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AGRICULTURE 4.0: INNOVATION AND ABSORPTIVE CAPACITY IN AGTECHS

ANDREI MIKHAILOV
UNIVERSIDADE DO VALE DO RIO DOS SINOS (UNISINOS)

FERNANDA MACIEL REICHERT
UNIVERSIDADE FEDERAL DO RIO GRANDE DO SUL (UFRGS)

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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, the mechanism of value creation was based mainly on production of physical goods. In the twenty-first century, services are the largest part of the economies of the majority of countries.

Some decades after its emergence, the fifth techno-economic paradigm brought changes to agriculture as well. Thus, During the current techno-economic paradigm where the value-creation is based on ICT 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 technology-based ventures engaged in developing new disruptive innovations for agriculture. These ventures 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).

Agtechs develop a wide range of ICT for agricultural production and distribution including 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., 2017; Zheng & Wang, 2019).

After the emergence of agriculture 4.0 the development of disruptive innovations for this sector started to require a combination of "traditional" agricultural knowledge, such as biological, chemical and engineering knowledge (Evenson, 1974) with new ICT technologies. While large companies 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 the new ventures typically lack financial and human resources (Freeman & Engel, 2007; Paradkar, Knight & Hansen, 2015). Therefore, exploitation of the knowledge resources becomes crucial for agtechs' development and growth.

The capability that enables firms to acquire external environments for new information, to assimilate it, and to apply it to generate innovation is the absorptive capacity (Cohen and Levinthal, 1990; Zahra and George, 2002). Particularly in turbulent markets, which is the case of ICT for agricultural production and distribution, the AC has large importance for the ability of the company to produce innovation and to survive.

2. Research question

Once AC is of high importance for enabling the creation of radical innovations by new ventures and, in turn, agtechs have crucial importance for innovation pace in agriculture, it is urged the absolutely-must to explore the use of AC by agtechs for creation of innovation. The following research guided the present research: **How agtechs use absorptive capacity to create innovation?**

Thus, the present study aims to fill the theoretical gap of agtech phenomenon in agriculture, as well as to identify the AC characteristics that enable innovation in 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.

This paper is structured as follows. Section 3 presents the literature review. In section 4, the method used in this research is explained. Results are described in section 5. The discussion of main findings is presented in section 6. Conclusions are made in section 7. Finally, references are listed.

3. Literature review

The present section is divided in two parts. First, literature on new waves in agriculture is described. Then, literature on absorptive capacity is presented.

3.1 Innovation and agriculture

Innovation is a collective process involving different agents of change. "Major innovations tend to be inductors of further innovations; […]. When they are sufficiently radical, innovations stimulate whole industries." (Perez, 2010, p. 188). In the sense, technological revolutions require both interconnectedness and interdependence between technologies and markets, and profound transformation of the rest of the economy. In the word of Dosi (1982, p. 147) the "continuous changes are often related to progress along a technological trajectory defined by a technological paradigm, while discontinuities are associated with the emergence of a new paradigm".

In the XXI century, two discontinuities appeared within agriculture. The first discontinuity was the emergence of ICT (Deichmann et al., 2016; Wolfert et al., 2017), which allowed a number of radically new technical and managerial solutions. Among new technologies in agriculture, it can be highlighted technologies such as artificial intelligence, Big Data, cloud computing, digital platforms, IoT, robotics and drones, advanced sensors (OECD, 2018). These technologies added à wide range of new possibilities for agricultural production and distribution.

The second discontinuity, partially stimulated by the arrival of the first one, was the emergence of agtechs (Mikhailov et al., 2018; Mikhailov et al, 2019; Wolfert et al., 2017). The reason for presuming the existence of the relationship between the occurence of first and second discontinuity resides in the fact that the advances in ICT field outside of the agricultural sector ade it cheaper to produce particular types of innovation for the agricultural production and the distribution. That's the case of, for instance, sensors and low-cost internet-connected devices (Oliveira et al., 2017).

