# ACAP MODEL AND INNOVATION IN U-I RELATIONSHIP

# MODELO DE CAPACIDADE ABSORTIVA E INOVAÇÃO NA INTERAÇÃO U-E

# MODELO DE CAPACIDAD ABSORTIVA E INNOVACIÓN EN LA INTERACCIÓN U-E

**Raquel Engelman**
Doutora em Administração – UFRGS, Porto Alegre, Brasil / Professora e Pesquisadora – Universidade Feevale, Novo Hamburgo, Brasil
raqueleng@feevale.br

**Dusan Schreiber**
Doutor em Administração – UFRGS, Porto Alegre, Brasil / Professor e Pesquisador – Universidade Feevale, Novo Hamburgo, Brasil
dusan@feevale.br

***Contextus***
ISSNe 2178-9258
Organização: Comitê Científico Interinstitucional
Editor Científico: Diego de Queiroz Machado
Editor Executivo: Carlos Daniel Andrade
Avaliação: double blind review pelo SEER/OJS
Recebido em 16/08/2017
Aceito em 19/06/2018
2ª versão aceita em 17/07/2018

**ABSTRACT**
The purpose of this study is to see how the relationship between universities and companies influences the latter's absorptive capacity and therefore competitiveness. The work focused on multiple-case studies with three companies based at the technology incubator of Feevale, a university center in Brazil's south. Data analysis was based on Zahra and George's (2002) ACAP model. Both diversity of search forms and harnessing new knowledge showed to be crucial in distinguishing those companies from others in the same sector. It is supposed that not only the university-business relationship may influence all businesses' absorptive capacity and competitiveness but also achieving and sustaining competitive advantage is directly related to realized ACAP through innovation and product development as well as to potential ACAP through flexibility in reconfiguring basic resources. The ACAP model was very useful for analyzing the ability to acquire knowledge and turn it into innovation.
**Keywords:** Absorptive Capacity; University-Industry Relationship; Knowledge; Competitiveness; ACAP model.

**RESUMO**
O objetivo deste estudo é analisar como a relação entre universidades e empresas influencia a capacidade absortiva e, portanto, a competitividade das firmas. O trabalho foi realizado com base em estudo de casos múltiplos, com três empresas sediadas na incubadora tecnológica da Universidade Feevale, situada no sul do Brasil. A análise dos dados foi feita à luz do modelo ACAP de Zahra e George (2002). Constatou-se que as diferentes formas de pesquisa e a utilização de novos conhecimentos foram cruciais para a diferenciação das empresas. Supõe-se que a relação universidade-empresa pode influenciar a capacidade de absorção e da competitividade de todas as firmas e que a obtenção e manutenção de vantagem competitiva está diretamente relacionada tanto com a ACAP realizada, através da inovação e desenvolvimento de produtos, quanto com a ACAP potencial, através da flexibilidade na reconfiguração dos recursos básicos. O modelo ACAP serviu de modo significativo para analisar a capacidade de adquirir conhecimento e de transformá-lo em inovação.
**Palavras-chave:** Capacidade absortiva; interação Universidade-Empresa; conhecimento; competitividade; modelo ACAP.

**RESUMEN**
El objetivo de este estudio es analizar cómo la relación entre universidades y empresas influye en la capacidad absorbente y, por lo tanto, la competitividad de las empresas. El trabajo fue realizado con base en estudio de casos múltiples, con tres empresas con sede en la incubadora tecnológica de la Universidad Feevale, situada en el sur de Brasil. El análisis de los datos se realizó a la luz del modelo ACAP de Zahra y George (2002). Se constató que las

diferentes formas de investigación y utilización de nuevos conocimientos fueron cruciales en la diferenciación de esas empresas. Se supone que la relación entre universidades y empresas puede influir en la capacidad de absorción de estas últimas y en su competitividad y que la obtención y el mantenimiento de la ventaja competitiva está directamente relacionada con la ACAP realizada, a través de la innovación y el desarrollo de productos, y con la ACAP potencial, flexibilidad en la reconfiguración de los recursos básicos. El modelo ACAP proporcionó análisis de la capacidad de adquirir conocimiento y transformarlo en innovación.
**Palabras clave**: Capacidad Absorbente; Interacción Universidad-Empresa; Conocimiento; Competitividad; modelo ACAP.

## 1 INTRODUCTION

In an environment marked by rapid change, characterized largely by technological and informational revolution, issues such as innovation are of key importance. By encouraging research and development (R&D), knowledge networks and an entrepreneur's eye for market opportunities, a country can develop and add value to its production. In dynamic sectors such as high technology, differentiation and innovation come to represent a strong role model and a very effective competitive strategy (PORTER, 1980). Schumpeter (1997) associates innovation to everything that differentiates and adds value to a business, not only the development of new products and processes, but also the exploration of new sources of supply, the restructuring of the organizational goals and activities involved in creating a new market.

In the new social and economic context, as knowledge becomes a source of competitive advantage, the importance of the university as a source of knowledge has grown. The competitiveness of a company can be improved from the moment it begins to use the university as a partner in its business activity, and not merely as a supplier of skilled labor (SEGATTO-MENDES; SBRAGIA, 2002; NEGRI, 2006). The relationship between universities and companies involves, besides the enterprises' needs of innovation and knowledge, the interest of higher education institutions in obtaining financial resources and playing a greater role in the environment in which they operate, adjusting itself to new market demands. From this perspective, the university is engaged in economic growth, becoming an agent of development and adding technological value to the knowledge generated within it (WOLFFENBUTTEL, 2013).

To have a university as a partner and an ally in the search for innovative solutions, whether in relation to technology, products, the manufacturing process or models, can bring great benefits to a company. Once the relations with the university become stronger, the company acquires a privileged access to science and technology and is able to count on the excellent technical and human resources, university facilities and government resources. So,

the firm may improve its image and obtain economic resources (SEGATTO-MENDES; SBRAGIA, 2002). That's one of the reasons for the innovation to become a motivating factor in the pursuit of university-business/industry cooperation, which includes the issue of the search for new resources, especially knowledge.

