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Post-incubation of technology-based firms: a case study on the effects of business incubators on growth patterns

Pós-incubação de empresas de base tecnológica: um estudo de caso sobre o efeito da incubadora nos padrões de crescimento

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Abstract: This study aims to evaluate the effects of business incubators' support on growth patterns of previously incubated firms that graduated at least three years prior the study. To this end, an exploratory study was carried out with five technology-based firms belonging to two incubators linked to the Universidade Estadual Campinas. Concerning the pre-incubation period, this study focused on their founding partners' technical and managerial attributes. As to the incubation period, the researchers sought to evaluate how successful the incubators had been in promoting the firms under investigation. Finally, the study investigates the incubators' performance, potential, and impact and the major barriers to growth on the post-incubation period. The main results suggest that the incubation process as well as the incubators' support system had little effect on the different growth patterns identified.

Keywords: Technology-based firms; Growth patterns; Incubator; Post-incubation period.

Resumo: *O presente estudo tem como propósito avaliar o efeito das ações e do sistema de apoio de duas incubadoras sobre o atual padrão de crescimento de empresas que passaram por processos de incubação e que se encontram graduadas há pelo menos 3 anos. Para tanto, realizou-se um estudo exploratório junto a 5 empresas de base tecnológica que pertenceram a 2 incubadoras ligadas à Universidade Estadual de Campinas. No período de pré-incubação analisaram-se características técnicas e gerenciais dos fundadores. No período de incubação buscou-se avaliar a atuação da incubadora na promoção das empresas. Por fim, no período de pós-incubação, considerou-se o desempenho, o potencial, o impacto da incubadora e as principais barreiras que podem vir a dificultar o crescimento. Os principais resultados indicam que o processo de incubação e o sistema de apoio das incubadoras exerceram baixo impacto ou efeito sobre os diferentes padrões de crescimento identificados.*

Palavras-chave: *Empresas de base tecnológica; Padrões de crescimento; Incubadora; Período pós-incubação.*

1 Introduction

Business incubators originated as a means to support the process of marketing new ideas and promote entrepreneurship and use of new opportunities in order to provide firms with a competitive edge in the product and service sectors of the market. Its main purpose is to not only support and encourage entrepreneurs to bring business ideas to fruition, but also contribute to the success of incubated firms.

Recent research has shown that mortality rates of previously incubated technology-based firms (TBFs) are very low, which points to the importance and effectiveness of this business-support mechanism. The incubation process aims to offset resource deficits at the early stages of firms to ensure business stability, long-term survival, and sustainable growth. In fact, it is a key purpose of business incubators to aim beyond supporting and providing incubated firms with a favorable environment for developing products and services; they should, as emphasized, endow them with resources so that they can reach maturity levels that surpass those needed for mere survival after incubation. For this reason, there is a growing interest on the part of researchers in what happens to firms after they graduate from incubators;

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notwithstanding, the post-incubation period is still a largely unmapped territory.

As regards the performance of incubators, graduation constitutes the best indicator of success. However, a high survival rate of graduated firms does not imply success per se. In reality, success should be defined as more than mere survival. In this sense, it is important to determine to what extent incubators' specific support components contribute to the survival and long-term growth of graduated firms.

Along these lines, this study aims to identify and investigate whether and how some incubation factors shape the growth pattern of graduated firms. To this end, this article is divided into sections presenting, in the following order, a brief theoretical framework about incubators of technology-based firms, the incubation period and process, and the post-incubation period. After discussing and employing the theoretical framework to construct the variables for this study, Section 4 presents its research methodology. In Section 5 are the results of the case study conducted with five previously incubated firms that had graduated at least three years before the study began. The last section presents the authors' final remarks.

2 Incubation process

Incubators of technology-based firms (TBFs) house firms that make systematic use of scientific/technological knowledge and advanced/pioneering techniques, i.e., their main input is technical-scientific information and knowledge. Most TBFs originate from spinoffs of projects developed at universities and research centers. According to Fontes & Coombs (2001), these firms are known for their "technological dynamism," i.e., their ability to identify and develop new technologies and grow rapidly after successfully introducing these new technologies to the market. This definition incorporates the dimension of technological capacity building effort, a useful definition in that these firms apply a significant portion of their resources to their activities despite not necessarily having the most solid and conventional R&D format (Côrtes et al., 2005).

The incubation process allocates a specified period of time to business building and development of innovations proposed in previously selected projects. According to Mas-Verdú et al. (2015), the key function of incubators is to support entrepreneurs in their initial stage of business operation. Andino (2005) maintains that the incubation process is important in that incubated firms can thus adequately acquire competencies that will help them adapt to the market and prosper after graduating.

