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AGRICULTURE 4.0: INNOVATION AND ABSORPTIVE CAPACITY IN AGTECHS

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Trabalho de Dissertação submetido ao programa de Pós-Graduação em Administração da Universidade Federal do Rio Grande do Sul como um requisito parcial para obtenção do título de mestre em Administração.

Orientadora: Profa. Dra. Fernanda Maciel Reichert

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“We are on the cusp of a third revolution in agriculture – the digitalization of the farm.”

Mike Stern

ABSTRACT

The fifth techno-economic paradigm brought profound changes to the world's economy. However, these changes only recently started to impact on agricultural production. During agriculture 3.0 virtually all innovations in agriculture production were developed by large companies. Currently this scenario is changing. The emergence of agriculture 4.0 brought a new element to the sector: the agtechs. Agtechs use information and communication technologies (ICT), such as Big Data, IoT and Machine Learning to allow farms to improve interconnectivity, reduce transation costs and deliver value to all elements of agribusiness value chain. Agtechs are small companies, therefore, they lack financial and physical resources which makes knowledge resources their crucial asset. The capability that allows these companies to acquire external information, to assimilate it, and to apply it to generate innovation is the absorptive capacity (AC). Thus, the objective of this study is to investigate how agtechs use AC to create innovation. To this end, it was conducted multiple case-study with four Brazilian agtechs two if which are technological leaders in their market fields. Results show that analyzed agtechs build their AC through internal R&D, wide use of science and market-based external knowledge and individual AC of its employees, which, in turn, enhance their ability to innovate. The diversity of knowledge backgrounds of agtechs' employees contribute to creation of knowledge complementarity, which makes it easier to manage companies' knowledge bases. Analysis also shows that despite their small size, studied agtechs are able to maintain structured information storage. It is argued that the emergence of agtechs also promotes the "agricultural servitization" and "agricultural manufacturization". The former refers to a shift from product-oriented value creation towards service-oriented value creation within agricultural inputs market. The latter presents increasing control over farms' production-factors, similar to the manufacturing production. Agriculture is one of the least digitalized economic sectors, therefore, the digital transformations the agriculture is going through have just begun.

Keywords: innovation; agriculture; absorptive capacity; agtech; ICT.

RESUMO

O quinto paradigma tecnológico-econômico trouxe profundas mudanças para a economia mundial. No entanto, essas mudanças só recentemente começaram a impactar a produção agrícola. Durante a agricultura 3.0, quase todas as inovações na produção agrícola foram desenvolvidas por grandes empresas. Atualmente esta situação está se transformando. O advento da agricultura 4.0 trouxe um novo elemento para o setor: as agtechs. Agtechs utilizam tecnologias de informação e comunicação (TIC), a exemplo de Big Data, IoT e Machine Learning, permitindo maior interconectividade das fazendas, reduzindo os custos de transação, gerando valor para todos os elementos da cadeia de valor do agronegócio. Agtechs são pequenas empresas, portanto, carecem de recursos financeiros e físicos, o que transforma os recursos de conhecimento em seus ativos essenciais. A capacidade que permite a essas empresas adquirir informações externas, assimilá-las e aplicá-las para gerar inovação é a capacidade absortiva (AC). O objetivo deste estudo é investigar como agtechs usam AC para criar inovação. Para tanto, foi realizado um estudo de casos múltiplos com quatro agtechs brasileiras, sendo que duas destas são líderes tecnológicos em seus campos de atuação. Os resultados mostram que as agtechs analisadas constroem sua AC por meio de P & D interno, amplo uso da ciência e conhecimento externo baseado no mercado, além de AC individual de seus funcionários, o que, por sua vez, aumenta sua capacidade de inovar. A diversidade de *backgrounds* acadêmico dos funcionários da agtechs contribui para a criação da complementaridade de conhecimento, o que facilita o gerenciamento das bases de conhecimento das empresas. A análise também mostra que, apesar de seu reduzido tamanho, as agtechs estudadas são capazes de manter o armazenamento estruturado de informações. Foi constatado que maioria das agtechs brasileiras são empresas de serviços. Assim, argumenta-se que a emergência das agtechs também promove a “servitização agrícola” e a “manufaturização agrícola”. O primeiro refere-se a uma alteração da criação de valor orientada para o produto para a criação de valor orientada para o serviço na agricultura. Já a manufaturização agrícola refere-se à controle crescente sobre os fatores de produção no campo. Agricultura é um dos setores econômicos menos digitalizados, portanto, as transformações digitais pelas quais a agricultura está passando estão apenas começando.

Palavras-chave: inovação; agricultura; capacidade absortiva; agtech; TIC.

FIGURES

TABLES

SUMMARY

1. INTRODUCTION

Each techno-economic paradigm brought profound changes to the world's economy. The shift from "fordist" paradigm based on mass-production to a value delivery based on information and communication technologies (ICT) occurred during 1980-s (Freeman & Perez, 1988). These technologies were among those that allowed to promote an increasing servitization of value-creation. Previously, this mechanism was based on production of physical goods. In the twenty-first, services are the largest part of the economies of the majority of countries (OECD, 2019).

Some decades after its emergence, the fifth techno-economic paradigm brought changes to agriculture as well. During the current techno-economic paradigm the digital agriculture, also called agriculture 4.0, raised. Before the emergence of agriculture 4.0 the large companies were responsible for development of virtually all technological innovations for agriculture (Pham & Stack, 2018). Currently, an increasing number of high technology-based ventures (HTBV) is engaged in developing new disruptive innovations for agriculture. These HTBV are called "agtechs". Agtechs are usually small companies engaged in developing all types of high technology solutions, however, the development of ICT is agtechs' main focus (Mikhailov, Reichert & Pivoto, 2018).

Use of ICT in agriculture include solutions based on the use of Big Data, Iot, Machine Learning, blockchain, remote sensing systems, drones and agricultural robots (OECD, 2018). These technologies allow to increase efficiency and reduce the transaction costs, as well to deliver value to a number of actors within agribusiness. The ICT allows the increasing control over production-factors through real-time monitoring of farm land, crops and animals, as well as equipment used for the production (Wolfert et al., 2019; Zheng & Wang, 2019). One can highlight also the biotechnological solutions which are among important innovations in agriculture 4.0 era agtechs (Parisi, Vigani & Rodriguez-Cerezo, 2015).

It can be argued that the emergence of high technology-based ventures (HTBV) engaged in development of disruptive innovations in a given sector is not a new issue (Kazanjian, 1988). However, unlike other type of HTBV, agtechs are the only HTBV that act within a sector that mainly adopts but not creates technological innovation (see Startup Genome, 2018), which is the agriculture.

After the emergence of agriculture 4.0 the development of disruptive innovations for this sector requires a combination of "traditional" agricultural knowledge, such as biological, chemical and engineering knowledge (Evenson, 1974) with new ICT technologies. Large and multinational companies (MNC) possess wide human, financial and technological resources that allow them to apply these wide range of knowledge fields for creation and promotion of disruptive technological innovations. But what about agtechs?

Typically, new ventures lack financial and human resources (Paradkar, Knight & Hansen, 2015). Therefore, knowledge resources are particularly important for agtechs. Internal knowledge resources are not enough to companies be able to innovate: they need to absorb new valuable information in order to transform it into new knowledge (Cohen & Levinthal, 1990).

The capability that enables firms to acquire external environment for new information, to assimilate it, and to apply it to generate innovation is the absorptive capacity (Cohen, Levinthal, 1990). Building of AC is influenced by a number of factors. Among them it can be highlighted internal R&D activities (Murovec & Prondan, 2009), companies' intellectual capital (Engelman, Fracasso, Schmidt & Zen, 2017), relationship with external actors and knowledge inflows (De Zubielqui, Jones & Lester, 2016), individual AC of company's employees (Cohen & Levinthal, 1990). Whether located in innovation ecosystem, it is particularly important to the companies to explore relationships with ecosystem's actor to complement their knowledge base and resources (Ferasso, Takahashi & Gimenez, 2018).

The AC is important for promoting the disruptive innovation within companies (Garcia-Morales, Ruiz-Moreno, Llorens-Montes, 2007). Hence, it is possible to infer that AC is crucial for enabling innovation in agtechs as well. The following research question arises: **How agtechs use absorptive capacity to create innovation?**

The ICT in agriculture has been a subject of many academic studies (i.e. Deichmann et al., 2016), but not the changes brought by the emergence of agtechs. The knowledge on how these innovations are created is still a black-box. The research's main objective is *to investigate how agtechs create innovation in light of the absorptive capacity theory*.

The following specific goals are set in order to achieve the referred main objective:

- To fill the theoretical gap of agtech phenomenon in agriculture;
- To analyze the use of each AC internal capabilitity by agtechs;

- To identify the AC characteristics that enable innovation in agtechs;
- To uncover innovation features of agtechs.

The proposed goals were achieved through multiple case study of 4 brazilian agtechs, two of which are technological leaders in their markets. The multiple case study method is suggested when researchers aim to obtain valuable insights about the investigated object, particularly those not identified by academic literature (Eisenhardt, 1989). It also allowed deep investigation of analyzed objects (Yin, 2015), which are agtechs.

The selected agtechs are located in Brazil, which is a hometown of 328 agtech companies (Agfunder, 2018). The country is the third biggest worlds' raw agricultural producer (USDA, 2017) and leader in tropical agricultural research was chosen as geographical location of agtechs (Embrapa, 2017). Agribusiness contributes to 24% of Brazilian GDP (IBGE, 2017). Likewise, Brazil is a hometown to Agtech Valley, the main agricultural technology research center in Latin American countries (Agfunder, 2018).

After all information gathered and analyzed, it was possible to gain an understanding of how the analyzed agtechs use absorptive capacity to create innovation. Thus, individual AC of employees and the use of wide range of external knowledge inflows are among the factors that enable innovation in the analyzed agtechs.

Since sustainable pressures are higher than even before, the opportunity to uncover the innovation and AC features of agtechs not only complement theoretical understanding of innovation in agribusiness, but also help policy-makers to appropriately support agtechs' development and growth, and consequently, promote more sustainable agricultural production.

In the following chapters, literature review covers innovation literature, agribusiness innovation and absorptive capacity. In chapter 2, there is a discussion innovation in agriculture, including analysis of technological paradigms and agricultural Eras, and a presentation of types of agtechs and its features, as well as technologies they develop. Chapter also includes description of AC theory, including its antecedents as well as its relationship with innovation and the framework for analysis of AC in agtechs. In chapter 3, the method used in this research is explained. Chapter 4 includes general description of agtechs analysed within multiple case-study, financial sources and proposed solutions, as well as analysis of absorptive capacity of agtechs. Discussion about how agtechs use absorptive capacity to create innovation and changes that agtechs bring to innovation in agriculture are made in chapter 5. Finally, theoretical, practical and social implication of the research, study's limitations and avenues for future research are outlined in chapter 6.

2. INNOVATION AND ABSORPTIVE CAPACITY

The present chapter includes four sections. First, it discusses AC. Then, it introduces innovation. Techno-economic paradigms and agribusiness Eras are characterized at the third section. The fourth section presents agtechs and agtechs' environments description.

2.1 ABSORPTIVE CAPACITY THEORY

According to Cohen and Levinthal (1990) the AC is the *"the firm's ability to recognize the value of new information from the external environment, to assimilate and then apply it for commercial purposes".* The AC theory has it roots on the investigation of R&D activities. The AC theory is particularly useful for studying innovation[1]. Dodgson et al. (2014) point out that when studying innovation, the AC lenses allow analysis with an internal focus into the process of configuring resources and capabilities within the organizations in a dynamic manner, responding to contextual change and disruption. For that reason, AC is a dynamic capability

According to Cohen and Levinthal (1989, 1990) the presence of knowledge spillover in the market would stimulate the companies to engage in R&D activities, which in turn would enhance firm's AC. Cohen and Levinthal (1989, 1990) add also that industry demand and technological opportunities are positively related to companies' R&D investment which enhance the AC (Cohen & Levinthal, 1989. In turn, the higher AC will positively impact on company's innovation outcomes (Cohen & Levinthal, 1990; Koch & Strotmann, 2008; Zou, Ertug & George, 2018).

2.1.1 AC THEORY

The AC is path-dependent (Cohen & Levinthal, 1990; Zahra & George, 2002; Zou, Ertug & George, 2018). It means that a failure in developing the absorptive capacity in a given area reduces the firm's posterior ability to create knowledge. This failure can prevent the firm from properly assessing the value of information from the external environment. Therefore, the *prior*

[1] When searched for business and management academic articles published in journalsby using an expression of: "absorptive capa*" and "innovat*" in Title, abstract and key-words, 2.582 results were found

knowledge will influence the fields in which a firm intends to conduct both R&D and innovative activity in general (Cohen & Levinthal, 1990; Zahra & George, 2002; Zou, Ertug & George, 2018).

The building of AC is influenced by company's internal and environmental conditions (Cohen & Levinthal, 1990; Lane et al., 2006; Volberda et al., 2009; Engelman et al., 2017). Thus, companies' AC depends of individual members' AC. Skills and competencies, knowledge base and mental models of employees show important to improve company's AC (Cohen & Levinthal, 1990; Engelman et al., 2017; Lane et al., 2006; Volberda et al., 2009). Todorova and Durisin (2007) argue that in order to be better assimilated and applied, new knowledge need to fit the current cognitive frames. For that reason, corporate training of employees engaged in related to innovation project is particularly important for improving not only individual's, but companies' AC (Murovec & Prondan, 2009).

However, companies' AC is not a mere sum of AC of its employees. Enhancement of company members' AC, external knowledge acquisition, such as personnel hiring or consulting services alone is not enough to build company's AC (Cohen & Levinthal, 1990). In order to develop the AC, the company needs to guarantee proper knowledge transfer within the whole organization. The reduction of hierarchical structures, effective internal communication and the decrease of power distances are crucial for effective knowledge circulation within the company. (Cohen & Levinthal, 1990; Zahra & George, 2002; Todorova & Durisin, 2007). In turn, these processes contribute to employees' and company's internal learning process (Engelman et al., 2017)

Some of firm's resources and needs are so idiosyncratic that they have to be developed internally (Barney, 1991; Barney, 1996; Grant, 1991; Wernerfelt, 1995). That is also the case of specific tacit knowledge, technological and human resources (Cohen & Levinthal, 1990; Engelman et al, 2017; Grant, 1991; Nonaka, 1994). For that reason, companies that seek to develop AC need to effectively manage its intellectual and organizational capital (Engelman et al., 2017; Nazarpoori, 2016).

The intellectual capital comprises social, human and structural capital. The human capital refers to employees' creativity, skills and competencies. The social capital relates to information sharing between employees. Knowledge storing and internal communication practices are important for building structural capital. Knowledge storing may include also the use of patents and licenses (Engelman et al., 2017; Nazarpoori, 2016). These use also contributes to intellectual property protection (Cohen & Levinthal, 1990).

Building of idiosyncratic knowledge and technological knowledge also requires the company's engagement in internal R&D process (Cohen & Levinthal, 1990). Murovec and Prondan (2009) add that companies need to engage in innovation cooperation. Innovation cooperation comprehend a number of activities, such as partnerships within innovation projects with universities, government and private research institutes. The cooperation within innovation projects also may include other firms, clients and equipment, material and software suppliers (Murovec & Prondan, 2009). It also facilitates to the company to access new knowledge and information sources, enhancing its knowledge base. In turn, the access to external knowledge sources is of huge importance for increasing of company's chances to innovate (Koch & Strotmann, 2008).

The external knowledge sources can be either science-based or market-based (De Zubielqui et al., 2016; Gao, Xu & Yang, 2008; Koch & Strotmann, 2008). The market-based inflows usually come from supplier's and customer's collaboration, as well as from communication with company's business partners. The science-based inflows come mainly from universities and research centers. However, the science-based and not the market-based inflows are particularly important for building firm's AC and creating disruptive innovation (De Zubielqui et al., 2016; Gao et al., 2008; Koch & Strotmann, 2008).

Companies that effectively manage its intellectual capital, innovation cooperation activities, and internal R&D activities can considerably improve its AC (Engelman et al., 2017; Lane et al., 2006; Murovec and Prondan, 2009; Volberda et al., 2009). However, the environmental factors also influence companies' AC. The influence of environmental factors goes beyond specific company's AC, as it affects the AC of all companies within a given business sector (Cohen & Levinthal, 1989; Cohen & Levinthal, 1990; Lane et al., 2006).

For instance, the weak appropriability regime within the sector stimulate the companies to engage in R&D activities, which in turn will enhance its AC (Cohen & Levinthal, 1990; Todorova & Durisin, 2007). In turn, the appropriability regime depends on intellectual property rights, related legislation, also sector-specific knowledge characteristics (Cohen & Levinthal, 1990; Lane et al., 2006). The influence of prior knowledge base on AC is also moderated by so called "activation triggers" (Cohen & Levinthal, 1990; Fosfuri & Tribo, 2008; Zahra & George, 2002).