The existence of organizations that invest in entrepreneurial action and co-creation of knowledge, either through firms, universities or other potential partners, indicates the need to understand the dimensions of these relationships. Ten years after the definition of absorptive capacity by Cohen and Levinthal (1990), Zahra and George (2002) developed a Model of Realized and Potential Absorptive Capacity (ACAP) by adding propositions and expanding the possibility of understanding the capability of firms to transform knowledge into innovation and competitive advantage in order to explain how this process happens. Due to the different priorities and structure between companies and universities, it is possible to verify that companies take time to adopt new technologies, as much to the products as to the processes (DALKIR, 2011).

In Brazil, few theoretical and empirical studies have attempted to investigate the absorptive capacity of enterprises, especially in cooperative relations, such as the university-industry relationship. Texts of Alvarenga Neto (2008), Moura et al. (2017), Cardoso and Gomes (2011), Cavalcanti, Gomes and Pereira (2001) and Lopes (2013) are some scientific productions that explore this theme.

Even fewer studies were performed in order to understand knowledge transfer while applying the ACAP model. Thus, the research question is: "How does the university-industry relationship influence the absorptive capacity and competitiveness of the related business partners?" To be able to answer this question, multiple-case studies were performed with technology-based firms, incubated at Feevale's incubator (ITEF).

This paper is divided into 7 sections. Firstly, there is an introduction to the references from the literature. Section 2 addresses the organizational knowledge and the university-enterprise relationship, in section 3 we discuss the ACAP model (ZAHRA; GEORGE, 2002). In section 4 the method and criteria for selection of cases are presented together with the framework that serves as support for the analysis of variables and propositions. The cases are presented in section 5 and analyzed in section 6. Finally, in section 7, the conclusions are drawn.

## 2 ORGANIZATIONAL KNOWLEDGE AND THE UNIVERSITY-INDUSTRY RELATIONSHIP

The notions of the information society and knowledge society require that the concept of the university be revised because, while the notion of information society is based on technological advances, the concept of knowledge society includes social and ethical dimensions and related policies (UNESCO, 2005). The university, previously seen only in its educational role and as a supplier of skilled manpower, in which the prime research role involved developing basic research, now finds itself motivated to take the reins of economic development from the transformation of the research into economic activity (WOLFFENBUTTEL, 2013).

Innovation is universities' response to an increasingly more complex, dynamic and competitive context in which knowledge underpins the process of innovation (REZENDE, 2014). In this context, the construction of knowledge, characterized by the constant transformation of tacit knowledge into explicit knowledge, offers benefits based on the cooperation between the participants within a knowledge network, which may include universities, businesses and government. The relationship among these actors is increasingly important in building knowledge (BOLISANI et al., 2018).

The benefits of university-industry cooperation can be summarized, from universities' point of view as the opportunity to attract additional resources to develop basic and applied research as well as to provide education linked to technological advances (LOPES, 2013). For the company, in turn, it represents the chance to develop technology with less financial investment, in less time and with a lower risk. This may be considered relevant because companies are facing several difficulties to obtain financial resources in order to invest in technological development (CARDOSO; GOMES, 2011). For the third partner—the government—, it means an opportunity to promote national growth with lower investment in infrastructure in order to provide capacity for research and development (COSTA; CUNHA, 2000). These three are the main contributions of the university's interaction with companies from the perspective of competitiveness to support research and development of firms and their capacity for technological innovation (OLIVEIRA; CALDEIRA; ROMÃO, 2012).

In his Triple Helix model, Etzkowitz (2003) describes the relationships between universities, industry and government in trying to integrate science, technology and government, which contradicts the traditional approach where the flow of knowledge is seen to take place in a single track from basic research to innovation. The new model is based on a

spiral, where the industry knowledge flows to the academic institution and vice versa (DALKIR, 2011; ARGOTE; MIRON-SPEKTOR, 2011). For Etzkowitz (2003), the triple helix is a key component for innovation strategies in the twenty-first century and the interaction among these three actors has an important role in innovation and wealth creation.

Plonski (1994) suggests that universities see cooperation as a way of overcoming the inadequacy of traditional sources of funding while maintaining the desired levels of education and research. As for the firms, they see cooperation as capable of providing a solution to the difficulty of coping alone with the multidimensional challenges of innovation, beyond the traditional interest in gaining privileged access to the recruitment of young talent. From the government's point of view, cooperation is strategically important for the economic and social viability of regions and nations in the new economic paradigm. As the generation of wealth becomes more connected to the ability to generate new knowledge, the role in basic research and the academic institutions' privileged view of the state of the art has become relevant to business, and the effects of these changes are felt in universities around the world (STAL, 1994; MOURA et al., 2017).

## 3 THE ABSORPTIVE CAPACITY MODEL

From the point of view of the dynamic capabilities of a firm, this is considered a place where knowledge is generated, processed and utilized (TEECE; PISANO; SHUEN, 1997). Gold, Malhotra and Segars (2001) conceptualized such capabilities as the organizational capacity to process knowledge, also known as absorptive capacity of organizational knowledge (COHEN; LEVINTHAL, 1990). A firm's ability to acquire and harness knowledge effectively is critical to its innovation activities and performance.

The absorptive capacity (ACAP) is the firm's ability to value, assimilate and apply new knowledge (COHEN; LEVINTHAL, 1990) and consists of a set of routines and organizational processes through which firms produce a dynamic organizational capability. The authors point out that organizations with higher levels of absorptive capacity tend to be more proactive by exploring opportunities in the environment, regardless of current performance. On the other hand, organizations that have a modest absorptive capacity will tend to be reactive, in search of new alternatives in response to the failure of some performance criteria.

The ACAP combines four capabilities of knowledge that lead the firm to create and develop the knowledge necessary to build other organizational capabilities, which are the basis

for a competitive advantage, while the capabilities are both different and complementary in influencing the results of the organization. The capabilities are divided into potential absorptive capacity (PACAP)—composed of acquisition and assimilation—and realized absorptive capacity (RACAP), consisting of processing and exploration, (ZAHRA; GEORGE, 2002). In contributing with studies on the absorptive capacity and the actual potential, Jones (2006) highlights the importance of the management's previous experience as an internal trigger for the absorption of new knowledge and skills in finding solutions to processes and products.

