SD	2009	3061	Spain,Czech rep	Manufacturer	X	X	X		universities	competitors	supplier	customer, conferences

Figure 8: Extraction and synthesis spreadsheet

Several tools and techniques should be used in the synthesis process [62] to provide reliable answers to the arisen research questions. Textual descriptions, tabular data, grouping and clustering, quantitative heuristic, relationships exploration, visual representations and narrative discussion will be used to report the results of this SLR. Firstly, information about the context of the contributions are rigorously reported using textual descriptions, tabular data, grouping, and visual representations. Then, the research questions will be answered applying heuristic, clustering information, exploring relationships, representing visually the conclusions and establishing narrative discussions. The findings emphasized in the included contributions are quantitatively integrated and qualitatively discussed in order to generate useful resources dealing with the research questions. They are answered using the following schemas:

RQ1: Which are the innovation sources in the software engineering field?

Firstly, the innovation sources identified by each study included in the SLR have been collected and reported properly in a table. But the raw list of innovation sources are not completely uniform because sometimes they refer to similar concepts with different words, or they refer to concepts that can easily be grouped. So, secondly, the identified innovation sources have been homogenized and integrated into an integrated list composed by the innovation sources suit-

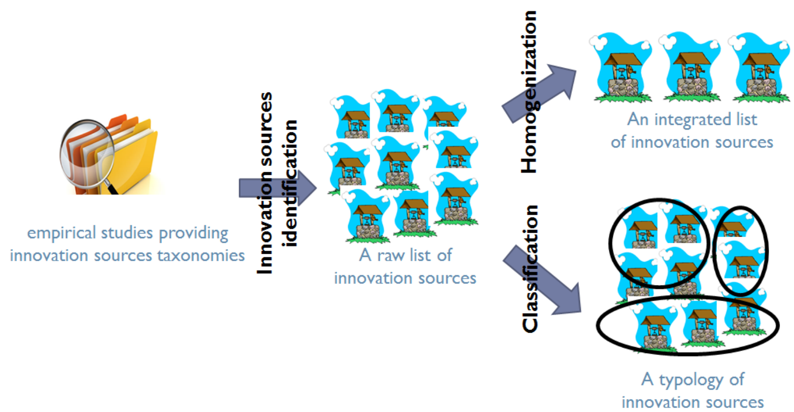


Figure 9: Data synthesis strategy (RQ1)

able for software engineering field, that are reported properly in another table. Thirdly, typologies and taxonomies to group the identified innovation sources are discussed narratively and reported properly in a table. Besides, these results are narratively discussed in order to integrate and generate knowledge about the innovation sources identified in software engineering field. This data synthesis strategy is represented in the figure 9.

RQ2: What is the order of relevance of the identified innovation sources?

Once the innovation sources have been identified, their relevance degree for software engineering field should be obtained through a specific criteria. Despite the designed criteria provides quantitative information about the relevance of a innovation source, its nature is qualitative and it is used to describe and understand issues related to innovation sources in a narrative discussion.

Several parameters could be considered to calculate the relevance degree of the identified innovation sources. The following indicators are considered in order to design a relevance criteria:

- **The number of occurrences** of each innovation source provide an indicator about the relevance of each innovation source. So, the number of occurrences (N) of each innovation source can be considered to assess the relevance of the sources of innovation.
- **The degree of relevance** provided by taxonomies of the included studies provide an indicator about the relevance of each innovation source. As most of the analysed contributions provide taxonomies ordered by relevance, the perceived importance of each innovation source in the analysed contributions can be considered to assess the relevance of each innovation

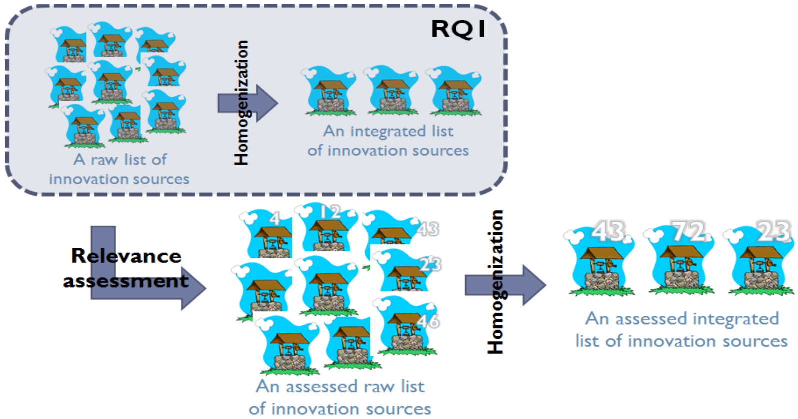


Figure 10: Data synthesis strategy (RQ2)

source. So, the relevance order (RO) of the innovation sources in the identified taxonomies are considered as a multiplier factor: the most relevance innovation source multiplies by four, the second one multiplies by three, the third multiplies by two, and the rest one multiplies by one.

- **The suitability of the included studies** to the software engineering field provide an indicator about the reliability of the results of the included studies. As the contributions only focused on technological and software engineering contexts are more reliable for our purposes than others, the suitability to the software engineering field of the contributions where the innovation sources appear can be considered to assess the relevance of each innovation source. So, if a contribution involves software organizations, the relevance degree of their innovation sources are multiplied by a suitability factor (SF).

Using the presented parameters, the Relevance degree of each Innovation Source (ISR) can be calculated through the following formula.

$$ISR = RO1 * SF1 + RO2 * SF2 + RON * SFN$$

The calculation of the relevance of every innovation source is properly reported in several tables and graphics. Concretely, a table providing the relevance degree of the innovation sources of the raw list, and a table and a graphic providing the relevance degree of the innovation sources of the integrated list, are reported. Besides, these results are narratively discussed in order to integrate and generate knowledge about the most relevance innovation sources in software engineering field. This data synthesis strategy is graphically represented in the figure 10.

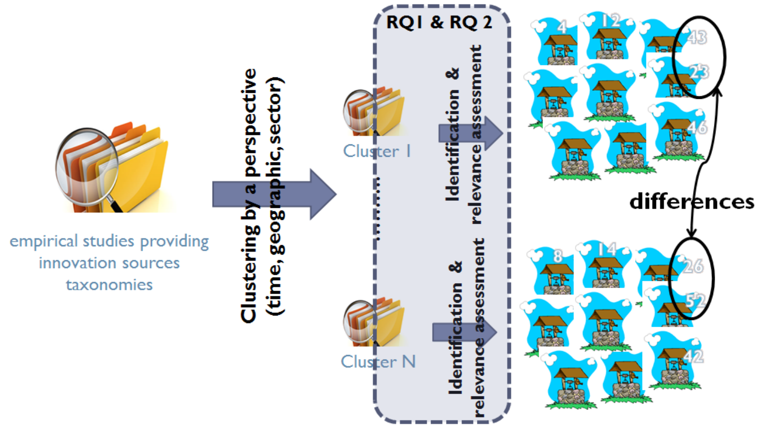


Figure 11: Data synthesis strategy (RQ3)

RQ3: Which is the trend on the usage of the identified innovation sources?

This question can be seen from different perspectives. The first one is related to the **time**, looking for usage trends during different time periods. The second one is related to the **countries**, looking for usage trends across different countries. The third one is related to the **knowledge fields**, looking for usage trends across different sectors.

The data synthesis strategies has been as follows: Once the raw list of innovation sources has been created (RQ1) and the relevance degree of each innovation source has been calculated (RQ2), the studies included in the SLR have been group into several clusters and the relevance degree of the innovation sources in each cluster has been re-calculated. The clusters designed for each perspective are as follows:

- **Time perspective**: Studies have been grouped by time periods. Three periods have been used to cluster the studies: (i)1980-1999; (ii)2000-2005; (iii)2005-2011.
- **Geographic perspective**: Studies have been grouped by countries. As the sample is not so large, two kind of countries have been used to cluster the studies: (i)developed countries; (ii)developing countries.
- **Knowledge field**: Studies have been grouped by knowledge field. As the sample involves mainly technological sectors and it is not so large, two kind of sectors have been used to cluster the studies: (i) strongly connected with software engineering field; (ii) not-strongly connected with software engineering field.

Once the clusters of each perspective has been obtained and the relevance degree of the innovation sources of each cluster has been re-calculated, these information have been reported properly in several tables and graphics. Besides, a narrative discussion supported on the differences between the relevance degree of some innovation sources in different clusters is established in order to identify usage trends of the innovation sources. This data synthesis strategy is represented in the figure 11.

5 Reporting the SLR: Results and Discussion

This section reports knowledge extracted from the included studies in the SLR. General information about the analysed studies and answers to the arisen research questions have been built-on empirical studies as follows.

5.1 General information

General aspects to be tackled in the whole studies are related to:

- a) The research method used in a study
  - a1)Based on the survey method
  - a2)Based on direct observations of key indicators of innovative projects or firms
- b) The sector of the firms or people involved on a study
  - b1)Non-Technological organizations
  - b2)Technological organizations
  - b3)Software organizations

  c) Contextual knowledge of a study.
  - c1)Country
  - c2)Year
  - c3)Number of involved firms (or people, countries, etc.)

Analysing general information of the included contributions, shown in table 10, the following ideas could be extracted.

- **The interest for innovation source issue is increasing in the last decade**. As it is depicted in figure 12, every year more and more contributions about the innovation sources issue are being provided. Furthermore, as it can be seen the columns b3 and c2 from table 10, the presence of innovation sources studies conducted in software contexts are also increasing in the last decade. This fact is strongly connected with RQ3, related to the trends of the innovation source usage, and it will be considered later.
- **The innovation sources topic is a relevant issue for many countries**. As is depicted in figure 13, studies in developed and developing countries from four continents (Europe, America, Asia, Oceania) have been included in this SLR. Furthermore, as it can be seen the columns b3 and c1 from table 10, innovation sources studies involving software contexts have been conducted in many different countries. This fact is strongly connected with RQ3, related to the trends of the innovation source usage, and it will be considered later.

Table 10: General overview

	a1	a2	b1	b2	b3	c1	c2	c3
Cooper[S7]	x	x	x	x		Canada	1986	123 firms
Yoon[S10]	x		x	x		Australia	1988	135 firms
Koen[S16]	x		x	x		Not provided	1998	12 firms
White[S32]	x		x	x		UK	2000	5 firms
Tian[S28]	x		x	x		China	2010	20 firms
Boomer[S3]	x			x	x	USA,Canada	2004	91 firms
Baranano[S1]	x			x	x	USA,Canada,Portugal	2005	191 people
Jun[S29]	x		x	x		China	2006	75 firms
Kruglianskas[S17]	x		x	x		Brazil	2007	72 firms
Xiaoqing[S33]	x		x	x		China	2006	6 firms
Wang[S31]	x		x	x	x	Taiwan	2009	61 firms
Chen[S4]	x		x			China	2005	1 firm
Chen[S6]	x	x		x		China	2008	1 firm
Ferreira[S12]	x		x	x	x	Brazil	2006	+25000 firms
Sheehan[S26]	x	x	x	x	x	Europe Union	2006	15 countries
Koc[S15]	x	x			x	Turkey	2007	91 firms
Raffa[S22]	x	x			x	Italy	1994	50 firms
Sirilli[S27]	x		x	x	x	Italy	1998	+19000 firms
Evangelista[S11]	x		x	x	x	Italy	1998	2056 firms
Yam[S34]	x	x	x	x		Hong Kong	2010	200 firms
Segarra[S24]	x	x	x	x		Spain	2008	+4000 firms
Chen[S5]	x	x	x	x	x	China	2011	209 firms
Belussi[S2]	x		x	x		Italy	2010	513 firms
Padmore[S21]		x	x	x		Canada	1997	Not provided
Romijn[S23]		x		x	x	UK	2002	33 firms
PJJong[S9]	x		x	x	x	Netherlands	2006	1631 firms
Sharif[S25]	x		x	x		China,Hong Kong	2011	492 firms
Florida[S13]	x		x	x	x	USA and others	1997	183 laboratories
Laursen[S18]	x		x	x		UK	2004	2655 firms
Knudsen[S14]	x	x	x	x	x	Denmark	2011	110 firms
Mention[S19]	x		x	x		Luxembourg	2010	1052 firms
Zeng[S35]	x		x			China	2010	137 firms
Uzun[S30]	x		x			Turkey	2001	2100 firms
Faria[S8]	x		x			Portugal	2010	766 firms
Murovec[S20]	x		x			Spain, Czech Republic	2009	3061 firms

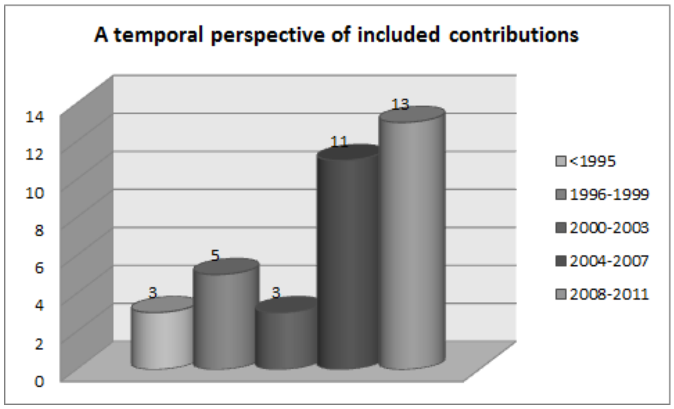


Figure 12: A temporal perspective of included contributions

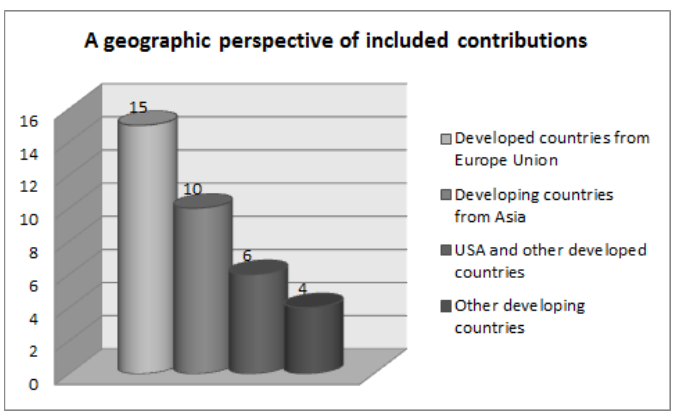


Figure 13: A geographic perspective of included contributions

- **The innovation sources topic is a transversal issue in many knowledge fields**. Despite contributions focused in software contexts have been the target of this SLR, hundreds of the pre-included contributions related to innovation sources topic were focused on contexts so far-away from software engineering field, such us tourism or ceramic sectors [2, 1]. Furthermore, 23% of the included contributions [S12, S27, S11, S24, S5, S9, S18, S14] involves a wide range of knowledge fields at the same time; these studies are relevant for this SLR because they involves technological organizations, but they also involves contexts not directly connected with software engineering like automotive industry, textile and clothing industry, agriculture industry, and many others. So, it can be concluded that innovation sources topic is tackled in many knowledge fields. This fact is strongly connected with RQ3, related to the trends of the innovation source usage, and it will be considered later.

5.2 RQ1: Which are the innovation sources in the software engineering field?

This section deals with the RQ1 using the data synthesis strategy exposed in the step 2.5 of the SLR. The first step is to build a **raw list** of the innovation sources identified in the whole contributions included in the SLR. The table 11 presents (i)the identified innovation sources and their number of occurrences in order to provide an answer to the RQ1, as well as (ii) the contributions where these innovation sources appear in order to enforce the traceability of the SLR.

The raw list of innovation sources is not completely uniform as sometimes they refer to similar concepts with different words, or they refer to concepts that can easily be grouped. The second step is the homogenization and integration of the raw list into a **integrated list**. The table 12 presents an ordered list composed by the innovation sources most suitable for software engineering field.