During the incubation period — typically three years long — incubated firms receive technical and managerial support in addition to logistics, which facilitates their access to funding mechanisms and promotes partnerships with innovation agents. According to Santos (2004), the incubation process aims to produce financially viable and self-sustaining businesses upon leaving the incubator. Lundqvist (2014) and Xiao & North (2016) have emphasized the importance of incubator support services to the successful development and growth of new TBFs.

The incubation process can be divided into three stages, according to Abreu et al. (2006). The first stage is called pre-incubation and lasts from three months to one year. The incubated firm uses this time to improve its business plan, conduct market research, and prepare technically for self-management. The next stage is the incubation proper. During this stage, the business plan — conceived in the previous stage — is developed. The firm can now take advantage of the facilities and other services supplied by the incubator. This stage is critical as regards value adding, and the incubator focuses on business orientation, monitoring, and evaluation. This stage usually lasts two years. Finally, the third stage — the post-incubation stage, which has no time limit — is when the firm is mature enough to operate on the market on its own. Then, the firm graduates from the incubator, but the latter's services remain available to the former. The goal of this stage is to foster the firm's autonomy and mitigate the impact of graduation from the incubator.

The incubation process pays special attention to the early phases. Aspelund et al. (2005) point out that the TBF entrepreneurs' control of resources and strategic and market decisions — particularly in the early stages of the business life cycle — are predictive of their survival and growth in later stages. During the initial incubation stages, some components such as physical infrastructure and shared use of a variety of business support services can reduce important operational costs of the incubated firms and assist them in areas lacking in knowledge and expertise, e.g., marketing, accounting, and human resources. According to Schwartz (2009), the extent to which these support mechanisms work together is of fundamental importance to the survival and growth of incubated firms after graduation. However, it should be noted that there are usually discrepancies among key resources, which are crucial to the viability of the firm and its actual resource base, as pointed out by Schwartz (2013).

It is important to emphasize that different firms have different behavioral, structural, strategic, and technological characteristics, which in turn generate different needs and require specific actions

during every one of the incubation years (Iacono & Nagano, 2014). Neglecting these factors — as well as discrepancies among resources that are crucial to the viability of the business and its actual resource base, as highlighted in Schwartz (2013) — can jeopardize sustainable business growth and success after graduation.

According to Hackett & Dilts (2004), the business incubation process can be evaluated in terms of the firms' economic performance and growth at the time of leaving the incubator. As regards business operation, there are five different, mutually exclusive result states for incubated firms at the end of the incubation period, namely:

- Firm is surviving and growing profitably;
- Firm is surviving and growing, and is on its path to becoming profitable;
- Firm is surviving but not growing, is not profitable or is only marginally profitable;
- Firm's operations have been suspended; it is still incubated, but its losses have been minimized;
- Firm's operations have been suspended; it is still incubated, and its losses have been large.

Historically, the literature has suggested that the first three result states are indicative of incubation success and the last two indicative of failure (Hackett & Dilts, 2004).

Other important considerations worth mentioning are the length of time spent in the incubator and exit policies. Schwartz (2008) claims that there is no ideal incubation time, but a longer incubation period may make incubated firms too dependent on the support received, leading them to stop investing in specific resource bases of their own.

As to exit policies, Grimaldi & Grandi (2005) argue that they must take into account the fact that incubated firms may take different times to reach a given development level, depending on their industry context (e.g., market access and size). In other words, company-specific factors require that more flexible graduation policies be devised. In this sense, the literature suggests adjusting the incubation time (an average time) to each firm individually, since it depends on its adopted business model (which may include different strategies, life cycle, target market, etc.). Rothaermel & Thursby (2005) claim that graduation criteria should be determined on a case-by-case basis, i.e., a different maximum incubation time should be set for each firm depending on its features and environment.

3 Post-incubation

According to Schwartz (2008, 2009), little is known about the dynamics of survival or exit of firms after graduating from incubators and the specific support factors that actually determine their failure, survival, and success after graduation. Despite the key function of incubation being to assist future entrepreneurs in establishing their businesses, post-incubation success is not a given (Mas-Verdú et al., 2015). Recent research has suggested that incubated firms may not benefit considerably from their relationship with their incubators and may even become more vulnerable to failure after graduation (Lasrado et al., 2016).

With regard to survival rates of firms that have undergone incubation, the literature has focused only on failure rates during the incubation period. Problems and difficulties associated to survival and failure rates of incubated firms, as indicative of incubators' performance, are often neglected. It has been implicitly assumed that business support should not aim at the firm's survival after leaving the incubator and that failure of graduated firms does not depend on their previous incubation process. Moreover, this view fails to acknowledge that successful graduation does not warrant long-term survival and success (Schwartz, 2009; Rothaermel & Thursby 2005).