The firm's ability to identify and obtain externally generated knowledge is critical to its operations (ZAHRA; GEORGE, 2002), which requires a concerted effort and a high degree of experience in recognizing and capturing new knowledge (NONAKA; TAKEUCHI, 1997). Several terms have been used to describe these processes: acquisition, search, generation, creation, capture and collaboration, and all have one thing in common: the accumulation of knowledge (GOLD; MALHOTRA; SEGARS, 2001). The effort spent on routines for the acquisition of knowledge has three attributes that can influence ACAP: intensity, speed, and direction.

The intensity and speed of the firm's effort to identify and gather knowledge can determine the quality of its ability to acquire knowledge. The direction of the accumulation of knowledge can influence the path the firm follows in order to obtain external knowledge (ZAHRA; GEORGE, 2002). Assimilation refers to the routines and processes of the firm, which permit the analysis, processing, interpretation and understanding of the information obtained from external sources, whereas understanding is particularly difficult when the value of knowledge depends on the existence of complementary assets that may or may not be available to the firm. In this sense, understanding promotes knowledge assimilation, which allows the firm to process and internalize the knowledge generated externally (ZAHRA; GEORGE, 2002)

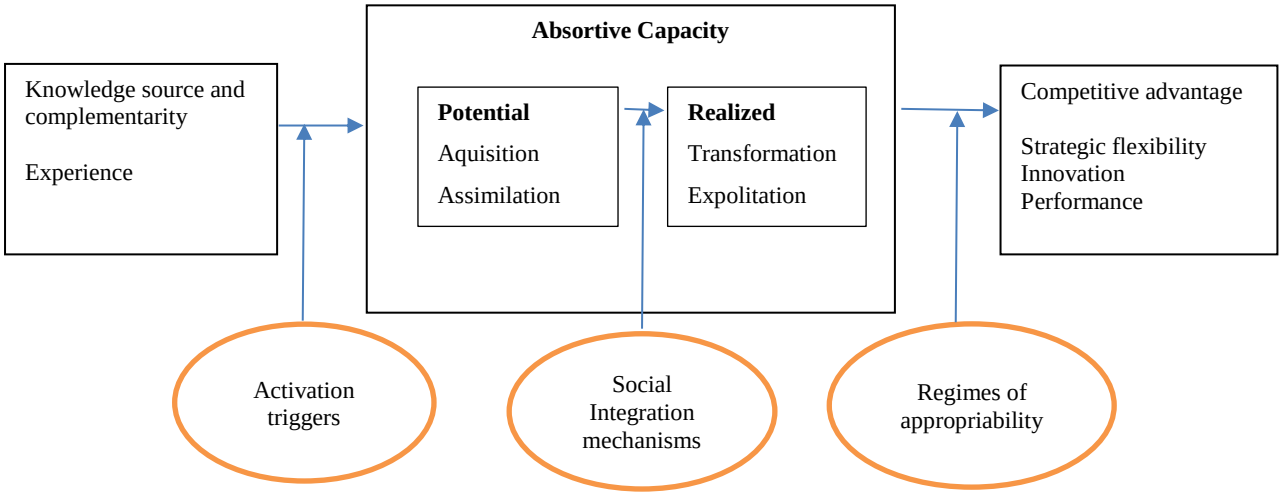
Transformation denotes the firm's ability to develop and refine the routines that facilitate combining the knowledge that already exists in the firm with the newly acquired and assimilated knowledge. This is accomplished by adding or deleting information, or even interpreting the same knowledge in a different way. The firm's ability to recognize two sets of seemingly incongruous information and then to combine them to reach a new scheme represents the processing capacity and enables new insights, makes recognition opportunities easier and, at the same time, changes the way the firm sees itself and perceives the competitive environment (ZAHRA; GEORGE, 2002).

Exploration refers to the routine-based organizational capacity that allows firms to refine, expand and leverage existing competences so as to enable the creation of new ones by

incorporating and transforming knowledge acquired in operations (ZAHRA; GEORGE, 2002). According to Gold, Malhotra and Segars (2001), the application-guided processes are those oriented towards using knowledge, and the mechanisms suited for this begin with storage and retrieval that allow the company to access knowledge quickly. Although firms may be able to explore knowledge accidentally, the result of systematic exploration routines is the continuous creation of new goods, systems, processes, technologies or organizational forms (ZAHRA; GEORGE, 2002).

The ACAP model from Zahra and George (2002), as shown in Figure 1, includes, besides these four dimensions, antecedents, moderators and outcomes of absorptive capacity. The external sources and complementarity of the firm's knowledge and experience are part of the antecedents of ACAP, which significantly influence the PACAP. The sources of knowledge and complementarity include: acquisitions; purchases through licensing agreements and contracts; inter-organizational relationships, such as R&D consortiums; alliances and joint ventures. The experiences relate to past success, environment examination, benchmarking, customer interaction, learning by doing, organizational memory and path dependency.

**Figure 1**—Model of Absorptive Capacity




Source: Zahra and George (2002, p. 192).

With regard to moderators, the triggers mediate the impact of knowledge sources and experience in the development of absorptive capacity. They are events that lead the firm to respond to specific stimuli such as internal organizational crises, or external stimuli such as radical innovations, technological changes or regulatory changes. When the triggers are broad in terms of their scope and potential impact, or are persistent, there is a greater tendency for

firms to seek external knowledge, while the intensity of the triggers will influence the investment in developing the PACAP.

The social integration mechanisms represent a second group of administrators that suggest sharing relevant knowledge among firm members and can help overcome barriers to this process. While informal mechanisms (e.g. social networks) facilitate the exchange of ideas, formal ones (e.g. the use of coordinators) are more systematic in promoting the flow of information and knowledge within the firm (ZAHRA; GEORGE, 2002).

Among the most cited mechanisms to promote integration are rules and standards, flowcharts, routines and group problem-solving and decision-making (GOLD; MALHOTRA; SEGARS, 2001). Another moderating factor is appropriability, i.e., the industrial and institutional dynamics that affect the firm's ability to create not only advantages and benefits out of new products or processes while considering the degree of legal protection manifested in records and patents but also isolating mechanisms to protect knowledge (ZAHRA; GEORGE, 2002).

