SHIFTING TECHNOLOGY FROM THE UNIVERSITIES TO A HIGH PERFORMANCE BUSINESS

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Abstract

The first aim of this study is to identify the external and internal factors that have shaped the performance of Technology-Based Start-up Firms (TBSF) in the US. The second goal is to compare this study with a previous study conducted in Brazil, to identify incubator best practices that may increase the performance of incubated firms. The US study focuses on graduated firms from the Indiana University incubator located in Indianapolis. The main partners of three technology-based start-up firms were interviewed, based on a semi-structured questionnaire. The outcomes from our analysis indicated that the TBSF have both internal and external factors that affect their performance. The analysis showed that as an external factor, the incubator's connection with university was helpful for obtaining capital. As internal factors, the technical expertise and entrepreneur managerial competence was identified as fundamental factors for TBSF success. The analysis also indicated that some of those factors are different between Brazilian firms and American firms. In Brazil, the management training offered by the incubator is considered very important for the performance of the incubated firms. This was not confirmed in the American study.

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Knowing what affects the performance of technology-based start-up firms will help incubators offer improved, and more comprehensive services enabling firms to develop and expand.
Keywords: *Incubator; Technology based start-up firm; Performance; Cross-cultural studies.*

1 Introduction

A lot of times state-of-the-art-technologies are generated in universities. The researchers are usually graduate students and professors. Although, they are technologically skilled they may not have the essential skills to transform it in commercializing technology, generating new products and making it available to the market. It is this critical time between getting a product from the lab to the market that is loaded with failure (MURRAY, 2008).

Shifting technology from the university to firms can be done through incubators. Incubators can reduce the number of failures by offering services that will support and encourage them to grow, and business advice that will guide start-up firms away from the many pitfalls that separate success and failure. Services offered can include low rental costs, lab facilities, patent assistance, university contact, technology infrastructure, administrative support, legal help, and early-stage capital access assistance. Also, incubators offer managerial education courses to the researchers, or the incubator can help recruit experienced entrepreneurs to manage these technology-based start-up firms. These services can enable the firms to achieve the level needed to stand alone in the market place, and without these services would be unable to do so.

Although, the technology-based start-up firms receive all the incubator support some incubated firms have become successful, while others have not. As a result, this research aims to investigate the external and internal factors that influence the performance of technology-based start-up firms that have been incubated. The external elements identified are networks, unilateral relationships, and bilateral relationships. The internal elements are entrepreneurial orientation, technological capabilities, and management of investment capital.

It is also important to observe that the services offered by incubators can vary in different countries, and from incubator to incubator; and this can impact in the performance of incubated technology-based start-up firms. Therefore, the second research goal is to compare the results of this study with a research conducted in a different country and incubator, to identify incubator best practices that may help to increase the performance of incubated firms. Establishing what affects technology-based start-up firm's performance can help incubators develop effective programs for firms' growth.

First, the paper presents the theoretical background based on technology-based start-up firm's performance. This theoretical background includes incubators definition and characteristics, along with the internal and external factors that affects these firms performance. Second, the paper describes the method used in the research field, conducted in U.S. and the comparative study conducted in Brazil. The requirements for the study are explained, and results are given based on the semi-structured questionnaire. Then, an analyses of the data is given, with a comparison between the US and Brazilian incubator. The study is wrapped up in the conclusion and references are recognized.

2 Incubators and technology-based start-up firms incubated performance

The business incubator was born to facilitate a region economic development. It is a program designed to accelerate the start-up firms development through a range of business support, resources and services (KNOPP, 2007). There are three major categories of incubators: empowerment, mixed-use, and technology (SHERMAN, 1999). Empowerment is an incubator promoting the micro enterprise in areas that have high unemployment, and community renewal. Mixed-use incubators focus on heavy and light manufacturing, services firms, and various other firms. This paper concentrates on technology-based incubators that are the ones involved in emerging technologies.

Incubators assist start-up firms by providing various support services such as developing market forecasts, networking, business strategies, providing management assistance, legal advice, acquisition of capital, and other specialized professional services (SHERMAN, 1999). Incubators also provide office space, equipment, and administrative services. Firms normally remain in the incubator for two to three years, after which the firm graduates as an independent, self-sustaining business.