Studdard (2006) contends that research on incubated firms should not be restricted to the incubation period; it should aim beyond their graduation. Rothaermel & Thursby (2005) argue in a similar vein, pointing to the fact that despite constituting an important milestone in the development of incubated firms, graduation per se does not guarantee their future success. According to Bruderl et al. (1992), the chances of survival of new firms can be associated to three groups of factors: (1) entrepreneurs/founding partners' individual attributes; (2) features, structural characteristics, and strategies of firms; and (3) firms' environmental conditions and challenges of firms.

Entrepreneurs' individual attributes have been investigated in many studies addressing the survival of new firms, especially in light of human capital, by researchers in the fields of organizational sociology and psychology. These studies have mainly focused on the effects of entrepreneurs' educational background and professional experience and work environment on business performance. According to this approach, business founders/entrepreneurs constitute, on the one hand, a key factor to organizational success, from which it follows that their shortcomings, e.g.,

lack of experience in the field or poor management skills, are determinants of organizational failure.

The organizational ecology approach emphasizes factors relating to organizational structure and environmental conditions, as stated by Hannan & Freeman (1977, 1989) and Aldrich (1979), cited by Bruderl et al. (1992). Business mortality is one of the major factors addressed in this approach. New companies have a higher risk of failing than those that have been on the market longer.

Another aspect to be highlighted is that companies that are followers — i.e., companies entering a market with established players — stand a better chance of surviving than those supplying something entirely new. Bates (1990) claims that follower companies can benefit from an existing customer network and/or internal organizational processes/routines of proven efficiency.

Establishing support mechanisms during incubation and a post-graduation follow-up process can improve the success rate of an incubated firm, including not only business survival, but also growth and profitability, which are relatively low after graduation from the incubator.

The factors influencing the success rate of new companies have been identified by several studies. These studies, according to Marino & De Noble (1997), have sought to understand the founding partners' experience and attributes, the product and market strategies, product originality, and structural specificities of the sector in which they operate. Criterion variables, in turn, have included sales growth, employee growth, time-to-market of first products, business survival, and financial performance. These elements can be categorized under four perspectives. The first perspective focuses on the conditions under which firms grow and survive. Gartner's (1985) new business creation model and Sandberg's (1986) new business performance model epitomize this perspective. Gartner's model encompasses a set of variables addressing the entrepreneur's attributes and the company's environment, organization, and business process. Correspondingly, Sandberg's model identifies entrepreneurial experience, strategy, and industrial structure as key determinants of performance.

Known as *venture capitalist*, the second perspective — based on Tyebjee & Bruno (1984), MacMillan et al. (1985, 1997) — puts emphasis on factors associated to managerial capacity, market attractiveness, competitive exposure, and resistance to external threats. The third perspective focuses on the business incubator proper, its management and support provided. Along these lines, Lumpkin & Ireland (1988) maintain that an incubator's success is closely related to that of its members.

Critical success in this perspective revolves around the management team's attributes, access to financing, and market factors.

The fourth perspective emphasizes market structure and product strategies (Biggadike, 1979; Hobson & Morrison, 1983; Sandberg, 1986). Structural characteristics include customer concentration, product heterogeneity, and development stage of industry. Business strategies focus on product differentiation, quality, and services provided (Hobson & Morrison, 1983; Sandberg, 1986; Robinson, 1990). In this context, it is important to note that while posing a barrier to entry, industry concentration may also represent an opportunity for growth. Wagner (1994) argues that new companies operating in concentrated industries find it more difficult to grow and, as a result, have higher failure rates. On the other hand, customers in a concentrated industry tend to welcome new suppliers as a means to regulate the industry leaders' decision power. Besides, a new company may very well converge its resources on a single segment that has been neglected by the market leaders in a concentrated industry sector, i.e., a niche, thus boosting its initial growth.

4 Methodology

The case study method was employed in this research. An investigation — of an exploratory nature — was conducted in 2012 by means of questionnaires and interviews with founding partners of previously incubated firms. The analysis unit comprised five previously incubated firms that had graduated at least three years before the study began.

The sample included firms that had graduated from two incubators in Campinas, Brazil: INCAMP (UNICAMP's incubator of TBFs) and SOFTEX (also belonging to UNICAMP).

The questionnaires addressed mainly issues related to the pre-incubation, incubation, and post-incubation periods.

The goal of the questionnaire concerning the pre-incubation period was to analyze and evaluate the founding partners' technical and managerial profile and knowledge before establishing the firms under investigation.