Activation triggers are events that change the environment where company operates. These events may include radical innovations, technological shifts, emergence of dominant design, legislation and policy issues. Some triggers can be activated by company's conditions, such as internal crisis or performance failures. Together, internal and external activation triggers contribute for company's search for new knowledge (Fosfuri & Tribo, 2008; Zahra & George, 2002).

The difficulty of learning external knowledge positively moderates the influence of propensity for knowledge spillovers in the industry and scope of technological opportunities on the R&D spending. In a scenario where learning is more difficult, the cost of absorption of new knowledge will increase, so the R&D activities will be more important in order to build the firm's absorptive capacity (Cohen & Levinthal, 1990).

The scope of technological opportunities and competitiveness within the sector also constitute an important environmental factors for building AC. High competitiveness tend to stimulate company's AC. Likewise, bigger opportunities in term of improvement in technological performance will stimulate the company to pay attention on its AC (Cohen & Levinthal, 1990).

The influence of AC on innovation is so significant that it may explain around 30% or even more of companies' innovation outcomes (De Zubielqui et al, 2016; Enkel, Heil, Hengstler & Wirth, 2017; Mamun, Muhammad & Ismali, 2017; Murovec & Prondan, 2009). Building AC is crucial for company's innovation outcomes. (Cohen & Levinthal, 1990; Zahra & George, 2002; Todorova & Durisin, 2007).

Particularly when the criteria of high technological opportunities, sector's competitiveness and weak appropriability regimes are fulfilled, it becomes absolutely must for the company to build AC in order to innovate. In general, through the AC it is possible improve all types of innovation outcomes. Thus, potential AC enhances the hability of NTBV to identify new business and technological opportunities.

AC impacts on explorative and exploitative innovation, incremental and radical, product, process and managerial innovation (Ali, Kan & Sarstedt, 2016; Ali & Park, 2016; Engelman et al., 2017; Limaj, Bernroider & Choudrie, 2016; Murovec & Prondan, 2009). In turn, the influence of AC on innovation is moderated by internal and external forces. Thus, appropriability affects the influence of AC on innovation (Todorova & Durisin, 2007; Zahra & George, 2002). The technological turbulence and environmental dynamism tend to reduce the innovative outcomes of

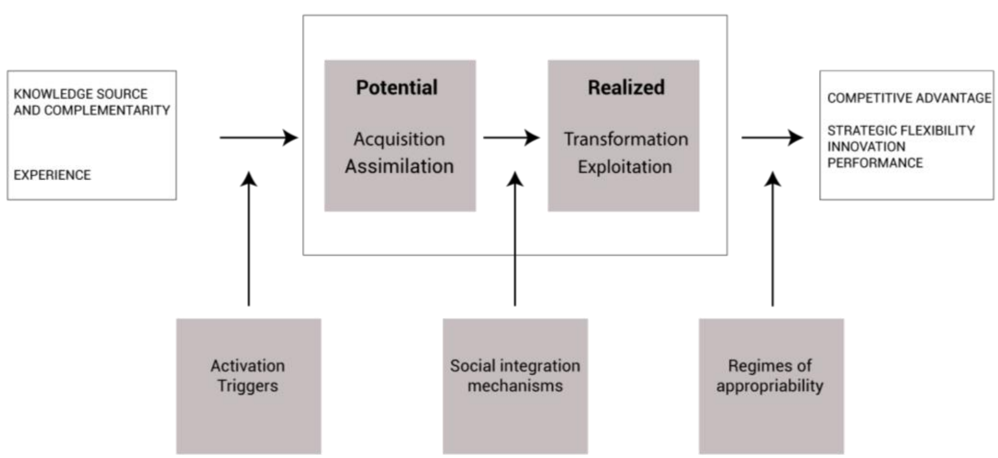
AC (Zou et al., 2018). It also moderates the impacts of knowledge base and knowledge inflows o innovation (De Zubielqui et al., 2016; Gao et al., 2008).

It is essential to highlight that AC conceptualization and measurement differs according to different models and constructs (Cohen & Levinthal, 1990; Flatten et al., 2011; Jansen et al., 2005; Lane et al., 2006; Todorova & Durisin, 2007; Zahra & George, 2002)

2.1.2 MODELS AND MEASUREMENTS OF AC

Cohen and Levinthal (1990) stated that absorptive capacity unfolds through a combination of three internal capacities: the capacity to identify useful external knowledge, the capacity of assimilation of acquired knowledge and the knowledge application for commercial ends. The influence of prior knowledge and knowledge base on AC was moderated by appropriability regimes. Subsequently, other studies have attempted to expand and elaborate on original theorical definition (e.g. Lane et al., 2006; Lewin, Massini & Peeters, 2011; Todorova & Durisin, 2007; Zahra & George, 2002). Zahra and George (2002) stated that AC is a multidimensional dynamic capability and divided it in potential and realized AC. As it can be observed at the Figure 1, the potential AC comprises acquisition and assimilitation capability, and realized AC is composed by transformation and exploitation AC.

Figure 1 - AC conceptual model according to Zahra and George (2002)



Source: Zahra and George (2002)

According to Zahra and George (2002), the acquisition capability refers to company's ability to identify and acquire external knowledge. The assimilation capability comprehends routines and processes that allow to process, analyze and understand the obtained information. The combination of external knowledge with current knowledge base takes part of transformation capability. Nonaka (1994) argues that the reconfiguration of information through sorting, adding, and recategorizing can lead to the creation of new knowledge. In turn, exploitation capability allows the company to apply the generated knowledge to obtain results. Thus, companies first acquire external knowledge, assimilate it, transform and explore for commercial and innovation outcomes. Zahra and George (2002) also stress the importance of social integration mechanisms for translation of potential AC into realized AC. Unlike in Cohen's and Levinthal (1990) approach, the Zahra's and George (2002) model suggests that appropriability regimes moderate the impact of AC on innovation. Authors also added the activation triggers to the model, that is, events such as company's internal crisis or disruptive sectoral transformations that pull company to R&D activities.

Zahra's and George (2002) four capabilities model became widely adopted by subsequent studies and served as a base for AC measurement models (Camisón and Forés, 2010; Flatten et al., 2011; Jansen et al., 2005; Jimenez-Barrionuevo et al., 2011). Likewise, some studies adopted the division of AC in potential and realized (Fosfuri & Tribo, 2008; Leal-Rodriguez et al., 2014). However, Todorova and Durisin (2007) stated that transformation not always occurs after the assimilation process.

According to Todorova and Durisin's (2007) model, the assimilation occurs when the new information fits the existing cognitive structures. In contrast, transformation occurs when the new knowledge cannot be assimilated through existing cognitive structures; therefore, there is a need of transformation of current structures in order to assimilate a new knowledge. Todorova and Durisin (2007) also stated that appropriability regimes mediation occurs before and after the AC process. Power relations were also included into the model.

There are also some other models of AC. As showed at Table 1, Sun and Anderson (2010) use the Zahra's and George (2010) typology for AC internal capabilities. The four-capability proces occurs through individual, group or organizational-level activities (Sun & Anderson, 2010).

Table 1 - AC internal capabilities according to different models

AC internal capabilities	Cohen and Levinthal (1990)	Zahra and George (2002)	Lane et al. (2006)[2]	Todorova and Durisin (2007)	Sun and Anderson (2010)
Acquisition		X		X	X
Assimilation	X	X	X	X	X
Exploitation	X	X	X	X	X
Transformation		X	X	X	X
Value recognition	X		X	X	

Particularly the acquisition process occurs at the individual and group levels, assimilation only at the group level and exploitation – at organizational level (Sun & Anderson, 2010). Lane et al. (2006) argue that AC comprehends exploratory, transformative and exploitative learning. In order to occure, learning processes requires recognition and understanding of external knowledge, its assimilation and than application of external knowledge.

AC structure also can be analyzed under a lens of type of knowledge flows. Thus, knowledge sources such as clients and suppliers contribute to development of demand-pull AC. Science-based knowledge sources such as universities are crucial for building of technology-push AC (Murovec & Prondan, 2009). Saemundsson and Candi (2017) divided the potential absorptive capacity into two sub dimensions. The first dimension is the problem absorptive capacity, which comprehends the ability to identify and assimilate knowledge about the goals, aspirations and necessities of current and potential customers. The second dimension is the solution absorptive capacity, focused on identification and assimilation of knowledge on methods for using this knowledge to fulfill human goals and aspirations (Saemundsson & Candi, 2017).

The empirical studies suggest two ways to measure AC. The first is through a use of proxy, that is, the indirect measure. R&D related measures are among most traditional proxy measures. Among them it can be highlithed R&D expenditures/intensity (Tsai, 2001; Clausen, 2013; Dutse, 2013) and R&D activities (De Zubielqui, Jones & Lester, 2016; Moilanen et al., 2014; Kostopoulos et al., 2011) and number of employees engaged in R&D activities (Huang, Lin, Wu and Yu, 2015;

[2] The division in four capabilities is based on of Lane et al. (2006) model description and Rezaei-Zadeh, Darwish (2016) perception. Thus, Rezaei-Zadeh et al. (2016) highlighted that "transformation learning" dimension corresponds to assimilation and transformation capabilities.

Huang, Rice & Martin, 2015). Other studies used indicators related to investment in corporate training Clausen, 2013; Dutse, 2013; Kostopoulos et al., 2011). Also there are studies that use employee education measures (Kostopoulos, Papalexandris, Papachroni & Ioannou, 2011; Moilanen, Ostbye & Woll, 2014).

However, the proxy measures do not fully explore the dynamic capabilities side of AC (Volberda et al., 2011; Lau and Lo, 2015). Likewise, particularly the internal R&D intensity varies among different economic sectors (OECD, 2011; Reichert et al., 2016; Smith, 2005). For that reason, not having high R&D intensity or many employees with degrees does not necessary implies that the company have not developed proper AC.

In order to fill the gap of dynamic measures, a number of validated AC measurement models was proposed (Camisón and Forés, 2010; Flatten et al., 2011; Jansen et al., 2005; Jimenez-Barrionuevo et al., 2011). Currently the AC direct measures are used by majority of empirical studies[3]. The majority of studies on innovation and AC apply direct measures (21 out of 24). created measurement instrument from at least two previous constructs. From this, it can be implied that usually the AC measures are adapted to the studies requirements. It seems that capturing AC within companies tend to require adjustments over validated constructs.

Here, it is crucial to highlight that virtually all constructs aimed to measure AC in mature companies, sometimes multi-unit firms (Camisón and Forés, 2010; Flatten et al., 2011; Jansen et al., 2005; Jimenez-Barrionuevo et al., 2011). For instance, Jansen's et al (2005) construct was applied to large multi-unit financial services firms. Camison's and Fores (2011) research focused only at manufacturing companies. Jimenez and Barrionuevo (2011) and Flatten et al. (2011) used more generic sample of firms.

While large firms tend to have formal and structured processes, new ventures tend to lack management capability (Dullius and Schaeffer, 2015). Hence, a high level of process formalization in agtechs is not expected. For that reason, it was chosed to adapt the existing AC measurement models for new venture's context, as showed at Table 2.

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[3] In order to study the AC measures applied within innovation studies a systematic literature review was carried out. The majority of articles (24 out of 37) used AC direct measures. Within the articles published since 2015 the proportion of use of direct measures was even higher (15 out of 18).

Table 2 - framework for AC qualitative analysis

Capability[4]	Identified topics through SLR	Authors
Acquisition	· External information sources used by the company	· Heil and Enkel (2015), Manun et al. (2017), Murovec and Prodan (2009)
	· Technology trends identification	· Heil & Enkel (2015), Mamun et al. (2017)
	· Identification of required information sources for NPD	· Jansen et al. (2005)
	· Role of employees in knowledge acquisition process	· Jansen et al. (2005), Lau et al. (2015), Kohlbacher et al. (2013)
Assimilation	· Understanding of knowledge utility	· Soo el al. (2017)
	· Market-oriented opportunity identification	· Jansen et al. (2005), Lau et al. (2015), Soo el al. (2017)
	· Acquired knowledge internal diffusion	· Flatten et al. (2011), Engelman et al. (2017), Soo el al. (2017)
Transformation	· Acquired knowledge structuration	· Engelman et al. (2017), Flatten et al. (2011), Heil and Enkel (2015), Soo el al. (2017)
	· Transformation of new knowledge into useful insights	· Engelman et al. (2017), Flatten et al. (2011), Soo el al. (2017)
	· Daily activities knowledge use	· Engelman et al. (2017), Flatten et al. (2011), Limaj et al. (2016)
Exploitation	· Evaluation of new knowledge use for innovation	· Engelman et al. (2017)
	· New technology use on products and services	· Camison and Fores (2011), Engelman et al. (2017), Mamun et al. (2017), Soo el al. (2017)
	· New knowledge use for value creation	· Jansen et al. (2005), Heil and Enkel (2015), Soo el al. (2017)
	· Role of employees in new product development	· Limaj et al. (2016)

It is important to add that educational heterogeneity and experience of the founding owners may positively influence on the creation of radical innovations in NTBV (Tzabbar and Margolis, 2017). Therefore, it's important to evaluate this heterogeneity also.

[4]In the beginning of the project a systematic literature review of AC theory was performed. For further information see Appendix B.

2.2 INNOVATION

According to Schumpeter (1912), innovation is a novelty that generates economic results and it's an impulse to economic development (Schumpeter, 1942; Freeman, 2002). Dodgson, Gann and Phillips (2014) add that this novelty resides on a "new combinations of existing elements, bodies of knowledge or technology". Nowadays innovation is so important that it became a central policy issue of different international organizations and countries (Reichert, 2016).

Innovation in companies can be analyzed under different perspectives (Reichert et al., 2016). For instance, in high-tech companies, such as those from pharmaceutical, aerospacial, electronics and communications sectors, innovation has long been associated to technological transformations and is measured by R&D investment, new product development (NPD) and patent applications (Hagedoorn & Cloodt, 2003). Likewise, the ratio of R&D expenditures to sales is particularly used for measuring innovation in manufacturing sectors. The Organization for Economic Cooperation and Development - OECD (2011) uses the R&D expenditures indicator to classify industries in four levels: high, medium-high, medium-low and low-technology intensity.

However, the researchers need to be careful when associating the innovation to mere R&D activities or patent creation (Dodgson et al., 2014). While the high-tech companies tend to develop innovation internally, the sectors of low technological intensity are rather adopters than creators of technological innovations (Reichert et al., 2016; Smith, 2005). For instance, that the case of leather and footwear industries, food and beverage companies which mainly adopt but not produce new technologies.

Reichert et al. (2016) add that innovation in low-tech industries is frequently misunderstood. It comes from process improvements, management activities and even better abilities to engage in transactions with companies' partners (Reichert et al., 2015; Reichert et al., 2016). Like for high-tech industries, launching new products is an important opportunity for low-tech companies to innovate. It is crucial to add that NPD in low-tech companies doesn't require high science-based capabilities as it does in high-tech sectors.

Smith's (2005) critics extends also to the use of "traditional" approach to innovation to service innovation. Rubalcaba, Gago and Gallego (2010) states that innovation in services refers to specific human and organizational factors that cannot be captures by applying traditional physical-good-based perspective. It's even more true if considered the intangible nature of services

(Djellal, Gallouj & Miles, 2013). Unlike innovation in manufacturing industries, which relates heavily on physical resources, expenditures in service industry tend to be allocated to market introduction effort (Rubalcaba et al., 2010). Service innovation also involves business model innovation (Tether, 2014)

The nature of innovation in startups and new ventures is still to be uncovered. New ventures differ from mature companies. The capabilities of new ventures, particularly the management and transaction capabilities, are usually undeveloped (Freeman & Engel, 2007). Therefore, it may be difficult to measure the innovativeness of startups by applying the traditional capabilities models such as Guan's and Ma (2003) or Zawislak's et al. (2012) constructs.

As argued before, some innovation studies use number of patents as the measure of innovativeness, however, patent application varies according to sector that startup take part of. For instance, in software industry the intellectual property protection is made through copyright and not the patent application (WIPO, 2019).

Another sector which presents innovation peculiarities is the agriculture. Historically, this sector adopts rather than develops innovation. This technology adoption may be even more intense than in low-tech industries. Thus, there are scholars that argue that innovation in agriculture comes from farmers' ability to recognize the importance of new technologies and than to adopt these technologies to agricultural's production needs (Oliveira et al., 2017; Tepic, Trienekens, Hoste & Omta, 2012).

For that reason, in the words of Pavitt (1984) agricultural sector is composed by so-called "supplier-dominated firms", and therefore benefits from innovation for agriculture are enjoyed rather by farms' suppliers than by the farmers. However, recently the agricultural sector saw and emergence of HTBV, which may be interesting in terms of innovation specifities they bring to the agricultural production (Mikhailov et al., 2018).