Moreover, a discussion about the **typologies and taxonomies** of the innovation sources most suitable for software engineering field can be established. Currently, the importance of internal capabilities and external openness in the current and competitive environment are clearly [34, 23, 47]. As it is exposed in the background chapter, initially innovation models were focused on the usage of internal resources as innovation sources, but they evolved and the usage of resources outside from the organization boundaries started to be another relevant innovation sources. Furthermore, it can be emphasized that the amount of knowledge available for everyone in this globally world is increasing day by day.

The most of the included contributions included in the SLR confirm totally these ideas. Also, we have found that the most suitable innovation sources for software engineering field can be classified using the following **typology**: internal sources, external sources and *cloud* sources. These categories are as follows:

Table 11: Innovation sources identification

Innovation source	**Ocurrences**	**Studies**
Users and customers	32/35	[S7],[S10],[S16],[S32],[S28],[S3],[S1],[S29],[S17],[S33],[S31],[S4],[S6],[S12],[S27],[S11],[S34],[S24],[S5],[S2],[S21],[S9],[S25],[S13],[S18],[S14], [S19],[S35],[S30],[S8],[S20],[S22]
Universities and Research center	30/35	[S28],[S3],[S1],[S29],[S17],[S33],[S31],[S4],[S6],[S12],[S26],[S27],[S11],[S34],[S24],[S5],[S2],[S21],[S23],[S9],[S25],[S13],[S18],[S14],[S19],[S35],[S30],[S8],[S20],[S22]
Suppliers	27/35	[S28],[S3],[S1],[S29],[S17],[S31],[S4],[S6],[S12],[S27],[S11],[S34],[S24],[S5],[S2],[S21],[S23],[S9],[S25],[S13],[S18],[S14],[S35],[S30],[S8],[S20],[S22]
Competitors	27/35	[S7],[S10],[S28],[S3],[S1],[S29],[S17],[S33],[S31],[S4],[S6],[S12],[S27],[S11],[S24],[S5],[S21],[S23],[S25],[S13],[S18],[S14],[S19],[S35],[S30],[S8],[S20]
R & D staff	22/35	[S7],[S10],[S16],[S3],[S1],[S33],[S31],[S4],[S6],[S12],[S26],[S27],[S11],[S34],[S5],[S21],[S23],[S13],[S18],[S14],[S19],[S30]
Marketing and Sales staff	17/35	[S7],[S10],[S16],[S32],[S3],[S1],[S33],[S12],[S26],[S27],[S11],[S34],[S5],[S21],[S18],[S19],[S22]
Consultancy organizations	15/35	[S28],[S3],[S1],[S31],[S12],[S27], [S11],[S34],[S24],[S25],[S13],[S18],[S14],[S30],[S8]
Production staff	15/35	[S10],[S16],[S3],[S1],[S33],[S12],[S26],[S27],[S11],[S34],[S5],[S21],[S23],[S18],[S19]
Journals	11/35	[S3],[S1],[S31],[S6],[S26],[S15],[S27],[S11],[S2],[S18],[S30]
Conferences	11/35	[S17],[S31],[S12],[S26],[S15],[S27],[S11],[S2],[S18],[S30],[S20]
Other enterprises	10/35	[S4],[S6],[S12],[S24],[S5],[S2],[S25],[S30],[S8],[S22]
Top management	8/35	[S16],[S3],[S1],[S15],[S5],[S21],[S13],[S18]
Patents	7/35	[S12],[S26],[S34],[S5],[S2],[S21],[S30]
Overseas technology	7/35	[S10],[S26],[S15],[S34],[S5],[S35],[S22]
Internet	6/35	[S3],[S1],[S26],[S15],[S2],[S30]
Management staff	5/35	[S7],[S12],[S5],[S21],[S18]
Training institutions	4/35	[S29],[S26],[S15],[S22]
Venture groups	4/35	[S16],[S5],[S13],[S35]
All the employees	3/35	[S4],[S6],[S5]
Industry associations	3/35	[S29],[S31],[S35]
Financial institutions	3/35	[S29],[S5],[S35]
Technological std.	3/35	[S17],[S18],[S22]
Co-workers	2/35	[S3],[S1]
Licensing enterprises	2/35	[S17],[S21]
Service providers	2/35	[S29],[S23]
Technology providers	2/35	[S33],[S35]
External environment	1/35	[S16]
Outsourced firms	1/35	[S17]
Experienced personal	1/35	[S33]

Table 12: Top innovation sources for Software Engineering Field

Position	Innovation sources	Ocurrences
1	Users and customers	32/35
2	Universities and Research center	30/35
3	Suppliers	27/35
4	Competitors	27/35
5	R & D department	22/35
6	Marketing and Sales department	17/35
7	Consultancy organizations	15/35
8	Production department	15/35
9	Journals	11/35
10	Conferences	11/35
11	Overseas tech.	7/35
12	Internet	6/35
13	Patents	7/35
14	Management department	5/35

- **Internal sources** are resources inside of the firm boundaries, mainly they evolve the hole organization staffs and it is recommended that they interact jointly with external sources to increase the value chain. They appears in most of the included contribution evolving the departments of an organization. They are considered as "internal sources within the firm or business group" in the Community Innovation Survey model [24].

- **External sources** are resources outside of the firm boundaries, mainly they evolve external sources which can be important in the value creation of the processes, products and services of the organization. They also appears in most of the included contributions evolving external actors who can interact with an organization. They are considered as "external market or commercial sources" and "educational and research institutions" in the Community Innovation Survey model [24];

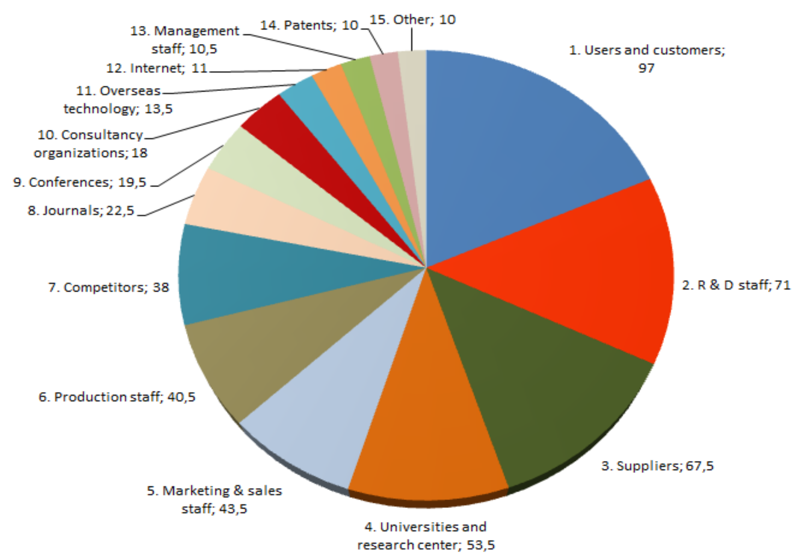
- We have established the term ***cloud sources*** to represent the innovation sources containing information, such as models, practices, frameworks, and technologies, that can be valuable for a organization. They are characterized because they are available in this globally world on a *knowledge cloud*, free or not. Normally, they appears mainly in recent contributions as external resources. They are considered as "general available information" in the Community Innovation Survey model [24].

Accordingly with the previous typology, the innovation sources most suitable for software engineering can be grouped in a **taxonomy** as it is shown in table 13.

Table 13: Innovation sources taxonomy

Internal sources	**External sources**	***Cloud sources***
R & D staff	Users and customers	Journals
Marketing & Sales staff	Suppliers	Conferences
Production staff	Competitors	Internet
Management staff	Universities & research center	Patents
-	Consultancy organizations	Overseas tech.

Figure 14: Innovation sources for Software Engineering field



5.3 RQ2: Which is the relevance of the available innovation sources?

This section deals with the RQ2 using the data synthesis strategy exposed in the step 2.5 of the SLR. The first step is to calculate the relevance degree of each identified innovation sources. The table 14 presents (i)the identified innovation sources and their relevance degree in order to provide an answer to the RQ2, as well as (ii) the formula previously exposed and the contributions where these innovation sources appear in order to enforce the traceability of the SLR. Secondly, the relevance degree of the innovation sources provided in the integrated list is presented in the table 15 and the figure 14.

Using the obtained results and the conclusions reported by the contributions included in the SLR, the following discussion about the relevance degree of the innovation sources most suitable for software engineering field can be established.

Table 14: Innovation sources relevance assessment

Innovation source	**ISR**	**Studies and assessment**
Users and customers	97	[S7]x4,[S10]x4,[S16]x3,[S32]x4,[S28]x3,[S3]x4x1'5,[S1]x4x1'5,[S29]x3,[S17],[S33],[S31]x [S4]x2,[S6],[S12]x3x1'5,[S27] x3 x1'5, [S11]x1'5, [S34], [S24], [S5]x1'5 x 2, [S2] x3, [S21]x4, [S9] x1'5 x4, [S25] x2, [S13] x1'5 x3, [S18] x2, [S14] x1'5 x4, [S19] x3, [S35] x2, [S30] x3, [S8], [S20], [S22] x1'5
R & D staff	71	[S7], [S10], [S16] x 4, [S3] x1'5, [S1] x1'5, [S33] x4, [S31] x4 x1'5, [S4] x4, [S6] x3, [S12], [S26] x2 x1'5, [S27] x1'5, [S11] x1'5, [S34], [S5] x1'5 x4, [S21] x2, [S23] x1'5 x4, [S13] x1'5 x4, [S18] x4, [S14] x1'5 x2, [S19] x4, [S30] x4
Suppliers	67'5	[S28] x4, [S3] x1'5, [S1] x1'5, [S29] x4, [S17] x2, [S31], [S4], [S6], [S12] x2 x1'5, [S27] x2 x1'5, [S11] x4 x1'5, [S34], [S24] x3, [S5] x 1'5, [S2], [S21], [S23] x1'5 x2, [S9] x1'5 x3, [S25] x4, [S13] x1'5, [S18] x3, [S14] x1'5 x3, [S35]x3, [S30] x2, [S8] x3, [S20] x2, [S22] x1'5
Universities and Research center	53'5	[S28] x2, [S3] x1'5, [S1] x1'5, [S29], [S17], [S33], [S31], [S4], [S6], [S12], [S26] x1'5, [S27] x1'5, [S11] x1'5, [S34], [S24] x4, [S5] x1'5, [S2] x2, [S21], [S23] x1'5 x3, [S9] x1'5 x2, [S25], [S13] x1'5 x2, [S18], [S14] x1'5, [S19], [S35] x4, [S30], [S8] x2, [S20] x4, [S22] x1'5
Marketing and Sales staff	43'5	[S7] x3, [S10] x3 , [S16], [S32] x 3, [S3] x2 x1'5, [S1] x2 x1'5, [S33], [S12], [S26] x1'5, [S27] x1'5, [S11] x1'5, [S34], [S5] x1'5x3, [S21] x4,[S19] x4, [S22]x1'5, [S18]x4
Production staff	40'5	[S10], [S16], [S3] x1'5, [S1] x1'5, [S33] x2, [S12], [S26] x1'5, [S27] x4 x1'5, [S11] x3 x1'5, [S34], [S5] x1'5 x3, [S21] x2, [S23] x1'5 x4, [S18] x4, [S19] x4
Competitors	38	[S7], [S10], [S28], [S3] x1'5, [S1] x1'5, [S29], [S17], [S33], [S31] x2 x1'5, [S4], [S6], [S12], [S27] x1'5, [S11] x1'5, [S24], [S5] x1'5, [S21] x3, [S23] x1'5, [S25], [S13] x1'5, [S18], [S14] x1'5, [S19] x2, [S35], [S30], [S8], [S20] x3
Journals	22'5	[S3] x1'5, [S1] x1'5, [S31], [S6] x2, [S26] x3 x1'5, [S15] x1'5, [S27] x1'5, [S11] x2 x1'5, [S2] x4, [S18], [S30]
Conferences	19'5	[S17], [S31], [S12], [S26] x3 x1'5, [S15] x1 x1'5, [S27] x1'5, [S11] x2 x1'5, [S2], [S21], [S18], [S30] x2, [S20]
Consultancy organizations	18	[S28], [S3] x1'5, [S1] x1'5, [S31], [S12], [S27] x1'5, [S11] x1'5, [S34], [S24], [S25], [S13] x1'5, [S18], [S14] x1'5, [S30], [S8]
Other firms	17	[S4], [S6], [S12], [S24] x2, [S5] x1'5, [S2], [S25] x3, [S30], [S8] x4, [S22] x1'5
Top management	15'5	[S16] x 2, [S3] x1'5, [S1] x1'5, [S15] x1'5, [S5] x1'5, [S21] x2, [S13] x1'5, [S18] x4
Overseas tech.	13'5	[S10], [S26] x4 x1'5, [S15] x1 x1'5, [S34], [S5] x1'5, [S35], [S22] x1'5
Internet	11	[S3] x1'5, [S1] x1'5, [S26] x3 x1'5, [S15] x 1 x1'5, [S2], [S30]
Management staff	10'5	[S7] x 2, [S12], [S5] x1'5, [S21] x2, [S18] x4
Patents	10	[S12], [S26] x1'5, [S34], [S5] x1'5, [S2] , [S21] x3, [S30]
Co-workers	9	[S3] x3 x1'5, [S1] x3 x1'5
Training org.	8'5	[S29], [S26] x3 x1'5, [S15] x1'5, [S22] x1'5
All employees	7	[S4] x3, [S6] x4
Tech. standard	5,5	[S17] x3, [S18], [S22] x1'5
Venture groups	5	[S16], [S5] x1'5, [S13] x1'5, [S35]
Financial firms	4'5	[S29] x2, [S5] x1'5, [S35]
Outsourced org.	4	[S17] x4
Tech. providers	4	[S33] x3, [S35]
Industry assoc.	3	[S29], [S31], [S35]
Service prov.	2'5	[S29], [S23] x1'5
Environment	1	[S16]
Licensing org.	1	[S17]
Experienced workers	1	[S33]

Table 15: Innovation sources for Software Engineering field

Position	**Innovation sources**	**Ocurrences**	**ISR**	**Type**
1	Users and customers	32/35	97	External
2	R & D department	22/35	71	Internal
3	Suppliers	27/35	67'5	External
4	Universities and Research center	30/35	53'5	External
5	Marketing and Sales department	17/35	43'5	Internal
6	Production department	15/35	40'5	Internal
7	Competitors	27/35	38	External
8	Journals	11/35	22'5	*cloud*
9	Conferences	11/35	19'5	*cloud*
10	Consultancy organizations	15/35	18	External
11	Overseas tech.	7/35	13'5	*cloud*
12	Internet	6/35	11	*cloud*
13	Management department	5/35	10'5	Internal
14	Patents	7/35	10	*cloud*

- It seems that the most relevant innovation source in software engineering is the **user**. Despite in some contribution [S23], frequency of interactions and proximity to the customers have no positive effects on product innovation index, in the majority of the analysed contributions the users or the customers are considered like the main source of innovation. As a token of that, evidences from [S21] reveals that the user is the most determining innovation source to design new products or services. As is pointed in [S32], customers can involve on the innovation process with different activities: (i)generation of the idea and active collaboration in its development (ii)development of the requirements (iii)redefinition of the applications that a product could be used, (iv)testing of solutions and (v)definition of the problems to solve. This finding is coherent with Von Hippel contributions [35, 78], where the key role of the user on innovation processes is emphasized and the concept of "lead user" is introduced. Nowadays, the utilization of users as innovation providers is widely discussed and developed [48, 60]. Focusing on software engineering, the customer involvement was identified by Wang [79] like a key principle to deal with the software engineering constraints. In fact, the growing agile methods emphasized the customer involvement as a key success factor [6, 13].

- Also the users, it seems that **other external innovation sources** (suppliers, universities and research center, competitors, consultancy organizations) can play a key role too into a software innovation process. The impact of Knowledge Intensive Business Services (KIBS) can be especially determining to improve the innovation transfer; KIBS are offered by organizations like universities, research center (well public, well private) and consultancy firms and they can provide innovative knowledge to other organizations [S34, S24]. Suppliers, which are especially important in manufacturing sector [S8, S30], can provide innovations to other organizations through equipments and technologies that open new possibilities. Finally, despite in some innovative developments the competitors role have not been considered a relevant resource [S14] and sometimes the information from competitors have negative influences [S19], most of the analysed contributions assumes the important function of the competitor to innovate in the current and changing market.

