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The use of knowledge management practices by Brazilian startup companies

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Abstract

To be competitive in current knowledge economy, startup companies should effectively use available knowledge to implement their development strategies. Consequently, it is necessary to identify which knowledge management (KM) practices are used by startup companies. This paper aims to identify KM practices used to overcome critical factors of startups' development in Brazil. It will be discussed the relation between the critical factors of startup development and the KM practices used. Interviews were conducted with startups established in business incubators in the southern region of Brazil. Results demonstrated that the main KM practices used to overcome critical factors of startup development – Opportunity Recognition, Entrepreneurial Commitment, Credibility and Sustainability – are related to company's internal knowledge. Internal knowledge is a company asset, which includes not only R&D activities but also its actions and routines. An important remark was that even though startups are not aware of KM practices, they have organized routines and standards aligned with current KM theories.

Keywords: Knowledge management; Startup companies; Brazil

Introduction

The development of innovative products and processes has driven the development of companies through the years. Big and small companies have applied different practices to keep competitive in the market, creating research and development routines to guide incremental or radical renovation of their portfolio (Parrilli & Elola, 2012). This renovation process is usually developed through innovative activities, driving companies ahead of their competitors since they will be pioneers in launching new products or services, obtaining improvements in both productivity and profit (Tsai & Li, 2007).

Considering that the development of innovative products and processes is an advantage for companies (Baumol, Litan, & Schramm, 2007), and that small companies may have some advantage in launching innovative products (Christensen, 2013; Criscuolo, Nicolaou, & Salter, 2012), fostering the creation and development of technology-based companies (startups) could be an alternative to a productive structure that struggles to develop innovation. In emergent countries such as Brazil, where only 5.7% of established companies have developed a new product or process nationally or internationally (IBGE, 2013), stimulating the creation of high-tech startups may be one alternative to foster social–economic development.

Adding to this, considering the current economic crisis Brazil is facing, the discussion about entrepreneurship and the creation of start-ups may be a good alternative to deal with high unemployment rates. This is true considering the relevant role of micro and small enterprises for economic growth. According to GEM - Global Entrepreneurship Monitor report (2016), 55.5% of the Brazilian population considers interesting the idea of starting a new company in the region they live in. This percentage is higher when compared to US and Mexico. In this context, it is important to promote the creation of start-up companies,

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discussing which are the best management practices to sustain its development.

Analyzing the role of startups in the development of innovative products and processes, we try to put together two issues related to the ability of startups to generate innovation. On the one hand, the use of knowledge management practices in the process surrounding the creation and development of high-technology startups. To foster the establishment of new startups, it is necessary to define processes to create and maintain knowledge in these companies. As defined by Tsai and Li (2007), new companies must effectively use the available knowledge to formulate and implement development strategies. On the other hand, the need to overcome critical factors that influence the development and sustainability of startup companies. The development of small companies is a survival and growth race (Sapienza, Parhankangas, & Autio, 2004) and the organization of knowledge management practices in which existing knowledge is evaluated and new knowledge is acquired to sustain companies' development may overcome critical development factors.

Analyzing these two issues, some articles were identified discussing the development of startup companies (De Cleyn & Braet, 2010; Gomes, Salerno, Fleury, & Saraiva Junior, 2015), acquisition of external knowledge (Presutti, Boari, & Fratocchi, 2007), knowledge management related to firm performance (López-Nicolás & Meroño-Cerdán, 2011; Mills & Smith, 2011) and creation of knowledge in startups (Tsai & Li, 2007) and high-tech manufacturing firms (Kao, Wu, & Su, 2011), and the development of e-learning tools to integrate knowledge management (Pohthong & Trakooldit, 2013). However, we were not able to identify articles that described which knowledge management practices were involved in the creation and development of startups.

Aiming to fill this gap in the literature, this article intends to identify the knowledge management practices used to overcome the critical factors of startup companies' development. The research model considered the critical factors of startup development described by Vohora, Wright, and Lockett (2004), in addition to new articles which have revised these factors (De Cleyn & Braet, 2010; Furlan & Grandinetti, 2014; Holland & Garrett, 2015; Rasmussen, 2011). Regarding knowledge management, the review of knowledge management practices of Baskerville and Dulipovici (2006) was used, in addition to other articles which analyzed these practices and the relation of knowledge and firm performance (Audretsch & Keilbach, 2007; Bembenek & Piecuch, 2014; Bender & Fish, 2000; López-Nicolás & Meroño-Cerdán, 2011; Mills & Smith, 2011; Mosconi & Roy, 2013; Naicker, 2013; Warren, Patton, & Bream, 2009).