Despite the different patterns of innovation within different sectors and companies, all innovations can be grouped according to specific categories. For instance, Schumpeter (1934) suggested four innovation types: new consumers' goods; new methods of production or transportation; new markets and; new forms of industrial organization. Tidd's et al. (2008) advanced Schumpeter's (1934) typology but also use four innovation types. Thus, the "product" innovation include either product or service innovation, that is, the change of "things" that company offers to the market (Tidd et al., 2008).

The process innovation refers to a new method of production, new sourcing activity, or the manner the firm delivers products and services to the customer. Position innovation occurs once there are contexts' changes in which company introduces products and services. It can also include the opening of new market, as argued by Schumpeter (1934). The fourth innovation type is the paradigm innovation. It includes the underlying mental model changes within company activities (Bessant, 2003; Tidd et al., 2008). However, Schumpeter's (1934) and Tidd's et al. (2003) are not the only typologies of innovation.

Freeman and Perez (1988) proposed a typology based on the impacts of innovation. Authors argued that innovations can be either incremental or radical. The incremental innovations occur more or less continuously in any business activity through "learning by doing" and "learning by using". The incremental innovations frequently pass unnoticed by their number is important to the overall growth efficiency and productivity of given technology. In contrast, radical innovations usually emerge deliberate R&D activity. Radical innovations are unevenly distributed over time and may bring considerable production changes when combined together (Dodgson et al., 2014; Freeman & Perez, 1988).

However, the impact of innovations is not limited to mere production changes. When combined together, innovations are able to direct the patterns of technical change in different industries (Pavitt, 1984). Creation of successive innovations is also able promote considerable transformation to the whole technological and economic system (Freeman & Perez, 1988). Changes in technology system are produced by a combination of radical, incremental, organizational and managerial innovation. These changes affect several interrelated economic sectors, as well as give rise to entirely new sectors. That is the case of cluster of syhthetic material innovations, petro-chemical innovations and machinery innovation (Freeman & Perez, 1988).

Some changes in technological systems are so profound that they impact the entire economy. These changes are called techno-economic paradigms[5] (Freeman & Perez, 1988; Perez, 2004). Techno-economic paradigm, also technological revolution, is a long-term change that transform the dominant thinking on how technical progress and economic system should behave. It is essential to highlight that unlike in Dosi's perspective (1982), where technological paradigm is related mainly to trajectories of engineering-problem solving and technical knowledge, the

[5] This term shoudn't be confused with "paradigm innovation" defined by Bessant (2003).

Freeman's and Perez (1988) approach enfasizes the importante of institutions and social context that allow new technologies.

In order to became a paradigm a technical change should fulfill the following conditions (Freeman and Perez, 1988):

- Clearly perceived low and rapidly falling relative cost. Unless it happens, the decisions rules will not be changed;
- Almost unlimited resource availability over long period of time;
- High potential for use or incorporation of new key factor of production in product and processes also with reduction of cost and quality changes.

Each new technological paradigm sets a pattern of "common sense" of how engineering or economic problems should be solved (Dosi, 1982; Freeman and Perez, 1988; Perez, 2004). Technological paradigms impact the technology systems of production. The agriculture is not a rule exception.

2.3 AGRICULTURE AND TECHNOLOGICAL PARADIGMS

The agriculture is a millenarian activity that promotes food security and creates production base to other business sectors. Currently agricultural sector is one of the world's largest economic sectors and has farm assets at around US $ 2 trillion (Dutia, 2014). The shift from a natural ecosystem to an agricultural production system focused on subsistence food production occurred ten thousand years ago, in Neolithic period, when humans started to grow plants and domesticate animals (Mazoyer and Roudart, 2006). Currently, farmers focus on making and selling the agricultural products rather than on producing their own food. Therefore, the path of technological improvements and innovations in agriculture is higher than ever before. The agriculture also is a part of larger agribusiness sector, which includes all activities from farm inputs, to agricultural raw production and food production and distribution (Davis & Goldberg, 1957).

Historically, agricultural innovations were developed through the use of four different knowledge fields: biological, chemical, mechanical and managerial knowledge (Evenson, 1974). However, in the twenty-first century the ICT, robotics and drones, smart farming tecniques appear to have crucial impact on ongoing innovation in the agribusiness sector (Basnet & Bang, 2018;

Deichmann *et al.,* 2016; Kamilaris *et al.,* 2017; Parisi et al., 2015; Wolfert *et al.,* 2017). In other words, the agricultural innovation can be represented as a "package" of technologies that aim to increase productivity of farm enterprises (Ogundari and Bolarinwa, 2018).

According to Oliveira, Pivoto and Pimentel (2017) the technical changes in agriculture can be divided in four Eras. The first Era of agriculture production started during the Neolithic Era and was heavily dependent of nature and climate conditions. The labor necessary to guarantee the agricultural production was either human and animal.

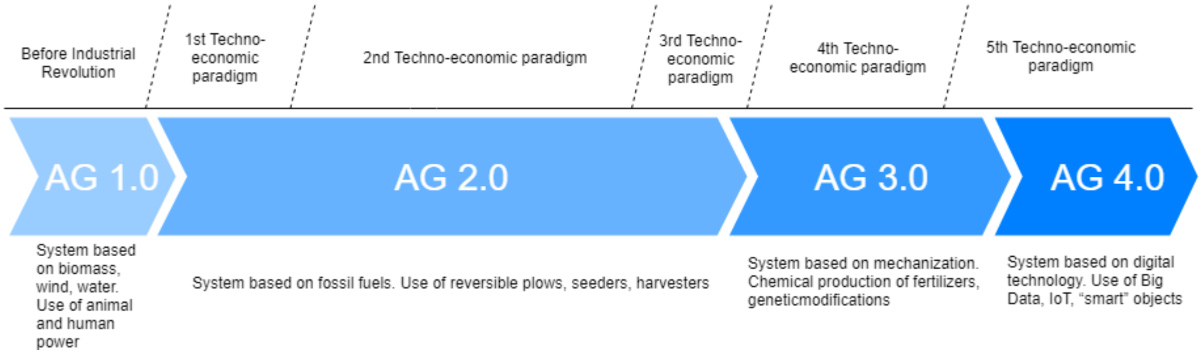
The second agricultural Era begun in the eighteenth century and its main feature was the growing use of agricultural machinery and fertilizers. During this stage technical innovations allowed the lesser use of manpower in agriculture and the farm's size growth (Oliveira et al., 2017).

During the third agricultural Era science engaged in agricultural's production changes, name as Green Revolution. This Era begun at the second half of twentieth century and saw the processing of raw agricultural material becoming much more diversified when compared with the first and second Eras. It was also chacterized by the entrance of new economic actors into the field, such as large corporations (Oliveira et al., 2017). Perhaps for that reason during third agricultural Era the term "agribusiness" was coined by Davis and Goldberg (1957). By the mid of 1990-s the third agricultural Era saw an appearance of first genetically modified crop and first precision agriculture techniques (Oliveira et al., 2017).

The fourth Era, also called as "agriculture 4.0", begun in a new millennium (Oliveira et al., 2017). It is characterized by the start of digitalization of agri-food production, use of IoT and UAV for agriculture (Basnet & Bang, 2018; Junior, Oliveira & Yanaze, 2019; Kamilaris, Kartakoullis, Prenafeta-Boldu, 2017; Wolfert, Ge, Verdouw, Bogaardt, 2017; Zhang & Kovacs, 2012). Which were the economic and technological context of these agricultural Eras?

As it can be observed at Figure 2, the first agricultural Era finished with the emergency of first Industrial revolution. The second era occurred during Freeman's and Perez (1988) first, second and third techno-economic paradigms.

Figure 2 - Framework for AC qualitative analysis



Source: adapted from Oliveira et al. (2017)

Thus, the first long-wave of growth paradigms comprised the emergency of technological innovations such as early mechanization. Steam power and railway construction became important during second long-wave of growth. Production of electrical equipment and heavy engineering emerged started during the third techno-economic paradigm.

The third agricultural era unrolled during the fourth and part of the fifth techno-economic paradigm. The fourth paradigm preconized mass production through the use of assembly lines and economies of scale. In the same period the term “creative destruction” was coinded by Schumpeter (1942), and his book “Capitalism, Socialism and Democracy” later gave origin to innovation studies (Perez, 2002). During 1960-s Silicon Valley became the largest hub of US semiconductor industry. A decade later the region attracted a critical mass of technology firms and supporting industries that allowed the personal computer creation. Thus, Silicon Valley started to emerge as the protagonist of world’s technological trends (Henton & Held, 2013).

The fifth long-wave of growth started by 1980-s with the entrance of ICT, including the internet technologies into the world’s economy (Freeman and Perez, 1988; Perez, 2004). After 2000-s a new creative disruption cycle of social midia was initiated within Silicon Valley (Henton & Held, 2013). It is important to stress that technical changes in agriculture came from adoption of technologies developed somewhere else (Oliveira et al., 2017; Ugochukwu & Phillips, 2018).

More than two decades after its emergence, the fifth techno-economic paradigm gave birth to agriculture 4.0. The ICT technologies are a recent phenomenon in agriculture (Kamilaris et al., 2017, Wolfert et al., 2017). Agriculture still legs far behind other sectors, and it is one of the less digitalized world’s economics sector. Despite that, ICT technologies are starting to bring huge transformation to a landscape of farms’ input production and commercialization.

During twentieth century technical changes in agricultural relied on innovation developed in biological, chemical and mechanical fields (Evenson, 1974). These innovations were developed by large companies. The publicly available data seems to confirm this supposition. Farm's chemical and biological inputs are mainly provided by MNC such as Dupont, Bayer, Syngenta (Pham & Stack, 2018). In Brazil it's not different. According to Saab and Paula (2008), the Brazilian fertilizer's market is controlled by three multinational conglomerates.

The John Deere company, CNH Industrial and Kubota Corp. are worldwide main agricultural machinery and equipment producers. In Brazil the concentration for agricultural machinery's market is even bigger. While in 1999 two multinational groups controlled 59,48% of agricultural tractor's market, in 2008 the market-share of two biggest groups increased to 80,95% (Felipe, Lima & Rodrigues, 2008). Particularly the chemical input's market tends to be heavily olipolized since the second half of twentieth century (Pham & Stack, 2018). During agriculture 3.0 each MNC worked within specific market fields. MNC such as John Deere produced only agricultural machinery and equipment solutions. Companies such as Bayer engaged in production of chemical inputs for agricultural production. The possibility of competition between agricultural machinery companies and companies producing chemical and biological inputs were almost null (Pham & Stack, 2018).

However, with the emergence of agriculture 4.0 the number of players in farms' input market and a competition among them considerably increased (Pham & Stack, 2018; Wolfert et al., 2017). During agriculture 3.0 chemical, biological and machinery and equipment companies dominated the farms' inputs market. With an emergence of ICT, traditional agribusiness companies and tech companies started to compete with each other. In agriculture 4.0 the market of farms'inputs is composed by three types of company.

The first type of company is a traditional agricultural equipment companies, such as John Deere. The second type of MNC comprise ICT companies such as Google, IBM and Oracle. Trimble company offers GPS solutions and produces UAV (Wolfert et al., 2017). The third type of companies include the so called "agbusiness companies" such as Dupont, which is specialize in chemical inputs.

Many of previous companies offer digital solutions to its clients. For that purpose, large companies started to acquire new ventures. For instance, Monsanto, which is a biotechnological company, pushes the Big-data analytics into its product line. For this purpose, Monsanto acquired

Climate Corporation, which is a farm management software company, in 2013 (Wolfert et al., 2017).

The ICT is much less concentrated than other inputs' market. First, because of the presence of larger number of players in the market. Second factor refers to limited adoption of ICT in the agriculture. For that reason, the potential growth of ICT market in agriculture is huge.

The third reason is a presence of NTBV at the ICT market. Brazil alone comprises 328 agtechs engaged in creating innovation for agribusiness value chain. The majority of these companies develop ICT solutions (Agfunder, 2018). These companies are called agtechs.

2.4 AGTECHS

Agtechs are NTBV which aim, by using any kind of high technologies, to improve the process of planting, growing and harvesting of agricultural products, or facilitating the farm management or connection of the farm or farmer to its stakeholders, like clients and suppliers (Mikhailov, Reichert & Pivoto, 2018). Until recently, innovation in virtually all farm's inputs production was dominated by large firms, frequently multinational groups (Felipe, Lima & Rodrigues, 2008; Pham & Stack, 2018; Saab and Paula, 2008). However, the increasing number of agtechs may reduce this dominance. Whether it happens, the pattern of technical change in agricultural will modify.

2.4.1 Typologies and developed technologies

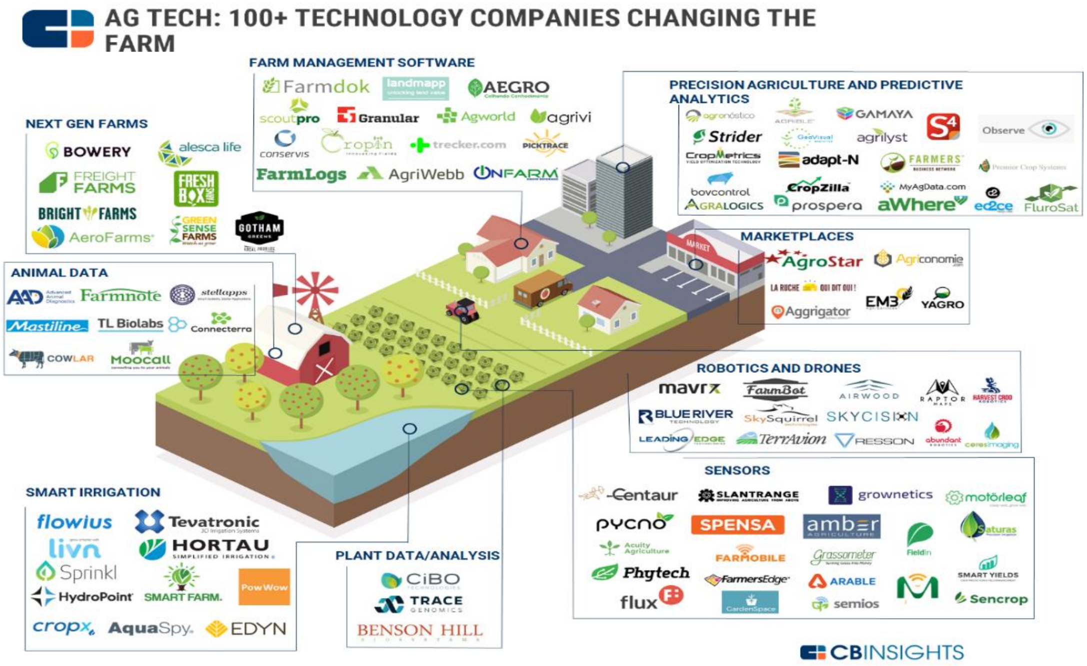
According to OECD (2018), there are nine types of ICT applied to agri-food sector in a form of broad range of tools and devices. They are:

- Digital platforms. Digital platforms collect information and provide broader access to a range of informations and services. The use of these platforms enable commercial and non-commercial transactions in B2B, B2C and C2C markets;
- Sensors. Sensors allow to transform properties of physical world into data. Through the use of sensors, it is possible to analyze the soil and plant health, as well as gather valuable data that will be used for prediction of yields (Basnet & Bang, 2018).

- The IoT allows to connect different digital and physical devices into unique information network. Within the farm IoT helps to monitor location of animals, humans and the production processes;
- Robotics and drones. Robots are small size automatic machines that can substitute traditional agricultural machinery within a number of farm's activities. Drones, also called unmanned aerial vehicles (UAV), support the application of precision agriculture techniques. UAV allow to obtain images of large agricultural areas. Their use turns possible to gather information about soil quality and plants' disease, (Zhang & Kovacs, 2012).
- Big Data is formed by large quantity of information collected from sensors, agricultural equipment, agricultural machinery and by monitoring farm's daily activities. It may include information such as history of incidence of pests, crop management, production results and historical information on agricultural commodities prices would be a suitable information for farmer to analyze. Particularly when analyzed through data analytics it supports the farmer's decision-making process (Junior et al., 2019).
- Cloud computing offers the capacity required for data storage and data aggregation. In this way cloud computing supports Big Data analytics (OECD, 2016);
- Artifical intelligence is defined as the hability to acquire and apply knowledge and to carry out the so called "intelligent" behavior (OECD, 2016).
- Blockchain is a distributed database replicated across many locations and operated by the users. Blockchain uses "smart contracts" to perform transactions. This ICT is particularly important for financial services, such as credit concession, without use of intermediaries. It allows to reduce the transaction costs in operation such as credit concession (Manski, 2017). Another application of blockchain is a food and agricultural commodities traceability. Use of blockchain allows to better evaluate the food origination and thus to deliver value to final customers.

What are innovations allowed by ICT? As it can be observed at Figure 3, through the use of ICT it is possible to create solutions such as farm management softwares, precision agriculture and predictive analytics, marketplaces, robotics and drones for agriculture, sensoring technologies.

