

## Article

# Distinctive Innovation Capabilities of Argentine Software Companies with High Innovation Results and Impacts

María Isabel Camio <sup>1,\*</sup>, María del Carmen Romero <sup>1,†</sup>, María Belén Álvarez <sup>2,†</sup> and Alfredo José Rébori <sup>1,†</sup>

<sup>1</sup> UNICEN, Facultad de Ciencias Económicas, Centro de Estudios en Administración (CEA), Tandil, Buenos Aires 7000, Argentina; romero@econ.unicen.edu.ar (M.d.C.R.); decano@econ.unicen.edu.ar (A.J.R.)

<sup>2</sup> CEA, CONICET, FCE—UNICEN (Pinto 399) Tandil, Buenos Aires 7000, Argentina; maria.alvarez@econ.unicen.edu.ar

\* Correspondence: camio@econ.unicen.edu.ar; Tel.: +54-249-438-5550

† These authors contributed equally to this work.

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**Abstract:** The software sector is of growing importance and, due to its degree of dynamism, the identification of capabilities for innovation is vital. This study identifies capabilities variables that distinguish Argentine software companies with high innovation results and high innovation impacts from those with lesser results and impacts. It is applied to a sample of 103 companies, a measurement model and the component variables of an innovation degree index for software companies (INIs) formulated in previous studies. A Principal Component Analysis and a biplot are conducted. In the analysis of results and impacts, 100% of the variability within the first two components is explained, which shows the high correlation between variables. From the biplots, it appears that companies with high results have higher degrees in the variables of motivation, strategy, leadership and internal determinants; and those with high impacts present higher degrees of structure, strategy, leadership, free software and innovation activities. The findings add elements to the theory of capabilities for innovation in the software sector and allow us to consider the relative importance of different capabilities variables in the generation of innovation results and impacts.

**Keywords:** innovation; capabilities; software; results; impacts

## 1. Introduction

The software sector has been growing in importance in countries like Argentina. Innovation generation becomes of vital importance in sectors with constant changes, which can reformulate strategic positions. In this context, and particularly for smaller companies, the identification of key capabilities for results achievement and innovation related impact becomes a key feature in terms of research objectives.

In the current business context, which is highly competitive and involves products and technology with short life cycles, it is essential for the software industry to manage innovation systematically. In this context, the management of innovation is decisive and at the same time requires analysis and intervention tools that allow identification of the key variables to be taken into account in order to improve the results and impacts of innovation.

The measurement of innovative activity and its effects is an area that, for a long time, has concerned those economists interested in analyzing innovation processes and their relationship with global economic dynamics. On the one hand, there is the question of how to measure “innovative activity” in itself. On the other hand, there is a concern to know how this innovative activity influences

the rate of growth of productivity and the economy. The massive introduction of “new technologies” and the transition to a knowledge-based society have increased the interest in investigating these subjects (López 1998).

This is extremely necessary in developing economies, in which it is necessary to focus analysis on the capacities, since in some cases these capacities do not have a direct association, at a given moment, with the innovation results achieved by the companies.

Different research analyzes innovative capabilities and relates them to other variables in different contexts and types of organizations; for example, Dolsen and Chinnam (2017) study the development of innovation capability in a mass production organization. Liao et al. (2010) investigate the relationships between knowledge acquisition, absorptive capability and innovation capability in Taiwans knowledge-intensive industries. Akman and Yilmaz (2008) examine the relations among market orientation, innovation strategy, innovative capability and innovation success in small and medium enterprises (SMEs) in developing countries.

In the specific context of software firms, studies such as that by Romijn and Albaladejo (2002) explore the determinants of innovation capability that might have contributed to the companies' innovative performance in 33 small UK electronics and software firms. Capaldo et al. (2003) propose a methodology that permits the evaluation of innovation capabilities in small software firms.

Research like that mentioned above focus on the study of innovation capabilities in specific contexts. Nevertheless, there is no research that focuses on identifying which capabilities in innovation management have been developed, and distinguish, companies with high innovation results and high innovation impacts. This gap becomes greater when addressing the study of software firms, especially in the context of Argentina.

Research questions arise from this work, such as: What capabilities have software companies developed with high innovation results and innovation impact? Are there differences in the degree of skills developed among companies with low, medium and high innovation results and innovation impact?

Based on the questions presented above, the following objective arises: Identifying the capabilities variables that distinguish Argentine software companies with high innovation results and high innovation impacts from those with lower results and impacts.

## 2. Literature Review

Drucker (1954; cited by Cavusgil et al. 2003) was one of the first scholars to address the importance of innovation capability for organizations. He suggested that a firm has to be innovative to survive in the volatile environment.

Through the content analysis of 51 articles from 30 journals published between 2000 and 2015, focusing on how innovation capability is defined, Iddris (2016) suggests that there is a lack of consensus regarding its definition. He states that generally the authors made reference to the terms knowledge transformation, learning, idea generation and processes.

Innovation capability is proposed as a higher-order integration capability, that is, the ability to mold and manage multiple capabilities. Organizations possessing this innovation capability have the ability to integrate key capabilities and resources of their firm to successfully stimulate innovation (Lawson and Samson 2001).

Amabile et al. (1996; cited by Zhao et al. 2005) state that innovation capability is the application of relevant knowledge to the attainment of market value and is the successful implementation of creative ideas within an organization.

In their acknowledged studies, Teece and Pisano (1994) and Teece et al. (1997) suggest that the winners in the global marketplace have been firms that demonstrate timely responsiveness and rapid and flexible product innovation, along with the management capability to effectively coordinate and redeploy internal and external competences. They call this source of competitive advantage, ‘dynamic capabilities.’

The term ‘dynamic’ refers to the shifting character of the environment; certain strategic responses are required when time-to-market and timing is critical, the pace of innovation is accelerating and the nature of future competition and markets is difficult to determine. The term ‘capabilities’ emphasizes the key role of strategic management in appropriately adapting, integrating and re-configuring internal and external organizational skills, resources and functional competences towards a changing environment (Teece and Pisano 1994; Teece et al. 1997).