Questions about the incubation period sought to evaluate the incubation process, with emphasis on the knowledge acquired by the participating firms and the incubators' support and other general contributions provided to them during this period. Finally, regarding the post-incubation period, the goal was to assess the performance, capacity, and potential of the firms and the main barriers to growth (or higher growth) encountered by them.

The questions focused on the level of importance in a 1-5 scale, 1 being not important and 5 very important, subsequently calculating the frequency and average for each indicator. The coefficients of variation from this scale were employed to evaluate the dispersion of responses among participants, i.e.,

the extent to which opinions were homogeneous or heterogeneous. Chart 1 details the set of variables and indicators used in this study.

5 Results

Based on the questionnaire and interviews carried out at the firms under investigation, this section presents the results in the form of summary tables and discussion for every variable analyzed.

5.1 Characterization of participating firms and profile of founding partners and management team

The firms under investigation supplied products and services in the areas of information technology and communication, biotechnology, and medicine. Four firms had been on the market for five years and one for three years at the time the study began. They marketed more than one product or service.

Chart 1. Description of research indicators and group of variables.

	Variables	Description	Indicators
INDIVIDUAL/ PRE-INCUBATION	**Attributes of founder/ entrepreneur and characteristics of firm**	Assess managerial attributes regarding previous work experience and technical knowledge of management team.	Education; professional history; experience in the sector; business experience; managerial competence; technical competence.
INCUBATOR/INCUBATION PROCESS	**Acquisition of knowledge via incubator**	Because firm is in incubator, how much has it contributed to obtaining knowledge needed for business development?	Necessary technical knowledge; necessary knowledge of business; necessary marketing knowledge; necessary knowledge in the financial area; knowledge about innovation.
	Support provided by incubator	Evaluation of assistance provided by incubator concerning several areas.	Technical monitoring; interaction between firm and incubator; actual business knowledge; management support; technological support; marketing support; market support.
	Competencies of incubator	Capacity of incubator to provide services in several areas	Access to sources of capital; legal support; accounting support; consulting; marketing; contact with university; interaction with industry/industry sector; training in entrepreneurship.
	Contribution of incubator in each incubation year	Evaluate how incubator acted and contributed in specific ways to solving main problems presented by firm every year throughout incubation.	Adequacy of incubation time; preparation for market; resources or infrastructure not offered and deemed important for promotion of firms; performance and contribution in each incubation year.
POST-INCUBATION PERIOD	**Performance of firm**	Assess current performance of firm.	Sales growth rate over post-incubation period; employment growth rate; profitability; time-to-market; amount of funds obtained from funding sources; financial performance, technological performance.
	Potential of firm	Assess qualities and competencies of firm to add value to product/service.	Qualification of management team; sophistication of firm's product; investment in R&D; profit potential; potential to attract capital investments; short-term balance.
	Present effect of incubator on business	Assess benefits of incubator and its impact on business.	Growth rhythm; level of competitiveness; business knowledge; self-confidence; incubator image; financial and infrastructure feasibility for business; personal and professional growth.
	Present needs and difficulties	Assess needs and difficulties encountered by firm after being incubated for several years.	Market information; working capital; training of management team; commercialization; technology development; fund-raising; partnerships; financing.

Source: Devised by authors.

Three firms already had more than one patent and two were at the stage of development and analysis. As for personnel, three firms employed from ten to twenty professionals and two fewer than five.

It is worth mentioning that all the firms under investigation had adopted product differentiation as a strategy for their main product. The low-cost strategy, when it occurred, was always for a second product. Another important aspect to be highlighted is the change in the business model that took place in three of the firms under investigation. One of the firms, in particular, merged with a foreign company after 3 years of incubation. This led the firm to offer its product and service on the foreign market. As for their market reach, two firms offered their products on both foreign and domestic markets, and the remaining ones only operated on the domestic market.

Regarding the entrepreneurs' and management team's profile, in all but one firm, the founding partners had not had any previous experience as entrepreneurs before establishing the firms. On the other hand, in all of the participating firms, the founding partners had a high academic level (graduate school). In relation to their familiarity with the industry sector, one firm had a good deal of experience and another did not have any. The remaining three had some experience, however little. As for the management teams, the members had had some previous business experience, however little as well, not exceeding five years.

5.2 Incubation process

The incubation period was analyzed with the aim of evaluating, from a technical and managerial standpoint, the extent to which the incubator had contributed to business development, the amount and quality of support provided to the incubated firms, and its ability to promote business development through the services it provided.

Several factors were taken into consideration such as time devoted to the incubated firms, quality and use of resources, and the incubator management team's quality and training. Table 1 shows the indicators used for evaluation, e.g., average and coefficient of variation. The distribution of coefficients of variation per set of indicators is shown in Figure 1.