Figure 3 - Main solutions developed by agtechs



Source: CBinsights report (2017)

Marketplaces, also called digital platforms (OECD, 2018), connect the farmers to upstream value chain actors. It is particularly beneficial to small-scale farmers. Small-scale farmers usually face more difficulties in achieving proper profit margins than large-scale producers. This happens due to lack of information on products' prices, lack of connections with target market and high transaction cost (Markelova et al., 2009). Therefore, digital platforms contribute to reducing the transactional costs disadvantages, particularly by connecting farmers directly to the consumers, without intermediates (Zeng, Jia, Wan and Guo, 2017).

Farm management softwares are also at the core of innovations allowed by ICT. For instance, one of Brazilian agtechs that offers this solution is Aegro company. The software developed by Aegro allows to maintain complete record of farm's financial transactions, track farming activities, and plan the harvesting process. Farm management softwares also allow to make a customized "prescription" for planting process, which is the case of Climate Corporation. In general, Big Data is a technology which is pervasive to different application of ICT in agricultural digitalization process. and (Sonka, 2014; Wolfert et al., 2017).

Despite the wide range of ICT application to food production and distribution, they are not the only solutions developed by agtechs. Thus, next generation farm is one of solutions that use knowledge background mainly outside of ICT. It is essential to argue that Brazil alone comprises 328 agtechs (Agfunder, 2018). Up to 86 Brazilian agtechs don't completely fit the OECD (2018) criteria for ICT. Here, it can be highlighted solution related to seed and seedling, biological control, bioenergy and innovative food.

Smart irrigation allows to address the sustainable issue by reducing water consumption. As authors argue, smart irrigation allows the farmer to "produce more crop per drop". (Kavianand, Nivas, Kiruthika & Lalitha, 2016).

Pragapontocom is a research company specialized in pest's biological control. The agtech produces insects for crop protection (Pragaspontcom, 2019). Gentros is a genomics company that uses biotechnology to produce solutions for agriculture. Companies engaged in developing innovative food upstream in agribusiness value chain and for that reason can also be called foodtechs or agri-food companies (Startup Genome, 2018). For instance, Ocean Drop is the first Brazilian agri-food company that produces food supplements from algae. Hakkuna company is specialized on protein-based processes food from insects. Company claims that protein obtained from the insects don't contain gluten neither lactose and ir rich in minerals and vitamins. (Hakkuna, 2019).

Agribusiness value chain is composed by input suppliers, farms itselves, processors, retailers and consumers (Gunderson, Boehlje, Neves & Sonka, 2014; Pham and Stack, 2018). From the analysis above it can be observed that agtechs are engaged not only in transforming the farm, but the whole agribusiness value chain.

2.4.2 Agtech ecosystems

Ecosystems are important in order to provide resources to support companies' daily activities (Adner & Kapoor, 2016; Kwak et al., 2018). They also provide access to investors, universitie and research centers, as well as to other companies from the same sector (Reynolds and Uyugun, 2018; Walrave *et al.*, 2018). Thus, in order to grow, agtechs interact with private institutions and foundations, MNC, venture capitalist, universities and other organizations.

The total investment received by agtechs increased from US $ 2.3 billion in 2013 to US $ 10.1 billion in 2017 (Agfunder, 2018). Venture capitalists, angel investors, government, research foundation represent important funding sources for agtechs' innovation activities. Particularly in the Silicon Valley context the angel investment is becoming one of the most important funding startups (Henton and Held, 2013). The same is true for other agtechs located in US. In 2016, 51% of investment occurred during seed stage. In 2017 the angel capital was responsible for 48% of total investment in agtechs (Cbinsights, 2017).

MNC are also important investors of agtechs. According to Cbinsights (2017), in 2013 corporation was responsible for only 5% of agtechs total investment, but in 2017 the participation increased up to 24%. The MNC are also engaged in business acelerators and incubators activities. For instance, according to CBinsights (2017), Bayer is involved with "AgTech accelerator" and "Radicle – accelerating agtech innovation". DuPont, one of the biggest worlds' chemical companies, has presence in "Cultivation corridor", "Iowa AgriTech Accelerator" and "Radicle – accelerating agtech innovation". John Deere is taking part of "Cultivation corridor" and "Iowa AgriTech Accelerator".

Syngenta, the MNC specialized in seeds and chemicals for agriculture, take part on "AgTech accelerator" and LandLakes, agribusiness and food company, in "Techstars". In Brazil, MNC Monsanto take part on "Fundo BR Startups". In addition to the growing investment, the agtech sector presented a number of acquisitions. As it can be observed at Table 3, Climate Corporation had the biggest valuation by the date of acquisition, of US$ 1.1 billion, and received a total investment of US$ 108.8 million.

Table 3- Biggest acquisitions of agtechs since 2013

Agtech	**1st inv.**	**Amount (million US$)**	**T. inv. (million US$)**	**Valuation (million US$)**	**Acquired by**
The Climate Corporation	2007	4,3	108,8	1.100	Monsanto (2013)
Blue River technology	2012	0,15	30,8	305	John Deere (2017)
Granular	2014	4,2	22,9	300	DuPont (2017)

Source: Agfunder (2018), CBinsigths (2017).

By using using Data Science technology, Climate Corporation developed solution that allowed the farmers to make better decisions. Company received its first investment of US$ 4.3 million in 2007, and by the date was specialized in. The second biggest acquisition occurred in 2017, when John Deere acquired the Blue river technology company for of US$ 305 million. Blue River company produces smart agriculture machinery and equipment, including drones. In the same year, Granular company, which is a farm management software company, was acquired by DuPont for US$ 300 million. Another important source of investment for agtechs is venture capital. From January to November of 2017 agtechs received funding from one hundred eighteen venture capitalists (CBinsights, 2017).

Frequently, agtechs are concentrated in specific geographical regions and agricultural technology innovation hubs. Startup Genome (2018) report indicates the Silicon Valley, Amsterdam and New Zealand as important world's agtech ecosystems. Dutia (2014) adds that some of traditional the US agricultural commodities producers, are a hometown for considerable part of US agtechs. In Brazil, Piracicaba City located in Sao Paulo State is the main agricultural technology hub (Agfunder, 2018; Mikhailov et al., 2018). According to a census conducted in 2016, the Piracicaba city - place where EsalqTec is located, with population of approximately 364 thousand people, responds for 18,6% Brazilian agricultural technology startups (Esalqtec, 2016).

The Piracicaba City, also called "Agtech Valley", is a hometown of Agriculture School Eusébio de Queiroz of State University of Sao Paulo (Esalq University). Esalq University is an important tropical agricultural science hub. It conducts agricultural R&D since the beginning of the twentieth century and (Scheinkman, 2017). In 1994 within Esalq was created an agricultural and zootechnical business incubator, which later became the top-tier agricultural technology UBI of Brazil (Esalq, 2019).

Agtechs Valley counts with a number of agtech innovation hubs and coworkings which aim to stimulate communication and experiences' sharing between agtechs. Innovation hubs and coworkings also helps to attract private investors and offer mentorship services. For instance, the Pulse Hub. The hub was created by an initiative of Raizen, a large company specialized in biofuel production. Currently Pulse Hub offers office facilities or have partnership with 18 agtechs (Pulse Hub, 2019).

"Usina Monte Alegre" is another important innovation hub of Agtech Valley. It functions as a co-working. However, it helps the agtechs to agtech to make a business modeling and to validate the value-proposition. It also counts with courses, trainings, and support for minimum viable product (MVP) development. (Usina monte alegre, 2019).

Differently from US, in Brazil the angel investment is almost non-existable. However, Brazil has some research foundation that provide funding for NTBV engaged in R&D activities. One of this foundations is Research Foundation of Sao Paulo state FAPESP[6].

FAPESP offers specific type of funding for scientific and technological projects conducted by SME, named Innovation research in small companies (PIPE[7]). The non-refundable grants are offered both for companies and for individual researchers, but these researchers need to have link with a small company (Fapesp, 2019). Currently the PIPE offers two type of grants. The phase I grant aims to fund companies that need to evaluate the technological viability of new product or process. The financing can last up to nine months and its maximum value is R$ 200 thousand. The phase II grant is offered to companies that are in phase of new product or process development. Phase II lasts for up to 24 months and the amount received by the company can reach R$ 1 million and (Fapesp, 2019).

PIPE funding also includes investment during phase III. FAPESP is not allowed to provide funding during these phase, but it connects the young company to other innovation funding agencies. One of this agencies is FINEP[8], which is a national innovation fund (FINEP) within Brazilian Ministry of Science, Technology and Innovation.

PIPE’s investment aims also to attract private investors to the NTBV’s market. By conceding funds for new ventures FAPESP seeks to put researchers into non-academic market and therefore to stimulate the creation of technology centers within SME (Fapesp, 2019). By doing this the organization hopes to promote social and economic development (Fapesp, 2019).

In Brazil the main venture capital investment comes from SP Ventures fund (Spventures, 2019). Agtechs is not the only type of company SP Ventures invests, however, the majority of investment is received by agtechs. A number of agtechs that received investment are located in Agtech Valley (Spventures, 2019).

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[6] Denomination of FAPESP is a composition of initials of “Fundação de Amparo à Pesquisa do Estado de São Paulo. It means “Research support foundation of São Paulo State”.
[7] Denomination of PIPE is composition of initials of “Pesquisa inovativa em pequenas empresas”. It means “Innovation research in small companies”.
[8] Denomination of FINEP is a composition out of initials of “Fundo de Projetos e Pesquisa”. It means “Fund for Scientific projects and Research”.

As pointed out in the beginning of the section, it is important to highlight that agtechs are usually NTBV. These companies are more startups rather than mature companies.

2.4.3 New ventures

New ventures are frequently defined as companies under six years of age (Dai et al., 2018; Saemundsson & Candi, 2017; Zahra, Ireland & Hitt, 2000). However, there are classifications based organizational and growth issues rather than companies' age. Kazanjian (1988) argues that new venture goes through four stages until becoming a mature company. The first phase is related to resource acquisition and technology development. The companies' main issues are technical ones. The owner' focus in on invention itself. Organizational structure is almost non-existable during this stage (Freeman & Engel, 2007; Kazanjian, 1988). In some cases, the owner is the only company's employee. Dalmarco (2018) adds that during first phase startups are located in "small room, with some furniture and few computers".

During the second stage production company seeks to start the production and commercialization of the developed solution. The more employees are hired, the more elaborated division of labor becomes. The coordination of the new ventures bbecomes more vertical. The startup often seeks its first round of venture capital investment in this point (Freeman & Engel, 2007; Kazanjian, 1988).

During the third stage a new venture becomes increasingly occupied with market growth and organizational issues (Freeman & Engel, 2007; Kazanjian, 1988). At this point the company has inventories to manage, assets to control, sales to record, orders to fulfill, and people to be hired, trained and managed. During this phase the number of employees increase rapidly. It is crucial to add that during second and third stages part of owner's control over he company is transferred to venture capitalist, who seeks to guarantee the returns over capital they invested. For that reason, they impose some organizational control over the company (Freeman & Engel, 2007). It may provoke situation where "agents become principals" (Freeman & Engel, 2007). In the fourth stage the new venture's sales growth slow down. The control over the company returns to the owners and new venture becomes a mature company (Freeman & Engel; Kazanjian, 1988).

It is important to highlight that new ventures may differ in terms of time required to achieve a given growth stage. Boehlje et al. (2011) states that agribusiness in general is subjected to the biological processes characterized by long production cycles and relatively slow production adjustments. New ventures tend to have highly concentrated portfolios, sometimes composed by unique product and service (Dalmarco et al., 2018; Hyytinen, Pajarinen, Petri, 2015) Therefore, it can be supposed that new ventures engaged in launching more technologically advanced, research-intensive and longer product development cycle will be subjected to “liability-of-product-type-nature” in terms of entrepreneurial growth life cycle. Thus, new ventures of a similar age but different type of solution may present different growth stages.

3. METHOD

An exploratory and descriptive research was performed in order to achieve the objective of this work, which is “to investigate how do agtechs use absorptive capacity to create innovation”. Considering the novelty and complexity of the object of this research, which is innovation in agtechs, it was applied a method of multiple case study. The use of multiple case study allows analyzing current phenomenon inside of the real-life context (Yin, 2015). It also assists the understanding of the dynamics presented within single settings (Eisenhardt, 1989), which is the case of new high-technology ventures in agribusiness sector.

3.1 CASE STUDY SELECTION

Agtechs were selected according to following criteria:

a) Owner’s academic background. In order to identify those agtechs that originated from agricultural sector, it was decided to select agtechs that have at least one founder with Bsc degree in agricultural sciences[9].
b) Growth stage. Authors focused on companies at the third new venture’s growth stage, that is, the scalability stage (Freeman & Engel, 2007; Kazanjian, 1988).
c) Location. All mapped companies should be located at Agtech Valley, which is LAC’s largest agricultural innovation hub. This location allowed easier access to startups engaged in state-of-art technological development.
d) Scalability and disruption. Selected companies should have a product or service that is scalable and that brings disruptive innovation to the agribusiness value chain.
e) Technological protagonism. Each company should be among technological leaders of its market.

Researcher also sought to select agtechs with different solution types according to the Cbinsights (2017) and Agfunder (2018) typologies[10]. The list of companies located in Agtech

[9] In this study the term “agricultural sciences” is defined according to Revised Field of Science and Technology classification in the Frascati Manual (OECD, 2007). Thus, it includes professions related to veterinary medicine, agronomy, dairy sciences.

[10] See types of typology of agtechs’ solutions at the page 25-26

Valley included over seventy companies. The list was composed by: (1) associated and incubated companies of Esalqtec incubator, (2) companies listed in Agtech Valley website and (3) companies that took part of one of the Brazilian agtech online communities.

3.2 DATA COLLECTION

All interviews occurred between October and November 2018. The semi-structured interview script (Appendix A) built from an AC framework (Table 3) were used for data collection. In addition to AC questions, interview script included section on general company information and on innovation issues. In order to decrease the research biases, the interview script was evaluated by two agribusiness specialists. The complete inteview script was applied to the owners. The companies' members were interviewed through a set of questions that took part of acquisition AC only. All interviews were recorded and transcribed in order to allow further analysis. Thus, it became possible to analyze four AC capabilities: acquisition, assimilation, transformation and exploitation, as well as to uncover the agtechs' innovation features.

In order to learn more about AC and its antecendents in agtechs, secondary data gathering took place. Cohen and Levinthal (1990) argue that knowledge base of company's individuals is an important component of knowledge base of company itself. For that reason, the academic background of owners and companies' employees was mapped through LinkedIn profile and Curriculum Lattes profiles[11]. In order to increase the comprehension of companies' business activities and market, the website and social midia profile of each company, the TV interviews given by the owners and the market reports were analyzed. The funding received by each company was estimated through information provided by the companies and publicly available investment information. CEO, IT manager, Marketing manager, IT stuff and meat specialist of company A were interviewed. CEO of company B was the only company's member to be interviewed. In company C it was possible to interview CEO, CTO, R&D manager, and Marketing manager.

Two companies, which are agtechs A and C met all 5 selected criteria. Two more companies, called agtech B and agtech D met 4 out ot 5 used criteria. Company B proved to stay at the first growth stage due to research-funding financial difficulties. Company D had no highly-

[11] Curriculum Lattes is a Brazilian national scientific platform that contains detailed description of academic experience of all country's current and former researchers.

scalable solution. Companies B and D were also much smaller than agtechs A and C, which made researcher to adapt the analysis of AC and innovation to the particular context of these two companies.

3.3 DATA ANALYSIS

The transcripted interviews passed through conventional content analysis with the use of *MS Excel* software. Conventional content analysis is suggested when the research literature on phenomenon is limited and when the study has a descriptive approach (Hsieh and Shannon, 2005). Therefore, the conventional content analysis was chosen for the proposed master thesis. The created categories were based on underlying components of AC internal capabilities as proposed by Zahra's and George (2002) model.

The data on academic background of employees passed through three-phase treatment. First, each academic degree was fit into one specific academic degree. Each specific academic degree was grouped into its small scientific fields. Finally, all small scientific fields were grouped into three categories of large scientific fields, according Frascati Manual typology (OECD, 2007)[12]. The categories were: (1) agricultural sciences, (2) exact and technological sciences, (3) applied social sciences.

Through compilation of secondary data sources and contents of interviews, each agtech was characterized according to following information: (1) company type, (2) interviewed members, (3) number of owners, (4) academic background of owners, (5) number of employees, including owners, (6) foundation context, (7) foundation date, (8) offered solutions, (9) value proposition, (10), business and scalability model, (11) location, (12) funding sources, (13) organizational structure, (14) whether company took or not part of business incubation program. Companies' academic knowledge base and applied knowledge fields were also analyzed. The AC of companies A nad C was analyzed according to capabilities proposed at the framework (Table 3), that is, acquisition, assimilation, transformation and exploitation. Due to smaller size of and consequently much lower development of organizational structure and processes of agtechs B and

[12] Professions such as information technology Bsc, computer science Bsc and Bachelor of Technology (B. Tech) in network analysis were considered as Bsc in Computer Science. The academic degrees in mechanical and electrical engineering were grouped into engineering scientific field. Finally, mathematics, engineering and computer science-related degrees were grouped into created category of "Exact and technological sciences".