- Furthermore, it seems that the performance of the **internal sources** are totally determining in the innovation capability of a software organization. Most of the contributions, following the ideas from linear models previously introduced [7], emphasize too the primary role of internal departments as R & D, Marketing & Sales, and Production in a innovation process of a organization. Open approaches do not imply that internal sources are neglected, the traditional close innovation paradigm (based mainly on internal sources usage) are included in open innovation model [34]. In fact, greatest innovations comes when various business units interact to develop product and processes [S3]. Lastly, the management department has been considered as a minor innovation source, but it can be deeply discussed [S26, S15, S22] and explored in future works.

- Lastly, it seems that the use of ***cloud resources*** (like journals, conferences, internet, patents, overseas technology, etc.) is not highly critical but it can provide innovative knowledge for software organizations. OECD emphasized in the Oslo Manual [56] and Community Innovation Surveys [24] the importance of available knowledge in *cloud resources.* Contributions related to innovation sources in technological environments [S3, S1] take into account this kind of knowledge as an important innovation source. Nevertheless, despite some exceptions [S26, S3, S1], most of the analysed contributions do not consider these innovation sources as especially relevant.

Furthermore, it is mentionable that **there is no a common understanding about how to measure the innovation sources relevance**. Most of the contributions [S3, S1, S27, S11, S12] focus clearly the assessment of the innovation sources relevance using questionnaires to measure the relevance in scales that can be from '1' (not at all important) to '5' (extremely important). Some study [S13] goes one step further and it considers the relevance degree and the usage degree using questionnaires with two scales; one to measure the innovation source usage from '1' (never used) to '4' (often used) and another one to measure the relevance degree from '1' (not important) to '3' (very important). But other studies [S18, S31] measure the importance degree of the innovation sources using at the same time two concepts (relevance and usage degree) using questionnaires with scales from '1' (not used) to '4' (highly important).

Table 16: Innovation sources usage trend in 1980-1999

#	Innovation source	Type	Occurrences	ISR
1	Users and customers	External	8/8	27
2	R & D department	Internal	7/8	17
3	Marketing and Sales department	Internal	7/8	15'5
4	Production department	Internal	7/8	14'5
5	Suppliers	External	5/8	11
6	Competitors	External	6/8	9'5
7	Universities and Research center	External	5/8	8'5
8	Consultancy organizations	External	3/8	4'5
9	Management department	Internal	2/8	4
10	Journals	*Cloud*	2/8	4
11	Conferences	*Cloud*	2/8	4
12	Overseas tech.	*Cloud*	2/8	2'5
13	Patents	*Cloud*	1/8	1
14	Internet	*Cloud*	0/8	0

This situation can be ambiguous because despite the relevance degree and the usage degree are correlated, these concepts are different and they should be well-distinguish and well-interpreted. It is possible that one innovation source is relevant, but in a concrete moment it could be not used due to different reasons: organization context, economic situation, application domain of firm projects, short-terms and long-terms strategies, organization policies, etc. So, it can be concluded that a well-understanding of the relevance degree and the usage degree of the innovation sources is required to manage them appropriately. **The following consensus to conduct innovation sources assessment activities is proposed: one scale to measure the usage degree and another one to measure the relevance degree**.

5.4 RQ3: Which is the trend on the usage of the identified innovation sources?

This research question is analyzed from three perspectives as it was exposed before. The first one is related to the **time**, looking for usage trends during different time periods. The second one is related to the **countries**, looking for usage trends across different countries. The third one is related to the **knowledge fields**, looking for usage trends across different industrial sectors. The results and the discussion related to each perspective are presented in the following sections:

5.4.1 RQ3.1: Time perspective

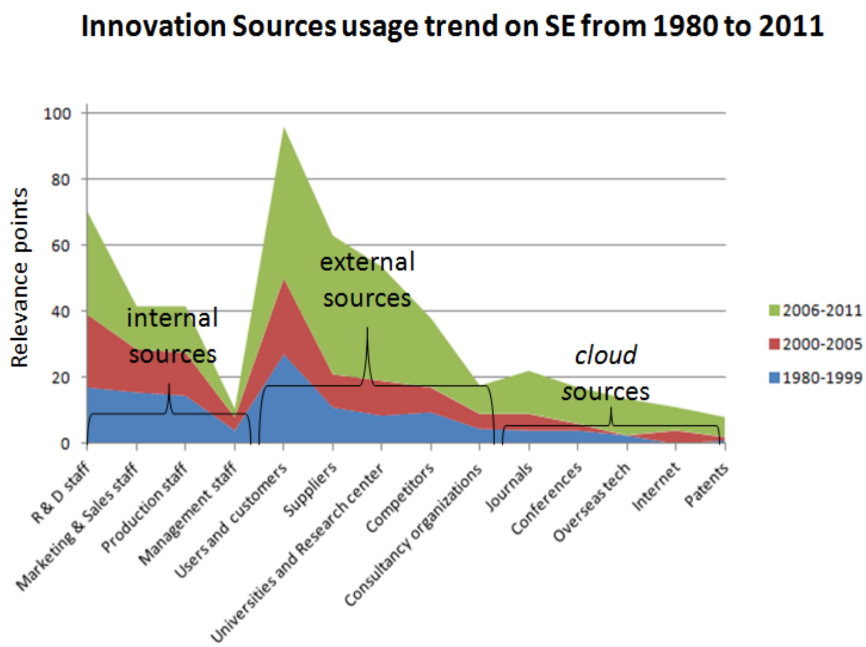


Figure 15: Innovation sources usage trend on SE from 1980-2011

Table 17: Innovation sources usage trend in 2000-2005

#	Innovation source	Type	Occurrences	ISR
1	Users and customers	External	6/7	23
2	R & D department	Internal	6/7	22
3	Production department	Internal	4/7	13
4	Marketing and Sales department	Internal	4/7	13
5	Universities and Research center	External	6/7	10'5
6	Suppliers	External	6/7	10
7	Competitors	External	6/7	7'5
8	Journals	*Cloud*	4/7	5
9	Consultancy organizations	External	3/8	4'5
10	Internet	*Cloud*	3/7	4
11	Management department	Internal	1/7	4
12	Conferences	*Cloud*	2/7	2
13	Patents	*Cloud*	1/7	1
14	Overseas tech.	*Cloud*	0/7	0

Table 18: Innovation sources usage trend in 2006-2011

#	**Innovation source**	**Type**	**Occurrences**	**ISR**
1	Users and customers	External	18/20	46
2	Suppliers	External	16/20	42'5
3	Universities and Research center	External	19/20	34'5
4	R & D department	Internal	9/20	31
5	Competitors	External	15/20	21
6	Production department	Internal	6/20	14
7	Journals	*Cloud*	5/20	13
8	Marketing and Sales department	Internal	6/20	13
9	Conferences	*Cloud*	7/20	11
10	Overseas tech.	*Cloud*	5/20	11
11	Consultancy organizations	External	8/20	8'5
12	Internet	*Cloud*	3/20	7
13	Patents	*Cloud*	5/20	6
14	Management department	Internal	2/20	2'5

This section deals with the time perspective of the RQ3 using the data synthesis strategy presented in the step 2.5 of the SLR. As it was previously exposed, to answer the research question from a time perspective three time clusters have been considered: (i)1980-1999; (ii)2000-2005; (iii)2006-2011. The *Appendix A* provides the tables where the number of occurrences and the relevance degree of all the innovation sources (raw list) in each cluster have been calculated. The tables 16, 17 and 18 presents the results obtained for the innovation sources of the integrated list in each cluster.

The results can be integrated graphically and the following discussion supported on the analysis of the figure 15 can be established. As it can be seen, from 1980 to 1999 the presence and the perceived relevance of external innovation sources are minor than internal innovation sources, but this trend has changed during the 2000s, and currently the presence and the perceived relevance of external innovation sources are significant major that internal innovation sources. Moreover, the consideration of both kind of sources are necessary to find and to exploit systematically the innovation sources. Furthermore, the presence and the perceived relevance of *cloud sources* have increased in the last 30 years: initially the *cloud* sources was almost insignificant, but currently they seem more relevant on this globally world. So, it can be said that **the presence and the perceived relevance of the innovation sources have evolved drastically in the time, being the internal sources a mandatory element, and becoming the external and the *cloud* sources more relevant day by day**.

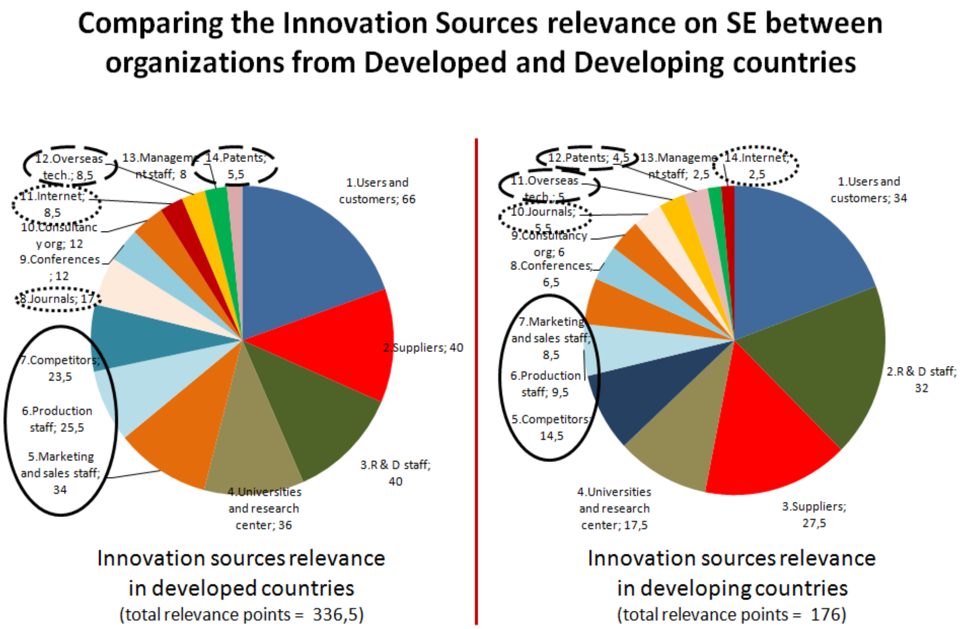


Figure 16: Comparison of innovation sources relevance between countries

This fact is coherent with the ideas provided by Cheesbrough and other many researchers [34, 23], who assert that in the open innovation as the advantages of cooperation are increasing and collaborations between organizations are a critical point in the industry, everyone who decides do not participate will get serious risk and competitive disadvantages [23]. Furthermore, the concept of *Systemic Innovation Capability* [47] points out to the importance of the holistic usage of internal and external innovation sources to provide competitive and valuable products or services to the customers. It seems clearly [34, 23] that the openness should be adequately managed for the organization success.

The current usage trends on the innovation sources points out the need of the software organizations to increase the collaboration in several aspects: intra-collaboration (between different units of an organization), inter-collaboration (between different organizations) and *cloud-collaboration* (between the organization and the *cloud* sources) in order to find and to exploit systematically the innovation sources.

5.4.2 RQ3.2: Geographic perspective

This section deals with the geographic perspective of the RQ3 using the data synthesis strategy presented in the step 2.5 of the SLR. As it was previously exposed, to answer the research question from a geographic perspective two

Table 19: Innovation sources relevance assessment in developed countries

Position	**Innovation sources**	**Ocurrences**	**ISR**	**Type**
1	Users and customers	19/21	66	External
2	Suppliers	15/21	40	External
3	R & D department	14/21	40	Internal
4	Universities and Research center	17/21	36	External
5	Marketing and Sales department	13/21	34	Internal
6	Production department	11/21	33	Internal
7	Competitors	14/21	23'5	External
8	Journals	7/21	17	*cloud*
9	Conferences	7/21	12	*cloud*
10	Consultancy organizations	9/21	12	External
11	Internet	4/35	8'5	*cloud*
12	Overseas tech.	3/21	8'5	*cloud*
13	Management department	3/21	8	Internal
14	Patents	3/21	5'5	*cloud*

Table 20: Innovation sources relevance assessment in developing countries

Position	**Innovation sources**	**Ocurrences**	**ISR**	**Type**
1	Users and customers	14/14	34	External
2	R & D department	9/14	32	Internal
3	Suppliers	12/14	27'5	External
4	Universities and Research center	13/14	17'5	External
5	Competitors	12/14	14'5	External
6	Production department	5/14	9'5	Internal
7	Marketing and Sales department	5/14	8'5	Internal
8	Conferences	5/14	6'5	*cloud*
9	Consultancy organizations	6/14	6	External
10	Journals	4/14	5'5	*cloud*
11	Overseas tech.	4/14	5	*cloud*
12	Patents	4/14	4'5	*cloud*
13	Management department	2/14	2'5	Internal
14	Internet	2/14	2'5	*cloud*

clusters have been considered: (i)developed countries, and (ii)developing countries. The *Appendix B* provides the tables where the number of occurrences and the relevance of all the innovation sources (raw list) in each cluster have been calculated. The tables 19, 20 presents the results obtained for the innovation sources of the integrated list in each cluster.

As it is depicted in the figure 16, the innovation sources usage trend is similar in both clusters, but some differences can be founded. On one hand, the role of the competitors seems more important in developing countries, whereas the role of production and marketing staff seems more important in developed countries. On the other hand, differences in the usage trend of the *cloud* sources can be also observed, the role of overseas technology and patents seems more important in developing countries, whereas the relevance of journals and internet seems more important in developed countries. Finally, it can be seen that the distribution of the innovation sources is more concentrated in the developing countries, where three innovation sources (users, R & D staff and suppliers) have more than 50 % of the whole relevance points and four external innovation sources are in the top 5 list of innovation sources.

Furthermore, some studies included in the SLR points out usage trend of the innovation sources in different countries, and the following narrative discussion can be established. In USA [S1], the external innovation sources (suppliers, competitors, etc.) are more valuable than internal innovation sources; In other developed countries from Europe Union or Canada [S24], the relevance of internal innovation sources and collaborations with public institutions is perceived like specially important. The contribution [S26] analyses data from 15 European countries founding significant variations across these countries, and more variation between the same sectors of two European countries are emphasized in [S20]. Another study conducted in Portugal, Canada and USA [S1] points out to important variations between the perceived relevance of several innovation sources in technological firms from these countries. In developing countries like China, Turkey and Brazil, despite some contradictory contribution [S35], the government support and the interaction with foreign companies are considered specially critical for a rapid growth [S29, S5, S30]. Also, significant differences have been identified [S25] on the relevance degree of the innovation sources in Hong Kong and China. Finally, studies with a large scope [S35] have found variations in the government role on innovation performance between developed and developing countries.

So, in line with the ideas provided by the Oslo manual [56], which asserts that the situation and the policies of every country are different and it is reflected on their innovation sources usage, it can be confirmed that the presence and the relevance of the innovation sources change across the countries. Moreover, this SLR has been found that **there are several differences between the usage trend of the innovation sources in software organizations from different countries, specially between developed and developing countries**.