In the words of Mikhailov et al. (2018), agtech aims "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".

Among new products and services developed by agtechs it can be highlighted solutions such as data analytics tools and farm management programs which supports the farmer's decision-making process (Junior et al., 2019). With the use of Big Data and IoT it allows the collection of large quantities 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 farmers to analyze. Smart machinery and unmanned aerial vehicles allow and to gather information about soil quality and plant's disease through images of large areas (Zhang & Kovacs, 2012).

Concerning the connection between different actors of agricultural production and distribution, the marketplace platform represents another important solution allowed by the emergence of ICT in agriculture. The marketplace platforms, also trade platforms, allows to connect the small-scale farmers directly to consumers without intermediates therefore contributing to reducing the disadvantages in terms of due to lack of information on products' prices, access to target markets and high transaction cost (Markelova et al., 2009; Zeng et al., 2017).

Solutions based on blockchain technology have two main applications in agriculture. First, blockchain technology is used in financial services, such as credit concession, without use of intermediaries, which reduces the transaction costs in operations such as credit concession (Manski, 2017). Another application of blockchain refers to food traceability. Use of blockchain allows to track the food origination and thus to deliver value to final customers. Blockchain uses "smart contracts" to perform transactions.

In sum, it is suggested that solutions developed by agtechs promote digitalization of the farm, as well as create opportunities for disintermediation of à range of activities that supports agricultural production and distribution. Also, it's possible to suppose that a creation of such à radical innovations in an environment with high pace of technological evolutions require strong knowledge effort from the firms engaged in the process, that is, agtech. It's particularly true for those companies engaged in intense R&D activities, which are, according to Mansfield (1991), the most riskiest firm's investments. Therefore, absorptive capacity is an essential element for allowing these innovations to be developed and to succeed.

3.2 Absorptive capacity

The AC concept was first conceptualized by Cohen and Levinthal (1990), who defined it as "the ability of a firm to recognize the value of new, external information, assimilate it, and apply it to commercial ends". They also argued that AC improves innovation performance.

AC is dynamic capability, thus, the development of the firm's AC implies an increase of its capacity to innovate (Zahra & George, 2002; Zou et al., 2018). AC may impact virtually all types of innovation, such as, among others, on explorative and exploitative innovation, incremental and radical, product, process and managerial innovation (Ali, Kan & Sarstedt, 2016; Engelman et al., 2017; Limaj, Bernroider & Choudrie, 2016; Koch & Strotmann, 2008).

AC is composed of two dimensions and four capabilities. Potential absorptive capacity (PAC) comprehends the process of acquisition and assimilation of external information and realized absorptive capacity (RAC) comprehends transformation and exploitation capacities

(Zahra & George, 2002). AC is path-dependent which means that a failure in developing AC in a given moment can prevent a firm from absorbing specific knowledge in the future (Cohen & Levinthal, 1990) and thus hamping the firm's ability to recognize new market and technological opportunities.

For that reason, firms need to pay attention to updating it's knowledge base by using both science-based and market-based knowledge sources (De Zubielqui et al., 2016; Gao et al., 2008; Koch & Strotmann, 2008). Innovation cooperation is also important (Murovec & Prondan, 2009). Some firm's resources and needs are so idiosyncratic that they have to be developed internally (Barney, 1996). That is also the case of specific tacit knowledge (Nonaka, 1994). Therefore, a firm needs to effectively manage its intellectual organizational capital, particularly skills and competencies of employees in order to innovate (Cohen & Levinthal, 1990; Engelman et al., 2017).

The proper knowledge transfer within the whole organization is also crucial. Therefore, the organizational routines and social integration processes, 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). Internal R&D activities are also considerably important for AC building (Murovec and Prondan, 2009). In turn, these processes contribute to employees' and company's internal learning process which enhances AC (Engelman et al., 2017).