Based on these two articles, an exploratory case study was conducted with startup companies established in business incubators in the southern region of Brazil. As a result, it was observed which knowledge management practices were described in relation to critical factors of startup development. A summary of these relations were presented as a result of this research, which may contribute to the current discussion about startup development (Furlan & Grandinetti, 2014; Rasmussen, 2011).

In sections '*critical factors in the development of startup companies*' and '*knowledge management practices*' we will review the critical factors of startup development and knowledge management practices, respectively. In section '*research method*', we will present the method used in the research, followed by the results in section '*results*' and final considerations in section '*final remarks*'.

Critical factors in the development of startup companies

The development of startup companies does not follow a linear path (Rasmussen, 2011). Unpredicted events or even improvements in business plan and technology exploration may alter time to market and performance (Brinckmann, Grichnik, & Kapsa, 2010; Holland & Garrett, 2015). As mentioned by Druilhe and Garnsey (2004), startups modify themselves while in development, refining business models and redefining opportunities.

However, there are critical factors that influence the development and sustainability of startup companies (O'Shea, Chugh, & Allen, 2008; Vohora et al., 2004). These factors arise during the company's learning process, in which the existing knowledge is insufficient for its development, being necessary to add more knowledge. Consequently, from time to time the startup company must review decisions and strategies previously defined, complementing its knowledge background (Rasmussen, Mosey, & Wright, 2011; Vohora et al., 2004). These critical factors are defined by four categories: Opportunity Recognition; Entrepreneurial Commitment; Credibility; and Sustainability, as described below.

- *Opportunity Recognition:* It is the first step of a startup based on a research spin-off – to recognize the business opportunity of its technology. The company's scientific knowledge is fundamental at this stage as it allows the development of technology focused on market opportunities. Several studies point out the lack of entrepreneurial knowledge among scientific researchers (Audretsch & Keilbach, 2007; De Clercq & Arenius, 2006; Markman, Gianiodis, & Phan, 2008; Van Burg, Romme, Gilsing, & Reymen, 2008; Wright, Lockett, Clarysse, & Binks, 2006), which is a critical factor as far as the beginning of the company is concerned. In order to overcome this factor, it is necessary to obtain enough market knowledge to identify an opportunity, which in some cases is done by external consultants (Lockett, Siegel, Wright, & Ensley, 2005; Van Burg et al., 2008).
- *Entrepreneurial Commitment:* After starting the startup company, the expectation of its success or failure may influence the commitment of the entrepreneur (Holland & Garrett, 2015). Vohora et al. (2004) state that there is huge uncertainty and risk involved at this stage of company development. Thus, entrepreneurs' commitment is necessary for the organization of internal resources, facilitating the learning process (Holland & Garrett, 2015; Lee & Jones, 2008). These resources include the necessary commitment for

production and coordination, materials, contacts with suppliers and clients, among others.

- *Credibility:* Credibility is described as a fundamental factor to obtain funding to start a new venture (Rasmussen et al., 2011). As a startup company is usually based on a single high-technology product new to the market (Midler & Silberzahn, 2008), risk and uncertainty are very high. Besides, it is harder to obtain resources from investors to a company that has existed for such short period (McAdam & McAdam, 2008). Consequently, establishing partnerships with potential clients and suppliers is important to ensure the acceptance of the new product by the market, often influencing modifications or adaptations. The company credibility is also guided by the product development, going through re-design, adaptation to the market and certification phases, in addition to publications of scientific articles to improve product publicity.
- *Sustainability*: To reach this stage companies should be able to sustain their activities through market transactions, continuously looking for new possibilities for product develop and improvement. As mentioned by Midler and Silberzahn (2008), startup companies maintain their development by the implementation of new projects that complement or redefine their initial experience.