As regards the acquisition of knowledge via incubator, the incubators' contribution to the incubated firms acquiring the knowledge needed for developing their business was assessed in management areas related to marketing, finance, and innovation. Table 1 shows that, on the whole, the participating firms consider the level of business development knowledge acquired via incubator as low.

Technical knowledge and that related to innovation rated the lowest. Marketing and business administration knowledge in general, in spite of obtaining the best rates, was considered low, too. In other words, the study results suggest that the knowledge acquired by the firms under investigation through their incubators contributed little to their development. Although it met the firms' basic needs, this knowledge did not adequately address market and, specially, technological aspects. This can be observed in the indicators of support provided by the incubators. As regards this set of indicators, it is worth highlighting the heterogeneity of the answers given by the participants. The coefficient of variation in Table 1 and Figure 1 points to some homogeneity in the answers about technical and administration knowledge acquisition, i.e., the majority of the participants evaluated these factors in the same way. However, the coefficient of variation indicates strong heterogeneity in the responses when it comes to other factors such as marketing and innovation, implying that the level of importance in relation to knowledge acquisition differs considerably in these cases.

The support offered by the incubators was considered mostly insufficient, especially regarding advice and follow-up about technical factors. Most participants stated that more support and attention to technological, marketing and marketing factors was necessary. With regard to these factors, a total lack of support and monitoring was found in some cases. From the businesspersons' viewpoint, more time should have been assigned to building the participating firms' knowledge of actual problems and monitoring subsequent actions in order to promote business development. However, it should be observed that the technical support provided to the firms also shows dispersion in the responses, which indicates that different firms evaluate it differently.

The incubator's ability to supply a variety of appropriate services to promote business was assessed in different ways. This heterogeneity is reflected in the coefficients of variation. The management consulting services encompassing several areas of the firms were considered of great relevance to the cases in which the entrepreneurs did not have previous experience in business management. The incubators — through their available resources — provided, in this manner, vital professional training, especially concerning business management.

However, in those cases where the entrepreneurs had already some professional managerial experience, little development was obtained, since the training programs were too basic. While some of the participating firms highlighted the incubator's legal support and assistance in evaluating sources

Table 1. Average and Coefficient of Variation (CV) of indicators during incubation.

Code	Indicators	Average	CV (%)
A	**Knowledge acquisition via incubator**	**Average**	**CV (%)**
A1	Technical (product design, manufacturing, etc.)	1.20	37.3
A2	Managerial (accounting, personnel, strategic planning, etc.)	2.60	34.4
A3	Marketing (sales, service provision, market conditions, etc.)	2.60	63.2
A4	Financial (risk capital, subsidies, angel investors, banks, etc.)	2.20	59.3
A5	Innovation (innovation process, project management, technology, etc.)	1.80	72.4
B	**Support provided by incubator**	**Average**	**CV (%)**
B1	Time devoted to monitoring firm from a business point of view	2.60	51.6
B2	Time devoted to monitoring firm from a technological point of view	1.20	37.3
B3	Interaction time between firm and incubator managers	3.80	28.8
B4	Time devoted to getting to know the firm's real problem	2.40	81.2
B5	Support and advice in management	3.20	51.6
B6	Support and advice in technology	1.80	39.1
B7	Support and advice in marketing	2.60	43.9
B8	Support and advice about the market	2.60	43.9
C	**Incubator's competencies**	**Average**	**CV (%)**
C1	Provision of administrative support services	2.60	43.9
C2	Provision of management knowledge	3.20	26.1
C3	Provision of access to sources of capital (banks, venture capitalists, and angels)	2.60	69.9
C4	Provision of legal support services	2.60	69.9
C5	Provision of accounting support services	2.00	86.6
C6	Provision of consulting services	4.20	19.9
C7	Provision of specialized marketing services	2.80	53.0
C8	Provision of contacts with universities	2.60	53.0
C9	Development of professional training	3.00	52.7
C10	Development of business as a whole	2.20	59.3
C11	Interaction with industry and/or industry sector	1.40	39.1
D	**Contribution of incubator to development of business**	**Average**	**CV (%)**
D1	First incubation year	2.8	29.9
D2	Second incubation year	2.6	43.9
D3	Third incubation year	2.5	51.6

Source: By authors based on research data.