D researcher seek to conduct the AC analysis of agtechs B and D were made mainly by analysis of companies' knowledge base.

Finally, primary and secondary data were crossed in order to answer the research question, which is: to investigate the creation of innovation in agtechs in a light of absorptive capacity theory.

4. RESULTS

The present chapter covers two sections. First, the foundation context, owners' experience and type of each analyzed company are described. The second part contextualizes solutions developed by agtechs, undergoing projects and financial sourcing.

4.1 GENERAL DESCRIPTION OF AGTECHS

All four agtechs were founded between 2013 and 2017. Founders of all agtechs were either entrepreneurial academics or academic entrepreuneurs (Miller, Alexander, Cunningham & Albats, 2018). As observed at Table 4, founders of all agtechs have at least Msc degree. All companies except one are academic spinoffs. All founders were at least twenty-five years old at the foundation date.

Table 4 - Agtechs general information

Characteristics	**Company A**	**Company B**	**Company C**	**Company D**
Location	Agtech Valley	Agtech Valley	Agtech Valley	Agtech Valley
Age (years)	5	under 2	5	under 3
N. owners	1	1	1	3
Owner's degree[13]	Phd	Phd	Msc	Phd
Owner's age[14] **(years)**	25-30	25-30	31-35	25-30
Owner's age[15] **(years)**	31-35	31-35	36-40	25-30
N. employees	30	5 (maximum)	30	10
Growth stage[16]	stage 3	stage 1	stage 3	stage 3
Incubation[17]	Yes	Yes	No	Yes
R&D company	Yes	Yes	Partially	Yes
Spinoff type	Academic	Academic	Corporate	Academic
Startup	Yes	Yes	Yes	No
Solution for	Animal production	Animal production	Crop production	Crop production
Solution acting at[18]	Downstream	Downstream	Upstream	Upstream
Investment received (US $)	Over 1 million	Under 100 Thousand	Over 1 million	None

[13] Owner academic degree during the foundation of company.
[14] At the foundation date
[15] By the interview date
[16] Typology according to Kazanjian's (1988), Freeman's and Engel (2007) approaches.
[17] Whether company took part of business incubation program.
[18] Refers to position in value chain of elements of value chain targeted by agtechs' solution

Likewise, all companies except one can be considered startups, that is, NTBV that develop highly scalable solutions. Number of companies' employees varies from five to thirty. Except for company C, all agtechs went through UTBI's incubation programs. In order to learn more about companies' foundation context, it becomes essential to provide further description of each analyzed agtech.

Company A

Company A is an academic spinoff founded by a researcher with Phd degree in agricultural sciences in 2013. During his Phd studies and particularly during his pos-doctoral studies the owner A saw an opportunity of applying the state-of-art scientific knowledge to the market commercialization. The owner A had no entrepreunerial experience before starting the company, however, some of his family members were entrepreneurs.

When founded, the owner A was the only member of company A. Later a mathematician and an IT specialist joined the company's team. Currently company A has approximately thirty employees with different background, but with a prevalence of IT-related HR. Company A started its activities at Esalqtec incubator, which is a university technology-based business incubator (UTBI) of Esalq University. Company A uses two different office facilities landed by agricultural innovation hubs in Agtech Valley. Company A has matrix organizational structure, thus, it has no formal departments.

Company A put together software and hardware in order to deliver value to animal production value chain. The focus of value creation of the company is on downstream elements of agribusiness value chain.

Company B

The company B was founded in 2017 by a researcher with Phd degree in agricultural sciences. The project of new company started in 2016, when owner B realized that his research could be commercialized. Still in 2016, company's B owner realized that a research foundation that was offering funding for research-intensive startups at the seed stage. Then he decided to start a company, which currently is an incubee of Esalqtec business incubator. CEO B explains that: *"While concluding the doctorate I started to evaluate the possibility of sending this project to*

FAPESP, because when we identified it (commercial opportunity), it would necessarily require academic research, there was no way out. I'll send it to FAPESP, whether project is approved I'll start the company."

When founded, owner of company B had mainly academic experience. Then company B hired employees and started to develop a project to create the solution prototype. The majority of employees had Bsc degree and no Msc or Phd. In the words of the owner B: "*the people who worked with me were very young, very immature (in academic and professional terms*".

Agtech B develops a project that aim to combine software and hardware in a solution oriented to animal production value chain. The focus of value creation of the company is on downstream elements of agribusiness value chain.

Company C

Company C was founded by an agribusiness entrepreneur in 2013. Back then he had more than ten years of entrepreunership experience and Msc degree in agricultural sciences. During college he made an academic internship in a top-tier university in the US. After receiving Bsc degree owner C started his Msc studies in precision agriculture. By that time the precision agriculture techniques were unkwown in Brazil. Years later he started a company which focused on providing consultancy services to farmers. The company grew and the need of opening a laboratory arose. The demand for laboratory analysis increased and company C started to invest in IT. Company's A owner decided to sell his business and to start new company dedicated entirely to digitalization of agriculture. CEO C explains that: *"I started to pay more attention to IT than to the consulting side. I got rid of all my businesses to start Company C focuses not only with precision agriculture but with digital agriculture"*.

When founded, the owner C had one business partner with IT background, who later left the company. Currently company C has its own office located in Agtech Valley. The company C has departmental organizational structure. It is divided in four main areas, which are: marketing and communication, administrative department, operations, and technology department. Currently company C has approximately thirty employees with a prevalence of IT-related background. It also has R&D team, which is a part of technology department.

Agtech C uses software-as-a-service (Saas) digital platform that connects the farm to its suppliers. The focus of value creation of the company is on upstream elements of agribusiness value chain.

Company D

Company D was founded in 2016 by three academic researchers: one of the researchers had Phd degree, the second one was a Phd student and third had Msc degree, all in agricultural sciences. Before starting the company D, the owners worked in the research laboratory facilities of Esalq University. Besides academic research, the laboratory was conducting a number of research services for private organizations. Some of research projects were not aligned with Esalq University and laboratory objectives.

Therefore, owners decided to supply the demand for private scientific research by starting a private company. Currently company is located in the Esalq University incubator facilities. CEO of company D argues that: "*Our company was formed by people who were from that field (agriculture).. some demands appeared in the laboratory that the professor could not absorb, could not do a service out, because it is not much function of the academy.* "

The company D has no formal departments and it organizes its activities mainly around projects. Currently company D has approximately ten employees. Agtech D combines software and hardware in order to deliver value to crop production chain. The focus of value creation of the company is on downstream elements of agribusiness value chain.

4.2 SOLUTIONS, PROJECTS AND FINANCIAL SOURCING

As observed at Table 5, company A and B are engaged in animal-production solutions and company C and D work with crop-production.

Table 5 – Value-delivery mechanism and financial sources of agtechs

	Solution	**Financial sources**
Company A	Solution that allows farmers and meat packer companies to commercialize their products with optimal efficiency	Own resources, venture capital, private investors, research foundations, revenue, services for large companies
Company B	Software solution that allows to predict precisely the properties of animal carcass	Own resources, research foundations
Company C	Integration of farm's supply chain through software-as-a-service platform	Own resources, venture capital, research foundations, revenue
Company D	Research-intensive consulting services with the use of state-of-art scientific experimentation	Funding from activities of second company founded by the owners, own revenue, research foundations

The solution developed by agtechs, agtechs' financial sources and current projects are described below.

Company A

Company A offers a solution that allows the meat value chain actors to better commercialize their products. The solution combines hardware and software technology that captures information on livestock, such as animals' feed and weight during the biological life-cycle. The software also collects information on farm's expenditures per animal as well as market prices information. By applying specific algorithm, the software determines the optimal selling date in terms of highest profit margin.

Company A works on ten projects, all related to current commercialized solution. The owner A intends to transform each project in a new startup. Company A is about to open its own animal science innovation hub for other startups. Currently company A uses more than ten patent applications. Company A use internally developed methods for project development which are validated through the publication of articles in academic journals.

Company's A funding includes a diverse range of options, such as bootstrapping, venture capital, private equity, research foundations, direct sales and specific services for large companies. Since foundation date it received a funding of more than US $ 1 million. Due to a product development scientific complexity, company A has recently started to raise revenue. The company's revenue depends on amount of monitored livestock production. Company A was the only Brazilian agtech able to promote the described solution and therefore agtech A is a technological leader in its market.

Company B

Company B is engaged in product prototype development. It intends to offer a solution that allows the meatpackers to evaluate precisely the quality of meat acquired from cattle producers. The Seed capital was raised through CEO's B own capital and funding from a research foundation. The research foundation also funded the wages of CEO B and company's B employees. Since foundation company B received a funding of less than US $ 100 thousand. Once the funding from research grant ceased, the company B fired all employees and was forced to almost stop the R&D activities. To overcome financial difficulties company B seeks private equity funding.

Company C

Company C developed a solution that promotes a digitalization of farm's supply chain. The solution was first commercialized more than one year ago through SaaS platform. In the last year, the total area monitored by company's software increased three-fold. Company's A solution scalability comes from increase of monitored farm land.

Currently company C conducts a number of R&D projects related to its main product. Company C submits R&D for research foundation. Besides, Company's C funding includes owners' resources, venture capital, revenue from sales. Since foundation date it received a funding of more than US $ 1 million. The revenue raised as the monitored land expanded. Company C is among Brazilian's agtech technological leaders within its business field.

Company D

Company D does customize scientific experiments and knowledge-intensive consulting services, particularly for big agribusiness companies, including MNC. The research experiments and consulting are not only knowledge-intensive activities, but also labor-intensive activities. Therefore, the company D business model presents lower scalability than the solutions of companies A, B and C. Thus, one can suggest that company D is more NTBV rather than a startup.

Company D had not received any external investment. R&D activities of company D are funded by another company's profit, hereinafter called company E. Company E was founded by three owners of company D and one owner who lives abroad. Company E business adapts hardware agricultural technology to tropical agriculture necessities. The owner outstanding academic background of company's D owners allows to create exclusive value-proposition. CEO D states that: "*we have solutions that are specific (adapted) to Brazil… other solutions out there exist, but the moment they arrive here, they find barriers… so the agronomic knowledge helps a lot in developing a solution*".

4.3 ABSORPTIVE CAPACITY AND INNOVATION OF AGTECHS

In this section AC of agtechs is analyzed First, companies' knowledge base in terms of academic background of employees is presented. Second, internal capabilities of AC are analyzed

4.3.1 Knowledge base of agtechs

Company A

Company's A knowledge base comprises a wide range of educational background and academic degrees. According to CV lattes and LinkedIn profile of company's employees, five employees are undergraduate students and twenty employees received at least Bsc degree.

Table 6 - Aacademic background of Company's A employees

Academic education	Agricultural sciences	Exact and Technological sciences	Applied social sciences	Total per degree[19]
University student	1	3	1	**5**
Bsc degree	6	10	4	**20**
Msc degree	5	2	3	**10**
Phd degree	4	1	1	**6**
Pos-doctoral studies	2	0	0	**2**
Total	**18**	**16**	**9**	**43**

Source: compilated from Linkedin and CV lattes profiles of 25 company's A employees

[19] Cohen and Levinthal (1990) argue that the sum of company's employees's knowledge background is a part of company's knowledge base. For that reason, in Table 6 the total number of academic degrees obtained employees is presented. It means that, for instance, an employee with Bsc and Msc degree in IT and Msc degree in animal science adds to the company's knowledge background an academic knowledge obtained from three different degrees: one Bsc degree in agricultural sciences, one Msc degree in agricultural sciences, one Msc degree in applied social sciences.

As observed at Table 6, the vast majority (34 out of 43) of company's A academic degrees come from agricultural, technological and exact sciences. Agricultural sciences contribute with 18 degrees. Exact and technological sciences place in second in terms of total number of degrees, with 16 degrees. Company A has 9 degrees in applied social sciences.

One can see that within all three big knowledge fields, the higher the academic degree, the lower the number of degreess obtained within given degree. However, most of degrees in agricultural sciences are advanced academic degrees (11 out of 18). In exact and technological sciences, the situation is opposite as 3 out of 16 degrees are advanced degrees. 4 out of 9 degrees in applied social sciences are advanced degrees.

It is important to highlight that Company's A owner states that the main focus of the company's activities is the software development. Around 60% of company's A employees work in the IT field. However only 3 out of 18 advanced academic degrees were received in exact and technological. Company A rather focus on agricultural science than on exact and tech sciences. Possible reason could be the fact that company's A solution is a basically a meat-science solution.

The IT provides a scalability of developed solution: *"I realized through my graduate studies, which were very focused on math modeling… that it would be possible to bring the science and innovation into the hands of decision makers using software."*

<u>Company B</u>

As observed at Table 7, all except one of company's former employees have only agricultural sciences academic background.

Table 7 - Academic background of Company's B employees

Academic education[20]	**Agricultural sciences**	**Exact and Technological sciences**	**Applied social sciences**	**Total per degree**
University student	0	1	0	**1**
Bsc degree	4	0	0	**4**
Msc degree	1	0	1	**1**
Phd degree	1	0	0	**1**
Pos-doctoral studies	0	0	0	**0**
Total	**6**	**1**	**1**	**7**

Source: compilated from CV lattes of company's B owner and employees.

[20] The only person to have undergradiate degree is the company's B owner.

Despite being a research-intensive company, none of company's employees had undegraduation degree. It is essential to argue that qualified HR are crucial for research-intensive company to develop new products. Thus, one can suggest that limited HR may turn difficult to conduct the research project for company B. This suggestion was confirmed by CEO of company B during the interview.

Company C

As company A, Company C knowledge base comprises a wide range of educational background and academic degrees. One of company's C empoyees is undergraduate student and twenty-four employees received at least Bsc degree. As observed at Table 8, unlike company A, the company's C academic knowledge is concentrated in exact and technological sciences degrees (17 out of 41).

Table 8 - Academic background of Company's C employees

Academic education	**Agricultural sciences**	**Exact and Technological sciences**	**Applied social sciences**	**Total per degree**
University student	0	0	1	**1**
Bsc degree	10	13	5	**28**
Msc degree	3	3	4	**10**
Phd degree	1	1	0	**2**
Pos-doctoral studies	0	0	0	**0**
Total	**14**	**17**	**10**	**41**

Source: compilated from Linkedin and CV lattes profiles of 25 company's C employees.

Agricultural sciences place in second in terms of total number of degrees, with fourteen degrees. Company C has ten degrees in applied social sciences. One can see that for all three big knowledge fields, the higher the academic degree, the lower the number of degrees obtained. The number of advanced academic degrees is equal for all three knowledge fields (4 out of 12). Company C, unlike company A, holds more Bsc than graduate degrees in agricultural sciences. The same happens in exact and technological sciences. What are the reasons for these differences?

For instance, unlike that company A posit itself as a R&D company, which is not the case of company C. The decision of owner C to start a new company occurred when developing business activities. In contrast, company A originated as research-intensive spinoff. One can suggest that company C doesn't need such high academic qualification as company A does.

Company D

As observed at Table 9, the majority of employees' of company D degrees was received in agricultural sciences (10 out of 15). Technological and exact sciences comprise 5 degrees. None of company's D employees have degrees in applied social sciences

Table 9 - Academic background of Company's D employees

Academic education	Agricultural sciences	Exact and Technological sciences	Applied social sciences	Total per degree
University student	0	4	0	**4**
Bsc degree	5	1	0	**6**
Msc degree	3	0	0	**3**
Phd degree	2	0	0	**2**
Pos-doctoral studies	0	0	0	**0**
Total	**10**	**5**	**0**	**15**

Source: compilated from employees Linkedin profile and CV lattes of 10 company's employees

All graduate degrees of company D were obtained in agricultural sciences by company's D owners. In contrast, none of degrees in exact and technological sciences is a graduate degree. The majority of degrees in agricultural sciences were obtained by the owners (7 out of 10). Likewise, all Msc and Phd degrees were obtained by the owners. One can observe that all employees from agricultural sciences have at least Bsc degrees. In contrast, only 1 out of 5 employees with exact and technological sciences academic background has Bsc degree.

Hence, the company's D main knowledge field is possessed mainly by the owners. Their graduate degrees seem to fit company's goal of being a private research-company. Apart from owner company D has 7 employees. Therefore, one can suggest that despite being at third growth stage the organizational issues hadn't rise yet for company D. However, company'C further growth may raise organizational's issues problems (Freeman & Engel, 2007).

4.3.2 Knowledge fields applied by the companies

Company A uses wider knowledge background than Company C does. Company A applies 8 knowledge fields: IT, mathematics, statistics, engineering, animal science, food science, genomics and managerial knowledge. It also has the highest number of Phd and Msc degrees in agricultural sciences, as well as total number of advanced academic degrees. It is important to stress that company A uses both hardware and software technologies to deliver value to its clients. In comparison, Company C uses four 4 knowledge areas: IT, statistics, agricultural and managerial knowledge. Unlike company A, company C doesn’t offer hardware solutions. Therefore, it doesn’t need such wide knowledge base as the company A.