The identification of critical factors for the development of startups may be important to guide the needs and demands that the starting company may face. Besides, managing available knowledge based on the company's strategy may improve innovative activities and firm performance (López-Nicolás & Meroño-Cerdán, 2011). Consequently, in order to improve the development of high-technology startups, it is important to identify which knowledge management practices are necessary to overcome the critical factors presented.

Knowledge management practices

The concept of knowledge management has been introduced and developed by Nonaka in the 1990s (Nonaka, 1994), mainly by the process of knowledge transfer and use described by the two types of knowledge – explicit and tacit. This concept remains a theoretical cornerstone of this discipline, being used to improve companies' strategy (Naicker, 2013) and partnerships (Bembenek & Piecuch, 2014).

In a bibliometric study of management journals from 1994 to 2014, encompassing knowledge management and knowledge sharing themes, Osinski, Roman, and Selig (2015) found significant research growth, especially in the period from 2010 to 2014. From a Brazilian perspective, Tonet and Paz (2006); Ramos and Helal (2010); Cunha and Ferreira (2011); Freire, Tosta, Helou Filho, and da Silva (2012) and Lemos and Joia (2012) describe that knowledge management has been studied for a long time in the area of management.

The relation between knowledge management theories and their use to improve companies' competitiveness has driven several studies. Baskerville and Dulipovici (2006) identified a list of theories from different areas of knowledge related to knowledge management practices. The authors have searched for articles published between 1995 and 2005 at the ABI/Inform and Web of Science databases. Among them the theory of information economics has been identified, which, according to Greenwald and Stiglitz (1986), is the influence of information on a company's economic performance. This review could be reinforced by the discussion of Burkhard, Hill, and Venkatsubramanyan (2011) and Denford and Chan (2011), who have analyzed knowledge management models and typologies that could be operationalized by companies. As the concept of information economics describes the use of knowledge in companies' practices, the knowledge management theories described by this concept will be analyzed from an entrepreneurial point of view, evaluating which one should be used by startup companies to overcome critical factors in their development. These knowledge management practices are described in six categories:

- *Knowledge Economy:* It is related to the knowledge life cycle and can be applied internally in the company or through market transactions (Baskerville & Dulipovici, 2006; Coase, 1937; Naicker, 2013). Internal knowledge is related to professional knowledge, which is considered as a company advantage because: (1) it decides when to buy external knowledge and when it can be produced internally through the rearrangement of existing knowledge; (2) it establishes, when needed, the relations of knowledge through external partnerships; (3) it decides when the internal knowledge may be commercialized, among others. Regarding its application in the market, it describes the possibility to reduce uncertainty and coordinate internal routines, such as standardization, adaptation, and improvement of routines;
- *Knowledge Clusters and Networks:* It takes place when different companies get together in networks or clusters aiming to create new or share existing knowledge, as can be observed in business incubators or technology parks. This type of strategy improves companies' competitiveness as sharing information improves the absorption of abilities and knowledge (Bembenek & Piecuch, 2014; Nonaka, 1994);
- *Knowledge Assets:* These are the company's specific advantages, indispensable for the creation of value (Mosconi & Roy, 2013). The advantages of internal knowledge are developed through the evolution of internal knowledge within the company, disseminating practices through company's employees;
- *Knowledge Spillover:* Is the absorption of knowledge by someone other than its creator. It takes place due to the difficulty of controlling knowledge, considering this is an inexhaustible and cumulative resource. These spillovers may improve the company's internal knowledge and generate a geographic location for innovation. Entrepreneurship is also fostered in environments with high levels of knowledge spillover, such as universities or technology clusters, while places with knowledge constrains limit this practice (Audretsch & Keilbach, 2007);
- *Continuity Management:* Refers to the preservation of knowledge within the company, reducing its susceptibility to employee turnover (Bender & Fish, 2000). To preserve intellectual resources knowledge managers need to stimulate the knowledge flow between individuals, institutionalizing

a company's available knowledge. Continuity Management is also related to knowledge decoding, which involves the documentation of tacit knowledge generated by individuals and its organization so it is not lost as time goes by. Besides, knowledge is organized in a way that it can be changed and improved over time.

- *Knowledge Organizations:* Describes the knowledge management practice within the company (Baskerville & Dulipovici, 2006). Led by an individual responsible for its management, the theory of knowledge organizations consists in the formulation and implementation of strategies of construction, incorporation, distribution, and utilization of knowledge.