Universities play a major role with technology-based incubators. New technology and research is being contentiously produced in labs and in class rooms around the United States in universities (MURRAY, 2008). Technology-based incubators bring together the resources needed for new technology to emerge from the university. However, the technology still has to be cultivated to reach the venture capitalist stage. The incubators connection with the university is vital at this juncture. Research building on this new technology done at the university provides the technical expertise to reach the product stage.

Incubated technology start-up firms success or failure is associated with the problems those firms face: lack of management experience, technical difficulties, poor management of innovative projects, and difficulty in penetrating the market (BIZZOTTO et al., 2002). In addition, the authors affirm that incubators can minimize these problems promoting the articulation of the incubated tenants with other resident firms, the university, established companies and entities providing support for the generation and development of enterprises of this type.

Moreover, the performance of technology-based start-up firms is influenced by external and internal factors (LEE et al. apud DORNELAS, 2002). There are three external factors. The first one is networks of contacts, regarded as crucial for discovering opportunities for testing new ideas and obtaining funds. The second one is the development of unilateral relationships, such as strategic associations with other firms, suppliers, key clients, capitalists/ investors, universities, research centers and professional associations. Lastly is the development of bilateral relationships, such as those established with support agencies for newly established firms and government agencies, for the obtainment of subventions. The internal elements are: an entrepreneurial orientation, based on a quest for innovation, and a willingness to undertake risk and pro-activity; a technological capability, as reflected by the volume of patents, certification and intellectual property; and an ability to manage the funds invested during the company's development period, so as to avoid jeopardizing its future. These external and internal factors are the base for the research data collection.

Another element that must be taken into account for the success of an enterprise offering a new product or service is to have a clearly defined market and to and attend to consumer needs (LEITE, 2002). This, in reality, has been one of the chief difficulties of technology-based start-up firms, because they often arise as a result of a technology push rather than of a

demand pull. Consequently, they have a great deal of difficulty in establishing the dimensions of their market. Other important elements for managing technology-based firms are: defining targets and executing a strategic business plan. Indeed, it is very important to think about the organization's future and how far it plans to go, so as to ensure that the company's work is focused and that its efforts target essentials and result-generating activities.

As for incubators and their management, in their role of facilitating tools that may influence the success or failure of the incubated concerns, Carleial (1997) states that institutional visibility is of particular relevance. Furthermore, that an incubator's capability to mobilize political, financial and organizational resources is important for the strategic definition and market performance of the incubated concerns. These are apparently the advantages enjoyed by a company that establishes itself within an incubator, i.e., not merely having the use of offices and services at prices lower than can be found in the market, but also gaining access to a whole range of intangible benefits.

One of the functions that an incubator must have in order to support the development of start-up firms and therefore to contribute to their success is operating as an intermediary between very small firms and assorted other research, public policy and financial enterprises, whether on a national, regional or local basis (CARLEIAL, 1997). Yet another function consists of placing the incubated concern at the center of formal and informal technological, legal and economic networks, thereby providing it with access to qualified human resources and establishing an arena for negotiation with local, regional or national authorities.

3 Methods and field procedures

This research project was divided in two parts. The first was based in a study conducted in U.S. to identify the internal and external factors that have shaped the performance of incubated technology-based start-up firms in the United States – U.S. The second part was to compare this study with a previous study conducted in the same way by Berte and Sbragia (2004) in Brazil, to determine any incubator best practices that may increase the performance of incubated firms. The U.S. research is described as well the Brazilian study to support both research parts.

Sample

Incubator characteristics

The U.S. research was done on the Indiana University Emerging Technologies Center (IUETC), an Indiana University incubator, in Indianapolis. This incubator was chosen because it is a university technology incubator, as well as the Brazilian incubator to which the study was compared.

Founded in 2003, IUETC has graduated over ten companies, and currently has a waiting list of potential tenants (IUETC, 2008). The Indiana University Emerging Technology Center's vision is to assist start-up firms in the fields of accelerate life sciences, biotechnology and bioinformatics. IUETC's focus is about promoting IU and industry partnerships to foster job creation. Located in the incubator are wet lab facilities and access to the Indiana University Purdue University Indianapolis (IUPUI) campus. The comprehensive services offered to tenants are on-site and below market cost. These services include short-term flexible leases, technology infrastructure with IT support, early-stage capital access assistance. The professional services include administrative, clerical, and bookkeeping support, business advisers, and common use of conference and meeting facilities.