From the analysis of academic knowledge background of agtechs’ employees it is possible to observe that companies A and C pay a lot of attention to its intellectual capital. Both companies have employees with graduate degrees. In turn, wider knowledge resources may allow to the company to create more innovation (Barney, 1991; Barney; 1996; Grant, 1991). Paying attention on its knowledge resources and intellectual capital is particularly important for agtechs A and C. Brazil alone comprise 328 agtech and therefore one suggests that a competition in agtech sector is fierce.

4.3.3 AC internal capabilities analysis

The subsection describes four internal capabilities of companies’ A and C absorptive capacity. Then, a summary of AC internal capabilities identified innovation antecendents are presented.

4.3.3.1 Acquisition AC

Acquisition capacity refers to a company’s ability to identify and acquire external knowledge that is critical to its activities (Zahra & George, 2002). As showed at Table 10, companies A and C acquire information from wide range of sources, in both formal and informal ways from market-based and science-based actors.

Table 10 – External information sources used by companies A and C

	Science-based knowledge	Market-based knowledge
Formal information sources	Academic article databases, online courses, graduate studies, patent databases (1)	Governmental statistics, institutions and foundations, business reports, e-books, outsourced market research (1)
Informal information sources	Partnerships with universities and research centers, external researchers, external research groups (1), blogs and online discussion groups, social midia, networking	Clients, industry specialists and consultants, benchmarking, traditional midia, specialized blogs and online discussion groups, internet, meetings and conferences, informal market research, networking, Agtech Valley ecosystem, business incubators and agtech hubs

Source: elaborated by the authors

By using the science-based sources companies A and C seek to map the scientific and technological state-of-art knowledge useful for companies' value generation. These sources include the reading of academic articles, access to universities, research centers and professional and academic networking and internet-based sources, such as thematic blogs, online discussion groups, research social network. The reading of articles is crucial for company's C R&D activities: "*the means I get it (articles) are diverse, I use internet, printed, social network, there are research social networks where the researchers publish and share their articles"* (R&D supervisor C).

However, the company A seems to be even more engaged in the use of academic literature for project development. The patent and articles search is used to hypothesis formulation and development of the method for NPD: "*product development is linked to an information network of a very solid scientific base ... after the state of the art and major bibliographic literature reviews on the subject, a methodological development takes place"* (CEO A). The patent research was not identified as the information source of company C. It is essential to highlight also that in software industry, which is the case of company C, the intellectual property is protected by copyrights, but not patents (WIPO, 2019).

The research-intensity of company A makes parnerships with universities and research centers particularly important for project development. Company A also absorbes an informal technical knowledge from Agtech Valley innovation hubs: "*today our office is [agtech hub], but we have activities with Esalqtect as non-resident company… it (having activities) is very good for us"*. The applied research is conducted directly by the company: "*we usually delegate it (basic research) to a partner (external research groups), and along with him today helping him (partner),* *the applied research we develop by ourself*" (CEO A). The basic research prior to NPD is usually outsourced, however, the company A closely monitor its conduction and some company's employees also get involved in basic research activities.

The internet-based information sources, such as blogs, virtual discussion groups, online research communities are particularly important for software development activities. Members' networking also shows to be important. CTO C argues that: "*I use internet as a whole, software development has several sources on the internet, the main ones are some websites, some groups, exchange of emails with colleagues, former colleagues".*

IT stuff A adds "*I search deep in the internet, but within it (internet) there is no a specific place we are looking for there*". R&D supervisor A states: "*I particularly look a for discussion blogs, I search for those that deal with programming languages.* For some employees wikipedia is important source of knowledge, particularly when they have little or no knowledge about studied subject. Employees of company A use Wikipedia as a platform for further investigations: *"if I start something very much from scratch…first I'll take a look for wikipedia (content), then I check the Wikipedia's references to learn which are the main books and articles"* (IT manager A). Online courses are also an important learning source of companies A and C.

Gathering of state-of-art scientific literature plays is essential for conduction of IT R&D activities of both companies: "*articles comprise 90% of my information sources"* (R&D supervisor C); IT stuff A adds that *"we search a lot for information from articles, in the databases of articles, in scientific articles to know right how it works.* Learning from scientific articles from top-tier peer-review journals is particularly important for company's A NPD.

Companies A and C gather extensively informal data from market-based sources as well. Informal data is collected through updates from meetings and conferences, communitation with companies' clients and industry specialists, internet-based sources such as blogs, thematic websites and online discussion groups, Agtech Valley ecosystem. The internet-based sources are particularly important for online marketing activities. Studying of the traditional marketing literature is unable to follow the pace of evolution of the digital midia: "*today if I buy a book it will already be out of date, the e-book from last month is already out of date because a lot of thing happened (during this time)*" (Marketing manager A). Company C also collects data mainly from internet, but considers important the theoretical knowledge from e-books for marketing activities: "*recently we started to focus on book purchase, particularly on e-books, on the theoretical* *literature with references*" (Marketing manager C). Meat specialist of company A confirms the importance of internet-based tools for external knowledge acquisition: *"Google is one of the greatest search tools that we use".*

In general, the lack of sectoral information particularly for agriculture is common for emerging economies. Thus, both companies struggle to gather reliable data on its market from official information sources. In the words of marketing manager A, even large farm crop producers tend to consider marketing as mere sale activities: "*there is almost no marketing activities within livestock farms..most agribusiness companies consider of marketing as sales..marketing content for livestock market is inexistable*" (Marketing manager A). Large cattle farms frequently frequently are not registered through company register number. Statistics on farmers' profile are scarce: "*agriculture in Brazil in general is a sector with little (sectoral) information"* (CEO C).

In order to overcome the lack market information sources companies A and C strive to collect information form both national and international sources. The large and renowened institutions are particularly interesting to the agtechs: ""*have to be reliable sources, market information from renowned institutions"* (Marketing manager A). Companies highlight institutions such as Food and Agriculture Organization (FAO), Ministry of Development, Foreign Trade and Commerce (MDIC), International Society for Technology in Education (ISTE).

Both companies seek to contact specialist and consultants that work directly with the farmers. The companies also exchange information with other startups of Agtech Valley ecosystem. This communication makes easier the access to latest market information: "*we have a lot of contact with the teams of other companies, with the (market) reality of other companies, there are many events of the digital marketing in which the companies, the startups are taking part."* (Marketing manager C). Meeting and conferences are also important: Marketing manager A states that: *"I always use events as a way to benchmark what the other agtechs are doing, what the news is, what we can learn from it".*

The personal networking of CEO is particularly important for company's C technology trend mapping. "*I travel a lot, I participate in events abroad, and here in Brazil as well, because of my training and my protagonism I end up being very invited and I end up having a lot of access, a lot of circles, in which the future of things is discussed*" (CEO C). Company C also has a sales team, which maintains communication with the farmers. The company A applies formal market research to learn more about its market. However, market research demands considerable financial resources which are not always available to the company A.

Despite the lack of formal information sources, recently new statistics on agriculture became available. That is the case of IBGE sensus (2017) that included information on farmers' profiles. It is essential to stress that socio-demographic factor such as farmer's age, educational background and computer confidence are important drivers of PA adoption. The size of farm and farmer' income also influence the decision of adopting new technologies. (Castle, Lubben & Luck, 2016; Pierpaoli, Carli, Pignatti & Canavari, 2013). Therefore, these information is crucial for sales and therefore scalability of companies' A and C solutions.

Informations sources of companies A and C also include data from different associations of farmers. Some of these associations seek to create their own statistics: "*recently one of association created a characterization of the purchasing profile of the farm producers*" (CEO C). As a matter fact, in Brazil different states, regions have their own sectoral associations. That is the case of Association of Cattle Farmers of MT stated (ACRIMAT), The association of farmers are considered as the source of knowledge's and equipment's sharing, increase of competitivity, and support for farm's daily activities. These associations are so relevant for Brazilian agricultural production that Brazilian Ministry of Agriculture launched a guide for creation of association of farmers (Brazilian Ministry of Agriculture, 2009). Empraba also launched a guide that aim to promote a creation of farmers' associations (Embrapa, 2006).

Currently the agribusiness market and digital environment are subjected to governmental and legal issues which may impact company's business. Thus, CEO C argues: "*I follow a lot of bills that are discussed at the Congress, those that will affect the agribusiness, especially in the digital aspect, which is a current tendency (to be subjected to legislation)*". During the interview CEO A didn't point out the importance of tracking the legal issues. Even though it is not possible to state that the company doesn't follow congress bills in process, it is definitely possible to assure that these issues may affect company's C business.

From the analysis of acquisition AC of agtech A and agtech C, one can highlight that both companies strive to maintain their sources of external information as large as possible possible. The science-based sources are complemented by market-based sources. The information sources of both companies are very similar Here, it is argued that agtech A due to being a research company, focus on formal science-based sources a bit more than the company C.

None of the companies felt into "technology-push" trap, common for new ventures engaged in disruptive innovation (Van Weele, Rijnsoever & Nauta, 2017). The awareness of necessity to maintain balance between technology-push and market-pull innovation is particularly important for company A, which started commercialization very recently.

Both companies seem to pay attention on their intellectual capital and HR. Their employees are highly skilled and have high academic qualification. The employees are stimulated to engage in continuing education programs. Particularly employees of company A that have Msc degree are empowered to start Phd studies. CEO A stresses that: "*my goal is to make 100% of my team to have Phd, at least the leadership team and employees with tecnological background*". Employees that do not have graduate degrees are motivated by company A to engage in Msc studies. CEO C argues that having MBA studies is particularly important for employees engaged in market-related activities.

Agtech Valley proves to be valuable source of knowledge, as it provides access to numerous market and science-based agents. Company A and C are also R&D intensive companies, that is, they generate new knowledge internally, which can be used for innovation. Together, HR qualification, internal R&D activities and partnership with external agents contribute to enhancement of companies' A and C absorptive capacity (Cohen & Levinthal, 1990; Zahra & George, 2002: Murovec & Prondan, 2009).

It's crucial to highlight that both companies benefit from all types of knowledge sources. However, there are slight differencies between the intensity of use of different knowledge sources between company A and company C. Scientific knowledge is more important for company A than to company C, as the former is more research-intensive company. For instance, the lack of internal technological knowledge is compensated by the knowledge inflows from Esalq University and from undergraduate studies of companies' employees. Accordingly, market-based knowledge sources may be a bit more important to company C than to Company A.

Despite wide range of information sources, there is one that is not fully explored by agtechs A and C: the outsourced market reseach. Due to business and technological novelty of proposed solutions it may be hard to test the potential acceptance of new technology it's relatively unknown to the farmers. Therefore, conducting informal market research gains crucial importance for companies A and C.

Thus, the knowledge complementarity is essential to agtechs A and C, as they seem to need more scientific and technological knowledge than other technology-based ventures. It is even more important when considered the lack of market information from formal information sources. The necessity to create knowledge complementarity through the use of wide range of information sources occurs because both agtechs are high research-intensive companies which act in turbulent environment. Thus, it is argued that agtech A and agtech C are quite versatile in gathering required information despite considerable financial and human resources constraints. It is also crucial to add that both companies developed solutions for different agribusiness value chains. Agtech A works with animal-production solutions and agtech C engages in creating value for crop production value chain. Likewise, while company's A solution create value mainly for downstream value chain elements, agtech C impact on downstream agribusiness value chain elements However, companies A and C use very similar knowledge and information resources for its activities. Thus, one can suggest that solution type and targeted value chain elements are not so important factors for selection of external information sources by agtechs

4.3.3.2 Assimilation AC

All described practices, such as taking part of conferences, articles reading, following the specializes websites and new updates, communication with Agtech Valley ecosystem widely contributes to creation of agtech's knowledge base which un turn will enhance the assimilation AC of companies A and C. However, having wide knowledge base is not enough to develop assimilation AC. Gathered information need to be internally disseminated among companies' members in order to be interpreted and comprehended (Limaj et al., 2016; Todorova & Durisin, 2007; Zahra & George, 2002).

Both companies conduct periodical meeting with leadership team and employees. Companies A and C also actively promote less formal knowledge sharing among its employees. As observed at Table 11, knowledge sharing is actively pursued by both companies. In company A informal communication plays a crucial role in promoting internal knowledge sharing. It requires an intense cooperation of all company's members and depends on the way information is transmitted: "*the way of transmitting the information it goes through a dialogue and go through a way of analyzing the information*" (CEO A).

Table 11 – Assimilation AC of companies A and C

	Company A	Company C
Recognition of external knowledge and new of opportunities	Analysis of alignment with strategic planning	Academic articles analysis
	Cost and benefits analysis	Clients feedback
		Data analytics
Knowledge sharing	Periodical meetings	Periodical meetings
	Informal communication (+)	Informal communication
	Learning from other members (+) [21]	Learning from other members
	Cross-departmental project teams	Work with other departments

Source: elaborated by the author

Employees not only share daily information, but also seek to learn from each other. The learning includes knowledge outside of employees' academic field. Meat specialist A argues that: *"speaking about database algorithms, I am quite lay, but with the help of the team (IT team) my technological knowledge particularly in programming languages has increased greatly"*. Marketing manager C explains that: *"we managed to extract a lot of cool information when we worked together with the support team (engaged in IT related activities"*.

Information and knowledge flows also occurs vertically, thus, between different organizational levels. Employees engaged in IT activities lack agricultural knowledge required to perform tasks. Therefore, they receive knowledge on agriculture from their leaders: "*all of them (employees from IT field) sometimes do not have the agronomic knowledge, which is obvious, so I give this support to them too"* (R&D supervisor C). Employees also seek to learn with their leaders: *"we ask questions (use as information source) to people inside the company, people like Leader X, he is another information source, he is one of our advisors here (in the company)"* (IT stuff A).

Promoting a cross-departmental communication is particularly important for company C as workers from different department work in different rooms. The knowledge sharing is easier for company A than to company C, as employee's of company A work in the same room. Company A focuses to share knowledge within conducted projects. It is also easier if compared the number of projects developed by each company, as well how they are developed. While

[21] Members refers to all employees, managers and owner of each company. Indication "+" means that the referred component is stronger for indicated company

Company A different teams develop 10 projects, R&D deparment of Company C is main responsible for project development. Therefore, one suggests that Company A present stronger informal communication and learning than Company C.

It is crucial to add that interpretation and learning of external knowledge is facilitated by heterogeneity of employees' academic and professional background. For instance, a number of employees with Bsc degree in agricultural sciences have programming skills: "*as I understand programming I can also follow (activities of programmers), give them some, when they have difficulties in performing the tasks"* (R&D supervisor C). Both companies have members which obtained academic degrees in different knowledge fields. There are members that have professional either experience outside of their academic degree or are self-taught: "*although I'm not from IT, I've always been very tech-savvy ... always playing with a mobile phone, video game, I was a small child but I was already playing video game"* (Marketing manager A).

Recognition of value of external knowledge and of opportunities new opportunities to serve the clients is also an essential part of assimilation AC (Zahra & George, 2002). As observed at Table 11, companies A and C do it in a different way. Company A uses constantly gathers clients' feedbacks on proposed solutions. It registers clients' perceptions and then seeks to adjust the proposed solution, creating incremental innovation.

Frequently a client is unable to perceive some of his difficulties. For that reason, company A obtaines valuable insights concerning existing problems and its patterns through software-based data analysis. These insights are particularly important to create disruptive innovation: "*through our algorithm you detect a recurring problem that we can solve in a way that it is not solved yet… and it opens the market, it is a disruption*" (CEO A). Company A also identifies new ways to serve the clients through academic article. Reading of peer-review articles allows to learn about solution that yet were not applied to the market.

Company C considers valuable the information that changes its strategic or tactic planning. When analyzing potential market opportinity company C seeks to evaluate cost and benefits of each opportunity. Then, company to analyze whether the opportunity is aligned with company's strategic planning. CEO C explains that: "*we analyze the opportunity and identify the level of effort that we have to apply versus the benefits… and the strategic alignment it (opportunity) has with the company, is a very pragmatic decision*". Valuable information is also recognized at the operational level, during daily activities. The decisions regarding the use of information at operational level area part of daily actitivites.

The analysis of assimilation AC suggests that companies A and C show knowledge complementarity within their knowledge bases. According to Zahra and George (2002), knowledge complementarity is beneficial for both acquisition and assimilation AC. The potential difficulties in dissemination of external knowledge within each company seem to be overcomed through a diverse knowledge background of each employee, self-taughtness of employees and reduction of power distances.

4.3.3.3 Transformation AC

Transformation capacity is an ability to combine existing knowledge base with newly acquired information and knowledge (Zahra & George, 2002). This capability requires to organize and to store the existing knowledge and its transmission through formal internal communication processes and data communication technologies (Camison and Fores, 2011; Flatten et al., 2011; Soo et al., 2017).