In order to analyze the use of knowledge management practices by startup companies, several articles that have discussed this issue were reviewed. Describing the factors involved in the knowledge acquisition process during startup incubation, Warren et al. (2009) mentioned that knowledge acquisition could be described as a two-stage process. First, knowledge was developed mainly based on the business plan. Second, inter-firm connections provided a unique set of knowledge flows that supports the company through the incubation process. In this article, two knowledge practices can be observed: *Knowledge Economy* and *Knowledge Clusters and Networks*, both of which are related to the development of startup firms through the incubation process.

Addressing the relationship between knowledge and firm performance, López-Nicolás and Meroño-Cerdán (2011) concluded that knowledge management strategies (codification and personalization) impact on innovation and organizational performance directly and indirectly, improving innovation capability. The typology of knowledge strategies – personalization and codification – is based on the distinction between tacit and explicit knowledge (Nonaka, 1994), where codification strategies are oriented to explicit knowledge and personalization strategies are oriented to tacit knowledge. On the same topic, Mills and Smith (2011) proposed a decomposed model of knowledge management capabilities, categorized into two broad types – knowledge infrastructure and knowledge process. Knowledge infrastructure has three components: technology, organizational culture and organizational structure, while Knowledge process identifies four broad dimensions: knowledge acquisition, knowledge conversion, knowledge application and knowledge protection. Their findings suggest that although individual resources collectively determine a firm's overall knowledge management capability, which as a composite is related to organizational performance, each individual resource is not directly linked to performance. Here two other knowledge practices can be identified: *Knowledge Assets* and *Knowledge Organizations*, describing internal and external knowledge as a specific advantage to the firm and the importance of managing it internally.

These articles reinforce the different approaches to knowledge management practices in a startup company's development – from acquisition to its reorganization, codification and dissemination. Consequently, in this research we aim to identify and discuss the knowledge management practices used to overcome the critical factors of startup companies' development.

Research method

This article aims to observe the relation between knowledge management practices and their use to overcome critical factors of startup companies' development. To observe this phenomenon an exploratory case study was conducted (as defined by Yin, 2013) with five startup companies established in multisectoral technology incubators of universities in the southern region of Brazil. The start-up companies were chosen based on the criteria of easy access, without randomness in this process. In this sense, the results cannot be generalized. This research method was used as this is an exploratory research that aims to examine a phenomenon within its context (Yin, 2013). Interviews were conducted with company founders, using questionnaires with open-ended questions. This kind of questionnaire provides richness to the topic discussed and insights that were not thought of initially (Jackson & Trochim, 2002).

The interview script was based on the article of Vohora et al. (2004). Based on a case study, the authors analyses important elements for the development of academic start-ups. In this sense, we based or script on a consolidated article, with limited use in the analysis of companies in Brazil.

The chosen companies have started their entrepreneurial development based on a single technology-based product, a factor that characterizes them as a startup. The company founders interviewed were involved in the development of the company and in knowledge management activities. Considering the small number of employees in this type of company, only the founders were interviewed. We considered that the founder has an important role on organizing the different processes of the company, so we considered that they best suited to describe the management of knowledge in their companies. The questionnaire used addressed matters such as the creation of the company, the use of knowledge management practices and the company actions taken during its development.

The interviews were fully transcribed by the researcher himself, to reduce possible biases by improper interpretation, thus increasing reliability. A database was generated with all the interviews, observations and notes made, both in audio and in file, following the suggestion of Yin (2013) on the creation of a database with the information collected during the realization of the data collection from case studies. All interviews were conducted at the startup, and the transcriptions were available for the interviewee review, but it were not requested. Characteristics of the five surveyed companies are described in Table 1.

The data analysis used content analysis approach, described by Bardin (2009), especially the categorical analysis. According to this analysis method, qualitative information such as interviews can be organized in order to improve their analysis and understanding. Thus, we organized the analysis into four major themes (dimensions), according to the literature review, in which the five cases were described. The themes were: (a) opportunity recognition; (b) entrepreneurial commitment; (c) credibility and (d) sustainability. In each of the dimensions we highlight the

Table 1
Profile of surveyed companies.