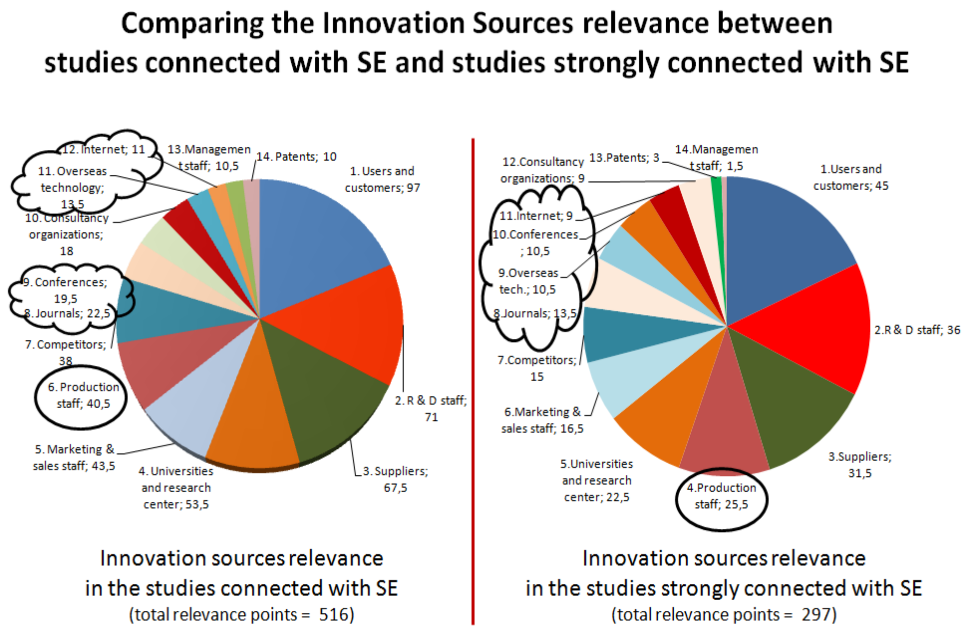


Figure 17: Comparison of innovation sources relevance in SE field

5.4.3 RQ3.3: Knowledge field perspective

This section deals with the knowledge field perspective of the RQ3 using the data synthesis strategy presented in the step 2.5 of the SLR. As it was exposed when the general information has been reported, the sample studies included of the SLR involves technological and software organizations, but some of the studies have a large scope and they also involves another knowledge fields such as manufacture or agriculture. Two discussions are be established, one about the usage trend of innovation sources on different knowledge fields, and another about the particularities of the software engineering field .

Firstly, a narrative discussion focused on usage trend of innovation sources on different knowledge fields is presented. Differences in the percentage of innovative firms have been clearly identified across different sectors [S27, S11] and significant differences on innovation sources perceptions can be observed in contributions [S24, S18] where a wide range of knowledge fields are studied. Also, differences in Europe Union have been identified [S26] between manufacturing sector, where suppliers and internal R & D are the most important innovation sources, and service sector, where suppliers and training are the most important innovation sources. Besides, studies conducted in Canada [S21] reveals that the relevance of innovation sources vary strongly across the science-based

Table 21: Innovation sources usage trend in studies connected with SE

Position	**Innovation sources**	**Ocurrences**	**ISR**	**Type**
1	Users and customers	32/35	97	External
2	R & D department	22/35	71	Internal
3	Suppliers	27/35	67'5	External
4	Universities and Research center	30/35	53'5	External
5	Marketing and Sales department	17/35	43'5	Internal
6	Production department	15/35	40'5	Internal
7	Competitors	27/35	38	External
8	Journals	11/35	22'5	*cloud*
9	Conferences	11/35	19'5	*cloud*
10	Consultancy organizations	15/35	18	External
11	Overseas tech.	7/35	13'5	*cloud*
12	Internet	6/35	11	*cloud*
13	Management department	5/35	10'5	Internal
14	Patents	7/35	10	*cloud*

Table 22: Innovation sources usage trend studies strongly connected with SE

Position	**Innovation sources**	**Occurrences**	**ISR**	**Type**
1	Users and customers	11/14	45	External
2	R & D department	10/14	36	Internal
3	Suppliers	11/14	31'5	External
4	Production department	7/14	25'5	Internal
5	Universities and Research center	11/14	22'5	External
6	Marketing and Sales department	7/14	16'5	Internal
7	Competitors	10/14	15	External
8	Journals	6/14	13'5	*Cloud*
9	Overseas tech.	4/14	10'5	*Cloud*
10	Conferences	4/14	10'5	*Cloud*
11	Internet	4/14	9	*Cloud*
12	Consultancy organizations	6/14	9	External
13	Patents	2/14	3	*Cloud*
14	Management department	1/14	1'5	Internal

firms (like bio-pharmaceutical companies), where the internal R & D and the public support are determining, and system integrator firms (like telecommunication companies), where the customers are the most determining innovation source. Also, more differences between electronics, automotive, chemical and biotechnology have been identified in [S13]. Moreover, considering the taxonomy for innovative firms proposed by Pavitt (science-based, specialised suppliers, supplier-dominated and scale intensive firms), significant differences on the innovation sources relevance have been detected across a wide range of innovative organizations [S9]. Consequently, and in line the Oslo manual [56] and Von Hippel ideas [35], who asserts that the role and the activities of users, manufacturers, suppliers and others actors involved on the innovation process varied widely across different industries; it can be concluded that **as the situation and the nature of every knowledge field are different, the presence and the relevance of the innovation sources change drastically across different sectors**.

Secondly, an analysis focused in the software engineering field can be accomplished it following the data synthesis strategy previously exposed. Taken into account the nature of the studies sample, they can be divided in two clusters: (i) studies strongly connected with software engineering field; (ii) studies not-strongly connected with software engineering field. The *Appendix C* provides the tables where the number of occurrences and the relevance degree of all the innovation sources (raw list) in each cluster have been calculated. The tables 21 and 22 presents the results obtained for the innovation sources of the integrated list in each cluster. As it is depicted in the figure 17, the innovation sources relevance extracted from the studies strongly connected with software engineering field is very similar to the innovation source relevance extracted from the studies (strongly and lightly) connected with software engineering field. Nevertheless, some particularities can be founded analyzing the relevance points of each innovation sources and the total relevance points of both samples. It seems that the production department and the cloud resources (journals, conferences, internet, overseas technology, patents) are specially important in software engineering. Consequently, despite the innovation sources usage trend is similar in both clusters, it can be concluded that **the production department and cloud resources are specially important in software engineering field.**

5.5 Limitations and Validity threats

The results reported in a SLR can be threaten by several limitations to be considered. The validity threats of this SLR are presented in the next paragraphs:

- **Survey method usage**
  Description: The survey method, widely used on the sample of contributions (33/35), implies some limitations. The participants recall their perceptions, but they can provide information not totally truth and reliable about certain topics [5]

Consequences: The reported results are based on studies providing subjective perceptions

- **Wide range of countries**
  Description: The analysed contributions have been conducted in different countries, concretely more than 10 countries of several continents are involved in the whole contributions
  Consequences: This fact could decrease the accuracy of some of the reported results

- **Wide range of knowledge fields**
  Description: Some of the included contributions involves a wide range of industries, concretely the 23% of the contributions of the SRL [S12, S27, S11, S24, S5, S9, S18, S14] are focused on the software engineering field and also on a wide range of knowledge fields
  Consequences: This fact could decrease the accuracy of some of the reported results

- **Relevance criteria heuristic**
  Description: Relevance criteria heuristic used to measure the relevance of the innovation sources is improvable. It involves only three parameters, but more determining relevance parameters could be founded
  Consequences: The heuristic to calculate the innovation sources relevance are not totally accurate and it could be discussed and improved

Considering these limitations, the answers to the arisen research questions are not totally infallible. The presence of useful innovation sources and the absence of not useful innovation sources are not totally guaranteed and the relevance of the identified innovation sources in software engineering field is not totally accurate. So, this fact must be considered and future contributions should dealt with these limitations, in order to enforce the reported results about innovation sources on the software engineering field.

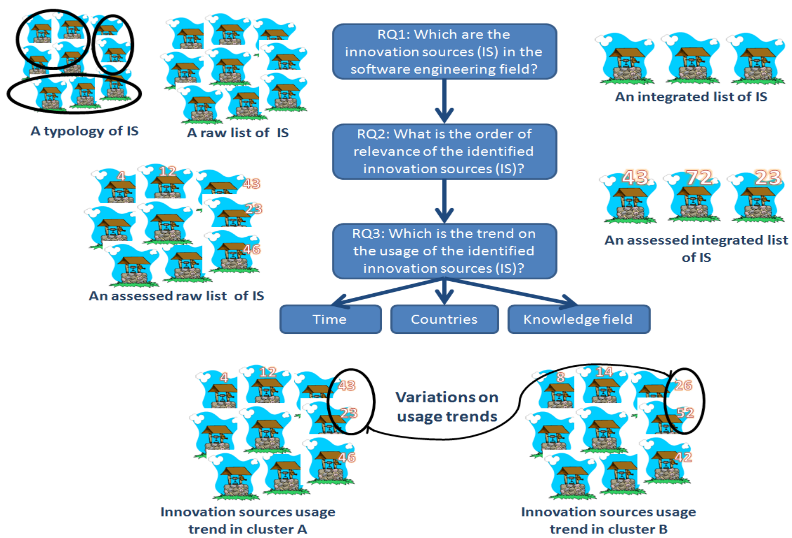


Figure 18: Resources built-on empirical studies provided research questions

6 Conclusions and Future Work

6.1 Conclusions

The results of this SLR has confirmed the key role played by the innovation and its sources, we have found that the innovation sources management is an extended challenge in many knowledge fields from many countries, and the interest for academia and industry has been increasing in the last decades. Nowadays, the organizations related with the software engineering field needs to increase their innovation capability adopting approaches that encourages a systematic identification of the available innovation sources and an adequate exploitation of the most suitable innovation sources.

The research questions have been answered designing resources built-on empirical studies, potentially useful for innovation researchers and managers of organizations related with software engineering field. As it is depicted in the figure 18, the identification and assessment of the most suitable innovation sources for software engineering have been provided, as well as the usage trends in several time periods, countries and knowledge fields.

The first research question provides the identification of the most suitable innovation sources, which can be classified in internal, external and *cloud* sources. We have found 29 innovation sources which have been integrated in a list containing the 14 innovation sources suitable for software engineering field. Furthermore, we have confirmed the widely use of internal and external criteria to classify the innovation sources, and we have also established the term *cloud* *sources* for resources available for everyone such us internet, journal, conferences, and so on.

The second research question provides the relevance assessment of all the identified innovation sources, which has enriching a narrative discussion about the relevance degree of these innovation sources and their role on software engineering field. We have found seven innovation critical sources to encourage the organization success: (i)user and customers, (ii) R & D staff, (iii)suppliers, (iv)universities and research center, (v)marketing & sales staff, (vi)production staff and (vii)competitors. They represents more than 75 % of the whole innovation relevance points, however the other innovation sources should be used to absorb and to exploit as much opportunities as possible.

The third research question provides the usage trends of the identified innovation sources from different perspectives: time, countries and knowledge fields. We have confirmed that the presence and the relevance of the innovation sources have evolved drastically in the last decades, and the innovation sources usage changes drastically across different countries and knowledge fields. We have found that the internal sources are a mandatory element, and the external and the *cloud* sources are becoming more relevant day by day. Consequently, approaches that emphasized the openness and promotes the collaboration in several directions are inspiring the organizations of these days. Moreover, as the situation of every country and every knowledge field has several particularities, we have found significant variations that should be considered to accomplish an adequate exploitation of the innovation sources.In developed countries we have found a balance between the usage of the internal and external innovation sources, whereas in developing countries the usage of innovation sources are more concentrated in external innovation sources. Otherwise, we have found that the production staff and *cloud sources* are specially important in organizations strongly connected with the software engineering field.

In conclusion, the outcomes of this SLR facilitates a systematic identification and an adequate exploitation of the innovation sources most suitable in the software engineering field. Innovation researchers can use the innovation sources lists and the usage trends analyses reported in the SLR to conduct studies related with the innovation sources research line. Whereas, organization managers and software practitioners can use the reported knowledge in a systematic way to improve their innovation capability, increasing consequently the value creation in the processes that they run to provide products and services useful for their environment.

6.2 Future Work

This SLR has started to research the innovation sources management in the software engineering field, and several aspects should be deeply study to increase the accuracy of the presented results and to obtain more resources useful

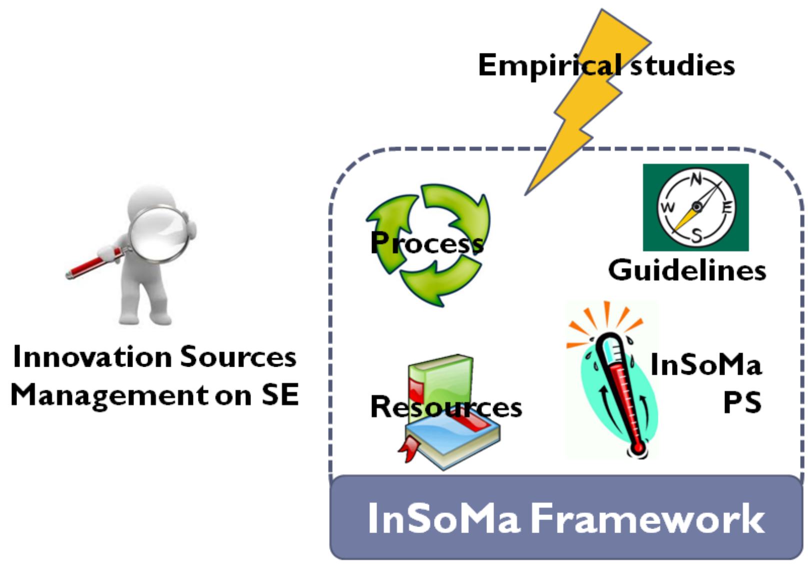


Figure 19: Future work researching innovation sources management on SE

for researchers, managers and practitioners on software engineering. A complete framework, named INnovation SOurces MAnagement (InSoMa), will support the future work providing resources, processes, monitoring systems and guidelines to conduct empirical studies on organizations involved on software engineering field. The figure 19 presents the future work proposed to continue increasing the knowledge related with the innovation sources exploitation on the software engineering field.

- **Resources to encourage the systematically identification of the innovation sources** The results presented in this master thesis will be used as resources in the InSoMa framework, they will be the basis for the processes and tools provided to improve the innovation sources management. Furthermore, in order to deal with some validity threats, the accuracy and the reliability of these resources, obtained through the SLR method, will be improved with empirical studies.

- **Process encouraging a synergistic interaction between the innovation sources** As future innovative processes, products and services are created as a result of the interaction of various innovation sources, it will be necessary to design processes to encourage the effective combination of the innovation sources reported in the SLR. Several interactions between innovation sources have been founded in the analyzed contributions, these evidences and the outcomes of the SLR will be used to establish processes to facilitate to the organizations related with the software engineering field the identification and exploitation of the available innovation sources in a systematic and holistic way.

- **INnovation SOurces MAnagement Positioning System (InSoMa PS)** A system to measure the innovation sources management capability of organizations related with the software engineering will be design in order to facilitate the monitoring and the improvement of the innovation sources exploitation. As the results reported by the SLR will facilitate the identification of the innovation management status of the organizations involved in the software engineering field, these results will be used to developed the InSoMa PS.

- **Guidelines to conduct empirical studies related to innovation sources** As the most of the included contributions use similar techniques and methods to identify and measure the innovation sources, guidelines to conduct rigorously empirical studies about innovation sources tailored to software organizations will be designed. The processes and the necessary resources to conduct in a reliable way studies on innovation sources will be properly provided by several guidelines.

- **Empirical studies related to innovation sources** Several studies to increase the accuracy of the reported results and to research more aspects related to the innovation sources management on software engineering field will be conducted. These studies will have at least two purposes: exploratory (case studies) and improvement (action research). Both studies will need reliable guidelines, automated resources and systems, and a network of organizations related with the software engineering field.

The InSoMa framework will be designed and tested empirically to increase the knowledge for innovation researchers and to improve the innovation sources management in organizations related with software engineering field.

7 Related contributions and research projects

Some outcomes of the presented Master Thesis have been presented in international conferences:

- **"Towards Estimating the Value of an Idea"** - Fernández, Carlos; López, Daniel; Garbajosa, Juan; Yague, Agustín - Mayo 2011- International Conference on Product Focused Software. Development and Process Improvement (Bari, Italia - PROFES 2011) - Workshop on Managing the Client Value Creation Process in Agile Projects - Second proceeding of PROFES 2011.