The RACAP influences not only the firm's performance through product and process innovation but also the consequent competitive advantage, while the PACAP contributes to the firm's ability to renew its knowledge base and the skills necessary to compete in dynamic markets with lower costs. Thus, the firms that use resources and capabilities flexibly can reconfigure them and capitalize on them in the emerging strategic opportunities so as to create competitive advantage (ZAHRA; GEORGE, 2002).

## 4 METHOD

To provide empirical evidence of the situation in Brazil, this study has focused on multiple-case studies. Performing in-depth analysis of each case, multiple-case studies are considered more representative than a single case (YIN, 2005). The companies that were used as units of analysis were chosen based based on their potential to contribute to the subject under study. The criteria that defined the units of analysis are the following: (i) being a Brazilian company involved in developing technologies, (ii) having an innovative product resulting from university-industry partnership in the marketing stage.

The research followed a protocol that specifies the sequence of procedures or tasks to be completed to meet the proposed purposes, to answer the research questions and to relate the

data to the propositions. The main conceptual elements that were raised in the theoretical review were grouped into sets of interrelated items forming the initial research protocol.

The primary data source was generated through in-depth interviews, held with managers of each company, in which a semi-structured script was used along with an analysis of the documents, contracts and company web-sites. The interviews were recorded and the data from the registered documents and information were systematized while considering the categories and variables defined in the ACAP model. In order to present each case study more clearly, it was decided to apply the ACAP model and the propositions put forward by Zahra and George (2002).

Data analysis was performed based on the ACAP model and the following categories were examined: sources of knowledge and complementary knowledge, experience, activation triggers, mechanisms of social cohesion, maintenance of competitive advantage and the rules of appropriation, related to the propositions suggested by the authors, as in Figure 2.

**Figure 2—ACAP Analytical Model**

| Categories | Variables | Propositions |
|---|---|---|
| **Sources of Knowledge** | Interorganizational relations (formal or informal with other companies, universities, associations, suppliers in search of diverse and complementary knowledge). | P1—The higher the firm's exposure to external sources of diverse and complementary knowledge, the greater the opportunity for the firm to develop its PACAP. |
| **Experience** | Experience; Company trajectory; Scanning the environment; Interactions. | P2—Experience influences the development of the PACAP, especially the location of the search for knowledge and skills dependent on the background of acquiring and assimilating externally generated knowledge. |
| **Activation Triggers** | Reasons for seeking new knowledge (which are the internal or external triggers). | P3—The activation triggers influence the relationship between the source of knowledge, experience and potential absorptive capacity (PACAP). Most importantly, the source of the trigger will define the location of the search for external knowledge, and intensity will influence the investment in developing the skill acquisition and knowledge assimilation. |
| **Social Integration Mechanisms** | Existence of formal and/or informal social integration mechanisms enabling assimilation, transmission and transformation of knowledge. | P4—Using social integration mechanisms reduces the distance between PACAP and RACAP and increases the efficiency factor. They reduce barriers to information sharing and increase the efficiency of the capacity to assimilate and transform knowledge. |
| **Competitive Advantage** | Transformation of knowledge gained in innovation and product development.<br>The capacity to acquire and assimilate knowledge makes the company flexible so as to take advantage of opportunities and resources as well as to reconfigure resources and changes. | P5—Firms that develop RACAP are more likely to gain a competitive advantage through innovation and product development than others.<br>P6—Firms that develop PACAP are more likely to sustain a competitive advantage, since they are more flexible in reconfiguring their resource base than the others. |

(TO BE CONTINUED)

(CONTINUATION)

| | | |
|---|---|---|
| **Appropriation Rules** | How the industry protects knowledge and innovations (records, patents, trade secrets).<br>Influence of this protection system in the company's decision to invest in acquiring knowledge and develop innovations. | P7—The ownership regime moderates the relationship between RACAP and sustainable competitive advantage.<br>P7A—Under strong ownership regimes, there is a significant positive relationship between RACAP and sustainable competitive advantage due to high costs associated with imitation.<br>P7B—Under weak ownership regimes, there is only a significant positive relationship between RACAP and sustainable competitive advantage when firms protect their knowledge assets and capabilities through isolation mechanisms. |

Source: Zahra and George (2002).

## 5 PRESENTATION OF THE CASES

### 5.1 Tecnodare Informática

Tecnodare IT is a Brazilian technology-based company with its headquarters in Campo Bom, Rio Grande do Sul. The company has 5 years' experience in the new technologies market and provides customers with property security solutions. There are PhDs, master's and graduate degree holders among its collaborators. Tecnodare is the result of a strategic decision to merge two companies: the one is a pioneer in alarm and in sensor monitoring services; the other developed and produced control and automation systems for shopping malls.

The company manager believes the security technology sector is very dynamic and must be kept constantly up-to-date and says that a new product will be obsolete within two years. Therefore, the first trigger that led them to seek knowledge came from the service company that told them the market was saturated with providers. Thus, they decided to become a supplier of equipment for the competitors and looked for a partner with expertise to develop and produce new products. The company's flagship product is Pet Par, an infrared device—unique in the Brazilian market—designed to recognize people faces outdoors in contrast to animals' faces. It also provides technical assistance and has other protection products such as telephone exchange equipment, gate movers and devices that use the telephone line, passive infrared equipment, heat compensation technology, as well as reach and pulse regulators.

The National Institute of Intellectual Protection (INPI—Instituto Nacional de Proteção Intelectual) published the patents for the software and hardware used in Pet Par in 2008. The company produces the processor in-house and includes encryption and protection devices. So far, the product has no competition, but the manager of the company recognizes the strategy

only delays the process. Anyway, he believes this period to be sufficient to obtain results and a competitive advantage.

The Pet Par was developed at ITEF (Feevale's incubator), with the participation of students, teachers and researchers. The project was funded by PAPPE—an initiative of FINEP in partnership with the Research Support Foundations—, which seeks to fund R&D activities for innovative products and processes undertaken by researchers who act directly or in cooperation with technology-based companies, preferably associated with company incubators.

The second trigger to initiate the search for new knowledge was the lack of resources to buy laboratory equipment and thus to keep innovating. In this sense, the manager of Tecnodare sought an educational institution that would provide in addition to the technological element: infrastructure, necessary support and qualified human resources. In order to achieve this now, besides Feevale, the company also has an agreement with the PUC and various R&D centers. The manager admits that without Feevale the project would have never had the same progress, because the company acquired new knowledge and used the resources of the institution. Moreover, Feevale collaborated in setting up the network of relationships with other companies that invest in other projects besides Pet Par.