Company	Industry	Year of foundation	Company origin	Resources support
A	Medical equipment	2003	Undergraduate final paper for the Engineering course by partners	Support program for company's R&D (PAPPE – FINEP)
B	Embedded electronics	2010	Spin-off of an academic research laboratory	Support program for graduate students conducting research at companies (RHAE – CNPq)
C	Automation	2010	Tutorial Education Program (PET)	Own resources
D	Automation	2011	Undergraduate final paper for the Engineering course by partners	Own resources + entrepreneurship prize
E	IT accessories	2011	The opportunity was identified when working at another company	Own resources

most relevant aspects and insert excerpts from interviews. It was a *ex post* analyses, that is, after the interviews, such described in Bardin (2009).

The reliability of the analysis followed Graneheim and Lundman (2004) and Bardin (2009) perceptions for content analysis, which describes the categories as: (a) homogeneous (one theme at a time); (b) exhaustive (the entire interview text was analyzed); (c) exclusive (one subject is addressed at a time and not confused with another); (d) adequate (the content met the objectives); and (e) objective (different coders have achieved the same results).

Results

The analysis of knowledge management practices were organized by each critical factors present in the startup development. Interviewees mentioned how knowledge management was used by their company to overcome such critical factor, providing relevant inputs about the relation between these two models.

Opportunity recognition

This category points out the identification of business opportunities, when scientific knowledge or technology turns into a business idea.

Companies A, C and D were created oriented toward the market, with a project designed to become a commercial product. According to an interviewee from Company A, this is the case with most technology-based companies. The main product of Company A was created based on an undergraduate final project that was, according to the interviewee, "a project that should be technically viable within our competences". One respondent from Company D mentioned that they surveyed the national market looking for technologies not explored, and identified which professionals would use the device. The interviewee emphasized that: "In fact, the barrier is not only to product development, but also to training the professional who will use it, to technical assistance – the service associated with the product you are offering".

In its turn, Company B is an academic spin-off created when an opportunity was identified during a field research. One of the founding members mentioned that: "We were testing a device to study cattle and the farmer asked where he could buy our device". As it was a prototype, they looked for partners to improve the technology before commercialization. At the end, they created a national technology with more resources than its current imported competitor. In this case, knowledge was created at the university and then transferred to Company B, which developed a commercial application.

Company E business opportunity was screened while one of the founding partners was working at another company. He identified an opportunity in which the place he was working at had no interest. As the interviewee mentions: "We found this technological trend in the USA and thought it could be a reality in Brazil in a couple of years". He found two partners from specific technological fields that would be useful for the development of the product and started the company.

Describing the category of opportunity recognition, two practices of knowledge were identified. First there is *knowledge spillover*, being identified in companies A, B, C and D by means of scientific research projects that have led to the development of prototypes or products targeted to the market (as mentioned by Audretsch & Keilbach, 2007). *Knowledge economy* was also identified, which relates to the creation of a company through the assessment of the new product, market and suppliers relations, risk assessment, and the creation of internal routines (Coase, 1937; Naicker, 2013).

Entrepreneurial commitment

At this stage of development, the company needs to organize itself, focusing on aspects such as infrastructure, staff, and financial resources. Companies A and B had, at its initial stage, one of the partners working full time with support from the Brazilian National Council for Scientific and Technological Development (CNPq). According to Company A: "Initial dedication was fundamental at the company's initial development stage, considering that the infrastructure needed to sell the product (sales, training, marketing, post-sales) is larger than the infrastructure to create the product".

Besides, the interviewee attended specialization courses on marketing, directing its studies to the company needs. Since the company was being structured and the product was being finalized, the interviewee took part in trade shows connected to the industry, evaluating what was being offered on the market and also searching for potential customers.

Company C had the support from a professor to structure its business plan, identifying customers, suppliers, and market opportunities. In this sense, the interviewee points out: "We looked for a professor to help us design a business plan and we needed to deepen our knowledge about the product. (..) We had difficulties with people's prejudice against our idea (..). Moreover, we didn't know the market".

Without much support, companies D and E started their activities based on their own resources, working part time at another place and during nights and weekends on their own company. Company D won an entrepreneurship prize, which influenced the founding member to quit his job and dedicate full time to the company for one year.