- **"Where can innovative ideas be found?: Innovation sources for organizations involved in software intensive systems development"** - López-Fernández, Daniel; Garbajosa, Juan; Yague, Agustín, Alarcón Pedro - Junio 2012- International Conference on Product Focused Software. Development and Process Improvement (Madrid, Spain - PROFES 2012) - Workshop on Managing the Client Value Creation Process in Agile Projects - Second proceeding of PROFES 2012.

Futhermore, this Master Thesis is involved in the following research projects:

- **INNOSEP**: INcorporing inNOvation in Software Engineering Processes. Funding by the Spanish Ministry of Science and Innovation (MICINN). Project code: TIN2009-13849.

- **iSSF**: iSmart Software Factory. Funding by the Spanish Ministry of Science and Innovation (MICINN) - Subprograma INNPACTO. Project code: IPT-430000-2010-038.

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9 Appendix A: Analysis of IS across the time

This appendix provides information about the number of occurrences and the relevance of the identified innovation sources in three time periods:

- 1980-1999
- 2000-2005
- 2006-2011

The tables 23, 24, 25 show information about the number of occurrences of innovation sources in these time periods. The tables 26, 27, 28 show information about the relevance of innovation source in these time periods.

Table 23: Innovation sources identification 1980-1999

Innovation source	**Occurrences**	**Studies**
Users and customers	8/8	[S7],[S10],[S16], [S27], [S11], [S21], [S13], [S22]
R & D department	7/8	[S7], [S10], [S16], [S27], [S11], [S21], [S13]
Marketing and Sales department	7/8	[S7], [S10], [S16], [S27], [S11], [S21], [S22]
Competitors	6/8	[S7], [S10], [S27], [S11], [S21], [S13]
Production department	5/8	[S10], [S16], [S27], [S11], [S21]
Universities and Research center	5/8	[S27], [S11], [S21], [S13], [S22]
Suppliers	5/8	[S27], [S11], [S21], [S13], [S22]
Top management	3/8	[S16], [S21], [S13]
Consultancy organizations	3/8	[S27], [S11], [S13]
Management department	2/8	[S7], [S21]
Journals	2/8	[S27], [S11]
Conferences	2/8	[S27], [S11]
Overseas technology	2/8	[S10], [S22]
Other enterprises	1/8	[S22]
Training institutions	1/8	[S22]
Licensing enterprises	1/8	[S21]
Technological standards	1/8	[S22]
Patents	1/8	[S21]
Venture groups	1/8	[S13]
Internet	0	
All the employees	0	
Industry associations	0	
Financial institutions	0	
Co-workers	0	
Service providers	0	
Technology providers	0	
External environment	0	
Outsourced firms	0	
Experienced personal	0	

Table 24: Innovation sources identification 2000-2005

Innovation source	**Occurrences**	**Studies**
Users and customers	6/7	[S32] ,[S3],[S1], [S4], [S18], [S30]
Universities and Research center	6/7	[S3], [S1], [S4], [S23], [S18], [S30]
R & D department	6/7	[S3], [S1], [S4], [S23], [S18], [S30]
Suppliers	6/7	[S3], [S1], [S4], [S23], [S18],[S30]
Competitors	6/7	[S3], [S1], [S4], [S23], [S18], [S30]
Marketing and Sales department	4/7	[S32], [S3], [S1], [S18]
Consultancy organizations	4/7	[S3], [S1], [S18], [S30]
Production department	4/7	[S3], [S1], [S23], [S18]
Journals	4/7	[S3], [S1], [S18], [S30]
Top management	3/7	[S3], [S1], [S18]
Internet	3/7	[S3], [S1], [S30]
Co-workers	2/7	[S3], [S1]
Other enterprises	2/7	[S4] , [S30]
Conferences	2/7	[S18], [S30]
All the employees	1/7	[S4]
Management department	1/7	[S18]
Technological standards	1/7	[S18]
Service providers	1/7	[S23]
Patents	1/7	[S30]
Overseas technology	0	
Training institutions	0	
Venture groups	0	
Industry associations	0	
Financial institutions	0	
Licensing enterprises	0	
Technology providers	0	
External environment	0	
Outsourced firms	0	
Experienced personal	0	

Table 25: Innovation sources identification 2006-2011

Innovation source	**Occurrences**	**Studies**
Universities and Research center	19/20	[S28], [S29], [S17], [S33], [S31], [S6], [S12], [S26], [S34], [S24], [S5], [S9], [S25], [S14], [S19], [S35], [S8], [S20],[S2]
Users and customers	18/20	[S28],[S29],[S17],[S33],[S31],[S6],[S12], [S34], [S24], [S5], [S9], [S25], [S14], [S19], [S35], [S8], [S20], [S2]
Suppliers	16/20	[S28], [S29], [S17], [S31], [S6], [S12], [S34],[S24], [S5], [S9], [S25], [S14], [S35], [S8], [S20], [S2]
Competitors	15/20	[S28], [S29], [S17], [S33], [S31], [S6], [S12], [S24], [S5], [S25], [S14], [S19], [S35], [S8], [S20]
R & D department	9/20	[S33], [S31], [S6], [S12], [S26], [S34], [S5], [S14], [S19]
Consultancy organizations	8/20	[S28], [S31], [S12], [S34], [S24], [S25], [S14], [S8]
Conferences	7/20	[S17], [S31], [S12], [S26], [S15], [S20],[S2]
Other enterprises	7/20	[S6], [S12], [S24], [S5], [S25], [S8], [S2]
Marketing and Sales department	6/20	[S33], [S12], [S26], [S34], [S5], [S19]
Production department	6/20	[S33], [S12], [S26], [S34], [S5], [S19]
Patents	5/20	[S12], [S26], [S34], [S5],[S2]
Journals	5/20	[S31], [S6], [S26], [S15],[S2]
Overseas technology	5/20	[S26], [S15], [S34], [S5], [S35]
Internet	3/20	[S26], [S15],[S2]
Training institutions	3/20	[S29], [S26], [S15]
Industry associations	3/20	[S29], [S31], [S35]
Financial institutions	3/20	[S29], [S5], [S35]
Top management	2/20	[S15], [S5]
Management department	2/20	[S12], [S5]
Venture groups	2/20	[S5], [S35]
All the employees	2/20	[S6], [S5]
Technology providers	2/20	[S33], [S35]
Technological standards	1/20	[S17]
Licensing enterprises	1/20	[S17]
Service providers	1/20	[S29]
Outsourced firms	1/20	[S17]
Experienced personal	1/20	[S33]
Co-workers	0	
External environment	0	

Table 26: Innovation sources relevance assessment 1980-1999

Innovation source	**ISR**	**Studies**
Users and customers	27	[S7] x4,[S10] x4,[S16] x3, [S27] x1'5 x3, [S11] x1'5, [S21] x4, [S13] x1'5 x3, [S22] x1'5
R & D department	17	[S7], [S10], [S16] x4, [S27] x1'5, [S11] x1'5, [S21] x2, [S13] x1'5 x4
Marketing and Sales department	15'5	[S7] x3, [S10] x3, [S16], [S27] x1'5, [S11] x1'5, [S21] x4, [S22] x1'5
Production department	14,5	[S10], [S16], [S27] x1'5 x4, [S11] x1'5 x3, [S21] x2
Suppliers	11	[S27] x1'5 x2, [S11] x4, [S21], [S13] x1'5, [S22] x1'5
Competitors	9'5	[S7], [S10], [S27] x1'5, [S11] x1'5, [S21] x3, [S13] x1'5
Universities and Research center	8'5	[S27] x1'5, [S11] x1'5, [S21], [S13] x1'5 x2, [S22] x1'5
Top management	5'5	[S16] x2, [S21] x2, [S13] x1'5
Consultancy organizations	4'5	[S27] x1'5, [S11] x1'5, [S13] x1'5
Management department	4	[S7] x2, [S21] x2
Journals	4	[S27] x1'5, [S11] x1'5 x2
Conferences	4	[S27] x1'5, [S11] x1'5 x2
Overseas tech.	2'5	[S10], [S22] x1'5
Other enterprises	1'5	[S22] x1'5
Training institutions	1'5	[S22] x1'5
Tech. standards	1'5	[S22] x1'5
Venture groups	1'5	[S13] x1'5
Patents	1	[S21]
Licensing enterprises	1	[S21]
Internet	0	
All the employees	0	
Industry associations	0	
Financial institutions	0	
Co-workers	0	
Service providers	0	
Tech. providers	0	
External environment	0	
Outsourced firms	0	
Experienced personal	0	

Table 27: Innovation sources relevance assessment 2000-2005

Innovation source	**ISR**	**Studies**
Users and customers	23	[S32] x4,[S3] x1'5 x4,[S1] x1'5 x4, [S4] x2, [S18] x2, [S30] x3
R & D department	22	[S3] x1'5, [S1] x1'5, [S4] x4, [S23] x1'5 x4, [S18] x4, [S30] x4
Production department	13	[S3] x1'5, [S1] x1'5, [S23] x1'5 x4, [S18] x4
Marketing and Sales department	13	[S32] x3, [S3] x1'5 x2, [S1] x1'5 x2, [S18] x4
Universities and Research center	10'5	[S3] x1'5, [S1] x1'5, [S4] x1'5 x3, [S23], [S18], [S30]
Suppliers	10	[S3] x1'5, [S1] x1'5, [S4], [S23] x1'5 x2, [S18] x3,[S30]
Co-workers	9	[S3] x1'5 x3, [S1] x1'5 x3
Competitors	7'5	[S3] x1'5, [S1] x1'5, [S4], [S23] x1'5, [S18], [S30]
Top management	7	[S3] x1'5, [S1] x1'5, [S18] x4
Consultancy organizations	5	[S3] x1'5, [S1] x1'5, [S18], [S30]
Journals	5	[S3] x1'5, [S1] x1'5, [S18], [S30]
Internet	4	[S3] x1'5, [S1] x1'5, [S30]
Management department	4	[S18] x4
All the employees	3	[S4] x3
Other enterprises	2	[S4] , [S30]
Conferences	2	[S18], [S30]
Tech. standards	1	[S18]
Service providers	1	[S23]
Patents	1	[S30]
Overseas tech.	0	
Training institutions	0	
Venture groups	0	
Industry associations	0	
Financial institutions	0	
Licensing enterprises	0	
Tech. providers	0	
External environment	0	
Outsourced firms	0	
Experienced personal	0	

Table 28: Innovation sources relevance assessment 2006-2011

Innovation source	ISR	Studies and assessment
Users and customers	46	[S28] x3, [S29] x3,[S17],[S33],[S31] x3 x1'5, [S6],[S12] x3 x1'5, [S34], [S24], [S5] x1'5 x 2, [S2] x3, [S9] x1'5 x4, [S25] x2, [S14] x1'5 x4, [S19] x3, [S35] x2, [S8], [S20]
Suppliers	42'5	[S28] x4, [S29] x4, [S17] x2, [S31], [S6], [S12] x2 x1'5, [S34], [S24] x3, [S5] x 1'5, [S2], [S9] x1'5 x3, [S25] x4, [S14] x1'5 x3, [S35]x3, [S8] x3, [S20] x2
Universities and Research center	34'5	[S28] x2,[S29], [S17], [S33], [S31], [S6], [S12], [S26] x1'5, [S34], [S24] x4, [S5] x1'5, [S2] x2, [S9] x1'5 x2, [S25], [S14] x1'5, [S19], [S35] x4, [S8] x2, [S20] x4
R & D department	31	[S33] x4, [S31] x4 x1'5,[S6] x3, [S12], [S26] x2 x1'5, [S34], [S5] x1'5 x4, [S14] x1'5 x2, [S19] x4
Competitors	21	[S28], [S29], [S17], [S33], [S31] x2 x1'5, [S6], [S12], [S24], [S5] x1'5, [S25], [S14] x1'5, [S19] x2, [S35], [S8], [S20] x3
Production department	14	[S33] x2, [S12], [S26] x1'5, [S34], [S5] x1'5 x3, [S19] x4
Other enterprises	13'5	[S6], [S12], [S24] x2, [S5] x1'5, [S2], [S25] x3, [S8] x4
Marketing and Sales department	13	[S33], [S12], [S26] x1'5, [S34], [S5] x1'5 x3, [S19] x4
Journals	13	[S31], [S6] x2, [S26] x3 x1'5, [S15] x1 x1'5, [S2] x4
Conferences	11	[S17], [S31], [S12], [S26] x3 x1'5, [S15] x1 x1'5, [S2], [S20]
Overseas technology	11	[S26] x4 x1'5, [S15] x1'5, [S34], [S5] x1'5, [S35]
Consultancy organizations	8'5	[S28], [S31], [S12], [S34], [S24], [S25], [S14] x1'5, [S8]
Training org.	7	[S29], [S26] x3 x1'5, [S15] x1'5
Internet	7	[S26] x3 x1'5, [S15] x1'5, [S2]
Patents	6	[S12], [S26] x1'5, [S34], [S5] x1'5, [S2]
Financial institutions	4'5	[S29] x2, [S5] x1'5, [S35]
All the employees	4	[S6] x4
Outsourced firms	4	[S17] x4
Tech. providers	4	[S33] x3, [S35]
Top management	3	[S15] x1'5, [S5] x1'5
Industry associations	3	[S29], [S31], [S35]
Tech. standards	3	[S17] x3
Management department	2'5	[S12], [S5] x1'5
Venture groups	2'5	[S5] x1'5, [S35]
Service providers	1	[S29]
Licensing enterprises	1	[S17]
Experienced personal	1	[S33]
Environment	0	
Co-workers	0	

10 Appendix B: Analysis of IS across countries

This appendix provides information about the number of occurrences and the relevance of the identified innovation sources in developing and developed countries. The tables 30, 29 show information about the number of occurrences of innovation sources in developing and developed countries. The tables 32, 31 show information about the number of occurrences of innovation sources in developing and developed countries.