The Brazilian study was developed in the *Centro de Incubação de Empresas Tecnológicas* – (CIETEC). It is an incubator positioned in the University of São Paulo which is located in Brazil. Founded in 1998 CIETEC's vision is to promote the advancement of national science and technology through the development of innovative products (CIETEC, 2008). The technology – based firms have direct access to the university's laboratories, and services. CIETEC's focus is on increasing the success rate of businesses, reducing capital required to start a new venture, and the creation of jobs. CIETEC incubated only fifteen firms in 1998, but now incubates 127 firms as of 2008. Both IUETC and CIETEC are university technology incubators.

Incubated firms requirement

In order to support our research goals, graduated technology-based start-up firms had to fulfill certain requirements before being chosen for this research. First, the firm must be connected to the university through a partner such as a student, professor, or a university alumni, to be characterized as a University incubated firm, having been incubated at IUETC, for U.S. study and at CIETEC for Brazilian study. Second, the firm must be technology based with innovative technology, because this is the object of our study. In order to verify the firm performance growth, the firm has to have existed for at least two years, been operating in the market with increasing sales and have generated jobs. Fourth, the firm has to be legally structured as a private company.

Based on these requirements, four companies were identified having ties with IUETC. However, only three firms would cooperate with the study. The three firms that met the study's requirements and participated in the research were code named Chi, Kappa, and Mu.

In the Brazilian research five technology based start-up firms were identified. Nevertheless, only four firms accepted to participate in the research. The four firms that participated in the research were code named Gama, Alpha, Beta and Delta.

Data collection

Research was accomplished through a semi-structured interview based on a questionnaire conducted by a personal interview, and, or telephonic interview with the main partner from each firm in the U.S. study. Also, some information was obtained from the firm's website and e-mail exchanged with the interviewers.

The questionnaire was comprised of three sections. The first section was firm and manager demographic data. The second section was the characteristics of the technology based start-up firm. The questionnaire's last section was the internal and external factors affecting performance described before (LEE et al. apud DORNELAS, 2002).

Findings

Technology-based start-up firms profile

Chi, Kappa and Mu profiles are revealed in Table 1. Following we discuss the findings. The first important conclusion is related to the firms' president type of education and professional experience. According to Santos (1997), Maculan (1996) and Dodgson and Rothwell (1989) generally one of the difficulties faced by technology-based start-up firms is their lack of managerial expertise. This is not confirmed in this study. As showed in Table 1 all the

firms' presidents have managerial experience, one of them with 14 years, and they do not have technical expertise in the company's field, what is also a commonality among technological-based firms. This can be explained by the policy at the IUETC. The inventors of the technology are not the presidents or the firms' managers. Sometimes they are one of the finance partners and or consulters in the technical field. When one Indiana University researcher develops a technology with an application, he or she is matched with a businessman and that person will run the business. This organizational structure gives the firms the managerial experience needed to succeed.

Table 1 shows that two of the firms interviewed had patents. The CEO of Kappa stated that the firm had patents, but felt it was in the company's best interest not to divulge how many the firm has. Mu firm has four patents. Patents are an important tool to protect the invention from being copied, but it is a long and expensive procedure, and one of the reasons firms fail to apply (DODGSON and ROTHWELL, 1989). What can explain the success of Mu and Chi, with all the patent granting procedure, is that IUETC incubator has a specific division designed just for that need. . This service offered by IUETC was probably valuable in grating the patent.

It is possible that one of the reasons that the IUETC incubator offers the patent grating procedure service is to have sure they are protecting the Indiana University patent's rights. Patents generated at the IUETC by IU professors and researchers are property of IU. The firms can lease the patent from the university, but the property rights are held by the university. The interviewee from the incubator stated that this allows IU graduate students and other professors to keep improving the technology, and build off the original patent, what can result in the development of new products.

The lead time for new products ranged from six months to fifteen years, among the firm's researched. Dodgson and Rothwell (1989) stated that the inability to keep up a research and development effort of the appropriate intensity is one of the difficulties of technology-based start-up firms.