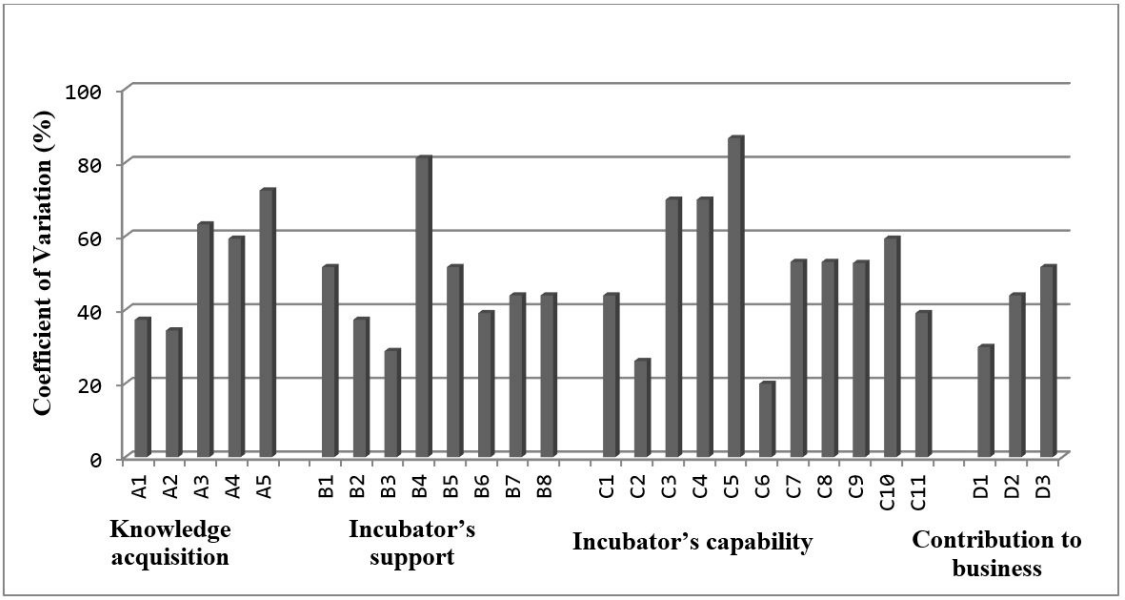

Figure 1. Coefficients of Variation of indicators in incubation process. Source: By authors based on research data.

of capital, for others, these same items were not addressed adequately. Another important aspect is the lack of interaction between the incubator and the industry or industry sector. For the participants, a closer relationship with the industry is of paramount importance when their firms are still incubated, novices in their industry sector, since they often do not have business references or direct contact with the market. It is worth mentioning that the network support provided by the incubator should allow the creation of internal and external networks, as emphasized by Soetanto & Jack (2016) and Scillitoe & Chakrabarti (2010). In other words, it appears that the incubators contributed more to managerial training, albeit at a basic level, than to business development in general. Differences in the types of needs and levels of support provided by the incubators are also found throughout the three years of the incubation period.

In the first year of incubation, most entrepreneurs considered the incubators' contribution as of little significance, as shown in Table 1. This is reflected in the coefficient of variation (29.9%), which is lower as compared to those relating to the following years.

Throughout the next stages of the incubation process, there is a decrease, however small, in the level of importance. According to the participants, the incubator's importance is greater in the first year because they get considerable support to develop their business idea and product. The firm owners stated that the incubators had not contributed consistently to solving the assortment of problems they faced in the second year, after the innovation stage of incubation. The incubators' contribution is considered even lower in the third year. It is important to note that in this context the necessities of the firms throughout the incubation process can differ considerably. It is also worth noting that, insofar as the importance assigned by the firms under investigation to the incubators' contribution decreases, the coefficient of variation increases, which indicates that the incubator's contribution to business development is not so low for some firms under investigation.

In the first year, it seems that the participating firms place more emphasis on business definition and possible sources of funds. Whereas the firms' major focus was on capacity building for product development and financial resources for its implementation in the first year, in the second year the innovation dynamics, marketing mechanisms, and partnerships appear to have been more relevant. In the third year, commercialization rose in importance, followed by financing, the latter already present throughout the whole period.

As regards the incubation time, 80% of the firms under investigation claimed it to be adequate. For one firm, in particular, the incubation time was too short. In this case, the interviewee stated that because the development of his product was complex, it demanded a longer incubation period as well as greater investment. Yet, it is worth noting that when asked about their need for follow-up support after graduation, only one firm declared that they did not need it; the majority stated that support regarding marketing and financial issues would be appreciated in order to accelerate growth.

In short, the results presented above clearly show that the participating firms' assessment of their incubator's performance as regards management is much more positive than that related to technology and innovation. As for indicators of dispersion of responses, the existing heterogeneity may be not only a result of mere diversity of opinion, but also due to the participating firms having different experiences.