Eisenhardt and Martin (2000) focus on the approach of dynamic capabilities in the more general framework of the resource-based perspective. These dynamic capabilities are of specific strategic and organizational processes, which create value for companies within dynamic markets by manipulating resources towards new value creation strategies.

In her study of innovative capability development in U.S. and Japanese firms, Un (2002) points out that the firm’s innovative capability is its ability to mobilize the knowledge embodied in its employees (Kogut and Zander 1992; cited by Un 2002) and combine it to create new knowledge resulting in product and/or process innovation. She states that this capability is dynamic in that it involves the interaction between a firm’s internal knowledge and the demands of the external market.

According to Lin et al. (2016), previous research emphasizes the relationship between dynamic capabilities and innovation (for example, Ambrosini et al. 2009; Aragón-Correa and Sharma 2003; Cheng and Chen 2013; Clausen 2013; Hart and Dowell 2010; Helfat et al. 2007; Kohlbacher 2013; Ridder 2011; Teece 2007; Teece et al. 1997) and argue that a company’s dynamic capabilities could significantly improve its ability to innovate (O’Conner 2008; cited by Lin et al. 2016), especially in the case of radical innovations.

Lawson and Samson (2001) suggest that dynamic capabilities theory is well-suited to the study of organizational innovation because there is no special focus on technology. For example, research and development is but one resource among many available to the firm. This facilitates development of a holistic model of organizational innovation.

Some studies, such as that by Miranda and Figueiredo (2010), contribute to the study of innovation specifically in the context of technological companies, such as those in the software sector. These authors (Miranda and Figueiredo 2010) define technological capability as the necessary resources (knowledge stock) to generate and manage innovative activities, products, processes and the organization of production, organizational systems, equipment and engineering projects—in other words, technological change.

Miranda and Figueiredo (2010) distinguish routine and innovative companies based on the degree of technological capabilities achieved by the firms. For each of the degrees, the identification of the relationship of the processes with quality measures, certifications and continuous improvement of the processes, the type of products or services and the type of software engineering tools used are highlighted.

Other research states that knowledge is related to absorption capability<sup>1</sup> and that the absorption capability of a company has a significant impact on its ability to innovate (Chang et al. 2012; Ralph and Hurmelinna-Laukkanen 2013; cited by Cheng et al. 2016). Therefore, a company with a well-developed absorptive capability can strengthen its knowledge base and adapt to environmental changes by renewing its products (Liao et al. 2003; cited by Cheng et al. 2016).

Addressing the variables that condition the ability to generate innovation, studies such as that by Lawson and Samson (2001) suggest that there is no one generic formula of innovation capability. There are, however, common threads running between highly and lowly innovative firms that vary only in degrees of importance (Tidd et al. 1997; cited by Lawson and Samson 2001).

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<sup>1</sup> Cohen and Levinthal (1990), in their seminal work, propose the concept of absorption capability, defined as the ability to exploit external knowledge, a critical component of innovative capabilities.

According to those authors, the elements making up an innovation capability are grouped into seven major elements: vision and strategy, harnessing the competence base, organizational intelligence, creativity and idea management, organizational structure and systems, culture and climate and the management of technology (Lawson and Samson 2001).

In his study, Saunila (2017) defines innovation capability through aspects influencing an organization's capability to manage innovation. These aspects include participatory leadership culture, ideation and organizing structures, work climate and well-being, know-how development, regeneration, external knowledge and individual activity.

Recent studies, particularly in the context of software companies, identify among the capabilities variables: strategy, structure, software tools, communication and other variables such as internal determinants—culture, background and skills, qualification of human resources, among others—and external determinants, which include the relationship with external actors and external barriers (Camio et al. 2016).

Engaging consciously and purposively in a business strategy supporting innovation defines systematic innovation capability. The business strategy determines the extent to which innovation is central to a business' competitive strategy (Keupp et al. 2011; Teece 2010; Ritter and Gemunden 2003; Rohrbeck and Gemunden 2011; Le Masson et al. 2010; cited by Samson et al. 2017).

Strategy has a decisive role in innovation, particularly the “orientation towards the future” (Tamm 2010; cited by Rueda-Cáceres and Sánchez-Torres 2015) and the “long-term strategic approach” (Tellis et al. 2009). On the other hand, Leavy (2005) emphasizes that many companies include a commitment to innovation in their mission statements. In addition, it should be noted that an innovation vision must be aligned with other strategic elements (Dobni 2008).

Guided by this strategic direction, organizations grow their innovation capability through a strong customer focus and external relationships that signify an open approach to innovation and resource innovation across their activities and operations (Samson et al. 2017).

According to the Oslo Manual (OECD and Eurostat 2005), a firm's organizational structure can affect the efficiency of innovation activities. A greater degree of organizational integration may improve the coordination, planning and implementation of innovation strategies. Organizational integration can work particularly well in industries characterized by incremental changes in knowledge and technologies. A looser, more flexible form of organization, which allows workers greater autonomy to make decisions and define their responsibilities, might be more effective in generating more radical innovations.

In line with the above, Crossan and Apaydin (2010; cited by Rueda-Cáceres and Sánchez-Torres 2015) understand that the more permeable and organic the structure, the greater the possibility that innovative ideas will emerge.

Other variables, such as the relationship between the processes and quality measures, certifications and continuous improvement of the processes, the type of products or services and the type of software engineering tools used, are highlighted in the study by Miranda and Figueiredo (2010) who, as we mentioned above, distinguish routine and innovative companies based on the degree of technological capabilities achieved by the firms.

When analyzing absorption capability, Cohen and Levinthal (1990) indicate that to understand the sources of a firm's absorptive capability, the focus needs to be on the structure of communication between the external environment and the organization, as well as among the subunits of the organization and also on the character and distribution of expertise within the organization. Empirical studies have shown that higher degrees of communication and information gathering are associated with organizational innovation (Aiken and Hage 1971; Evan and Black 1967; Kanter (1982, 1988); Tjosvold and Mcneely 1988; cited by Monge et al. 1993) and with higher degrees of performance with the groups of R&D projects (Katz 1982; Keller 1986; Keller and Holland 1983; Pelz and Andrews 1966; cited by Monge et al. 1993).