Table 1 – Firms' Profile

Characteristics\Firms	CHI	KAPPA	MU
Interviewed managers	President	President	President
Professional experiences of interviewed managers	Undergrad and executive experience	MBA with 14 years as an executive	Executive experience Level of education N/A*
Technology inventor level of education	MD	3 with Ph. D in the medical field, and 1 MD.	Ph.D. in biomedical field
Legal structure	L.L.C	Incorporated	Incorporated
Field of activity	Medical Education	Biomedical	Biomedical
Main products	Comprehensive diagnostic support of musculoskeletal conditions	One diagnostic test for cancer, two more products in pipe line.	Ten software products and three laboratory analysis systems.
Date of establishment	1999	2006	1989
Date of incubation	2003	2006	2003
Inventors' Univ. relation	IU Alumni, and IU employee	IU Alumni, and IU professors	IU Professor
Start of product sales	2000	Beginning of 2008	2008
Graduation year	2005	2008	2008
Key events	Acquired in 2004	Innovation of the year at the Techpoint Mira Awards.	Funds from Indiana's 21st Century.
Patents	None	Has patents, but deemed number classified.	Four
Lead time for New Product Development	6 months	2.5 years	2 years for software and 10 to 15 years for drugs
Exports	Not exporting, but is considering it	Not exporting, but is considering it	Not exporting, but is considering it
Number of jobs generated	6 jobs	5 and are looking to add two more in 2008	6 jobs

Source: Primary data, 2008.

*N/A: Information not available.

4 External factors affecting technology-based start-up firms performance

The external factors affecting the performance of the firms interviewed are presented in Table 2. The interviewees were asked yes and no questions, and to expound on their response.

Two of the firms stated that the incubator had provided a facilitating environment and only one firm stated otherwise. Maculan (1996) affirms that one of the functions of incubators is to enable a formal connection between the firm and research centers. The interviewee from the Mu firm stated that the incubated period was more of a hindrance than a help. The Interviewee went on to explain that the Mu firm was one of the first firms to be incubated. The successful firm was used as a "poster child" or advertisement for attracting new tenants. The firm was not able to interact with the university's networking relations or use some of the services promised by the incubator. However, the interviewee from the Kappa firm said that the firm benefited from being located at the IUETC incubator. The firm engaged in discussions with other researchers, shared scientific equipment, and felt that the general supportive atmosphere was beneficial for its development.

Table 2 – External factors

QUESTIONS	CHI	KAPPA	MU
1. Did the University provide a facilitating environment?	Y*	Y	N*
2. Financing specifically offered for technology firms	Y	Y	N
3. Risk associated with investing in technological firms	Y	Y	Y
4. Importance of prestige of the University	N	Y	N
5. Importance of Incubator services	Y	Y	N
6. University's associations with other institutions was helpful to the firm	Y	Y	N
7. Existence of network among he incubated firms.	Y	Y	N
8. Incubator's connection with university was helpful for obtaining capital	Y	Y	Y
9. Existence of financial partner	Y	Y	N
10. Used services provided by other incubated firms	N	Y	N

Source: Primary data, 2008

*Y: Yes and N: No.

All the firms used financing funds specifically for technology-based firms. One firm stated that firm used seed funding from Biocrossroads, but did not received any money directly through the university. Two of the firms interviewed received 21st century matching grants, a specified grant. All of the firms interviewed also had received multiple awards that were accompanied by prize money ranging anywhere from ten thousand to fifty thousand dollars. The president of Chi stated that getting cash infusion is imperative to funding the research to get products to market. The CEO of the Mu firm also stated that the firm does not have an outside

financial investor, but is looking for one. To obtain financing resources is one of the start-up firms difficulties (SANTOS, 1987) and to help the firms to obtain it should be one of the incubators goals (MACULAN, 1996).

Two of the firms acknowledged the services provided by the incubator were important for their success. A technology incubator's reason for existence is to provide support, resources and services enabling technology based start-up firms to succeed (KNOPP, 2007). The start-up firm that reported they were not pleased by the IUTEC offered services was one of the first firms to be incubated at IUETC. This could be explained by the young age of the incubator, which was still in a learning phase although it is not justified by it.

For two firms the cost of renting office and laboratory spaces in the incubator was considered expensive. What it is a surprise since this is one of the general goals incubators have: to offer affordable rent prices. The IUTEC incubator's manager declared that the incubator offer the only wet lab space in the entire state and that it is very expensive. It seems that although this was the only way the tenants firms could have access to it, they still were not pleased about the rental prices charged. The success of an Incubator depends on attending the incubated firms needs (SHERMAN, 1999). The IUTEC incubator should work on lowering their renting costs.