The background and experiences of the company, its interorganizational relations and the constant analysis of the sector were very important to develop the skills needed to acquire and assimilate knowledge as well as to identify where to obtain it. Before starting any new project, Tecnodare studies the market needs, outlines the initial product and defines what technologies are needed. As it does not always have all the necessary knowledge, the company seeks partners that have different and complementary knowledge. It uses a computerized management system that makes it possible to gather and work with a large volume of information and combine the different pieces of knowledge in an integrated manner. The database can be used by several different machines and systems and accessed from anywhere. The projects are documented, and the staff record activity reports and comments. All team members have access to them, including those linked to Feevale.

At first, the knowledge socialization was centered on the figure of one of the partners and the interactions among the members were only formal. To share the knowledge with a multidisciplinary team, a plan of action and a flowchart were developed and distributed during meetings. The informal social integration really began when a member entered the company who had the ability to relate and promote the integration of everyone, managing to aggregate the various types of knowledge.

The creation of social ties intensified the assimilation and transformation of knowledge, providing even new product ideas that emerged during informal events. The manager explained the importance of an entrepreneur who is creative when it comes to merging these types of knowledge. The combination of a computerized management system with the informal integrating mechanisms and with previously acquired knowledge enabled the company to build new expertise and to make new product development faster. Tecnodare manager emphasized that the acquired expertise and experience are present in an intangible way in the company routines and have also made the company more flexible in reconfiguring its resources, providing a sustainable advantage.

## 5.2 Máquinas CNC

Máquinas CNC is a spin-off of a company incubated at ITEF that, being in direct contact with the knowledge, saw a new opportunity in the market through partnerships with other companies. The new company was formally established as a result of a partnership with six other companies, aiming to develop an SMD machine—a robot that assembles integrated circuit boards. The companies that joined the partnership to develop the product are members of the machinery, equipment and industrial automation association that represent this economic sector politically. The main reason for the association was the interest in developing differentiated competitive technologies for the sector.

For the manager of Máquinas CNC, there is an understanding on the part of the managers of the partner companies that, for all of them to survive, they need to develop solutions in partnership. He cited the example of Máquinas Concórdia, which is diversifying its production base because of the crisis in the leather-footwear industry, which is competing with firms that commercialize used machines. Therefore, the solution must be to innovate, i.e., in addition to producing machines for the footwear industry, to draw on the existing experience and knowledge of machinery and other sectors.

Companies in the sector traditionally produce parts directly and discard those that are not suitable, increasing the process costs. Over the years, the companies in the partnership had tried to innovate, but as their processes were based on successive trial-and-error experiments, they had to face the high costs of their failures. Máquinas CNC uses a system of computer-aided engineering, based on a computerized library model, which allows developing the project for subsequent implementation.

Currently, the company continues to maintain close relationships with the academic world and is also incubated at ITEF, even though the development of the new company and the creation of the SMD machine began before the incubation process. Despite the knowledge already acquired, processed and available in the company, it is still encouraged by researchers to maintain that partnership as a necessary condition to enhance knowledge acquisition. In this way, the relationship with the university went clearly beyond seeking technical knowledge insofar as it provides information related to market opportunities too. The company is constantly encouraged to participate in fairs (MERCOPAR) and to use the laboratories for technological development.

From the experience gained in developing the SMD machine, other products began to be created also through partnerships with other companies and involving a Feevale's multidisciplinary team. According to the company manager, the U-I relationship has been positive and decisive for the development of projects at Máquinas CNC.

The company uses the "Business Plan" tool to determine what knowledge is necessary for developing the products and then seeks to establish relationships with companies, colleagues, university students or technical courses and researchers in the field of knowledge of interest. This knowledge has also facilitated an understanding of the development mechanisms that are available at the National System of Innovation (FINEP and CNPq calls).

The knowledge structuring by means of a system similar to that used in libraries allows using knowledge resulting from the assimilation of new contents together with existing ones. All development done for the production of the SMD machine as well as other products can be used to build other machines. However, the manager stresses the importance of creativity in the R&D department.

The manager expresses no great concern with the "leakage" of knowledge because the business is always innovating and is in a favorable position in relation to existing knowledge in the market. Even so, the company believes the machinery and component sector to be concerned with the protection of existing knowledge and the transfer of employees among firms, which may imply the transfer of knowledge and information. For this reason, the company uses confidentiality clauses that maintain the advantage needed for future economic exploration.

The manager of the company believes that the industry generally takes care to protect the knowledge and innovation (records, patents, trade secrets). In the case of Máquinas CNC, the protection system influences the company's decision to invest in knowledge and to develop innovations. To this purpose, the partner companies are not direct competitors but have complementary skills that are subject to a contract-protected exchange strategy (they exchange

knowledge and resources among each other with a contract to protect them against information leaks), which facilitates the development of innovation, since corresponding investments are high in the industrial sector.

### 5.3 Astech Brasil

Astech Brasil was created by students from Feevale University after two of their projects were accepted by the Company Research Support Program (*Programa de Apoio à Pesquisa em Empresas—PAPPE*). The company, which is incubated at ITEF, aims to develop technological solutions for the leather sector, specifically in software for manufacturing machinery and equipment, through partnerships with research institutions, as well as manufacturing and marketing novel high-performance products with an excellent cost-benefit ratio.

The manager noted that, despite the significant changes that have occurred in the sector in recent years, few competitors are prepared to innovate because, as they are consolidated in the market, they keep a reactive behavior without investing in developing and launching differentiated machines. In contrast, Astech Brasil has cultivated closer ties with academia, as this partnership produces mutual results both in technological development based on partnership with PhD and master's degrees holders and in providing job opportunities for young talents. With this approach towards the institution, the company keeps its research and development active, which has great influence on the its strategic planning.