Other drivers of innovation results are linked to higher degrees of fluency, breadth and depth in the processes of organizational communication (Aramburu and Sáenz 2010). Issues such as trust,

empowerment, open communication and a greater degree of freedom become essential in encouraging innovative activity through collaboration and individual satisfaction (Lemon and Sahota 2004).

Aramburu and Sáenz (2010) present a model that contrasts, among others, the hypothesis that the agility and fluency in the channels of horizontal and vertical communication and the physical design of workplaces (organizational design) act as catalysts for knowledge sharing in management processes. According to its results, both the information flows and the organizational culture significantly influence the results of innovation, especially in medium-high and high technology companies.

In a systematic review, Iddris (2016) identifies different studies that have all recognized organizational culture as a driving force for innovation capability (for example, Lawson and Samson 2001; Çakar and Ertürk 2010; and Martins and Terblanche 2003). He points out that an organization that promotes the empowerment of employees, tolerance, effective communication between focal firms and significant partners and a positive attitude towards achieving organizational goals can be seen to promote an innovation culture.

According to Lemon and Sahota (2004), organizational culture has been recognized as a primary determinant within innovation and the need to better understand this relationship or process is a necessary prerequisite to nurturing it in a more structured and systematic manner. Innovation is holistic in nature and is inseparable from the culture that facilitates or constrains the ability to 'add value.'

The use of team-based working is dependent on other factors, such as an open and collaborative organizational culture and a participatory management style; thus, employees working in teams will be more open to discussing and implementing new ideas within their teams (Smith et al. 2008).

In their study of capabilities critical to innovation performance for 131 very small high-tech firms Börjesson and Löfsten (2012; cited by Akinwale et al. 2018) include, among others, capabilities variables such as education level of the employees and employer and their work experience.

A high educational attainment should provide individuals with necessary background knowledge about the current state of science and technology. In addition, it should provide highly educated people with the training to recognize, analyze and solve complex problems, all of which contribute towards individual ability to conceive innovative business ideas (Koellinger 2008).

Romijn and Albaladejo (2002), in specific studies of small electronics and software companies, found that the proportion of engineers with university education over the total number of employees correlates positively with the index of central product innovations. They also identified internal resources, such as the background of founders or managers, as determinants of innovation capability. Studies conducted by Koc (2007) identify that the depth and variety of skills and experiences of employees are considered to be important elements of innovation in the software companies examined.

Along the same lines, Carter et al. (2001), in their software company research found in staff training an important resource, a formal mechanism that generally had positive impact on adoption.

Through strong senior executive leadership and role modelling of innovation, organizational behavior and culture are deeply embedded within an innovation "mindset" that permeates the entire organization (Samson et al. 2017).

In reference to different studies, Chang et al. (2015) points out that leadership is considered one of the most important factors that affect innovation, as leaders not only influence organizational characteristics such as culture, strategy, structure, reward systems and resources (Mumford et al. 2002; cited by Chang et al. 2015) but also encourage creativity in their followers (Jung 2001; cited by Chang et al. 2015; Gumusluoglu and Ilsev 2009).

Specific studies, such as that by Gumusluoglu and Ilsev (2009)—on micro and small software companies—and that by Jung et al. (2003)—on electronics and telecommunications companies—deepen the study of the style of transformational leadership and its relationship with organizational innovation. According to Bass (2000), transformational leaders have a vision that motivates their followers, increases their willingness to work beyond expectations and challenges them to adopt innovative approaches in their work (Gumusluoglu and Ilsev 2009).



Hotho and Champion (2011; cited by Saunila 2017) point out that people who have creativity and intrinsic motivation (as well as skills) for their work will be favorable for creating a work environment that supports the creation of innovations.

In a study that links knowledge management and organizational innovativeness, Sajeve and Jucevicius (2008) assume that the innovative organization supports creative individuals and provides the conditions in which they can share and create knowledge. In this context, they state that the main goal of an organization is to create an environment that could motivate individuals to be more innovative and to use knowledge creatively, to share their knowledge and to collaborate in producing and adopting new innovations. Innovative firms should also align an organization's rewards and recognition with the goals of innovation (Sajeve and Jucevicius 2008).

The literature supports the view that employees that are empowered and autonomous have a greater degree of control over their work. This degree of control means that employees feel comfortable in their role to be innovative in their own work environment (Thamhain 1990; Tang 1999; Zwetsloot 2001; Amar 2004; Mostafa 2005; Muthusamy et al. 2005; Nystrom et al. 2002; cited by Smith et al. 2008).

According to Sulistyo (2016), empowerment significantly influences innovation capabilities and performance. The better the empowerment in terms of decision-making authority, access to information, providing positive impact and following the planning process will encourage innovation capabilities and the performance. This supports the findings by Çakar and Ertürk (2010; cited by Sulistyo 2016) who conclude that empowerment directly affects innovation capabilities.

The optimal incentive scheme that motivates innovation exhibits substantial tolerance (or even reward) for early failure and reward for long-term success. Also, commitment to a long-term compensation plan, job security and timely feedback on performance are essential ingredients to motivate innovation (Manso 2011).

Regarding innovation activities, the Frascati Manual (OECD 2002) states that technological innovation activities are the set of scientific, technological, organizational, financial and commercial stages, including investments in new knowledge for the implementation of new or improved products and processes.

In reference to different studies, Samson et al. (2017) point out that innovation activities and operations that support the implementation of innovation processes include research and development (Enkel et al. 2009), creativity and lateral thinking (Hilles et al. 2009; Abraham and Knight 2001; Amabile et al. 1996) and a commitment to quality philosophy and practices (Lages et al. 2009; Revelle 2010; Kim et al. 2012; Perdomo-Ortiz et al. 2006).

R&D is just one of the innovation activities and can be carried out in different phases of the innovation process. The software that is part of an R&D project must be classified as R&D, the R&D activities associated with a software if it constitutes a finished product, the upgrade to a more powerful version and the improvement or modification of a program or an existing system (OECD 2002).