As observed at Table 12, both companies store information in a similar way. Companies A and C store a large amount of information through SaaS. The software includes information on clients' profile as well as data collected from either land or cattle. The grant applications represent one of the storing relevant knowledge of companies' potential project. For instance, the R&D supervisor of Company C is responsible for managing the bureauratical issues related to approval of projects funding: *"my main job here is to conduct the projects that we have in partnership with FAPESP, the PIPS that we have approved, deal with the bureaucratic issues of the project, with the documentation"* (R&D manager C). Company's A CEO is the main responsible for submitting the new project application for funding approval. However, CEO A intends to divide the responsibility of projects' submission with other companies' employees. Both companies also generate internal reports related to technical and commercial issues. In order to maintan organizational issues under control Company A and Company C hired employees responsible for accountability and general management activities.

Table 12 – Transformation AC of companies A and C

	Company A	Company C
Information storage	Internal reports	Internal reports
	Project documentation	Project documentation
	Performance indicators	Performance indicators
	SaaS platform	SaaS platform
Creation of new knowledge	Learning-by-doing	Learning-by-doing
	Project development (+)	Project development
	Data analysis and analytics	Data analysis analytics

Source: elaborated by the authors

They use a perfomance indicators. Next phrase is particularly remarkable: *"currently we conduct several projects, we have the investors that evaluate our performance, the performance evaluation is severe, it is based on the control of delivering record, there is a specific platform (for delivering control) that we use"* (CEO A).

The issue of new company's growth and control may considerably affect the company innovation-path (Freeman & Engel, 2007; Kazanjian, 1988). For instance, Freeman and Engel (2007) argue that:

> The creative process of invention tends to generate complexity in organizations and in deals. Venture capitalists reduce this complexity, they push entrepreneurs to develop business systems, organization structures, and operating processes that both can be understood by those outside the company and are scalable (Freeman & Engel, 2007)

It is suggested then the situation of company C related to control issue proves traditional theory on growth of new ventures. It is important to highlight that Company A started to raise revenue very recently. Therefore, one suggests that investors have stronger control over company A than company C.

Companies A and C create new knowledge in a similar way. As showed at Table 12, new knowledge is created through individual and collective *learning-by-doing* process, project development and software-based data analysis. The individual learning-by-doing process is particularly intense when the employee lacks knowledge to perform a given activity. That is the case of software development activity, which demands intense knowledge acquisition. Frequently IT professionals need to perfect his programming skills in order to perform a given task. For that purpose, he searches for online code libraries and consults with other specialists. Then, an IT professional combines acquired knowledge with his prior knowledge, and through congnition and heuristics creates more code.

Next phrases illustrate the software-related knowledge creation process: "*there is the intrinsic knowledge to people who code (software), this knowledge has a lot to do with core code, so when the more people code (software), the more it develops"* (CEO A). IT manager C argues that: *"quantity of information in the software development is very big, and the best source of information is the code"*. The production of digital marketing content for farmers is another good example of individual learning-by-doing process.

Companies' employees that has no background in agricultural and technological sciences learn from other employees in order to applye the acquired knowledge to business and marketing activities. For instance, Marketing manager C states that: *we were able to extract a lot of nice information when we worked together with the support team, we stayed during some time with them"* (Marketing Manager C). Both companies A and C struggle to adapt the traditional marketing practices to the agribusiness field. That's because the low educational level of Brazilian farmers limits their ability to comprehend technical content related to new digital technologies. As a matter fact, less than 21,3% of Brazilian farmers concluded high school education (IBGE, 2017).

To overcome this educational constrains of its clients, company A intends to transform technical content to the more easily-understable digital content for cattle farmers: *"after starting to provide more content cattle confinor, we will bring some scientific articles, of course, adapted to the farmers' slang"* (Marketing manager A). Company C seeks to mix the traditional marketing knowledge with knowledge acquired from local agtechs. Marketing manager C argues that: *"(we seek to) translate this (information from the books) to ag, we read a lot, we acquire a lot of relevant content from other startups"*.

Company C is an owner of online discussion group oriented to marketing for agriculture. The group includes agribusiness professionals, university researchers and agtechs' owners and employees who are engaged in building marketing strategies adapted too agriculture. Company A and C learn a valuable knowledge from this group and then combine the acquired knowledge with prior knowledge base.

Both companies A and C create new knowledge through project development, thus, R&D activities. However, the organization of R&D in company A is quite different from company C. Company's A main knowledge creation process occurs during project development. Thus, employees with different background interact and learn with each other. All projects are related to current company's A commercialized solution, therefore, they require wide knowledge base. Employees with IT background need to learn with engineers, and members with biotechnological expertise need to interact with those who are specialized in animal science. Within these projects each employee has an opportunity of take parte in new knowledge creation process. *"Everyone who participates in that project, who are part of our team, study, evaluate, understand, improve, and so we generate a new knowledge, within these new projects"* (CEO A).

Unlike in company A, in company C R&D are conducted by R&D team. Thus, new project development is restricted to small group of people. Therefore, one suggests that project development is the main sources of new knowledge creation of company A and possibly not of company C. It seems also that decisions related to R&D activities in company C are more "top-down" than in company A: *CEO C comes to me with the idea of the agronomic part, I help him to transform the idea into software"* (IT Manager C). Wolfert et al. (2017) posit that the use of data analytics is an important tool for value creation process. Thus, both companies use data analytics in order to extract valuable knowledge from large amount of information.

4.3.3.4 Exploitation AC

Once external knowledge is assimilated and transformed into useful state it becomes possible to apply this knowledge to commercial ends (Zahra & George, 2002; Todorova & Durisin, 2007). A summary of exploitation AC of agtechs A and C is presentd at Table 13.

Table 13 – exploitation AC of companies A and C

	Company A	**Company C**
Decision-making for NPD	Top-down	Top-down
Role of employees in NPD	Relative autonomy of project managers	Employees' autonomy in operational activities
Difficulties in NPD	Management of R&D process	Environmental uncertainty
	Human and financial resources	Human resources
Strategies used to overcome resource constraints and environmental uncertaintly	Diversification of investment sources	Strategic planning
	Balance between incremental and disruptive innovation	Corporate learning-by-doing
	Ad hoc consultancy for new projects	Own NPD method
	Market-oriented NPD methods	
	Very solid scientific base	

Source: elaborated by the author

In both companies the decision-making on NPD is top-down and is centralized at CEO (company A) and board of directors (Company C). Particularly the company C has clear decision-chain: "*board of director is the main responsible for NPD.. each one (employee) creating a product and innovating is not a good idea can not each create a product and innovate..without a clear decision-chain things will get out of control"* (CEO C). Both companies recognize the importance of human capital for NPD. That's particularly the case of Company A, where each product is managed by a leader. The aim of conceding this autonomy is to empower company's managers, as well as to allow him to acquire and create new knowledge during the process, as well as to other employees. CEO A explains that: *"I delegate it (submission of new project) to a project manager, and it (project) gains a signature, an DNA of him (leader) ... that empowers him and generates a* *new knowledge for him and for his team"*. Well-being of employees is also a great concern of Company A.

Companies A and C act in extremally turbulent business and technological environment. Therefore, they need conduct innovative projects through a number of constraints. Company C focus on following the strategic planning and on rapid decisions based on recent information. After each meeting of board of directors, company C seeks for agile start of put the mande decisions into practice.

Due to high technological and business uncertainty sometimes company C frequently don't count with reliable information. Therefore, the company seeks to collect information along the way. It also seeks to explore the weekly directory board meeting for short-term decision-making. Next phrase illustrates the situation described above:

> You are not sure of the future, you do not know if what you are doing is going to work, so the information gathered along the way has a very big impact on the operational level and on changes made in the company…when new information comes up, we leave the meeting already applying (our decision regarding the information) (CEO C).

It is crucial to argue that there is a significant gap between the launch of new technology to the market and its wide use by farmers (Sunding & Zilberman, 2011). In the beginning of its market introduction new technologies can be rejected by the farmers (Ugochukwu & Phillips, 2018). NTBV that develop too radical innovation may have lower probability to survive that less innovative new ventures (Hyytinen, Pajarinen & Rouvinen, 2015). Thus, company's C will to transform new ideas into projects sometimes is counterbalanced by risks imposed by market and technological uncertainties: *"to put new idea quickly into practice, usually it is not a good idea, the chances of things going wrong is very high"* (CEO C).

It is crucial to stress that return from scientific research may take more than a decade to occur (Mansfield, 1991). That's because the conduction of research is a long and labor-demanding process The difficulties in predicting outcomes or R&D activities is also the case of company A. It requires a lot of effort for company A to acquire financial and human resources for new projects. However, the main difficulty of company A is related to organizational and managements issues: "*I would not say a difficulty, but I would say that the optimal mechanism of creating new solutions is the orchestration of the whole process in a timely manner, in the case of startup we have to be very agile*". Yet again, CEO's A perception fits perfectly the Freeman's and Engel (2007), as well as Kazanjian's (1988) perception, who argues that the main problems of new ventures after developing product prototype are related to organizational and managerial issues.

All previous difficulties make companies A and C to be skillfull in innovation despite resource and organizational constraints. CEO of Company A states that currently all solutions and undergoings projects follow the user-centered desing and fit-to-market approaches. Company C developed own method for NPD.

Company A seeks to maintan a balance between a creation of disruptive and incremental innovation. The short-term innovation, provides funding to company's daily activities. The disruptive innovation guarantees company profit in a long-term. Both types of innovation complement each other. Next phrase illustrates perception of CEO A:

> The payment for a solution, whether it is disruptive or it is incremental, it is important in both ways, because something disruptive is difficult to develop, but you know that it tends to guarantee something in the long run. Something incremental, is what will pay your bills in the short term, so you need to have the two things that pay you the account in the short, medium and long term, otherwise you do not do the business to stand, then these two lines important, it is not one or the other that is right (CEO A).

In order to reduce technological uncertainties, company A deeply explores the state-of-art of academic knowledge through literature review and patent research. In turn, state-of art academic knowledge is used to develop a method for new project development, as well as research hypothesis. Next phrase illustrates the process: "*product development is linked to an information network of a very solid scientific base ... after the state of the art and major bibliographic literature reviews on the subject, a methodological development takes place"* (CEO A).

CEO A argues that decision on innovation investments frequently are made by adhoc advisors. It is essential to Company A goes through strict performance evaluation of investors. Likewise, company C commercializes its solution for more than one year and a half, company A started to sell its product only recently. One suggests that CEO C has more control over his company than the owner of company A. Here, it is essential to argue that period between new venture's engagement in organization issues and transformation of new ventures in a mature company is when the founders have least control over the company (Freeman & Engel, 2007).

Both companies make a great effort to overcome difficulties imposed by resource constraints, technological and business uncertainties, particularities of agriculture. Thus, Agtech Valley and Esalq University are used for qualified labor-force sourcing. Company A and C maintain proximity to Esalq University and thus access the state-of-art academic and technological knowledge. Both companies diversified their investments sources in order to minimize the constraints imposed by the lack of financial resources. Non-refundable investment is used particularly for funding of R&D activities.

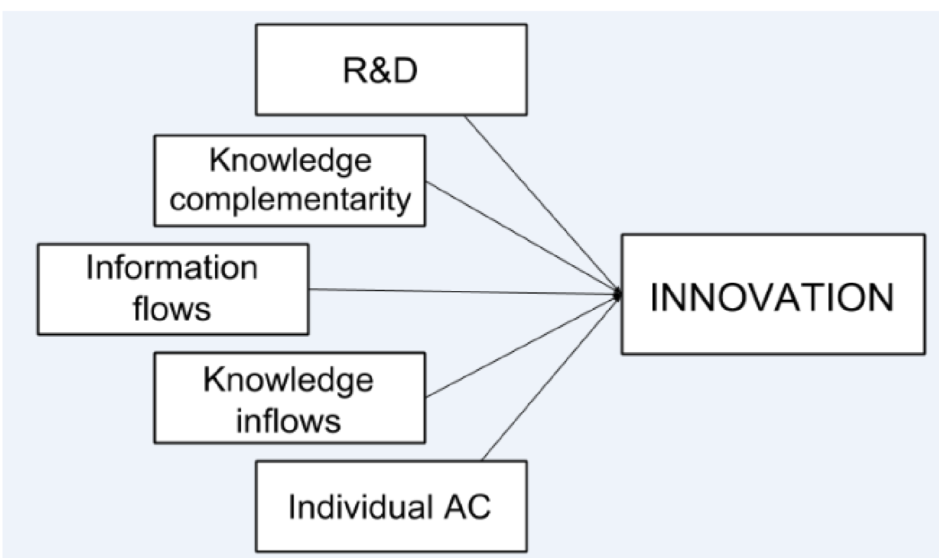
Both companies are managed by visionary leaders. They set ambitious goals that drive their whole effort into innovation: *"we will change the way people (value chain elements) trade their assets (meat products)"* (CEO A). CEO C points out that: "*Mckinsey reports place agriculture as the least digitalized sector of the economy, it means that this sector represents the greatest opportunity for digitalization… that's what people are doing here at Company C, we are working for digitalization of agriculture"*.

These visions are huge drivers of disruptive innovations developed by both companies.

4.3.3.5 Summary of use of AC for innovation

In the previous sections processes that underly internal capabilities of AC were analyzed. In the present section the main aspects of AC used during innovation process are highlighted at Figure 4.

Figure 4 - Key aspects of AC and its antecendents enabling innovation in agtechs



Source: elaborated by the author

Thus, R&D activity, which is also AC antecendents, contribute to innovation in agtechs by allowing creation of new disruptive technologies. The knowledge complementarity performs the function of combining different knowledge fields into one unique solution. For both companies, presence of employees with academic and professional background in more than one knowledge field contribute to creation of knowledge complementarity. Thus, the individual AC also is enhanced. However, possibly the most important factor for individual AC of employees is the high academic qualification of members of both companies. The small size of companies A and C contribute to rapid dissemination of information across the companies, which enhances the agtechs' ability to make quick decisions. Finally, external knowledge inflows play a crucial role in enabling the innovation in agtechs. Science and market-based knowledge from formal and informal information sources is a crucial production factor for agtechs' innovation. The combination of these knowledge allows the creation of new one, which in turn is applied to products and services.

5. DISCUSSION

As observed from the case-studies, companies A and C act in environment where available market information is scarce. To overcome the informational constraints, companies diversify their information sources. They gather large quantitites of formal and informal information from science-based and market-based sources. The vast majority is usually publicly-available and cost-free, except for the time used to acquire it. This strategy contributes to reduction of for-innovation resource constraints faced by agtechs A and C.

Companies A and C have the ability to quickly understand the value of external knowledge. The internal knowledge flows are facilitated by strong informal communication and companies' size. Agtechs differ in terms of the way they recognize external opportunities. The influence of academic and entrepreneurial owner's profile on companies' activities is particularly evident. Company A, which is an academic spin-off, focuses on state-of-art academic knowledge and data analysis and analytics. Company C, which is a corporate spinoff founded by an experienced entrepreneur, prefers to follow the strategic planning and cost-benefit analysis. Here it is essential to argue that Company C is closer to the stage mature company than Company A. Therefore, company C tends to be more market-oriented than company A.

Wolfert et al. (2017) argue that the use of data analytics is an important tool for value creation process. Thus, particularly Company A engages in data analytics to find out solutions that clients are unable to perceive. Companies A and C store knowledge through internal reports and SaaS software. Thus, unlike suggests conventional literature, these new ventures seem to have have well structured processes for data storage. It is essential to add that companies are also an information-based companies. That could be the idiosyncratic aspect that improves knowledge structuration and storage in agtechs A and C.

Company A and Company C are similar in the way they create new knowledge. Companies engage in learning-by-doing in their market and technological activities, Knowledge transformation is a crucial process for new knowledge creation (Zahra & George, 2002). Both companies engage in learning-by-doing, particularly within R&D activities. The data analytics also allows the creation of new knowledge, as it suggests solutions to companies' clients that they are not able to perceive.

Prior knowledge base, intellectual capital, internal R&D activities, communication ties with market-based and science-based actors are important AC antecendents (Cohen & Levinthal; 1990; Engelman et al., 2017; Murovec & Prondan, 2009; Zahra & George, 2002; Volberda et al., 2010). As showed by analysis, companies A and C have all previously cited antecendents. They also have high AC. Here, theoretical postulates of AC theory are proved by the analysis of AC of agtechs.

Constraints for creation of innovation by agtechs are similar to the constraints of other new ventures argued by academic literature. It is highlighted the lack if financial and human resources (Paradkar et al., 2015), and organizational issues (Freeman & Engel, 2007; Kazanjian, 1988). However, analysed companies are able to successfully overcome these contraints. For instance, company A seeks to diversify its financial sources.

Freeman and Engel (2007) state that after first maturity stage the issue of control over the company becomes a main issue for new ventures. That's the case of Company A, as its investors impose control mechanisms such as performance indicators over the company. Among analyzed agtechs, those companies that were not able to find an investor could have difficulties to grow: that's the case of company B.