Astech searches for potential clients to identify their needs and from this establishes formal interaction with other companies with complementary knowledge. An example is ColorMap—a technology developed for interpretation of color in uneven surfaces, making color accuracy more efficient and the work of professional dyers and colorists easier, especially in the leather-footwear industry. It was developed in partnership with Feevale and represents the result of 4 years of R&D, with financial support from FINEP. The experience and knowledge gained in this project were essential to develop others because they enabled the company to mature and participate in bidding for new development. The project presented in the INOVA call for bids, for example, was based on scientific and technological knowledge developed in the previous project.

In the beginning, the R&D was based on the technical expertise of the team, which was not enough to estimate the market potential of products or to develop them scientifically and technologically. This shortcoming has been resolved by establishing the university-industry

relationship, which cancelled the business relationship with clients and encouraged the opening of other possibilities. The approach to professors and researchers has been crucial to the development of projects by accessing infrastructure and complementary knowledge.

The new knowledge was socialized in regular meetings, and the incubator is considered an important mechanism of integration between the company's and the university's knowledge, mainly due to its location next to the Feevale. The knowledge and the firm's internal routines are registered and managed using software designed to control versions and new features, an experience also developed in the university-industry relationship. Socialization is understood as crucial for developing the innovation process for the company's products. They are currently developing a project in partnership with the Escola Liberato (another educational institution of Novo Hamburgo) where they select student projects to support.

The partnership between Astech and other companies is also essential. Therefore, the company tries to approach them by means of associations such as the Brazilian Association of Components for Leather, Footwear and Artifacts (ASSINTECAL) and the Brazilian Association of Machinery and Equipment for the Leather, Footwear and Related Industries (ABRAMEQ).

With regard to the ownership regime in the industry, the company highlights the need to protect the knowledge developed. Therefore, the central part of the software developed by Astech has been patented, because it represents the largest research effort of the company. It is known there to be a likelihood of the technology being copied, especially after it was awarded the 2009 FIMEC New Releases Prize, in the machinery category. The company believes the protection of knowledge facilitates and encourages the development of new technologies, which is also perceived by customers that buy technology rather from a knowledge protecting company than from one that does not care about this issue.

## 6 DATA ANALYSIS

To carry out the analysis, data were organized according to categories and variables contained in the ACAP model: sources of knowledge and complementary knowledge, experience, activation triggers, social integration mechanisms, sustaining competitive advantage and the property rules of ownership regime. Figure 3 presents a summary of the main evidence regarding the potential absorptive capacity (PACAP) and the realized absorptive capacity (RACAP) observed in the cases studied.

In relation to sources of knowledge, all the companies acquired it from the university-industry relationship, which was shown to be a diverse and complementary external source to the existing knowledge. Moreover, all the companies sought diverse and complementary knowledge/expertise in other interorganizational relationships with institutions and companies, mainly in a formal way. Exposure to such varied sources of knowledge provided companies with the opportunity to develop their capacities to acquire and assimilate knowledge, i.e., their PACAP, which can be seen in the continuous search for outside expertise and constant development of innovations.

The experiences and background of companies, especially in their contact with Feevale were very important and influenced the development of PACAP. In all three cases, systems were implanted to scan the environment, formulate projects, define what knowledge businesses need and where to get it. It was clear that the companies developed the "habit" of forming networks and partnerships in order to innovate.

For the three companies, the triggers that inspired the search for knowledge were: lack of infrastructure and insufficient market and technical expertise, though all three identified market opportunities and lack of innovation on the part of their competitors. Two companies, Máquinas CNC and Astech Brasil, were also influenced by the pre-existing university-industry relationship, a factor that influenced the development of the ability to acquire and assimilate knowledge. In all cases, the source of the trigger influenced the search for external knowledge, though it was not possible to verify the influence on the intensity of investment in developing the skills for the acquisition and assimilation of knowledge.

With respect to the social integration mechanisms, formal instruments can be seen to exist in all cases, such as action and business plans as well as computerized systems. The latter include the library used by Máquinas CNC, which stimulates knowledge sharing. In this case, the possibility of assimilating and transforming the knowledge is performed essentially by the team of that company.

In addition to these formal mechanisms, all the companies highlighted the existence and the need for the team to get together socially, usually in the form of meetings. In the case of Tecnodare IT, integration favored the creation of social ties, which accelerated the assimilation and improvement in knowledge transformation. It is noteworthy that, in the case of Astech Brasil, the environment within the incubator is considered a mechanism for integration and knowledge transmission. In all cases, the knowledge developed in previous projects can be seen to represent the ingredient for generating new product projects. Also, the experience of using

formal mechanisms is an advance or a result of the university-industry relationship, which reduces the distance between PACAP and RACAP.

Regarding the competitive advantage of companies, in all cases, the path towards new knowledge, coupled with the ability to assimilate and transform that knowledge into products, is observed to be a decisive factor in differentiating these companies from others. Such an ability is directly linked either with partnership networks, sometimes with other companies, such as in the case of Máquinas CNC, or with keeping the university-industry relationship, especially in exploring new research projects submitted to funding agencies, as in the case of Astech Brasil. All companies stress their difference from others in the sectors where they operate, especially with respect to innovation capacity as opposed to a strategy of copying.

It can be seen that the strategy adopted by the companies confirms the proposition that achieving and sustaining competitive advantage is directly related to RACAP through innovation and product development, as well as to PACAP, through flexibility in the reconfiguration of basic resources.

All companies stress the existence of strong ownership regimes in sectors where they operate. Thus, it is essential to protect the knowledge developed. In the case of Tecnodare IT, besides registering the industrial property, isolation mechanisms are used, such as the in-house production of the processor itself, which is also encrypted, as they believe that appropriability is of great importance to competitive advantage and contributes to the decision to invest in innovation and to seek external expertise. Máquinas CNC also uses confidentiality clauses with its employees and formal contracts with their partners. Astech Brasil believes that the protection of knowledge facilitates and encourages the development of new technologies, because some customers prefer to buy protected technology, favoring the maintenance of its competitive advantage in relation to other companies. However, the managers of two companies considered that, whatever the ownership regime, being in constant pursuit of new knowledge and developing innovation ensures that the company is always ahead of its competitors.