Table 29: Innovation sources identification - Developed countries

Innovation source	**Ocurrences**	**Studies**
Users and customers	19/21	[S7],[S10],[S16],[S32],[S2],[S3],[S1], [S27], [S11], [S24], [S21], [S9], [S13], [S18], [S14], [S19], [S8], [S20], [S22]
Universities and Research center	17/21	[S3], [S1], [S26], [S27],[S2], [S11], [S24], [S21], [S23], [S9] , [S13], [S18], [S14], [S19], [S8], [S20], [S22]
Suppliers	15/21	[S3], [S1], [S27], [S11] ,[S24] , [S2], [S21], [S23], [S9], [S13], [S18], [S14], [S8], [S20], [S22]
Competitors	15/21	[S7], [S10], [S3], [S1], [S27], [S11], [S24], [S21], [S23], [S13], [S18], [S14], [S19], [S8], [S20]
R & D department	14/21	[S7], [S10], [S16], [S3], [S1], [S26], [S27], [S11], [S21], [S23], [S13], [S18], [S14], [S19]
Marketing and Sales department	13/21	[S7], [S10], [S16], [S32], [S3], [S1], [S26], [S27], [S11], [S21], [S18], [S19], [S22]
Production department	11/21	[S10], [S16], [S3], [S1], [S26], [S27], [S11], [S21], [S23], [S18], [S19]
Consultancy organizations	9/21	[S3], [S1],[S27], [S11], [S24], [S13], [S18], [S14], [S8]
Journals	7/21	[S3], [S1], [S26], [S27], [S11], [S2], [S18]
Conferences	6/21	[S26], [S27], [S11], [S2], [S18], [S20]
Top management	6/21	[S16], [S3], [S1], [S21], [S13], [S18]
Other enterprises	4/21	[S24], [S2], [S8], [S22]
Internet	4/21	[S3], [S1], [S26], [S2]
Patents	3/21	[S26], [S2], [S21]
Overseas tech.	3/21	[S10], [S26], [S22]
Management department	3/21	[S7], [S21], [S18]
Training institutions	2/21	[S26], [S22]
Venture groups	2/21	[S16], [S13]
Tech. standards	2/21	[S18], [S22]
Co-workers	2/21	[S3], [S1]
Licensing enterprises	1/21	[S21]
Service providers	1/21	[S23]
Environment	1/21	[S16]
All the employees	0	
Industry associations	0	
Financial institutions	0	
Tech. providers	0	
Outsourced firms	0	
Experienced personal	0	

Table 30: Innovation sources identification - Developing countries

Innovation source	**Ocurrences**	**Studies**
Users and customers	14/14	[S16], [S28], [S29],[S17],[S33],[S31],[S4],[S6],[S12], [S34], [S5], [S25], [S35], [S30]
Universities and Research center	13/14	[S28], [S29], [S17], [S33], [S31], [S4], [S6], [S12], [S34], [S5], [S25], [S35], [S30]
Suppliers	12/14	[S28], [S29], [S17], [S31], [S4], [S6], [S12], [S34], [S5], [S25], [S35], [S30]
Competitors	12/14	[S28], [S29], [S17], [S33], [S31], [S4], [S6], [S12], [S5], [S25], [S35], [S30]
R & D department	9/14	[S16], [S33], [S31], [S4], [S6], [S12], [S34], [S5], [S30]
Consultancy organizations	6/14	[S28], [S31], [S12], [S34], [S25],[S30]
Other enterprises	6/14	[S4], [S6], [S12], [S5], [S25], [S30]
Marketing and Sales department	5/14	[S16],[S33], [S12], [S34], [S5]
Production department	5/14	[S16], [S33], [S12], [S34], [S5]
Conferences	5/14	[S17], [S31], [S12], [S15], [S30]
Journals	4/14	[S31], [S6], [S15], [S30]
Patents	4/14	[S12], [S34], [S5], [S30]
Overseas tech.	4/14	[S15], [S34], [S5], [S35]
Top management	3/14	[S16], [S15], [S5]
Venture groups	3/14	[S16], [S5], [S35]
All the employees	3/14	[S4], [S6], [S5]
Industry associations	3/14	[S29], [S31], [S35]
Financial institutions	3/14	[S29], [S5], [S35]
Internet	2/14	[S15], [S30]
Management department	2/14	[S12], [S5]
Training institutions	2/14	[S29], [S15]
Tech. providers	2/14	[S33], [S35]
Tech. standards	1/14	[S17]
Licensing enterprises	1/14	[S17]
Service providers	1/14	[S29]
Environment	1/14	[S16]
Outsourced firms	1/14	[S17]
Experienced personal	1/14	[S33]
Co-workers	0	

Table 31: Innovation sources relevance assessment - Developed countries

Innovation source	ISR	Studies and assessment
Users and customers	66	[S7] x4,[S10] x4,[S16] x3,[S32] x4,[S3] x4 x1'5,[S1] x4 x1'5, [S27] x3 x1'5, [S11] x1'5, [S24], [S2] x3, [S21] x4, [S9] x1'5 x4,[S13] x1'5 x3, [S18] x2, [S14] x1'5 x4, [S19] x3, [S8], [S20], [S22] x1'5
R & D department	40	[S7], [S10], [S16] x 4, [S3] x1'5,[S1] x1'5, [S26] x2 x1'5, [S27] x1'5,[S11] x1'5, [S21] x2, [S23] x1'5 x4, [S13] x1'5 x4, [S18] x4, [S14] x1'5 x2, [S19] x4
Suppliers	40	[S3] x1'5, [S1] x1'5, [S27] x2 x1'5, [S11] x4 x1'5, [S24] x3,[S2], [S21], [S23] x1'5 x2, [S9] x1'5 x3,[S13] x1'5, [S18] x3, [S14] x1'5 x3,[S8] x3, [S20] x2, [S22] x1'5
Universities and Research center	36	[S3] x1'5, [S1] x1'5, [S26] x1'5, [S27] x1'5, [S11] x1'5,[S24] x4, [S2] x2, [S21], [S23] x1'5 x3, [S9] x1'5 x2, [S13] x1'5 x2, [S18], [S14] x1'5, [S19], [S8] x2, [S20] x4, [S22] x1'5
Marketing and Sales staff	34	[S7] x3, [S10] x3 , [S16], [S32] x 3, [S3] x2 x1'5, [S1] x2 x1'5, [S26] x1'5, [S27] x1'5, [S11] x1'5, [S21] x4, [S19] x4, [S22] x1'5, [S18] x4
Production department	33	[S10], [S16], [S3] x1'5, [S1] x1'5, [S26] x1'5, [S27] x4 x1'5, [S11] x3 x1'5, [S21] x2, [S23] x1'5 x4, [S18] x4, [S19] x4
Competitors	23'5	[S7], [S10], [S3] x1'5, [S1] x1'5, [S27] x1'5, [S11] x1'5, [S24], [S21] x3, [S23] x1'5, [S13] x1'5, [S18], [S14] x1'5, [S19] x2, [S8], [S20] x3
Journals	17	[S3] x1'5, [S1] x1'5, [S26] x3 x1'5, [S27] x1'5, [S11] x2 x1'5, [S2] x4, [S18]
Top management	12'5	[S16] x 2, [S3] x1'5, [S1] x1'5, [S21] x2, [S13] x1'5, [S18] x4
Conferences	12	[S26] x3 x1'5, [S27] x1'5, [S11] x2 x1'5, [S2], [S18], [S20]
Consultancy organizations	12	[S3] x1'5, [S1] x1'5, [S27] x1'5, [S11] x1'5, [S24], [S13] x1'5, [S18], [S14] x1'5, [S8]
Co-workers	9	[S3] x3 x1'5, [S1] x3 x1'5
Other enterprises	8'5	[S24] x2, [S2], [S8] x4, [S22] x1'5
Internet	8'5	[S3] x1'5, [S1] x1'5, [S26] x3 x1'5, [S2],
Overseas tech.	8'5	[S10], [S26] x4 x1'5, [S22] x1'5
Management department	8	[S7] x 2, [S21] x2, [S18] x4
Training institutions	6	[S26] x3 x1'5, [S22] x1'5
Patents	5'5	[S26] x1'5, [S2] , [S21] x3
Tech. standards	2,5	[S18], [S22] x1'5
Venture groups	2'5	[S16], [S13] x1'5
Service providers	1'5	[S23] x1'5
Licensing enterprises	1	[S21]
Environment	1	[S16]
Financial institutions	0	
Outsourced firms	0	
Experienced personal	0	
Tech. providers	0	
Industry associations	0	
All the employees	0	

Table 32: Innovation sources relevance assessment - Developing countries

Innovation source	**ISR**	**Studies and assessment**
Users and customers	34	[S16] x3,[S28] x3,[S29] x3,[S17],[S33],[S31] x3 x1'5,[S4] x2,[S6],[S12] x3 x1'5,[S34],[S5] x1'5 x 2,[S25] x2,[S35] x2,[S30] x3
R & D department	33	[S16] x4,[S33] x4, [S31] x4 x1'5, [S4] x4, [S6] x3, [S12], [S34], [S5] x1'5 x4, [S30] x4
Suppliers	27'5	[S28] x4, [S29] x4, [S17] x2, [S31], [S4], [S6], [S12] x2 x1'5, [S34], [S5] x 1'5, [S25] x4, [S35]x3, [S30] x2
Universities and Research center	17'5	[S28] x2, [S29], [S17], [S33], [S31], [S4], [S6], [S12], [S34], [S5] x1'5, [S25],[S35] x4, [S30]
Competitors	14'5	[S28], [S29], [S17], [S33], [S31] x2 x1'5, [S4], [S6], [S12], [S5] x1'5, [S25], [S35], [S30]
Production department	9'5	[S16],[S33] x2, [S12], [S34], [S5] x1'5 x3
Marketing and Sales staff	8'5	[S16],[S33], [S12], [S34], [S5] x1'5 x3
Other enterprises	8'5	[S4], [S6], [S12], [S5] x1'5, [S25] x3, [S30]
All the employees	7	[S4] x3, [S6] x4
Conferences	6'5	[S17], [S31], [S12], [S15] x1'5, [S30] x2
Consultancy organizations	6	[S28], [S31], [S12], [S34], [S25], [S30]
Journals	5'5	[S31], [S6] x2, [S15] x1'5, [S30]
Overseas tech.	5	[S15] x1 x1'5, [S34], [S5] x1'5, [S35]
Top management	5	[S16] X2, [S15] x1'5, [S5] x1'5
Patents	4'5	[S12], [S34], [S5] x1'5, [S30]
Financial institutions	4'5	[S29] x2, [S5] x1'5, [S35]
Outsourced firms	4	[S17] x4
Tech. providers	4	[S33] x3, [S35]
Venture groups	3'5	[S16],[S5] x1'5, [S35]
Tech. standards	3	[S17] x3
Industry associations	3	[S29], [S31], [S35]
Internet	2'5	[S15] x1'5, [S30]
Management department	2'5	[S12], [S5] x1'5
Training institutions	2'5	[S29], [S15] x1'5
Service providers	1	[S29]
Experienced personal	1	[S33]
Environment	0	
Licensing enterprises	0	
Co-workers	0	

11 Appendix C: Analysis of IS across knowledge fields

This appendix provides information about the number of occurrences and the relevance of the identified innovation sources in studies strongly connected with the software engineering field. The tables 33 and 34 show information about the number of occurrences of the innovation sources and its relevance degree.

Table 33: Innovation sources identification in studies strongly connected with software engineering

Innovation source	**Occurrences**	**Studies**
Users and customers	11/14	[S3],[S1],[S31],[S12], [S27],[S11],[S5],[S9],[S13],[S14],[S22]
Suppliers	11/14	[S3],[S1],[S12],[S27],[S11],[S5],[S23],[S9],[S13],[S14],[S22]
Universities and Research center	11/14	[S3],[S1],[S26],[S27], [S11],[S5],[S23],[S9],[S13],[S14], [S22]
R & D department	10/14	[S3],[S1],[S31],[S26],[S27], [S11],[S5],[S23],[S13], [S14]
Competitors	9/14	[S3],[S1],[S31],[S27],[S11], [S5],[S23],[S13],[S14]
Production department	7/14	[S3],[S1],[S26],[S27], [S11],[S5],[S23]
Marketing and Sales department	7/14	[S3],[S1],[S26],[S27],[S11],[S5],[S22]
Consultancy organizations	6/14	[S3],[S1],[S27],[S11],[S13],[S14]
Journals	6/14	[S3],[S1],[S26],[S15],[S27], [S11]
Top management	5/14	[S3],[S1],[S15],[S5],[S13]
Overseas technology	4/14	[S26],[S15],[S5],[S22]
Conferences	4/14	[S26],[S15],[S27],[S11]
Internet	4/14	[S3],[S1],[S26],[S15]
Training institutions	3/14	[S26],[S15],[S22]
Co-workers	2/14	[S3],[S1]
Patents	2/14	[S26],[S5]
Other enterprises	2/14	[S5],[S22]
Venture groups	2/14	[S5],[S13]
Management department	1/14	[S5]
Technological standards	1/14	[S22]
Financial institutions	1/14	[S5]
Service providers	1/14	[S23]

Table 34: Innovation sources relevance assessment in studies strongly connected with software engineering

Innovation source	**ISR**	**Studies and assessment**
Users and customers	45	[S3] x4 x1'5,[S1] x4 x1'5,[S31] x3 x1'5,[S12] x3 x1'5, [S27] x3 x1'5, [S11] x1'5, [S5] x1'5 x 2, [S9] x1'5 x4, [S13] x1'5 x3, [S14] x1'5 x4, [S22] x1'5
R & D department	36	[S3] x1'5, [S1] x1'5, [S31] x4 x1'5, [S26] x2 x1'5, [S27] x1'5, [S11] x1'5, [S5] x1'5 x4, [S23] x1'5 x4, [S13] x1'5 x4, [S14] x1'5 x2
Suppliers	31'5	[S3] x1'5, [S1] x1'5, [S12] x2 x1'5, [S27] x2 x1'5, [S11] x4 x1'5, [S5] x 1'5, [S23] x1'5 x2, [S9] x1'5 x3, [S13] x1'5, [S14] x1'5 x3, [S22] x1'5
Production department	25'5	[S3] x1'5, [S1] x1'5, [S26] x1'5, [S27] x4 x1'5, [S11] x3 x1'5, [S5] x3 x1'5, [S23] x1'5 x4
Universities and Research center	22'5	[S3] x1'5, [S1] x1'5, [S26] x1'5, [S27] x1'5, [S11] x1'5, [S5] x1'5, [S23] x1'5 x3, [S9] x1'5 x2, [S13] x1'5 x2, [S14] x1'5, [S22] x1'5
Marketing and Sales department	16'5	[S3] x2 x1'5, [S1] x2 x1'5, [S26] x1'5, [S27] x1'5, [S11] x1'5, [S5] x1'5 x3, [S22] x1'5
Competitors	15	[S3] x1'5, [S1] x1'5, [S31] x2 x1'5, [S27] x1'5, [S11] x1'5, [S5] x1'5, [S23] x1'5, [S13] x1'5, [S14] x1'5
Journals	13'5	[S3] x1'5, [S1] x1'5, [S26] x3 x1'5, [S15] x1'5, [S27] x1'5, [S11] x2 x1'5
Overseas technology	10'5	[S26] x4 x1'5, [S15] x1'5, [S5] x1'5, [S22] x1'5
Conferences	10'5	[S26] x3 x1'5, [S15] x1'5, [S27] x1'5, [S11] x2 x1'5
Consultancy organizations	9	[S3] x1'5, [S1] x1'5, [S27] x1'5, [S11] x1'5, [S13] x1'5, [S14] x1'5
Internet	9	[S3] x1'5, [S1] x1'5, [S26] x3 x1'5, [S15] x1'5
Co-workers	9	[S3] x3 x1'5, [S1] x3 x1'5
Top management	7'5	[S3] x1'5, [S1] x1'5, [S15] x1'5, [S5] x1'5, [S13] x1'5
Training institutions	7'5	[S26] x3 x1'5, [S15] x1'5, [S22] x1'5
Patents	3	[S26] x1'5, [S5] x1'5
Other enterprises	3	[S5] x1'5, [S22] x1'5
Venture groups	3	[S5] x1'5, [S13] x1'5
Management department	1'5	[S5] x1'5
Technological standards	1,5	[S22] x1'5
Financial institutions	1'5	[S5] x1'5
Service providers	1'5	[S23] x1'5

12 Appendix D: Narrative analysis of SLR studies

In this section an overview of every contribution included in the SLR are presented. These information have been also collected in several spreadsheet in order to support the data extraction and the synthesis strategy. For each SLR contribution it has been emphasized: (i) contextual information, (ii) evidences related to our research questions, mainly assessed innovation sources taxonomies based on empirical data and several narrative discussions related to usage trends of the innovation sources, and (iii) quality and suitability for our SLR.

12.1 Cooper´ s contribution

An exploratory study about 253 new product histories at 123 industrial product manufacturers firms was done by Dr.Cooper in Canada in 1986 [S7]. He analysed the hole innovation process and the required activities to get success on the new products. One of the aspects to tackle was the origin of the idea that produced the innovative product. To accomplish that the following list of ideas sources, with the percentage of occurrence measured in the analysed projects, was provided: customer (20), sales force (17.4), management (13.3), R & D department(12.3), competitors(7.7), engineering department(7.2), etc.

For our study, this classification have a couple of weaks. In one hand, this classification assumes that the origin of an idea is only one; but like it said before, the innovative ideas identification have an holistic character and normally an idea comes from various sources. In the other hand, the sample of firms are industrial product manufacturer not software organizations; so the percentages of the sources are relative and the absence of not useful sources for software engineering or the presence of useful sources for software engineering is not guaranteed.

Anyway, the provided list of ideas sources are relevant for our study: an innovation can come from internal sources like **sales force, management, R & D and engineering department** or external sources like **customers and competitors**.

12.2 Yoon´ s contribution

An exploratory study at 135 firms, that were classified in different sectors like (i)engineering equipment, (ii)electric and electronic equipment, (iii)chemical, plastic, minerals and metals industry, etc, was done by Dr.Yoon in Australia in 1988 [S10]. He analysed the role of the distributors as an innovation participant, and its influence in the hole innovation process. For our purpose, it have been found a list of innovation sources, ordered by the importance perceived through questionnaires filled by the involved firms, that is as follows: customers, market research, sales and marketing departments, overseas technology, R & D department, production department, competitors, etc.