The Frascati Manual (OECD 2002) proposes that staff data measure the volume of resources devoted directly to R&D activities and the expenditure data measure the total cost of R&D execution, including the cost of indirect (auxiliary) support activities.

In his work on three high-tech industries, Wagner (2011) refers to the fact that one of the measures of R&D activities is the intensity of R&D, that is, the ratio between R&D expenditure and sales; this variable is frequently proposed as a measure of innovation effort and input (Brouwer and Kleinknecht 1999; Deeds 2001 cited by Wagner 2011).

Another aspect to consider is the use of free software and its impact on the generation of innovation. Open source software (OSS) is viewed as one of the most well-established examples of both open innovation (Morgan et al. 2013; West 2007; Gassmann and Enkel 2004; cited by Morgan and Finnegan 2014) and commons-based peer production (Feller et al. 2008; Benkler 2002; cited by Morgan and Finnegan 2014).

Generally, as part of an open innovation strategy, firms are increasingly treating open source software (OSS) communities as a complementary asset to be leveraged and combined with the firm's own internal assets to deliver competitive solutions (Dahlander and Wallin 2006; cited by Teigland et al. 2014).

Emphasizing that innovation is a social and interactive process underline the importance of establishing reliable and long-lasting communication channels, both within the firm and with external agents such as suppliers, customers, competitors, universities, research institutes and so forth. (López and Lugones 1997).

As a result of his study on knowledge intensive firms, Indarti (2017) suggests that the more capable a firm is of grasping external knowledge, the better it is able to utilize this information in the development of innovative products. Interaction enables firms to access knowledge from various kinds of external innovation partners who can provide access to widely differing knowledge domains such as technology, design, customer insights and market trends (Brunswick and Vanhaverbeke 2015; cited by Indarti 2017).

According to Chesbrough (2003), Open Innovation means that valuable ideas can come from inside or outside the company and can go to market from inside or outside the company as well. This approach places external ideas and external paths to market on the same level of importance as the reserved for internal ideas and paths to market during the Closed Innovation era.

The threefold idea behind open innovation is that firms are part of an environment characterized by knowledge distributed over various actors, external knowledge is accessible through a multitude of channels, and the innovation process itself, in order to be successful, has to be distributed across a number of actors (Bigliardi and Galati 2016).

Networking with other organizations, whether long-term or short-term, can result in an organization's attitude to innovation changing (Hadjimanolis 2000; Kandampully 2002; Pavitt 2002; Flor and Oltra 2004; Jaskyte and de Riobó 2004; Medina et al. 2005; Mudrak et al. 2005; cited by Smith et al. 2008).

Within the framework of external determinants, the factors that may hinder or slow down innovative activity are considered. The Bogota Manual (RICYT et al. 2001) mentions factors such as legislation, labor standards and regulations, poor response from customers to new processes and products, information about technologies and the ability to imitate innovations.

According to Drucker (1954; cited by Cavusgil et al. 2003), innovation capabilities are critical to achieving superior innovation performance. This is because markets are characterized by short products life cycle and a high rate of new product introduction. A firm with a great innovation capability will enjoy a high innovation performance.

Innovation results degree refers to innovation types of products, processes, commercialization and organization and to its novelty degree (new to the world, the market, the industry, the company) (OECD and Eurostat 2005).

In their empirical study on three Brazilian companies in the ICT sector, Comin et al. (2015) identify that innovation management processes aligned with the company's strategy can be associated with improved business performance.

Other research has focused on the impact of the results of radical innovation on the success of new products and the performance of companies (for example, Chandy and Tellis 2000; Han et al. 1998; Sorescu et al. 2003; Sorescu and Spanjol 2008; cited by Baker et al. 2014).

According to its nature, innovation can have very different impact on the results of companies and economic progress. This is the reason why it is important to be able to identify the introduction and impact of different types of innovation (OECD and Eurostat 2005). Innovation impact on company results range from the effects on sales and market share to the improvement of productivity and efficiency (OECD and Eurostat 2005).

### 3. Methods

A descriptive analysis is carried out based on the results of a study on a sample of Argentine software companies.

An *innovation measurement model*, previously developed, is applied (Camio et al. 2015), which includes three dimensions: *capabilities*, *results* and *impacts* of innovation (Table 1).

**Table 1.** Innovation measurement model: dimensions and variables.

Dimensions	Variables
CAPABILITIES	• Structure
	• Software tools
	• Strategy
	• Communication
	• Leadership
	• Motivation
	• Free software
	• Innovation activities
	• Internal determinants
	• External determinants
RESULTS	• Products
	• Processes
	• Organization
	• Marketing
IMPACTS	• Performance measures
	• Generation of intangibles

In order to select the variables for the construction of the innovation measurement model, it was realized a literature review regarding distinctive elements of the measurement of innovation for the software sector (especially the R&D concept) and it was analyzed the data collected in previous studies (Romero et al. 2010).<sup>2</sup>

Consequently, for the collection of data, a structured questionnaire with 133 questions was designed. This instrument was validated both in terms of internal and external validity.

The questions proposed for the questionnaire were (internally) validated in order to assess their degree of representation with respect to the content universe of which they are a part. This validation was carried out by the researchers themselves based on their prior knowledge and taking into account the theoretical framework that was developed ad hoc. In addition, key informants from the sector (researchers, businessmen, representatives of intermediate organizations) were consulted and aspects surveyed from other studies in Latin American contexts were considered.

Reliability was corroborated by the method of internal consistency (or average interrelation); Cronbach's alpha showed a value equal to 0.85, which means that the instrument (analyzed at the degree of base variables) is reasonably reliable.

Given the lack of a single database of software companies in Argentina, for the present study, an ad hoc database was created that includes 699 companies. Answers were obtained from 103 companies (response rate: 14.73%). Due to the characteristics of the sample considered, the analysis carried out and the findings obtained are limited to this group of companies.

The capabilities variables included in the analysis are ten and are specified in Table 2.

<sup>2</sup> In the cited work, the proposal of an index of level of innovation (INI) was studied, which was applied in the context of an exploratory study of multiple cases (Yin 2009) to Argentinian SMEs companies from different sectors. From the data collected on that occasion, those referred to the subgroup of software companies were analyzed in depth in order to identify recurrent problems in obtaining them.