Two of the three firms at the IUETC had an outside financial partner, and one of them is still looking for one. The Research & Development – (R&D) costs of technology-based start-up firms are in general high, mainly if considering the biotechnology field.

Regarding the existence of a network between other incubated firms two of the three firms interviewed said a network existed. Networking can provide technology–based start-up firms accessibility to resources and knowledge (PREVEZER, 2000), and it should be an important gain for these firms during their period of incubation. However, only one of the firms that reported the existence of a network between incubated firms used the services provided by other incubated firms. The interviewee from the Kappa firm said that the network was not particularly important for scientific enhancement, but more for moral which was really important at the early stages. The IUETC incubator interviewee stated that the network at the Incubator and across the region was still being built, and was not really visible. One firm stated that even after having graduated from the incubator it still had weak networking capabilities.

5 Internal factors affecting performance

Table 3 presents the internal factors affecting the performance of technology-based start-up firms. All three firms stressed the creativity of their work teams, as well as the innovation of their products was a strong characteristic of the work teams and subsequently their products. One firm is working on a product that is badly needed in the medical field, and is considered both innovative domestically and internationally. None of the interviewees regarded themselves as born entrepreneurs. However, the president of the Chi firm believes he has become an entrepreneur, which happened because of the experience he gained over the years.

Leite (2002) affirms the necessity of technology-based start-up in doing their market demand estimative for their success. Even though the IUETC incubator provides services to assist the firms to develop demand estimates, and requires it from them, all the incubated firms researched reported that it was difficult to prepare it. One main reason is due to the product being based on new technology, viable substitute products are not available, and the market for these products still needs to be developed. These are some of the technology-based products characteristics.

All firms reported that no survey data on foreign markets had been conducted, although Mu had reported some exporting, but in a limited amount. All firms declared that establishing a foreign presence would be evaluated in the long term.

Participative management was used by every firm researched, as well as clearly management structure definition.

Table 3 – Internal factors

QUESTIONS	CHI	KAPPA	MU
11. Creativity as a strong characteristic of the work team.	Y*	Y	Y
12. Innovative products	Y	Y	Y
13. Firm strength in the technical area.	Y	Y	Y
14. Partners regard themselves as born entrepreneurs.	N*	N	N
15. Difficulty in preparing demand estimates.	Y	Y	Y
16. Existence of an international alliance.	N	N	Y
17. Firm's networking capabilities.	Y	Y	N
18. Survey data on markets other than domestic.	N	N	N
19. Use some kind of information management technique.	N	Y	Y
20. Existence of planning that includes budgeting and targets for the next five years.	Y	N	Y
21. Existence of some formal technique for identifying new business opportunities.	Y	N	N
22. Use of participative management styles in connection with work teams.	Y	Y	Y
23. Clearly defined positions and functions in the management structure.	Y	Y	Y

Source: Primary data, 2008

*Y: Yes and N: No.

6 Comparison between IUETC and CIETEC

There are several differences between the IUETC study presented in this paper and the CIETEC study presented by Berte and Sbragia (2004). First, managerial differences in terms of who runs the firms and the role of the inventors in the firms. Secondly, the services offered to help to obtain patents, and if this is a goal for the firms or not. Third, whether or not networking is among the firms. Fourth, this study will compare the difference of availability and rent prices of offices and laboratories. In the sequence, the quality of services offered in the early stage of the Incubator and finally the market researched by the firms. The comparing of these two technology incubators facilitates the identification of best practices university technology incubators.

Managerial differences between the incubated firms were found in the study. The IUETC requires that the inventor or inventors relinquish the management of the new firm to an experienced business manager. This allows the inventors, usually professors at Indiana University

to continue to teach and conduct research at the university. Second, it gives the new firm the managerial skills needed to succeed in the market. The CIETEC has a very different approach. The inventors are allowed to open and run the new technology start-up firm. In general they have a PhD. in the technical field and none or very inexpressive business experience (BERTE and SBRAGIA, 2004). In order to deal with the lack of managerial skill from the incubators the CIETEC offers various management training and consulting. In IUETC this is not so important, once the person who runs the firm already have management expertise. This allows IUETC to concentrate their efforts in other areas, once this is not a problem for their tenants.