For our study, this classification have a couple of weaks. In one hand, the method to get the importance of an innovation source are a survey based on the subjective opinion of the involved firms, not in objective analysis like the Cooper´ s studies; so, the reliability of this classification is relative. In other hand, the sample of firms are very heterogeneous, not being focused in software organizations; so, the assigned importance is relative and the absence of non useful sources for software engineering or the presence of useful sources for software engineering is not guaranteed.

Anyway, the provided list of innovation sources are relevant for our study: an innovative idea can come from internal sources like **sales and marketing departments, R & D department or production department** and external sources like **customers, competitors or overseas technology**.

12.3 Koen´ s contribution

An exploratory study to know who has the best ideas was done by Koen [S16] in 1998, mechanisms based on interviews and questionnaires were used to identify the importance of the innovation sources in 34 innovative projects on 12 firms. Different kinds of innovation were taken in account to make the study: (i) radical innovation, when the new product or service provides new features and benefits to the customer (ii)platform innovation, when the new product or service enables possibilities of innovation, and (iii)incremental product innovations, when the current product or service is updated with minor changes.

The taxonomy of innovation sources was identified on interviews conducted with corporate executives and it was as follows: **(i)customers, (ii)external environment, (iii)president, (iv)marketing & sales staff, (v)R & D staff, (vi) operations staff and (vii)venture groups**. The participants had to fill the degree of responsibility of the innovative ideas occurred in the projects and they had the possibility to select various sources like involved on the innovative idea generation.

The results of the study shows the best ideas sources in the kinds of innovation previously defined. In case of radical innovations, the best innovation sources were engineers and scientists of the R & D staff, customers and product managers. In the case of platform innovations, the best innovation sources were engineers and scientists of the R & D staff, customers, the president and senior sales managers. In the case of incremental innovations, the best innovation sources were engineers, scientists and managers of the R & D staff and engineers and managers of operations staff. The study shows the importance of the managers involvement on the innovation process and find in the interactions between the engineer or scientist and the customer the most important source of ideas.

For our study, this contribution have some weaks mentioned previously. The method to get the importance of an innovation source are subjective because it is only based on questionnaires and interviews, not in objective analysis. Besides, the sample of innovative projects not are directly connected with software engineering. So, the importance of the innovation sources is relative and the absence of non useful sources for software engineering or the presence of useful sources for software engineering is not guaranteed.

Anyway, the provided list of innovation sources will be taken in account to build our taxonomy and the finding about the **high importance of interactions between engineers or scientist and customers** could be extrapolate to innovative ideas generation in the software intensive systems development.

12.4 White´ s contribution

Ten case studies about innovation in different kinds of industry were analysed by White [81] in United Kingdom in 2000 to find the most important innovation sources. To increase in a scientific way the knowledge surrounding the sources of innovation the paradigm of Phenomenology [S32] was used to find the following conclusions:

- **Customers** can generate and develop some of the successful ideas. They can involve on the innovation process with different activities: (i)generation of the idea and active collaboration in its development (ii)development of the requirements (iii)redefinition of the applications that a product could be used, (iv)testing of solutions and (v)definition of the problems to solve.
- An individual, internal or external to the company, is the responsible for conceiving, accessing and sponsoring the innovation.
- The mechanisms, technologies or practices used in an innovation process can have been already applied in **another contexts**.
- The **knowledge and understanding of market trends and the characteristics and behaviours of the customers** can be used as sources of new ideas. This knowledge can be used to (i)facilitate the generation of ideas, (ii)verify the demand for an idea already conceived and (iii)develop an idea already in existence.

Probably, some of these findings can be applied to software engineering, but its reliability can not be guaranteed due to the ten case studies are very far of the software engineering field. Once more time, studies more focused on software organizations are required to develop successfully an innovation sources taxonomy for software engineering field.

12.5 Tian´ s contribution

An exploratory study about the categories of external technology sources in open innovation was conducted with 20 Chinese firms, involving 95 people, in 2010 by Tian et al [S28]. To make the study, an innovation source taxonomy was built based on the available literature, specially on the Oslo Manual [56] and Community Innovation Survey [24], and a subjective approach based on interviews with technical managers and questionnaires was used.

The following taxonomy for external innovation source was used: **users, suppliers, competitors, universities and research institutes, and R & D service companies**. The results of the survey, analysed with statistical techniques, shows the perceived importance of every innovation source. The most important source is the supplier (more than 75% considered it important or very important), the second one is the users (more than 45% considered it important or very important), the third one are universities and research institutes (more than 35% considered it important or very important), finally the competitors and the R& D services companies are not perceived as critical innovation sources (only 25% and 20% respectively considered it important or very important).

This survey was conducted with different Chinese organizations, technological or not; so the reliability of the results for software engineering field is relative. Anyway, the used taxonomy for external innovation sources and the obtained results could be useful for our work and it could be partially applied to software engineering field.

12.6 Boomer´ s contribution

An exploratory study to compare the importance of different sources of innovation was conducted by Boomer [S3] in 2004. 235 R & D professionals, who worked in large and small technology-based firms, provided their opinion about the importance of different sources on the innovative ideas generation.

The following classification of the innovation sources was elaborated though interviews and it is as follows: internal sources like **co-workers, internal R & D, marketing department, top management and manufacturing department** and external sources like **users or customers, competitors, cooperation with other companies, suppliers, universities or research institutions, consultants, acquisition of new equipment, professional journals, internet** are taken in account to elaborate the survey. The results, obtained using statistical techniques, shows that customers, co-workers, marketing, professional journals and suppliers (specially in large firms) are the most relevant sources of innovation.

These findings are much more reliability than other analysed studies because the sample are technology-based firms, not industrial or service firms.

12.7 Baranano´ s contribution

An exploratory study about the sources of innovation for high-technology Small and Medium Enterprises (SMEs) in USA, Canada, and Portugal was conducted in 2005 by Baranano et al [S1]. The study was done too by Boomer, so it had several similarities with the previously analysed contribution [S3]. The purpose of the authors was to compare the importance of different sources of innovative ideas in high-technology SMEs in USA, Canada, and Portugal. To do that a strategy very close to the previous contribution [S3], based on interviews and questionnaires filled by 191 R & D workers, was executed.

The results were similar to the previous contribution [S3], but significant differences were found between countries. The perceived importances of several sources (customers, co-workers, competitors, internal R & D, manufacturing, top management, cooperation with other firms, university and research institutions, and professional journals) are different, being the internal sources more important for workers in Canada and Portugal and the external sources more important fort workers in USA, where the findings about the benefits of external sources are more extended. So, it can be said that the perceived importance of the innovation sources changes across technology firms of different countries like Portugal, Canada and USA.

Despite the global context, currently the situation about innovation sources management not is the same for every country. Probably, there are several differences too between Spain, country where this work is being done, and other European countries and USA, where the most of the analysed studies for this work were conducted. Like it said before, the current situation in Spain in activities like the identification of innovation sources and its use could be different to another countries, but no researches with Spanish technology firms about this topic have been found.

12.8 Jun´ s contribution

An empirical study about determinants of innovation capability in Small and Medium Enterprises (SMEs) in China was conducted in 2006 by Jun et al [S29]. The authors provide a model with a set of determinant factors on innovation capability, some of them involves directly innovation sources and they are useful for our study, and others no. This model is tested empirically using the survey method in 75 SMEs (some of them related to software firms, others no) to find the relation between these factors and the firm´ s innovation capability.

To classify the innovation sources the criteria of internal and external to the firm was used. Like internal sources the authors pointed out to education background and work experience of the entrepreneurs, the skills of employees and the finance and technology resources that have influence in R & D investment; adapting these ideas to our study about innovation sources, it can be tailored as follows: **entrepreneurs, employees and R & D investment**. Like external sources the authors provide the following agents: **suppliers, customers, financial institutions, training institutions, R & D institutions, service providers, industry associations and competitors**. The previous taxonomy could be useful for our study.

The results of the survey pointed out to the internal R & D investment and the relations with customers and public institutions like the most determinant factors. Anyway, these results are partially valid for our study due to many firms of the study are not involved in software activities and there is no segmentation of the results by sectors. So, the relevance of these innovation sources, the presence of useful innovation sources and the absence of not useful innovation sources in software engineering field is not guaranteed. The importance of its findings is minor than others.

12.9 Kruglianskas´ s contribution

An exploratory study in Brazilian large enterprises about the management of external sources of technological information was conducted in 2007 by Kruglianskas et al [S17]. The authors set out the relationship between the innovation performance and two variables: the access modality to sources of technological information and the types of sources of technological information. The relevance of these variables are empirically analysed collecting with a survey the perceptions of managers of the technology area of 72 companies of different contexts: electronic, telecommunications, chemicals and automotive.

Initially, the authors provided a large taxonomy of 26 items to classify the sources of technological information. Finally, this taxonomy is reduced taking account the results of the survey about the relevance of these sources. The resulting classification, ordered by the number of found correlations with innovation performance, are as follows: **contracted-outsourced firms, technological standards adoption, suppliers, clients, competitors, research institutes, professional and scientific conferences, visits to other enterprises and licensing enterprises**. Despite the previous taxonomy are focused in sources of "technological information" (not in "innovation"), these ideas could be useful for our study.

Like it has be seen in another studies, this contribution is not focused in software organizations. For our study, the relevance of these innovation sources, the presence of useful innovation sources and the absence of not useful innovation sources in software engineering field is not guaranteed. So, the importance of its findings is minor than others.

12.10 Xiaoqing´ s contribution

An study in China about the external knowledge sources for accumulation of technology capabilities was conducted in 2006 by Xiaoqing et al [S33]. The authors present a model, composed by three stages, for technological capability evolution in Chinese context during the last decades. Using the survey method, the evolution and the current importance of knowledge sources in 6 large Chinese firms is analysed.

A taxonomy for internal and external innovation sources is provided in the present contribution. These classification have been used in the survey to identify the importance of each innovation source in every firm. There are differences between the information provided by the involved firms, but they are not relevant for our study. The resulting taxonomy is as follows: **Internal R & D, cooperation with foreign technology providers, reverse engineer to foreign equipment and product, acquiring foreign experienced technology personal, cooperation R & D with other Chinese firms, Chinese universities and the institutes of scientific research, acquiring Chinese experienced technology personal, customer relationship, sale men and customer involved in innovation, and customer involving innovation**.

This contribution and the provided taxonomy of innovation sources can be useful for our purposes, nevertheless it is necessary to emphasize some aspects that decrease the suitability of the present contribution for our study. Firstly, the high tailored degree to Chinese context can hinder the extension of the findings to another contexts. Secondly, this contribution is not focused in software organizations; so, the relevance of these innovation sources, the presence of useful innovation sources and the absence of not useful innovation sources in software engineering field is not guaranteed.

12.11 Wang´ s contribution

A study in Taiwan about the innovation profiles of outstanding companies was conducted in 2009 by Wang et al [S31]. The authors tried to identify the innovation profiles of a set of companies involved in Taiwan Industrial Technology Advancement Awards. Using a survey based on the Community Innovation Survey [24] from Oslo Manual [56], 61 valid questionnaires about critical innovation aspects were fulfilment. The innovation sources topic was one of the aspects dealt in the present contribution.

A taxonomy for the sources of information for innovation activities was provided to enable the measurement of the importance degree of the innovation sources for Taiwan companies. The resulting classification, ordered by relevance, is as follows: **Internal R & D, clients or customers, competitors or other enterprises of the sector, conferences and similar events, suppliers,**

professional and industrial associations, scientific journals and technical publications, consultants or private R & D institutes, universities or other higher institutions, government or public research institutes.

The provided classification, based on the Community Innovation Survey [24] from Oslo Manual [56], is useful for our study. However, the relevance of the innovation sources is not totally suitable for our study due to the Taiwan context can differ from European context. Besides, the study do not specify the sector of the involved firms and there is no guaranteed that these companies are focused on software development. Anyway, the findings of the present contribution are taking into account for our study.

12.12 Chen´ s contribution (1)

A study in China about the allocation of innovation resources was conducted in 2005 by Chen et al [S4]. The authors present the open innovation paradigm and emphasizing the use of a large pool of innovation sources. A large Chinese company of the steel industry, named Shanghai Baosteel Corporation, is studied under the open innovation paradigm.

The innovation sources used by this exemplary firm are as follows: **Internal R & D, all the employees, customers, suppliers, R & D collaboration with universities, research institutes and international enterprises**.

The provided taxonomy is partially useful for our study. The analysed firm, focused on steel industry in Chinese context, is strongly disconnected from the software engineering field in developed contexts. Anyway, the innovation sources used by the presented company can be considered too by software development firms.

12.13 Chen´ s contribution (2)

A case study in China about the determinants of the growth of absorptive capacity from an open innovation perspective was conducted in 2008 by Chen et al [S6]. The authors provide a connection between two concepts related to innovation sources: the open innovation paradigm and the absorptive capacity. Then, a Chinese firm, focused on telecommunication sector and named HX Consulting Co, is studied under both concepts.

The critical factors for HX success are identified like a set of innovation drivers: Knowledge bases, R & D activities, Organizational management and Social capital. These factors can be translate into an innovation sources classification as follows: **employees, internal R & D, staff training -previously performed projects, professional magazines, training course-ware, etc.-, non-competing companies, competing companies, customers, suppliers, scientific research institutions, universities and government de-**

partments. The relevance of every innovation source is not provided, thus the presented taxonomy are not ordered.

This contribution is partially suitable for our study. In one hand, the analysed firm is framed on technological sector, not in software engineering field. In the other hand, and like it is said in other cases, the Chinese context can differ from developed contexts. Despite these undesirable features, the provided taxonomy will be considered in our study.

12.14 Ferreira´ s contribution

A study in Brazil about the technological innovation in Knowledge Intensive Business Services (KIBS) was conducted in 2006 by Ferreira et al [S12]. The authors present KIBS in the Brazilian context and uses like data source the Economical Activity Survey in Sao Paolo (PAEP), which is based on the Community Innovation Survey [24] from Oslo Manual [56]. The data source was fed by more than 25.000 companies involved in a wide set of sectors, being specially relevant for our study the computer-related firms. Different innovation aspects have been tackled in this contribution, and the innovation sources is one of them.

A taxonomy for the sources of information for innovation activities was provided to enable the measurement of the importance degree of the innovation sources for Brazilian companies. The resulting classification, ordered by relevance, is as follows: **Company departments, clients, suppliers, companies of the same group, competitors, fairs and expositions, conferences and similar events, consultancy firms, acquisition of licenses and patents, universities and other higher education, research institutes**.

The provided classification, based on the Community Innovation Survey [24] from Oslo Manual [56], can be useful for our study. However, the relevance of the innovation sources is not totally suitable for our study due to Brazil is a developing country and its situation can differ from the European developed countries. Besides, a wide set of sectors have been included on this study, not only companies focused on software development. Anyway, the findings of the present contribution are valuable for our study.

12.15 Sheehan´ s contribution

An analysis of innovation on services sector in developed countries, mainly in Europe Union, was done in 2006 by Sheehan [S26]. The author uses empirical data from Eurostat [25], that have been gathered by means of the Community Innovation Survey from 2004 or CIS3 [55], to emphasize the importance of the services sector (with a high rate of telecommunications or computer-related firms) generating innovation.

One of the aspects analysed by the author are the activities that contribute to innovation on services firms, which can be seen as the innovation sources. The following taxonomy, ordered by relevance, is provided: acquisition of equipment, training -knowledge from conferences, journals or internet and training institutions-, internal R & D, market innovations, production activities, acquisition of knowledge -patents, etc., external R & D.

This contribution is suitable for our purposes due to it is grounded on data from 15 European countries and it is focused on services organizations, that includes software firms. Besides, some interesting ideas related to innovation sources are provided. The internal R & D activities relies less in service sector than in traditional manufacturing sector, being more important for service companies the acquisition of equipment and the trained people. Finally, another innovation source pointed out by the author is related to the research on non-technological aspects of services sector innovation using the advances from social sciences and management.