**Table 2.** Capabilities variables and subvariables.

Variable		Subvariables
Name	ID. Variable	
Structure	V1_Struct	<ul style="list-style-type: none"> <li>• Departments of R + D + quality</li> <li>• Structure characteristics</li> <li>• Networking</li> <li>• Process degree</li> </ul>
Software tools	V2_Tools	<ul style="list-style-type: none"> <li>• Tools degree</li> <li>• Documentation and methodology</li> </ul>
Strategy	V3_Strat	<ul style="list-style-type: none"> <li>• Strategic priorities</li> <li>• Customer orientation</li> <li>• Innovation management</li> <li>• Strategic / innovation decisions</li> <li>• Portfolio of products and services</li> </ul>
Communication	V4_Communic	<ul style="list-style-type: none"> <li>• Circulation of communication</li> <li>• Communication frequency</li> <li>• Transfer of innovation decisions</li> </ul>
Leadership	V5_Leader	<ul style="list-style-type: none"> <li>• Selection and ranking of the 5 most important features of leaders</li> </ul>
Motivation	V6_Motiv	<ul style="list-style-type: none"> <li>• Generation of innovative ideas</li> <li>• Recognition of innovative ideas</li> </ul>
Free software	V7_FreeSoft	<ul style="list-style-type: none"> <li>• Knowledge / use of free software</li> <li>• Reasons for free software use</li> </ul>
Innovation activities	V8_InnAct	<ul style="list-style-type: none"> <li>• Innovative people / activities (and time)</li> <li>• Innovation budget / activities</li> <li>• Degree of products and services</li> </ul>
Internal determinants	V9_IntDet	<ul style="list-style-type: none"> <li>• Culture</li> <li>• Background and skills</li> <li>• Internal barriers</li> <li>• HR qualification</li> <li>• Training</li> </ul>
External determinants	V10_ExtDet	<ul style="list-style-type: none"> <li>• Relationship with external actors</li> <li>• External barriers</li> </ul>

For the evaluation of results and impacts of innovation in the companies studied, the following variables are taken into consideration:

- **Results:**
  - Products: Introduction of new or significantly enhanced products, degree of novelty of products and changes in the central characteristics of the product.
  - Processes: Introduction of new processes and significance of process improvements.
  - Organization: Organizational innovations and types of organizational innovations carried out.
  - Marketing: Marketing innovations and types of marketing innovations carried out.
- **Impacts/performance:**
  - Performance measures: Sales share percentage of innovated products, impact of product innovations, impact of process innovations, impact of organizational innovations, impact of marketing innovations.
  - Generation of intangibles: requested patents, obtained patents, licensed technology, free software licenses use, quality certification.

The data collected from the questions of the questionnaire are qualitative and quantitative and belong to different measurement scales (nominal, ordinal, interval or ratio). Based on these questions,

base variables were constructed (subvariables—Table 2), which are all qualitative ordinals with 5 possible values: very high, high, medium, low and very low. These values were assigned creating a correspondence between the responses of the original variables and the contribution of these responses to the degree of innovation. This step is carried out ad hoc considering empirical and conceptual criteria (Camio et al. 2016).

The ordinal qualitative variables (subvariables) provide answers to the variables of higher degrees (variables—Tables 1 and 2). Each higher degree variable results in an index constructed from the combination of subvariables; each subvariable was assigned a numerical rating according to the following: very high: 5, high: 4, medium: 3, low: 2 and very low: 1. Each index was constructed considering the sum of the component subvariable valuations weighted by their degree of importance. Since they are indexes, all the variables of higher degrees are quantitative.

*Capabilities* variables are considered according to the above specification. *Result* and *impact* variables are used to classify the companies studied into 3 degrees (high, medium and low) according to the values of the index.

The perspective of the proposed analysis considers the linkages between the *capability* dimension and the dimensions considered as result in the aforementioned model, particularly the *results* and *impacts* of innovation.

Correlation matrices expose the correlations between the ten variables (taken in pairs) for both the innovation result groups and the innovation impact groups. (Table 3a,b).

In order to respond to the stated objective and, given the quantitative nature of the data—indices created ad-hoc—(Camio et al. 2016), a Principal Component Analysis (PCA) and a biplot were carried out. The 103 cases studied are considered, divided into three groups of results in each case. Using the same technique are analyzed, on the one hand, the group of companies with high results of innovation, with medium results of innovation and with low results of innovation. On the other hand, the three groups of companies with different degrees (low, medium and high) of innovation impact are analyzed in the same way.

The Principal Component Analysis tries to explain the entire variance-covariance structure of a set of variables through a few linear combinations of those variables. The biplots graphics proposed by Gabriel (1971) show the observations and the variables in the same graph, so that interpretations can be made about the joint relationships between observations and variables.

In biplots, the distance between symbols representing observations and symbols representing variables has no interpretation but the directions of the symbols from the origin *can* be interpreted. The observations (row points) plotted in the same direction as a variable (column point) could have relatively high values for that variable and low values in variables or column points that are plotted in the opposite direction. The angles between the vectors that represent the variables can be interpreted in terms of the correlations between variables (Balzarini et al. 2008).

To contribute to the analysis of the data, summary measures were calculated for each of the variables of capabilities in analysis, taking into account the different degrees (low, medium and high) both in relation to innovation results and in relation to the impacts of innovation. The average and the minimums and maximums in each case were particularly considered. This is shown in Table 7.

The statistical software InfoStat (Di Rienzo et al. 2016) was used for the analysis.

#### 4. Results

Taken into account the aim of identifying capabilities variables that distinguish those Argentine software companies with high innovation results and high innovation impacts from those with lower innovation results and innovation impacts and following the methodology described above, first we expose the correlations between the capabilities variables for both the innovation result groups and the innovation impact groups and then the results of the Principal Component Analysis (PCA) and a Biplot were carried out.