The transition through the entrepreneurship commitment factor is mainly the result of the structuration of *Knowledge Organizations*. This knowledge management practice makes it possible to organize knowledge that is internal to the company (tacit and explicit), standardizing routines and facilitating troubleshooting in the development of products and commercial transactions (Holland & Garrett, 2015). Besides, the organization of *Knowledge Assets* and *Continuity Management* is important to develop a learning process inside the company, integrating its routines and consequently reducing its dependence on staff and even partners (as mentioned by Bender & Fish, 2000; Mosconi & Roy, 2013). The company must have a knowledge stock that is not susceptible to collaborator turnover.

Credibility

The credibility factor identifies the actual conditions for the company's product to remain in the market, influencing modifications and improvements. This factor is characterized by the company's contact with potential consumers and partners, which ends up influencing its marketing reorientation and product adaptation. Items such as articles, product validation by opinion-makers, and even the project of a new version of the product are eventually necessary for developing a company's credibility.

Commitment and professionalism in the organization of Company A were, according to the interviewee, essential to obtain credibility in the market. As he puts it: "What matters is to be seen in trade shows as in the medical market the brand counts a lot. If they frequently see you in conferences and fairs, they will end up taking an interest in your product. We also publish a bunch of articles (..), because medical doctors want to know if there are publications, who tested the equipment, how the test was carried out. (..)".

To leverage its credibility, Company B, aware of the market constraints a new company faces, set partnerships with other renowned professors in their area of activity, as the interviewee states: "We had a partnership with a professor who lectures and is a consultant in our area. He helped us to map this project, and will help us sell this product, also because he has an interest in this product. In the end it is very important that his name is connected to the product so it reaches the market with high credibility".

Selling products and services is the main goal to most startup companies. However, gaining market credibility is important to achieve this goal, as mentioned by Rasmussen et al. (2011). Analyzing the relation between critical factor credibility and knowledge management practices, *Knowledge Clusters and Networks* was identified in relationships between the startups commercial partners and in the company's relation with experts who validate their technology (Bembenek & Piecuch, 2014). *Knowledge Assets* was observed when reorganizing the company's internal knowledge was important to adapt the product to market demands. Besides, with reorientation and consequent development of a new or modified product, *Continuity Management* practices became necessary to avoid losses in the product reformulation or due to staff turnover.

Sustainability

Economic sustainability is the result of continued innovation within the company. When a product reaches its financial sustainability, i.e., it becomes an innovation, companies start the development of a new product in order to keep ahead of market competitors.

In this context, Company A was already developing a new product while planning improvements to its current product. According to the interviewee, in a new product development process, "everyone in the company gives their opinion," but there is only one person in charge of collecting market information from the sales department". Moreover, projects "begin with scientific research conducted by doctoral staff, based on a literature review, new and old articles, and the development team finishes the job."

Company B reported the importance of using project management and knowledge management software for the company's development: "Nowadays we have project documentation in the company's computer server, but from now on two software tools will be acquired: one to control different versions of product development, saving each design change in a new version; and another to organize tasks, defining who will do what, deadlines, etc."

Considering knowledge management, Company C says that it does not have such practices. With the reorientation of the company, their work is now focused on customization requested by the client. However, Company C's sustainability was also achieved because they are offering training courses for technicians and engineers. As reported by the respondent: "We are promoting courses for engineering and architecture professionals and students to further promote our business and our products/services, as there is little information out there on the possibilities of this sector. In fact, we do not invest in advertising, but we are investing in our website, since individuals interested in automation are not averse to technology. The first place they will seek information will be the Internet."

Company E is in the product delivery phase but it is already working on new projects to proceed with its business plan. As reported by the respondent: "There's a line that goes like this – 'those who do not change will not prevail'. Therefore, that was always at the top of our mind. (..) We want to take our

Table 2
Relation between the knowledge management practices and the critical factors to the development of startup companies.

Critical factors	Knowledge management practices
Opportunity recognition	Knowledge Economy; Knowledge Spillover
Entrepreneurial commitment	Knowledge Organizations; Knowledge Assets; Continuity Management
Credibility	Knowledge Clusters and Networks; Knowledge Assets; Continuity Management
Sustainability	Knowledge spillover; Continuity Management

product to a higher level. That is why we work together with clients and professors. While our clients give us feedback and data, researchers generate articles while feeding our software."