12.16 Koc´ s contribution

An study about the organizational determinants of innovation capability in software companies was conducted in 2007 by Koc [S15]. This contribution use the survey method and statistical techniques to get knowledge from 91 Turkish SMEs focused on software development activities.

The innovation sources issue is not directly tackled in this study, but some ideas for our study can be extracted. An identification and relevance assessment of innovation sources are not provided, but factors related to innovation capability that involves some innovation sources are analysed. Sources like training, overseas technology, employees skills and top management involvement are identified like suitable elements to be considered to increase the innovation capability in software organizations.

This contribution does not provide a complete and ordered taxonomy of innovation sources, but it is so focused on software development and it deals indirectly with innovation sources issue.

12.17 Raffa´ s contribution

A study about the sources of innovation and professionals in small innovative firms was conducted in Italy in 1994 by Raffa et al [S22]. The survey method and case studies was used to gather information from 50 small software firms strongly focused in software development. The authors present a model to explain the oscillating behaviour of small software firms, which need to balance the structure of the firm and their innovation source usage during its life.

The list of innovation sources extracted from this contribution, not ordered by relevance, is as follows: overseas technology, training, standards, market knowledge, customers, suppliers, other firms, and universities. Despite, suitability degree of some innovation sources vary across the different phases of a firm, the previous list and the relevance of its elements are not directly provided in this contribution.

However an explicit and ordered taxonomy of innovation source is not presented and some information is not enough justified with empirical knowledge, this study is strongly focused on software firms. This fact is very valuable for our SLR, where only a few studies totally focused on software development are being founded. Despite, this publication has more than 15 years, its findings will be taken into account in our study.

12.18 Sirilli´ s contribution

An study about technological innovation in service and manufacturing firms was conducted in Italy in 1998 by Sirilli et al [S27]. This contribution uses a survey executed by the National Statistical Institute in 1997 and it is based on the guidelines provided by the Oslo Manual [56]. The survey involves more than 19.000 firms, and some of them (exactly, 972) are related with computing and software activities. Different issues are dealt in the contribution, and the sources of innovation is one of these.

The innovation sources taxonomy, ordered by relevance degree, are as follows: Production department, customers, suppliers, consultancy firms, internal R & D, competitors, marketing, knowledge from conferences, seminars and specialized journals, knowledge from fairs and exhibitions, patents, universities and higher educational institutes, public research institutes and private research institutes.

The knowledge are not segmented by service sector, and information focused only in software activities is not provided. Anyway, this knowledge about innovation sources are valuable for our study due to it involves a large set of companies and some of them are related with computing and software activities.

12.19 Evangelista´ s contribution

A study about innovation in service firms was conducted in Italy in 1998 by Evangelista et al [S11]. This contribution uses a survey executed by the National Statistical Institute in 1997 and it is based on the guidelines provided by the Oslo Manual [56]. The survey involves more than 19.000 firms (some of them are related with computing and software activities), but the data set of this article involves 2056 companies. Different issues are dealt in the contribution, and the sources of innovation is one of these.

The innovation sources taxonomy, ordered by relevance degree, are as follows:

Suppliers, production department, knowledge from conferences, seminars and specialized journals, consultancy firms, competitors, customers, marketing, knowledge from fairs and exhibitions, internal R & D, universities and higher educational institutes, patents, and public research institutes.

The knowledge are not segmented by service sector, and information focused only in software activities is not provided. Besides, the criteria to build the data set are not enough explained. Anyway, this knowledge about innovation sources are valuable for our study due to it involves a large set of companies and some of them are related with computing and software activities.

12.20 Yam´ s contribution

An analysis about the sources of innovation and the innovation performance was conducted in Hong Kong in 2010 by Yam et al [S34]. The authors introduce the importance of the national and regional innovation systems on the firms innovation performance and they try to check a set of hypothesis related to the benefits of using different sources of innovation. They gather data from a survey to 200 manufacturing firms, following the guidelines proposed by the Oslo Manual [56].

The innovation sources that have been considered in the study are as follows: overseas technology, patents, universities, consultancy firms, customers, suppliers, R & D department, marketing department and production department. Most of these elements have positive inter-relationships and some of them improve the sales performance of the firm.

Despite the previous sources of innovation are not ordered by relevance and the collected data are gathered from manufacturing organizations, they can be taken into account for our study.

12.21 Segarra-Blasco´ s contribution

An analysis about the sources of innovation and industry-university interaction was conducted in Spain in 2008 by Segarra-Blasco et al [S24]. Information gathered from more than 4000 firms by means of the Spanish version of the Community Innovation Survey [24] are used to identify the relevance of the external innovation sources and the impact of the university-industry interactions.

The resulting taxonomy of (external) innovation sources, ordered by relevance, is as follows: universities and research center, suppliers, other firms of the same group, customers, R & D firms, consultancy firms, competitors. Actually, this list are not ordered by relevance, it is ordered by the percentage of agreements between the firms and external actors.

Despite the provided taxonomy is not really ordered by relevance and the gathered data is not focused in software organizations, this findings are valuable for our study.

12.22 Chen´ s contribution (3)

A study about the influence of scope, depth and orientation of external technology sources on the innovative performance was conducted in China in 2011 by Chen et al [S5]. The authors use the survey method, getting knowledge from 209 firms of different industry sectors, being software development one of them. The authors study a set of topics related to innovation performance, and one of these topics is the innovation sources.

The resulting taxonomy, ordered by use degree or relevance, is as follows: internal R & D, other company departments, users, suppliers, competitors, governments, universities and research institutes, patents, overseas technology and venture groups.

It would be desirable to get information segmented by industry sector to achieve this information tailored to software engineering field. Anyway, the provided taxonomy can be useful for our purposes.

12.23 Belussi´ s contribution

An study about an open regional innovation system was conducted in Italy in 2010 by Belussi et al [S2]. The open innovation paradigm is explored through three research questions, one of them related to the relevance of the innovation sources. To provide empirical answers, the survey method is applied to 513 firms on life sciences industry (biomedical, pharmaceutics, etc.).

The resulting taxonomy, ordered by relevance, is as follows: knowledge from scientific journal, customers, institutional R & D, external R & D, patents, suppliers, knowledge from internet, knowledge from fairs, and other enterprises.

Despite this taxonomy is strongly oriented to life sciences industry, it can be partially suitable for our purposes and it will be taken into account in our study.

12.24 Padmore´ s contribution

A model of systems of innovation from an enterprise-centered view was developed in 1998 by Padmore et al [S21]. The authors introduce some well-known models of innovation, such as the linear model, the chain link model and the cycle model, and they provide a new model where the innovation sources and their interactions play a key role. The five categories used in the model are as follows: in-house (firm departments), suppliers, peers (including patents), customers, public sector (research laboratories, public conferences, etc.).

This taxonomy is not supported by empirical data, but the authors use data from the National Research Council of Canada to make an estimation of the relevance of each innovation source in science-based firms (like bio-pharmaceutical industry) and system integrator firms (like telecommunication industry, more close to the software engineering field). In the concept or re-invention phase of the cycle innovation model, the innovation sources are ordered by relevance in science-based firms and in system integrator firms. For the first one: in-house, public sector, peers, customers and suppliers; for the second one: customers, peers, public sector, in-house and suppliers. Like it can be seen, the relevance of innovation source vary across different industries.

Despite the estimation of the authors based on observations of objective data, the empirical component of this contribution is confused. Anyway, the provided taxonomies and findings are useful for our purposes.

12.25 Romijn´ s contribution

A study about the determinants of innovation capability in small electronics and software firms was developed in UK in 2002 by Romijn et al [S23]. Indicators from 33 companies are analysed to find relevant knowledge related to internal and external sources of innovation capability in electronics and software sector. The contribution do not provide directly an ordered taxonomy for innovation sources and some adaptations are required.

The mainly innovation sources, that have a positive impact in the product innovation index of the analysed firms, are as follows: Production or Internal R & D experience and skills, R & D institutions, suppliers, competitors, and service providers. Strangely, interactions and proximity to the customers have not a positive effect on product innovation index.

Despite the context of the study are not enough described and some adaptations have been required, the provided taxonomy is suitable for our purposes due to it is grounded in software companies.

12.26 PJ de Jong´ s contribution

A study about innovation in small firms was conducted in Netherlands in 2006 by PJ de Jong et al [S9]. The authors present the Pavitt taxonomy of innovative firms, and they study a set of topics related to innovation. To gather empirical information, the survey method is applied with 1631 firms of a wide range of industry sectors, like computer and related sectors.

Like it is said by the authors, the provided taxonomy of innovation sources is very simple: suppliers, customers and scientific developments. These sources have different relevance for each kind of innovative firms, but the following average have been obtained in the study: customers (3.19), suppliers (2.64), and scientific development (2.19).

Despite the presented taxonomy does not consider the wide range of innovation sources, it can be useful for our purposes. Besides, findings about the differences in the innovation source exploitation between innovative firms are valuable for our study.

12.27 Sharif´ s contribution

A study about innovation strategies in manufacturing sector was conducted in China and Hong Kong in 2011 by Sharif et al [S25]. The authors introduce the context of the study, where Hong Kong firms who manufacture in Guangdong province of China are studied using the survey method with 492 organizations. The conducted survey is based on Community Innovation Survey [24] from Oslo Manual [56], and the innovation sources topic is dealt.

The innovation sources, ordered by relevance, in Hong Kong are as follows: suppliers, other enterprises, clients, universities, public research institutes, competitors and consultants. The innovation sources, ordered by relevance, in Guangdong are as follows: suppliers, other enterprises, clients, competitors, consultants, universities, and public research institutes. Like it can be seen, there are differences in the relevance degree of the innovation sources in both places.

Despite the context of this contribution is related to manufacturing sector, the presented taxonomy can be useful for our purposes. Besides, findings about the differences in the innovation source exploitation between different places are valuable for our study.

12.28 Florida´ s contribution

A study about the globalization of R & D using foreign-affiliated R & D laboratories in USA as sample was conducted in 1997 by Florida [S13]. The author uses the survey method with 186 foreign-affiliated R & D laboratories in USA involved on different industry sectors (electronics, automotive, chemicals, and biotechnology). The parents of the analysed laboratories are mainly from UK, Japan, France, Germany and Switzerland. A set of topics, like the innovation sources relevance, are tackled in the present contribution.

The innovation sources, ordered by relevance, for the foreign-affiliated R & D laboratories in USA are as follows: Internal R & D, Customers, other R & D laboratories, competitors, ventures, universities, top management, suppliers, and consultants. Significant differences have been founded between laboratories from different sectors.

Despite this contribution is strongly focused on R & D activities from a wide range of industry sectors, the obtained findings cab be considered in our study.

12.29 Laursen´ s contribution

A study about the use of universities as innovation source was conducted in UK in 2004 by Laursen et al [S18]. The authors set out some hypothesis about university-industry interactions to be checked through empirical data gathered from the UK innovation survey [75], based on Community Innovation Survey [24] from Oslo Manual [56], involving 2655 firms from widely range of sectors. The innovation sources issue is dealt in the present contribution.

The resulting taxonomy, ordered by relevance, is as follows: Internal departments, suppliers, customers, standards, knowledge from conferences, competitors, and others. Besides, significant differences have been founded between organizations of different sectors.

Despite this contribution does not deal with software engineering firms, the provided findings can be useful for our purposes.

12.30 Knudsen´ s contribution

A study about the immediate, but negative, effects of openness on product development performance was conducted in Denmark in 2011 by Knudsen et al [S14]. The authors uses data gathered from 110 Danish firms involved in a wide range of industries, like software engineering field. The innovation sources issue is dealt studying the participation of internal and external in new product developments.

The resulting taxonomy, ordered by relevance, is as follows: customers, suppliers, internal R & D, consultants, universities and research center, and competitors. It would be useful to get a taxonomy like this using only the information collected from software firms.

The suitability for our purposes of this contribution is partial. Software organizations are involved in the study, but the sample is composed too by organizations from sectors like textiles, furniture, etc. It can distort the obtained results for software sector. Anyway, the resulting taxonomy can be considered in our study.

12.31 Mention´ s contribution

A study about open innovation practices in the service sector was conducted in Luxembourg in 2010 by Mention [S19]. The author presents a set of hypothesis related to the impact of different information sources on the novelty of innovation introduced by firms. Empirical data, from 4th edition of the Community Innovation Survey [24] following the Oslo Manual [56], are analysed to check the arisen set of hypothesis.

Tailoring some information, the resulting innovation sources taxonomy is as follows: Internal departments, marketing-based sources, competitor-based sources, and science-based sources. Besides, one interesting finding shows the negative influence of the information from competitors on the degree of novelty of innovation.

Despite the analysed firms on the study are not involved on software activities, the findings provided by this contribution can be useful for our study.

12.32 Zeng´ s contribution

A study about the relationship between cooperation networks and innovation performance was conducted in Shanghai(China) in 2010 by Zeng et al [S35]. The authors propose a set of hypothesis related to the positive impact of some innovation sources. To check empirically the arisen hypothesis, the survey method is used to collect information from 137 SMEs involved in manufacturing sectors.

The provided taxonomy of external innovation sources, ordered by relevance order, is as follows: Research institutions, universities, technology intermediaries, technical institutes, suppliers, customers, innovation service departments, competitors, industry associations, overseas technology, venture groups, other government support agencies. Many lectures can be extracted from this knowledge.

Most of the hypothesis about the positive impact on innovation performance of relationships with customers, suppliers, competitors, research organizations and intermediary institutions are supported. But surprising, no positive impact on innovation performance of relationships with government agencies are founded. Despite the sample of firms are involved in manufacturing sector, this findings can be useful in software engineering field.

12.33 Uzun´ s contribution

A study about technological innovation activities was conducted in Turkey in 2001 by Uzun et al [S30]. The author uses information gathered in a survey to 2100 Turkish manufacturing firms to emphasized some issues related to innovation field.

The taxonomy provided in this contribution, ordered by relevance degree, is as follows: Internal R & D, Customers, knowledge from conferences, suppliers, competitors, knowledge from journals, knowledge from internet, consultancy firms, other enterprises, universities and research center, and patents. Like it can be seen, internal R & D are the most important source of innovation for manufacturing firms, but collaboration with universities and research center are not very valuable in this context.

Despite the context involves manufacturing firms, the findings provided by this contribution can be useful for our purposes.

12.34 de Faria´ s contribution

A study about the importance of partners and cooperation in innovation activities was conducted with Portuguese firms in 2010 by de Faria et al [S8]. To get empirical evidences, the authors use data gathered through III Portuguese Community Innovation Survey [24] following the Oslo Manual [56]. The external innovation source issue is dealt considering 766 manufacturing firms.

The resulting taxonomy, ordered by relevance degree, is as follows: Other firms, suppliers, R & D laboratories, customers, universities, public research institutes, consultants, competitors.

Despite this data are related to manufacturing firms, the provided findings can be valuable for our purposes.

12.35 Murovec´ s contribution

A study about the impact of the absorptive capacity on innovation output was conducted with Spanish and Czech Republic firms in 2009 by Murovec et al [S20]. The authors present a set of hypothesis related to many innovation issues, for example, relationships between the absorptive capacity, as well demand-pull as well science-push, and innovations sources are analysed in this contribution. Empirical data from 3061 manufacturing Spanish and Czech republic firms, which are gathered through the 3rd edition of the Community Innovation Survey [24] following the Oslo Manual [56], are analysed to check the arisen set of hypothesis.

The resulting taxonomies of external innovation sources are as follows. For Spanish firms: research institutes, suppliers, competitors, universities, customers, knowledge from fairs and exhibitions. For Czech republic firms: universities, customers, competitors, research institutes, suppliers, knowledge from fairs and exhibitions. As can be seen, there are significant differences on relevance perception of innovation sources in these countries.

Despite this data are related to manufacturing firms, the provided findings can be valuable for our purposes.