From the analysis of correlation between the ten capabilities variables for the groups determined for *innovation results*, correlations higher than 0.9 arise (in all cases with a positive sign) (Table 3a): V1\_Struct and V2\_Tools, V1\_Struct and V7\_FreeSoft (with value 1: perfect direct linear dependence), V1\_Struct and V9\_IntDet, V2\_Tools and V7\_FreeSoft, V2\_Tools and V8\_InnAct, V3\_Strat and V5\_Leader, V3\_Strat and V6\_Motiv (with value 1: perfect direct linear dependence), V5\_Leader and V6\_Motiv, V5\_Leader and V9\_IntDet, V7\_FreeSoft y V8\_InnAct.

The same analysis for the groups determined for *innovation impacts*, yields correlations greater than 0.9 between the capability variables (with a positive sign) (Table 3b): V1\_Struct and V2\_Tools, V1\_Struct and V3\_Strat, V1\_Struct and V5\_Leader, V1\_Struct and V7\_FreeSoft, V1\_Struct and V2\_ActInnov, V3\_Strat and V5\_Leader, V3\_Strat and V7\_FreeSoft, V3\_Strat and V8\_InnAct (with value 1: perfect direct linear dependence), V4\_Communic and V9\_IntDet, V5\_Leader and V7\_FreeSoft (with value 1: perfect direct linear dependence), V5\_Leader and V8\_InnAct (with value 1: perfect direct linear dependence), V7\_FreeSoft and V8\_InnAct, V7\_FreeSoft and V9\_IntDet.

Correlations with values higher than 0.90 and with negative sign (Table 3b): V4\_Communic and V10\_ExtDet, V7\_FreeSoft and V10\_ExtDet, V9\_IntDet and V10\_ExtDet (Table 3b).

**Table 3.** (a) Correlation Matrix/ Analysis of Results. (b) Correlation Matrix/ Analysis of Impacts.

(a)										
	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10
V1_Struct	1.00									
V2_Tools	<b>0.98</b>	1.00								
V3_Strat	0.64	0.45	1.00							
V4_Communic	−0.02	−0.24	0.76	1.00						
V5_Leader	0.81	0.66	<b>0.97</b>	0.57	1.00					
V6_Motiv	0.60	0.42	<b>1.00</b>	0.78	<b>0.96</b>	1.00				
V7_FreeSoft	<b>1.00</b>	<b>0.99</b>	0.57	−0.10	0.76	0.54	1.00			
V8_InnAct	0.88	<b>0.96</b>	0.18	−0.50	0.43	0.14	<b>0.91</b>	1.00		
V9_IntDet	<b>0.92</b>	0.82	0.88	0.36	<b>0.97</b>	0.86	0.89	0.62	1.00	
V10_ExtDet	−0.47	−0.65	0.38	0.89	0.13	0.42	−0.54	−0.84	−0.10	1.00
(b)										
	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10
V1_Struct	1.00									
V2_Tools	<b>0.90</b>	1.00								
V3_Strat	<b>1.00</b>	0.88	1.00							
V4_Communic	0.52	0.09	0.56	1.00						
V5_Leader	<b>0.98</b>	0.80	<b>0.99</b>	0.68	1.00					
V6_Motiv	0.53	0.84	0.48	−0.45	0.35	1.00				
V7_FreeSoft	<b>0.97</b>	0.76	<b>0.98</b>	0.72	<b>1.00</b>	0.29	1.00			
V8_InnAct	<b>0.99</b>	0.84	<b>1.00</b>	0.61	<b>1.00</b>	0.43	<b>0.99</b>	1.00		
V9_IntDet	0.76	0.41	0.80	<b>0.95</b>	0.88	−0.15	<b>0.90</b>	0.83	1.00	
V10_ExtDet	−0.75	−0.39	−0.78	− <b>0.95</b>	−0.87	0.17	− <b>0.90</b>	−0.82	− <b>1.00</b>	1.00

Principal Component Analysis was applied to explore the capability variables according to the degree of innovation results (*low*, *medium* and *high*). It appears that the first component explains 64% of the variability and in conjunction with the second component they explain 100% (Table 4a). In the first component, the variables with greater weight are V1\_Struct, V2\_Tools, V3\_Strat, V5\_Leader, V7\_FreeSoft and V9\_IntDet; in the second component, V4\_Communic and V10\_ExtDet (Tables 5a and 6a).

**Table 4.** (a) Eigenvalues/Analysis of Results.<sup>3</sup> (b) Eigenvalues/Analysis of Impacts.<sup>4</sup>

(a)			
Lambda	Value	Proportion	Cum Prop
1	6.38	0.64	0.64
2	3.62	0.36	1.00

(b)			
Lambda	Value	Proportion	Cum Prop
1	7.67	0.77	0.77
2	2.33	0.23	1.00

**Table 5.** (a) Eigenvectors/Analysis of Results. (b) Eigenvectors/Analysis of Impacts.

(a)		
Variables	e1	e2
V1_Struct	0.38	−0.13
V2_Tools	0.35	−0.23
V3_Strat	0.32	0.31
V4_Communic	0.09	0.51
V5_Leader	0.37	0.20
V6_Motiv	0.31	0.33
V7_FreeSoft	0.38	−0.17
V8_InnAct	0.29	−0.36
V9_IntDet	0.39	0.08
V10_ExtDet	−0.10	0.51

(b)		
Variables	e1	e2
V1_Struct	0.35	0.15
V2_Tools	0.28	0.41
V3_Strat	0.36	0.12
V4_Communic	0.25	−0.47
V5_Leader	0.36	0.02
V6_Motiv	0.11	0.62
V7_FreeSoft	0.36	−0.02
V8_InnAct	0.36	0.08
V9_IntDet	0.32	−0.30
V10_ExtDet	−0.32	0.31

<sup>4</sup> Only the first two eigenvalues are exposed since the others are equal to 0.<sup>3</sup> Only the first two eigenvalues are exposed since the others are equal to 0.

**Table 6.** (a) Correlations with the original variables/Analysis of Results. (b) Correlations with the original variables/Analysis of Impacts.