Second, the way patents are viewed by the graduated firms is different compared to the firms from IUETC and CIETEC. Two of the three firms have patents from the IUETC. None of the firms from the CIETEC held patents (BERTE and SBRAGIA, 2004). Patents are seen from the interviewed firms at the IUETC as essential to build the business' competitive advantage. In addition, the IUETC provide services during the whole process of granting patents, along with any legal information needed to do so. The Brazilian firm's presidents felt that obtaining a patent can be a long and expensive process that they are not willing to pursue. They believe that the patent won't once they do protect their inventions. CIETEC also, did not offer services for helping grating patents. Differences in terms of patents laws, processes and protection in U.S. and Brazil can be affecting the differences founded in the comparative study between these countries incubators.

At the IUETC the network between the firms inside the incubator can be characterized as weak. Only one firm reported using the services of another incubated firm in the IUETC. The network outside the incubator is also week, but it is visible. In the other hand, the firms located inside the CIETEC have developed a strong network capability and the firms exchange knowledge, resources and support (BERTE and SBRAGIA, 2004). The difference age between the Incubators researched could help to explain it. The IUETC is much younger than CIETEC, thus CIETEC has had a longer period to learn how to help the incubators to develop strong ties among them, and to take the benefits originated from it.

The wet labs at the IUETC are located in the incubator. The incubator was responsible for paying the labs investment that was very high, and it is transferred to the incubated firms. However, at the CIETEC the labs are located at the university campus and with the partnership with the University the Incubator is allowed to make them available to incubated firms without costs (BERTE and SBRAGIA, 2004). Because the use of labs and the same time the lack of finance resources are common among technology-based start-up firms, CIETEC developed a strategy that favor the incubators more them IUETC. The CIETEC is financed mostly through the university and the Brazilian government. The CIETEC is then able to offer very low rental space to tenants. The IUETC is self-sustaining. The rental proceeds support the incubator. This along with the high cost of the lab equipments at IUETC is possible to be reflecting in the high rentals prices.

One firm in the IUETC study and one firm in the CIETEC study were not satisfied with the services offered by the incubator. Both firms were incubated in the early stage of the Incubator. It is believed that both Incubators maybe were not totally prepared to offer their best service to their customers, the incubated firms in its early stage of business. This should be something all the Incubators should pay attention when open to business. They should be prepared to high quality services to the incubators.

Two out of the four firms incubated at the CIETEC surveyed data on markets other than domestic. All three firms located at the IUETC incubator surveyed data only on the domestic market. High technology products are still not in huge demand in Brazil, a developing country,

which makes these technology firms look for international markets. On the other hand the United States has a mature technological domestic market and imports more products than any other nation in the world.

7 Conclusions

In this research, it was proposed to investigate the internal and external factors that influence the performance of technology-based start-up firms that have been incubated at IUETC, in U.S., and its comparison with a previous study done in CIETEC, Brazil, to identify incubator's best practices that may contribute to the performance of technology-based-start-up firms.

The external and internal factors that contributed the most to the performance of IUETC technology-based start up firms were several: the importance of the incubator to offer a facilitating environment; support to obtain financing; to promote the networking among the incubated firms; to offer cheap offices and labs renting cost; services for granting patents and help to establish market demand estimative.

In comparing the IUETC study and the CIETEC study some best practices were identified and should be noted by incubators, in order to help the development of technology-based start-up firms. First, the IUETC procedure of bringing an experienced business person to be the manager of the firm and letting the researcher to continue to be involved just with the R&D part of the business it is a strategy that minimizes the lack of managerial skills from technological firms, and helps to improve their performance, and should be followed by other incubators. Secondly, the patents service offered by IUETC helps the incubated firms to be grated patents and thus should be well-known as a best practice. Third, the support to the incubated firms networking development by CIETEC should be studied and established in other incubators. As well as the CIETEC partnership with the University that allows the technology-based start-up firms to use the Universities labs without costs.

It is recommended that further studies, in other incubators and other countries, be developed, in order to continue identifying another incubators best practices, helping the technology shifting from Universities to firms and to improve the performance of technology-based- start-up firms.❖❖

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