**Figure 3—Presentation of data**

| Categories | Tecnodare Informática | Máquinas CNC | Astech Brasil |
|---|---|---|---|
| **Sources of knowledge** | • Product development based on knowledge acquired in relation to the university-industry, involving students, professors and researchers, facilitated the development of PACAP.<br>• The relationship with other companies and organizations enabled the development of skills acquisition and assimilation. | • Being a spin-off of another incubated company allowed the acquisition of knowledge and development of the PACAP, also envisioning new opportunities.<br>• The subsequent relationship with other companies and organizations also enabled the development of acquisition and assimilation skills. | • The university-industry relationship has enabled the company to acquire knowledge and develop the PACAP.<br>• The subsequent relationship with other companies and organizations also enabled the development of acquisition and assimilation skills. |
| **Experience** | • The background and experiences of the company and their inter-organizational relations and the constant analysis of the sector were very important in developing the knowledge acquisition and assimilation skills and identifying the knowledge needed and where to get it.<br>• The university-industry relationship has also led the company to participate in networks of relationships with other companies, seeking different and complementary knowledge to its own. | • The background and experience of the company before becoming a spin-off were very important in developing the potential absorptive capacity, in identifying what knowledge it needs and where to get it.<br>• Based on the experiences gained, the company employs the Business Plan tool to determine which skills are necessary to develop the product and seeks to establish the necessary relationships.<br>• The university-industry relationship has led the company to seek partnerships with other companies, where it seeks different and complementary knowledge to its own in order to develop new products. | • Experience gained with project management involving the university was the basis for the articulation of new projects, the development of capacities and knowledge about where to acquire the necessary expertise.<br>• Astech approaches potential customers to identify market needs and establish formal interaction with other firms and institutions with complementary skills. |
| **Activation triggers** | • The 1st trigger came from the service company that realized the market was saturated, and decided to become a supplier of equipment for the competitors in the industry and look for a partner with expertise to develop and produce products.<br>• The 2nd trigger, which initiated the search for new knowledge, was the lack of resources to buy laboratory equipment and, thus, keep innovating. Tecnodare sought an educational institution that had technology, infrastructure and trained human resources. | • The trigger was the realization that it could not develop innovation alone, thus seeking to establish itself in relation to a university and make partnerships with other companies. | • The trigger was the participation in the Program of Research Support in Companies (PAPPE), from which it realized there was a need for additional knowledge and infrastructure to go ahead with the projects. |

(TO BE CONTINUED)

(CONTINUATION)

| | | | |
|---|---|---|---|
| **Social integration mechanisms** | • Formal mechanisms: the action plan and flow chart developed and distributed during team meetings.<br>• Informal mechanisms: informal social integration has intensified with the entry of a member in the company with the ability to relate to and promote staff integration, managing to bring together diverse areas of knowledge. Since the creation of social ties, assimilation and transformation of knowledge has improved. | • Formal mechanisms: the structuring of the knowledge through a kind of computerized library allows the use of the knowledge produced from the assimilation of new knowledge, combined with the existing knowledge, so facilitating the transformation. The transformation of knowledge into innovation is mostly carried out, only by Máquinas CNC, not by the partners. | • The new knowledge is socialized through regular meetings and the incubator is considered an important integration and knowledge transmission mechanism.<br>The knowledge and the firm's internal routines are entered and managed using a software to control versions and new features, an experience also developed in the U-B/Irelationship, which reduces the distance between PACAP and RACAP |
| **Competitive advantage** | • The addition of a computerized management system with the informal integration mechanisms and the previously acquired knowledge enabled the company to combine new knowledge and gain competitive advantage from new products.<br>• The computerized management system, the background and acquired expertise and experience are present in an intangible way in the company routines and also make them more flexible in reconfiguring their resources, providing sustainable advantage. | • In addition to producing machines for the footwear sector, the company can draw on its experience and existing knowledge, exploring and transforming the knowledge from other products.<br>• The acquisition and assimilation capabilities developed by the company allowed it to quickly perceive market shifts and opportunities, reconfigure resources to form new partnerships and maintain a sustainable advantage. | • The experience and expertise acquired were essential to the development of other products, as they facilitated the maturation of the company and participation in new development tenders. |

**Source: the authors.**

## 7 CONCLUSIONS

This study has achieved the aims of investigating the relationship between the absorptive capacity of enterprises and their competitiveness in a university-industry relationship, using the ACAP model from Zahra and George (2002). Empirical research conducted in multiple-case studies was used to investigate theoretical propositions that reflect the research question and the reviews made in the literature, in order to contribute to the topic of ACAP and the competitiveness of enterprises

From the data collected, we can infer that the university-industry relationship influences the absorptive capacity and competitiveness of all the businesses. The companies acquired knowledge from the university-industry relationship, which was shown to be an external source of diverse knowledge that complemented the existing knowledge. Exposure to these and other diverse sources of knowledge provided an opportunity to develop their capacities to acquire and assimilate knowledge. Companies whose background and experience are marked by the presence of a university-industry relationship are seen to be in constant pursuit of knowledge and innovation, as well as partnerships and formal relationships. Previous experience and relationship with Feevale were markers for the development of the PACAP because systems were deployed to scan the environment, to develop projects, to define what knowledge businesses need and where to get it.

The data analysis confirms the importance of an activation trigger in the search for knowledge outside the company, since the perception of an opportunity in the security equipment sector was the event that led to the search for a partner company, which in turn led to the merger, as well as incubation in the Feevale incubator, leading the company to acquire new knowledge, successfully develop a new product and influence competitive advantage. The fact that the companies maintain routines and well-defined processes in the search for external knowledge proved decisive to the speed and direction of the acquisition of such knowledge. The processes include incorporating the routines and culture into the company, constantly acquiring new knowledge, developing partnerships and innovating. When managers perceive that sharing knowledge helps to develop new projects, there is an even greater sharing.

Despite strong ownership regimes within the sectors in which the companies operate, as well as records and patents, they also use other protection and isolation mechanisms because they believe this strategy is of great importance to keep competitive advantage and contributes to the decision to invest in innovations and to seek external expertise. However, some managers felt that, whatever the ownership regime, the fact of being in constant pursuit of new knowledge

and developing innovation is what guarantees the company is able to maintain a sustainable competitive advantage and take ownership of the due profit.

Regarding the ACAP model (ZAHRA; GEORGE, 2002), the development of absorptive capacity does not always follow the step order proposed by the model. The RACAP also contributed to sustainable competitive advantage, as knowledge transformation and exploration were incorporated into the business routines, making them more flexible and agile in reconfiguring resources.