5.3 Post-incubation

The post-incubation period was analyzed in order to evaluate the participating firms' trajectories after graduation from their corresponding incubators. To this end, the performance of the firms was observed and so were their external environment (market and competitiveness), their current potential to compete, develop, and add value, their incubators' current effect on them, and their needs and/or difficulties regarding business development. The firms' performance was evaluated with reference to financial results, personnel, management, and product. Table 2 presents the indicators used for evaluation.

Table 2 indicates that, in general, the participating firms had an average performance, which was corroborated by their own perceptions (Figure 2). It should be mentioned that just four of the participating firms responded to this question. One of them was still at the stage of product development and completion for commercialization due to lack of funding and resources for the final project.

Some firms evaluated their sales performance as reasonably good, since the revenues ensured their business sustainability. As for profitability, just one firm considered it good; the remaining three considered it average. It should be noted that this is in line with the current state of the firms as pointed out by their founding partners/owners, i.e., the firms were either surviving or growing towards profitability, however with modest results. For three of the participating firms, performance and time-to-market results were unsatisfactory. For most participants, marketing mechanisms constituted the

Table 2. Average and Coefficient of Variation (CV) of post-incubation indicators.

Code	Indicators	Average	CV (%)
A	**Firm's performance**	**Average**	**CV (%)**
A1	Sales growth	3.25	25.5
A2	Profitability	3.25	13.3
A3	Global (finances, projects, sales, technologies)	3.25	25.5
A4	Time-to-market: from product conception to launch on the market	2.75	30.2
B	**Firm's Potential**	**Average**	**CV (%)**
B1	Firm's product/service is better than its competitors'	4.80	9.3
B2	Competitive edge strongly based on firm's product/service	4.80	9.3
B3	Firm invests heavily in research and development	4.00	50.0
B4	Firm's product/service is highly sophisticated and complex	4.80	9.3
B5	Management team is highly qualified	4.20	19.9
B6	Firm's profit potential	4.60	11.9
B7	Probability of firm achieving financial balance in the short run	3.40	33.5
B8	Firm's potential to attract venture capital investments	3.00	66.7
C	**Needs/Difficulties**	**Average**	**CV (%)**
C1	Market information	1.80	72.4
C2	Working capital	2.00	52.7
C3	Training of firm's managers	2.00	50.0
C4	Marketing mechanism	3.20	51.3
C5	Partnerships (universities, research centers, suppliers, etc.)	2.00	50.0
C6	Firm's capital	3.80	54.1
C6	Financing	3.60	31.7
C7	Business management	2.00	61.2
C8	Development of technology	2.00	35.4

Source: By authors based on research data.

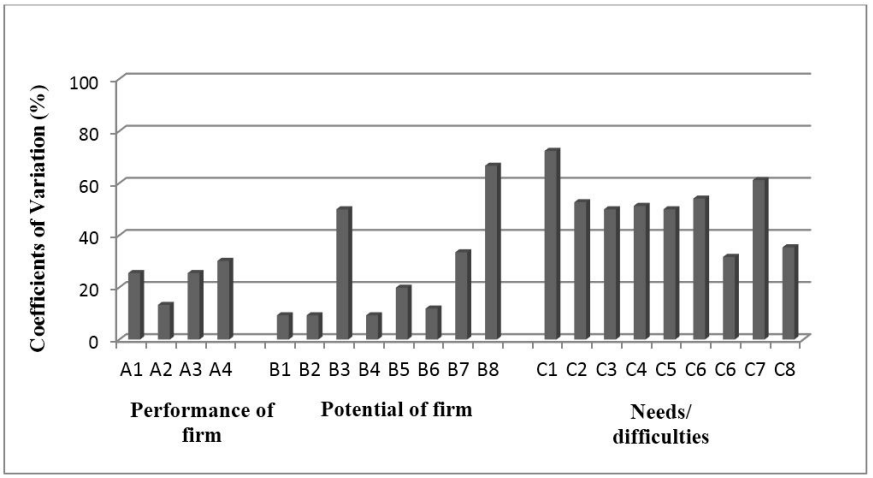

Figure 2. Coefficients of Variation (CVs) of post-incubation indicators. Source: By authors based on research data.

highest barriers. As regards the occupancy rate, with the exception of one firm, all presented an increase in personnel over the years.

In relation to their external environment, entry barriers were significant. Some of the participating firms' markets are relatively new, and product promotion as well as marketing investments are constrained by scarce resources. Incubated firms that face price competition have many difficulties, as they are still small-scale producers and their processes are not fully efficient. Competitive intensity was considered average-to-high by most participating firms. One of the strategies adopted by them to operate in competitive markets was to invest in niches.