As it could be seen in this factor, knowledge management practices are mentioned not only in the sustainability of the company through market return for its product, but also in the creation of new practices and routines for the development of a new product, as mentioned by Midler and Silberzahn (2008). Thus, practices as *Knowledge Spillover* and *Continuity Management* are considered important to maintain a company's innovative cycle.

Summing up, the formation of a startup company can be a difficult task due to the lack of entrepreneurial knowledge, whether related to business planning or to the market. Thus, the description of knowledge management practices can facilitate this process, improving the development and performance of startup companies.

Final remarks

Fostering the creation of startup companies based on research outcomes is the main strategy to develop high-tech sectors and, consequently, innovative ventures. However, the creation and development of new businesses in general demands commitment, market knowledge and internal organization, which may be improved by the use of knowledge management practices.

Thus, the discussion of which knowledge management practices are used at the development stages of startups may show how these companies deal with critical issues on their way to market. In other words, organizing knowledge management practices may influence the development of enterprises, where not only the learning process but also its management is crucial to overcome critical factors (Rasmussen et al., 2011; Vohora et al., 2004; Warren et al., 2009).

In this sense, the main knowledge management practices observed on each critical factor is presented in Table 2, in accordance to what was observed on the interviews.

As it can be seen, the results showed that *Continuity Management* was the most frequent knowledge management practice among critical factors, observed in three of them. As observed, continuity management is aligned with the continuity of the startup's development process, emphasizing the need to constantly preserve and improve knowledge in the company. As in the PDCA method (Kanji, 1990), which deals with continuous improvement, institutional knowledge should be preserved and improved over time. Consequently, from entrepreneurial commitment to sustainability factor, continuity management was identified in practices described by the companies surveyed.

In addition, *Knowledge Spillover* and *Knowledge Assets* were identified as important practices in the development of startup companies, observed in two of four factors. Knowledge Spillover, described in opportunity recognition and sustainability factors, reinforces the importance of approaching science and technology institutes. These institutes may be a source of new technologies which guide not only the creation of startups but also their sustainability through the development of new products and services. As mentioned before, a startup is usually based on a single product, and its sustainability also depends on developing new products or services. *Knowledge Assets*, in its turn, was observed in the intermediary factors – entrepreneurial commitment and credibility – describing its focus on the development of internal abilities to improve existing knowledge and turn the company's technology into a commercial product. Finally, it could be observed that the use of knowledge management practices may assist in the development of enterprises, since they help in the identification and organization of their routines, improving their internal knowledge and influencing their longevity in the market.

It was also important to notice that sometimes companies were not aware that they were implementing knowledge management practices, even though such practices were observed on their interviews. Through the critical factors we were able to observe that some knowledge management theories were applied, mainly in processes such as purchases, delivery time and product development. These procedures are considered important to the company's growth, applying features from their business plan to market intelligence.

Finally, this research brings light to how knowledge management may be used in the development of high-tech startup enterprises. Although the process of creation and development of new companies is not linear, the knowledge management practices indicated here may be used by startup companies in different situations, strengthening the relationship between knowledge and the development stages of new companies. In other words, the relation between knowledge management practices and the critical factor of startup development here described may seed light on how startups can improve knowledge management practices, supporting their development. Startups can organize their development strategy combining technology development, marketing approach and knowledge management.

Our main limitation to conduct this research was the number of interviews. We were able to address startup companies in the southern area of Brazil, but interviews in other regions of Brazil and other countries (emerging and developed) would improve our results and analysis. In addition, since the interviewed companies were not aware of knowledge management practices, sometimes it was difficult to connect their activities to the practices described in this article.

Another limitation of this paper to be pointed out is that only the founders of the company were interviewed. This may limit the research results, since only one point of view from each company was reported. There is no sharing of opinions

of other components, which could enrich the research, emerging topics related to tacit knowledge, developed by practical routines.

For future research, the number of interviews should be increased, analyzing differences between companies established in a single business incubator, differences between business incubators and differences between companies from the same industrial sector. In addition, the relation between knowledge management practices and the development (or not) of startups from one phase to another could be investigated, guiding further studies on entrepreneurship and the creation of technology-based companies.

Conflicts of interest

The authors declare no conflicts of interest.

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