(a)		
Variables	PC 1	PC 2
V1_Struct	0.97	−0.24
V2_Tools	0.89	−0.45
V3_Strat	0.80	0.59
V4_Communic	0.22	0.98
V5_Leader	0.93	0.37
V6_Motiv	0.78	0.63
V7_FreeSoft	0.95	−0.32
V8_InnAct	0.73	−0.68
V9_IntDet	0.99	0.15
V10_ExtDet	−0.24	0.97

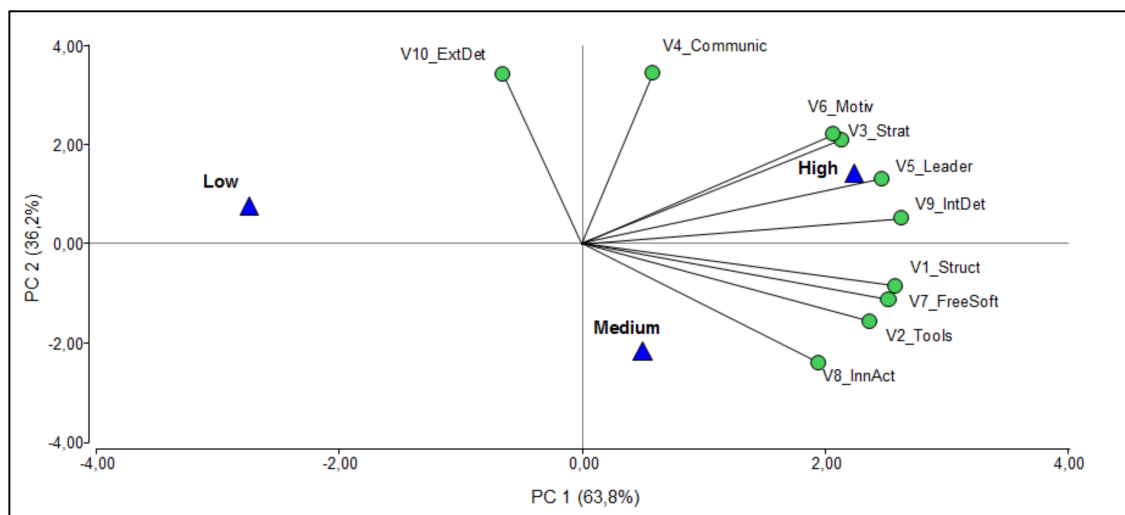
(b)		
Variables	PC 1	PC 2
V1_Struct	0.97	0.23
V2_Tools	0.78	0.63
V3_Strat	0.98	0.18
V4_Communic	0.70	−0.71
V5_Leader	1.00	0.04
V6_Motiv	0.32	0.95
V7_FreeSoft	1.00	−0.03
V8_InnAct	0.99	0.12
V9_IntDet	0.89	−0.45
V10_ExtDet	−0.88	0.47

If the analysis (PCA) of capabilities variables is applied to the groups of *innovation impacts* (*low, medium and high*), the first component explains 77% of the variability and, with the second, they reach the 100% (Table 4b). In the first component, the highest weights are represented by the variables V1\_Struct, V3\_Strat, V5\_Leader, V7\_FreeSoft and V8\_InnAct. The second component is highly represented by the variable V6\_Motiv (Tables 5b and 6b).

It is important to note that in both analyzes, 100% of the variability with the first two components is explained. This shows that the intervening variables have a high correlation between them (Table 5a,b and Table 6a,b).

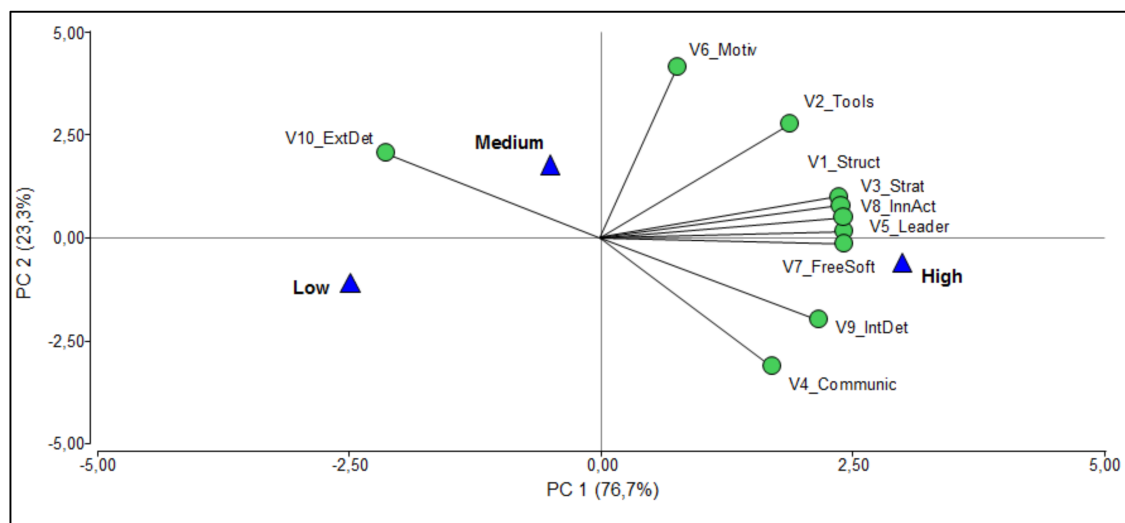
From the biplots graphs below, it can be affirmed that companies with high degree of results are distinguished from those of medium and low degrees by having higher degrees in the variables of V6\_Motiv, V3\_Strat, V5\_Leader and V9\_DetInt (Figure 1). The particular values of the indices of these variables can be seen in Table 7a.





**Figure 1.** Biplot for the result groups and each of the capability variables.

Figure 2 illustrates the capabilities variables that distinguish companies with high impacts from those of medium and low degrees. These variables are: V1\_Struct, V3\_Strat, V5\_Leader, V7\_FreeSoft and V8\_InnAct. The particular values of the indices of these variables can be seen in Table 7b.



**Figure 2.** Biplot for the impact groups and each of the capability variables.

**Table 7.** (a) Summary measures (mean, minimum and maximum) by variable for each degree of Results. (b) Summary measures (mean, minimum and maximum) by variable for each degree of Impacts.