Perhaps because of the relatively small size of the companies in the sample, the importance of personal skills such as creativity became apparent in the development of the acquisition, assimilation, transformation and exploration skills. The ACAP model hardly contemplated this perspective.

Finally, the study contributes new information to the discussion, allowing other case studies to be carried out based on the logic of both internal and external "replication", in order to achieve similar results, especially in relation to the type of ACAP. It is also suggested that further work be done in order to measure the contribution of each dimension towards competitive advantage.

## REFERENCES

ALVARENGA NETO, Rivadávia Correa Drummond. **Gestão do conhecimento em organizações**: proposta de mapeamento conceitual integrativo. São Paulo: Saraiva, 2008.

ARGOTE, Linda; MIRON-SPEKTOR, Ella. Organizational learning: from experience to knowledge. **Organization Science**, v. 22, n. 5, p. 1123-1137, 2011.

BOLISANI, Ettore et al. The emergence of knowledge management. *In*: BOLISANI, Ettore; BRATIANU, Constantin. **Emergent knowledge strategies**. Cham: Springer, 2018. p. 23-47.

CARDOSO, Leonor; GOMES, Duarte. Knowledge Management and Innovation: mapping the use of knowledge in organizations. In: MESQUITA, A. **Technology for creativity and innovation***:* tools, techniques and applications. Hershey: IGI Global, 2011. p. 237-266.

CAVALCANTI, Marcos; GOMES, Elisabeth; PEREIRA, André**. Gestão de empresas na sociedade do conhecimento**. Rio de Janeiro: Campus, 2001.

COHEN, Wesley M; LEVINTHAL, Daniel A. Absorptive capacity: A new perspective on learning and innovation. **Administrative Science Quarterly**, v. 35, n. 1, 1990.

COSTA, Vânia Maria Gomes; CUNHA, João Carlos. A universidade e a capacitação tecnológica das empresas. In: ENCONTRO NACIONAL DE PROGRAMAS DE PÓS-GRADUAÇÃO EM ADMINISTRAÇÃO. **Anais...** Florianópolis, Brasil, Anpad, 2000.

DALKIR, Kimiz. **Knowledge management in theory and practice**. Cambridge, MA: The MIT Press, 2011.

GOLD, Andrew H; MALHOTRA, Arvind; SEGARS, Albert H. Knowledge management: An organizational capabilities perspective. **Journal of Management Information Systems**, v. 18, n. 1, 2001.

JONES, Oswald. Developing Absorptive Capacity in Mature Organizations: The Change Agent's Role, **Management Learning**, v. 37, n. 1, 2006.

LOPES, Edson Gonçalves. **Conexão entre estratégia e conhecimento na criação de valor adicional para stakeholders expressivos:** uma nova forma de organizar os contextos capacitantes. Tese (Doutorado em Administração de Empresas) – Fundação Getúlio Vargas, Brasil, 2013.

MOURA, Renata; SERRA, Fernando; VILS, Leonardo; SCAFUTO, Isabel. Capacidade absortiva em clusters de baixa intensidade tecnológica. **Revista de Administração FACES Journal**, v. 16, n. 1, p. 123-141, 2017.

NEGRI, Fernanda. Determinantes da Inovação e da Capacidade de Absorção nas Firmas Brasileiras: qual a influência do perfil da mão de obra? *In*: NEGRI, J. A.; NEGRI, F.; COELHO, D. (eds.). **Tecnologia, Exportação e Emprego**, Brasília: IPEA, 2006.

NONAKA, Ikujiro; TAKEUCHI, Hirotaka. **Criação de conhecimento na empresa**: como as empresas japonesas geram a dinâmica da inovação. Rio de Janeiro: Campus, 1997.

OLIVEIRA, Mírian; CALDEIRA, Mário; ROMÃO, Mário. Knowledge management implementation: an evolutionary process in organizations**. Knowledge and Process Management**, v. 19, n. 1, p. 17-26, 2012.

PLONSKI, Guilherme Ary. Cooperação universidade-empresa na Iberoamérica: estágio atual e perspectivas. In: SIMPÓSIO DE GESTÃO DA INOVAÇÃO TECNOLÓGICA. **Anais...** São Paulo, Brasil, USP/NPGCT/FIA, 1994.

PORTER, Michael. **Competitive Strategy:** Techniques for Analyzing Industries and Competitors. New York: The Free Press, 1980.

REZENDE, José Francisco. **Gestão do conhecimento, capital intelectual e ativos intangíveis**. Rio de Janeiro: Elsevier, 2014.

SCHUMPETER, Joseph Alois. **Teoria do desenvolvimento econômico**: uma investigação sobre lucros, capital, crédito, juro e o ciclo econômico. São Paulo: Abril Cultural, 1997.

SEGATTO-MENDES, Andréa Paula; SBRAGIA, Roberto. O processo de cooperação universidade empresa em universidades brasileiras. **Revista de Administração da USP**, v. 37, n. 4, 2002.

STAL, Eva. A contratação empresarial da pesquisa universitária. In: SIMPÓSIO DE GESTÃO DA INOVAÇÃO TECNOLÓGICA. **Anais...** São Paulo, Brasil, USP/NPGCT/FIA, 1994.

TEECE, David J.; PISANO, Gary; SHUEN, Amy. Dynamic capabilities and strategic management. **Strategic Management Journal**, v. 8, n. 7, 1997.

UNESCO. Knowledge Societies concept. Available in: <http://portal. unesco.org>. Accessed in Jul. 10, 2005.

WOLFFENBUTTEL, Alexandre Pinto. **Avaliação do processo de interação universidade-empresa em incubadoras universitárias de empresas**: um estudo de caso na incubadora de empresas de base tecnológica da UNISINOS. Dissertação (Mestrado em Administração). Universidade Federal do Rio Grande do Sul, Porto Alegre, Brasil, 2013.

YIN, Robert K. **Case study research**: design and methods. 3. ed. Porto Alegre: Bookman, 2005.

ZAHRA, Shaker A.; GEORGE, Gerard. Absorptive capacity: A review, reconceptualization, and extension. **Academy of Management Review,** v. 27, n. 1, 2002.