Company C, which started to raise revenue more than 1 year ago, seeks to carefully evaluate cost-benefit of each potential projects. It is crucial to highlight that the riskiest investments, thus, R&D investments (Mansfield, 1991) of company A and C, are funded by non-refundable investments. Thus, agtechs are able to manage technological uncertainties. It's important to stress that none of four analyzed companies received venture capital investment at the first growth stage. This situation is a particularity of Brazil: here, venture capitalist tend to invest only in companies that raise revenue. Therefore, government is the main angel investor of Brazilian agtechs. The role of FAPESP institution is particularly important.

The Agtech Valley allows to complement internal resources of companies, such as human, knowledge and technological resources. The Agtech Valley environment is particularly important for sharing knowledge on factors of adoption of technologies in agriculture, which is scarced within formal information sources. Esalq University provides technology-push for creation of disruptive solutions for agriculture. Governmental entities, such as FAPESP, stimulate the creation agtechs by offering funding during the seed stage. These entities also provide funding for highrisk innovative activities, that is, R&D activities. In turn, these investments enhance the chances of survival particularly of highly-innovative new ventures.

The third important element of Agtech Valley is an entrepreneur itself, who takes the risks in return for potential profit. Some of these entrepreneuris came from academic field. Hence, it seems that Agtech Valley acts as innovation ecosystem that supports creation and growth of new agtechs (Adner, 2006; Adner & Kapoor, 2016). The present research didn't aim to identify spinoff companies. Oddly, three out of four contacted agtechs were academic spinoffs. Another company was a corporate spinoff founded by entrepreneur with outstanding academic background. Owners of all companies stress the importance of Esalq University as technological knowledge provider. Hence, the proximity with universities and research is particularly important for creation of disruptive innovations by agtechs.

As suggested before the investigation, agtechs should have longer NPD cycle than other software-based ventures. It is particularly the case of company A, which develops hardware and software. Naturally, the scalability of analyzed agtechsAlso there is an issue of rate of technological adoption (Hall, 2004; Rogers, 2003). Due to high cost, uncertainty and low margin, farmers may not will to adopt new technology.

Perhaps, the most important hability of agtechs that help to overcome resource constraints for innovation is their ability to properly arrange quite different knowledge fields for NPD. These arrangement is enabled by the presence of knowledge complementarity in agtechs A and C. The knowledge complementarity is created through the heterogeneity of companies' employees have knowledge background. Thus, some employees with agricultural background engage in business and management learning. Employees with background in applied social sciences seek to learn about technological science fields. Part of agtechs' employees have academic degrees in different knowledge areas. This knowledge complementarity seems enhance the ability of agtech to innovate.

The rise of agtechs that develop disruptive innovation has an important theoretical and practical implication for innovation in agribusiness. As it can be observed from case-studies, despite resource constraints, even small technology-based firms are able to generate disruptive innovation. Therefore, for large agribusiness corporation may become more interesting to acquire or invest in top-tier agtechs than to develop disruptive innovations internally. The data on increasing acquisition and investment pace of MNC in agtechs seems to reinfornce this tendency.

From 2013 to 2017 the investment of corporations in agtechs grew from 5% to 24% of total investment received (Cbinsights, 2017). Large MNC, such as Dupont, Syngenta and John Deere support activities of a number of large agtech accelerators. Hence, the pattern of technical change in agribusiness sector, previously dominanted by large companies, seems to be shifting towards innovation developed by small companies, that is, agtechs.

Back in 1950s and 1960s the Green revolution promoted agricultural industrialization, that is, the heavy use of fertilizers, pesticides and machinery for agriculture production (Pham, 2018), In other words, during Green revolution the use of physical resources, that is, physical matter, became crucial for raw agricultural output. Based on the results of present research, it is argued that currently the nature of innovation in agriculture moves towards increasing importance of services. It means that the tendency of servitization described by Vargo and Lusch (2004) came to agriculture as well. Here, this process is called "agricultural servitization".

The Green revolution stimulated the raise of sustainability issues. In contrast, the agricultural servitization through the use of digital technologies brings a possibility of concilitation between high agricultural output and the use of resource-saving technologies. Green revolution allowed to transform agriculture production into mass production. The number of workers required to produce given output significantly decreased (Oliveira et al., 2017). However, even after Green revolution agricultural production were suggested a number of uncertainties. These uncertainties continued to exist due to a lack of valuable information such precise soil quality, plant and animal health, plant diseases location.

With the emergence of digital agriculture, it is possible to have detailed information on smaller and smaller land units. The use of Big Data, IoT, drones and predictive analytics allows the farmers to access a detailed real-time information and to take advantage of decision-support technologies (Wolfert et al., 2017). All these technologies allow the sharp increase in monitoring and control over production environment, similarly to what occurs in manufacturing. Thus, a combination of incremental and disruptive innovation in agribusiness produces far-reaching changes that affect several branches of economy, in this case, agribusiness sub-sectors. Altogether, these innovations create, as called by Freeman and Perez (1988), changes of "technology system".

Before agriculture 4.0 raw agricultural production relied on use of tangible inputs, such as machinery, chemicals, fertilizers. Now digital technologies make room for use of intangible production factors in agriculture. It is suggested that unlike previous studies stated (i.e. Oliveira et al., 2017; Ugochukwu & Phillips, 2018), disruptive innovation in agriculture can be developed internally by agricultural specialists with outstanding academic background. It cannot be argued that it never happened before. However, it seems that the influence of agriculture itself on its internal technological innovation had increased.

6. CONCLUSION AND AVENUE FOR FUTURE RESEARCH

After combining all previous analysis, it is possible to answer the research question, which is: how agtechs use absorptive capacity to create innovation? Innovation in agtechs is created through application of virtually entire knowledge base to NPD and market-promotion. The ability of companies A and C to acquire knowledge from wide range of cost-free information sources comes from high individual AC of its members: they are self-taught and combine formal and informal information source to deliver results.

The necessity of wide knowledge base seems not to be an issue for agtechs: most of employees have background in more than one knowledge fields and therefore knowledge complementarity is created. Agtechs A and C acquire state-of-art academic and technological knowledge which allows them to reduce technological uncertainty and thus to have more opportunities to innovate. The result of present study adds more theoretical robustness to AC theory. Thus, AC antecendents such as internal R&D, knowledge inflows from market and science-based actors, and individual AC of employees do improve companies' AC.

These antecendents of AC of companies A and C which enhance the ability of companies to innovate are exactly the same pointed out by theoretical and empirical AC literature (i.e Cohen & Levinthal, 1990; Engelman et al., 2017; Murovec & Prondan, 2009; De Zubielqui et al., 2016). Knowledge complementarity and rapid information dissemination within the companies were also identified as important factor for enabling innovation in agtechs A and C. These findings are in line with Cohen and Levinthal (1990) and Zahra and George (2002) perceptions on the factor that are crucial for building proper AC.

Therefore, one concludes that despite all specifities of agtechs, and particularly of companies A and C, the AC theory seems to behave in agtechs the same way it behaves in mature, small, medium and large companies. It is also crucial to highlight that, as previously stated by Apriliyanti and Alon (2017), the AC theory one more time proves to easily integrate with other academic knowledge fields. In the case of present study this knowledge field is the agricultural innovation.

The present thesis also has a number of theoretical, practical and social implications. The first theoretical implication refers to agriculture being able to push some disruptive innovation into the market. It is possible due to entrepreneurial academics. Here it is essential to add that all owners of analyzed agtechs had some knowlegde either in computer science or mathematics/statistics in addition to their background in agricultural sciences. Could this owners' background heterogeneity be a *sine-qua-non* to creation of disruptive innovation within and for agriculture?

It is crucial to add that the present thesis shows that innovation and agricultural academic literature can be linked with each other. The findings of the study suggest that there is ongoing process of "agricultural servitization", where services are gaining increasing importance for agricultural production. Still concerning theoretical implications, it is suggested that the process of "agricultural manufacturization", where management of agricultural production-factors becomes more similar to the manufacturing sector than it was before.

This study also shows practical implications. Another practical implications concerns the innovation features of agtechs: in general, agtechs' innovation characteristics seem to be quite similar to those of other types of new ventures. Therefore, it is suggested that it is possible to include agtechs in the policies that target other new ventures, with an exception of incubation time limits.

Still concerning the incubation time, it is important to highlight that besides similarity ot other new ventures, one of the agtechs' characteristics make it different from other new ventures, particularly from IT-based new ventures, which is a lower scalability of agtechs. Particularly those companies that deliver value beyond the software technology need time to launch solution to the market. That's because the NPD within agtechs is suggested to biological cycles of plant and animals, as well as the rate of technology adoption by quite conservative consumers, which are the farmers.

Therefore, UTBI and Science parks managers need to pay attention to this issue when imposing incubation time limits to agtechs. The agribusiness and technology policy-makers need to do the same for grants' concession. Finally, venture capitalists need to be patient when expecting rapid returns over investments in agtechs.

Technological changes and new waves in agriculture may induce social transformations in the rural areas. It could lower manpower and resource consumption even more due to interconnectivity allowed by use of ICT in the farms. ICT technologies are also expected to drastically reduce the energy, water and chemical use in agriculture. This reduction will allow more environmental-friendly agricultural and food production. It generates one more reason for investing in agtechs in order to reduce negative environmental effects derived from agricultural commodities production.

It is suggested also that it is emerging the modifications in the patterns of technical change in agriculture. Until recently virtually all major disruptive innovations in agriculture were developed by large companies. Currently, even small new ventures are able to develop these technologies. Government and policy agencies need to be aware of these changes in order to conduct innovation policies for agricultural sector.

For future research it is suggested to conduct quantitative studies on the use of AC for innovation in agechs. It also would be interesting to expand the current research to innovative economies. In this study some aspects on interaction between mature companies and agtechs were analyzed, however, deep investigation is required. Study about Agtech Valley innovation ecosystem would be an interesting opportunity. It is suggested to deeply analyze the complementarity of resources between agtechs and agtech' innovation ecosystems.

Spillovers enabled the digital revolution agriculture. What is a mechanism of indirect technology transfer between traditional digital industries and agtechs that underlies digitalization process? It is suggested also that despite some opportunities created for small farmers by ICT, furthers impacts of these technologies on small farmers' activities remain unexplored.

Analysis of technologies developed by agtechs and conducted case-studies allowed to identify the tendencies of "agricultural servitization" and "agricultural manufacturization". The agriculture came into a new era. In this era the ICT plays a crucial role. It is absolutely must to unravel this new wave in agriculture.

6.1 STUDY LIMITATIONS

The study presents some limitations. For instance, due to reduced number of analyzed agtechs it is not possible to generalize the results to whole agtechs population. Moreover, the specifities of selected agtechs made even more difficult to generalized obtained results to agtech population.

In this study, the analysis of knowledge base of agtechs was limited by academic education, therefore it could be interesting to include professional experience and employees' skills into knowledge base analysis. The interview script was created from validated AC measurement models, all of which were elaborated for application in mature companies, Therefore, the questions included in present interview script, even adapted to the investigated context, could fail to evaluate some of idiosyncratic aspects of AC of new ventures.

Unlike in the case of use of structured questionnaires, the AC interview script doesn't allow to completely separate four AC capabilities from each other. It is particularly the case of assimilation and transformative AC capabilities, which have strong tacit, cognitive and heuristical component. As argued by academic scholars, the AC unfolds through a dynamic rather than static process. Therefore, the evaluation of AC internal capabilities in qualitative studies becomes even more difficult. It is highlighted also that it was not possible to obtain specific measures of innovation and innovative performance of analyzed agtechs.

The study looked for very specific type of agtech. Therefore, it was not possible to test the created interview script with agtechs before data gathering. Despite positive feedbacks of interviewed CEOs, managers and employees, interview script could miss aspects required to achieve research objective, which is to *investigate how agtechs create innovation in a light of absorptive capacity theory*.

Only a few studies have tried to investigate AC in new ventures, therefore, there might be more gaps that would need to be worked in the future.

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Appendix A – interview script

I. General information

1. Como surgiu a empresa?
2. Quem são os fundadores e qual sua formação acadêmica e experiência profissional? Qual é a relação desta com o ramo de atuação da empresa?
3. Qual a proposta de valor da empresa para o mercado?
4. Qual o diferencial da proposta em relação aquilo que já existe no mercado?

II. Absorptive capacity

Acquisition (adapted from Jansen et al., 2005; Kohlbacher et al., 2013; Lau et al., 2015; Manun et al., 2017; Murovec and Prodan, 2009)

1. Descreva as principais fontes de informação utilizadas para o desenvolvimento de produtos da empresa (exemplo: grupos de pesquisa e desenvolvimento, especialistas técnicos, clientes..).
2. Quais as principais áreas de conhecimento utilizadas pela empresa para criar soluções em termos de produtos e serviços? Ex: microbiologia, química, IoT...
3. Como a empresa acompanha as principais tendências tecnológicas do seu setor?
4. Como a empresa identifica as fontes de informação necessárias para o desenvolvimento de novos produtos e serviços?
5. Existe coleta de informações e dados sobre o setor de maneira formal ou informal?
6. Qual o papel de funcionários da empresa na aquisição de novos conhecimentos?

Assimilation (adapted from Engelman et al., 2017; Flatten et al., 2011; Jansen et al., 2005; Lau et al., 2015; Mamun et al., 2017; Soo el al., 2017)

1. De que maneira a empresa reconhece a utilidade de novo conhecimento externo?
2. De que maneira a empresa identifica novas oportunidades de atender seus clientes?
3. De que maneira o novo conhecimento adquirido é comunicado para os integrantes da organização?

Transformation (adapted from Flatten et al., 2011; Engelman et al., 2017; Kotabe et al., 2017)

1. Como a empresa organiza o conhecimento adquirido? Existem bancos de dados?
2. De que maneira o conhecimento adquirido é aplicado nas atividades do dia-a-dia da empresa?

Exploitation (adapted from Engelman et al., 2017; Jansen et al., 2005; Heil and Enkel, 2015; Limaj et al., 2016; Mamun et al., 2017; Soo el al., 2017)

1. Como a empresa avalia as possibilidades da aplicação de seus conhecimentos para a inovação?
2. Quais as dificuldades na inserção das novas tecnologias dentro dos produtos e serviços?
3. Como a empresa aplica o novo conhecimento para a geração de valor?
4. Como os funcionários se envolvem na criação de novos produtos?

III. Innovation

1. Quais são as principais inovações de produtos ou serviços que a empresa implementou/está implementado nos últimos 3 anos?
2. A inovação de produto ou a inovação de serviço é a mais importante para a empresa??
3. Qual é a média de faturamento da empresa nos últimos três anos?

Appendix B – review plan

The protocol is a plan that helps to protect objectivity by providing explicit description of the steps to be taken. Besides, the protocol, on the one hand, should not compromise the researchers' ability to be creative in the literature review process and, on the other hand, must ensure the reviews to be less open to researcher bias than the more traditional narrative reviews are (Transfield, 2003).

The selection of eligible literature was performed through systematic review process based on Tranfield et al.'s (2003) methodology. The present SLR used two well-established peer-reviewed scientific literature databases, ISI Web of Science (WoS) and Scopus. The database choice was supported by the fact that recent literature reviews of absorptive capacity (i.e. Apriliyanti & Alon, 2017; Rossetto et al., 2017) used Web of Science database.

The selection criteria were the following:

Criteria	**Web of Science**	**Scopus**
Terms	• "absorptive capacit*" • OR "absorptive capabilit*" • AND "innovat*"	• "absorptive capacit*" • OR "absorptive capabilit*" • AND "innovat*"
Field	Title[22]	Title
Period	1990 - november 2017	1990 - november 2017
Document type	Journal article	Journal article
Research/Subject areas	Business, management	Business, management and accounting
Language	English	English

Note: In the beginning of the systematic review, in October 2017, the same keywords were applied to "Title, abstract and keywords" of each database and, in the case of Web of Science, researchers found 2031 articles. Thus the decision to apply the same searching criteria only for "Title".

In order to provide deeper and more precise analysis of the literature, a number of specific questions were added in order to provide an answer to the SLR research questions. They are: (1) AC approach, (2) constructs applied, (3) methods of analysis and (4) key findings. *NVivo 11* software was used to analyze the gathered data. The AC approach analysis included: AC measure type, measurement model type and the impact on innovation.

Appendix C – article selection protocol

After reading an abstract of each article, 72 articles from Scopus and 76 from Web of Science remained. By filtering the repeated studies, 101 articles were obtained. It is important to emphasize that in the present SLR, the target was presence of a measurable **direct influence** of AC on innovation in **commercial firms**. Articles that analyzed AC only mediating or moderating variable were excluded from the sample. For that reason, after a brief reading of 101 articles, 46 remained. Finally, in-depth reading allowed obtention of 36 articles.

Procedure	**Number of articles**
Search for keywords at *Scopus* and *Web of Science*	231
After reading titles and abstracts	147
After removing the duplicates	99
After brief reading of remaining articles	45
After in-depth reading of remaining articles	37