(a)															
Result Degrees	V1_Struct			V2_Tools			V3_Strat			V4_Communic			V5_Leader		
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
High	3.16	1.75	5.00	3.64	1.00	5.00	3.27	1.50	4.88	3.92	1.65	4.95	3.67	1.00	5.00
Medium	3.13	1.60	4.85	3.70	1.00	5.00	3.11	1.38	4.00	3.83	0.99	4.95	3.37	1.00	5.00
Low	2.85	1.45	4.70	3.17	1.00	5.00	3.10	1.50	4.50	3.89	1.32	4.95	3.23	1.00	5.00
Result Degrees	V6_Motiv			V7_FreeSoft			V8_InnAct			V9_IntDet			V10_ExtDet		
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
High	3.02	1.00	5.00	4.18	2.00	5.00	2.92	1.00	4.60	3.78	2.00	4.60	3.15	1.65	4.35
Medium	2.73	1.00	5.00	4.17	2.00	5.00	3.09	1.40	4.60	3.65	2.80	4.40	2.96	1.65	4.00
Low	2.73	1.00	5.00	3.86	2.00	5.00	2.65	1.00	4.20	3.50	1.80	4.40	3.16	2.00	4.35
(b)															
Impact Degrees	V1_Struct			V2_Tools			V3_Strat			V4_Communic			V5_Leader		
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
High	3.25	1.60	4.85	3.76	1.00	5.00	3.60	2.38	4.63	4.25	2.64	4.95	3.60	2.00	5.00
Medium	3.14	1.75	5.00	3.76	2.40	4.40	3.29	2.00	4.88	3.71	0.99	4.95	3.50	1.00	5.00
Low	2.99	1.45	4.85	3.30	1.00	5.00	2.95	1.38	4.50	3.93	1.32	4.95	3.43	1.00	5.00
Impact Degrees	V6_Motiv			V7_FreeSoft			V8_InnAct			V9_IntDet			V10_ExtDet		
	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max
High	2.87	1.00	5.00	4.27	2.00	5.00	3.37	1.40	4.40	3.92	3.40	4.60	3.05	1.65	4.35
Medium	3.14	1.00	5.00	4.12	2.00	5.00	3.00	1.00	4.60	3.62	2.00	4.40	3.11	1.65	4.35
Low	2.63	1.00	5.00	4.04	2.00	5.00	2.68	1.00	4.60	3.66	1.80	4.40	3.10	2.00	4.00

## 5. Discussion

The present work is based on the interest for studying innovation capabilities in specific contexts, such as companies in the software sector operating in developing countries as Argentina.

Despite the breadth of the literature on innovation capabilities, there is no researches that focuses on identifying which capabilities in innovation management have developed companies with high innovation results and high innovation impacts.

Different studies have identified multiple variables that condition the ability to generate innovation (for example, [Camio et al. 2016](#); or [Lawson and Samson 2001](#)). Based on the study carried out, it was possible to identify specifically those capabilities that software companies with high results and impacts of innovation have developed and that distinguishes them from companies with low and medium innovation results and impacts.

Applying the technique of Principal Components Analysis, it is highlighted that 100% of the variability is explained with the first two components for the analysis of groups according to the degree (low, medium and high) of results and impacts of innovation.

It is identified that companies with high results are characterized by having higher degrees in the variables of motivation and internal determinants. This supports the theoretical framework regarding the importance of aligning rewards and incentive systems with innovation objectives ([Manso 2011](#); [Sajeva and Jucevicius 2008](#)) and focuses on internal factors such as culture ([Baker et al. 2014](#); [Aramburu and Sáenz 2010](#)), background and skills, training and qualification of employees ([Romero and Martínez-Román 2012](#); [Koellinger 2008](#); [Koc 2007](#); [Romijn and Albaladejo 2002](#)), among others.

Companies with high innovation impacts are characterized by higher degrees in the following variables: structure, free software and innovation activities. These results are in line with the contributions of different authors who recognize that structure is an important factor in promoting learning and innovation ([Rueda-Cáceres and Sánchez-Torres 2015](#)), identifying the consideration of innovation activities as a key aspect ([Wagner 2011](#); [OECD 2002](#)) and studying the impact of the use of free software in the generation of innovation ([Morgan and Finnegan 2014](#); [Teigland et al. 2014](#)).

Furthermore, two variables that distinguish companies with high results and impacts could be identified: strategy and leadership. The above affirms what is proposed in the theoretical framework, particularly in relation to the strategy by [Tamm \(2010\)](#); cited by [Rueda-Cáceres and Sánchez-Torres 2015](#)), [Tellis et al. \(2009\)](#) and [Dobni \(2008\)](#). Regarding leadership, the results obtained support the findings of [Gumusluoglu and Ilsev \(2009\)](#) about the impact of transformational leadership and its relationship with organizational innovation.

Considering the capabilities under study, particularly in the case of external determinants (which include the relationship with external actors and the identification of lower external barriers), it is understood that the inverse relationship identified would require a more in-depth analysis in the search for answers, among others, the degree of personal identification of external barriers for innovation in companies with different degrees of results and impacts.

These findings are in line with what is proposed by [Drucker \(1954\)](#); cited by [Cavusgil et al. 2003](#)) who points out that innovation capabilities are critical to achieving a superior innovation performance and that a firm with a great innovation capability will enjoy a high innovation performance. Also contribute elements to the theory of capabilities for innovation, in terms of its particularization with respect to the software sector, in a territory, Argentina and allow to consider the relative importance of the variables of capabilities in the generation of results and impacts of innovation.

This study contributes to the identification of key variables, in terms of capabilities, to be taken into account for diagnosis and intervention in the management of innovation in software companies, which has been possible given the potential of the applied methodology: Principal Component Analysis.

However, the methodological proposal of the present study, which is based on a specific model for the management of innovation in software companies, a methodology of data collection, analysis and

synthesis through indices of different degrees, would make possible the replication of the study in other territorial contexts and would allow to include, in future analysis, other dimensions such as the size of the companies and study their relationship with the variables of results analyzed in the present work.

**Author Contributions:** These authors contributed equally to this work.

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