Regarding the potential of the firms, i.e., their then capacity to be competitive and add value to their businesses, this study aimed to evaluate,

among other aspects, their product performance as compared to that of their competitors', investment in R&D, product sophistication, management team's skills and qualification, and profitability potential.

According to the respondents, all participating firms considered their products competitive. They also considered having the technical and management training needed to develop and grow profitably. At the same time, for 60% of the participants, their firms were not attractive enough to venture capital investments.

For one firm, its product — due to its radical innovation — represented a high risk to investment, which made the firm less attractive to venture capital. It is also worth highlighting and drawing attention to short-term financial issues. Eighty percent of the firms found it difficult to reach financial balance in the short term, which indicates the need for greater revenue and profitability. Financial oscillations can inhibit investment and future growth. However, the results regarding this group of factors indicates a degree of homogeneity in the responses given by the participants, as shown in the low coefficients of variation. That is, there is greater agreement among the participants, as expected, since the indicators depict the entrepreneurs' opinions about their own firms' potential.

Regarding current needs and/or difficulties, the objective was to evaluate the level of intensity of factors related to marketing, financial, commercial, and technological issues, as shown in Table 2. At the stage of growth in which the participating firms were, the major difficulties were related to marketing mechanisms and fundraising, whether through financing sources or via risk capital. It should be observed that the firms' products, on the whole, were at a mature and technologically competitive stage, thus requiring viable and effective marketing mechanisms. Due to their size, small companies sometimes cannot obtain the financial resources needed to leverage sales because in most cases they lack the required guarantees and financial balance.

Nevertheless, it is important to observe that there is some dispersion in the responses about needs and difficulties, (Figure 2), which indicates that the intensity of these needs and difficulties was the same for all the firms under investigation.

6 Conclusion

This study aimed at evaluating the growth pattern of TBFs in the post-incubation period and the impact of incubation on this pattern. The incubated firms displayed some growth, however small with respect to profitability.

While graduating was relatively easy for the firms, post-incubation survival and growth were not. The analysis of this process and the performance of the participating firms indicates that:

- Three firms display growth and are on the way to profitability, however at a slow pace, which can compromise survival in the medium term, given that they their products have shorter life cycles and are sold in highly competitive markets;
- Two firms are at the survival stage despite their potential.

In short, the results suggest that the incubation process and the incubator support system had little or no effect on the growth patterns identified. Despite the potential presented by the participating firms, reflected in the sophistication of their products and in their managers' and technicians' qualifications, these firms lack — in different measures throughout the incubation process — support in order to sort out marketing, financial, and product promotion issues, which rise to paramount importance after graduation. In this sense, it is possible to affirm that the main objective of the incubator, i.e., to produce financially viable and independent companies, is lacking since it is often limited to the evaluation of their "success" at graduation. In other words, the assessment of incubators' contribution has focused more on the incubation process itself than on post-incubation challenges.

It is important to emphasize: firstly, that these are preliminary results within a broader research project; secondly, that other aspects of this research need to be further investigated and, finally, that the issues addressed in this study refer to the participants' opinions and perceptions. Despite the importance of participants' perceptions, further exploration of these issues is required, as reported opinions may differ somewhat from reality.

7 Final remarks

The incubation process was important to all firms under investigation, especially concerning provision of infrastructure and support in business management and training, important aspects to nascent firms and, especially, to those whose founding partners lack prior business experience.

Throughout this period, the incubators usually provided the necessary conditions for testing business hypotheses and studying the market as reported by some participants. Notwithstanding, the incubators' actions were limited to these contributions. The prevailing environment could be considered "academic" and support on issues that demand knowledge of different areas of a business was not

provided. Overall, the incubation process focused more on internal issues of the participating firms (organizational management) than on their external environment (market).

In this sense, it is important that the incubation program strive for meeting, on a company-to-company basis, the diverse needs arising during this period. This fact can be verified by the high degree of dispersion found in the entrepreneurs' responses. The heterogeneity presented by the participants, through the coefficients of variation, should be considered as of great importance, since the incubation process includes the establishment of new company with novice entrepreneurs, whose attributes and potentialities differ greatly among themselves. It is also worth emphasizing that the introduction of new technologies or technological advances by companies requires efforts and support that differ from those required by traditional ones. Solutions to these problems, due to the size and condition of nascent companies, exceed their strengths and conditions.

Thus, the importance of qualified management is clear; managers should be capable of interacting with all the actors involved, inside and outside the organization, so that the necessary support can be adequately provided to different incubated firms. It is also worth noting that the incubation process should mostly help firms acquire capacities effectively in order to accomplish the goal of adapting to the market and prospering. Since nascent companies are more vulnerable, the incubation program should aim to meet a wide assortment of needs arising over the three-year incubation period.

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