The building of AC is influenced by the environmental conditions as well. Thus, turbulent technological environments and uncertainty tend to encourage firms to develop AC as it becomes even more crucial to firm's survival. In general, idiosyncrasies of firms' AC also influence the fields in which a firm will conduct both R&D and innovative activity in general (Zahra & George, 2002).

Particularly when the pace of technological substitution is high it becomes absolutely must for the company to build AC in order to innovate.

4. Method

The case-study method was chosen as it allows to conduct deep investigation of specific theories and to obtain valuable insights about the investigated object (Yin, 2015), which is the case of absorptive capacity in agtechs.

Then, à selection of agtechs eligible for à case study took place.

3.1 Case selection

Before performing a case study, the researchers engaged in à preliminary investigation of the environment agtechs take part in. Thus, researcher took part of the LAC largest agtech conference[1]. Also, facilities of some agtech' incubator and innovation hubs were visited in order to get familiar with the investigated object. The data collected during the visits were summarized into à report. Then, two agtechs were selected according to the following criteria:

a) Owner's academic background. In order to identify those agtechs that originated from the agricultural sector, it was decided to select agtechs that have at least one founder

[1] The name of the conference was "1st Agrotech Conference" occurred in Sao Paulo city, september 21st of 2017

with a strong agricultural background. Only agtechs that have at least one owner with Bsc degree in agricultural sciences[2] were considered for the analysis.

b) Growth stage. Authors focused on companies that already started to raise revenue, that is, their technologies were already validated by the market. Technological protagonism. Each company should be among technological leaders of its market.
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 agtechs engaged in state-of-art technological innovation.
d) Aiming to reach higher diversity within analyzed agtechs, the researchers applied a "polar types" case selection process (Eisenhardt, 1989; Martin & Eisenhardt, 2010) for value chain position, type of solution, company's owners profile and company type.

3.2 Data collection

Before the data collection, case-study protocol was set (Stake, 1995). The researchers used à semi-structured interview script as the main data collection instrument. The main interview script, aiming to evaluate AC of agtechs, contained three sections, which are: general description of the company, absorptive capacity, innovation. The absorptive capacity was evaluated in terms of four capabilities proposed by Zahra and George (2002). The interview script was evaluated by two agribusiness specialists with both market and academic experience. As shown at Table 1, it was applied with owners, managers and employees of agtechs À and C.

The second interview script targeted to collect data on agricultural technology innovation hubs which were judged by agtech owners as important for their innovation activities. Thus, general managers of Esalq Business Incubator and of so called "Innovation Mill" were interviewed.

Table 1
List of interviewed persons

Position	Age	Time in the organization	Highest academic degree
CEO A	32	5 years	Phd in veterinary medicine
IT Manager A	31	< 1 year	Phd in computer science
Marketing manager A	26	< 1 year	Msc in marketing
IT stuff A	22	< 1 year	B.tech in computer science
Gastronomer A	27	< 1 year	Technical course in gastronomy
CEO C	37	5 years	Msc in agriculture
CTO C	45	2 years	Bsc by military academy
Marketing manager C	26	2 years	Bsc in communication science
R&D supervisor C	29	< 1 year	Msc in agriculture
GM EI	49	13 years	Bsc in agriculture

[2] Companies with only owners with at least Bsc degree in any agricultural science were considered for the analysis. 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.

GM IM	31	2 years	B.tech in energy engineering

All interviews applied between september and november of 2018, were recorded and fully transcribed. All except one interview were applied directly in agtech's or agtech innovation hubs facilities.

The knowledge base of companies, which is an important antecedent of AC, were also mapped. Cohen and Levinthal (1990) argue that the knowledge base of company's individuals is an important component of the knowledge base of the company itself. For that reason, through LinkedIn profile and Curriculum Lattes profiles[3] academic education of owners and companies' employees was mapped.

Extensive secondary data gathering also took place. The website and social media profile of each company, the TV interviews given by the owners and the market reports were analyzed. The total funding received by each company was estimated through information provided either by the companies or publicly available investment information.

3.3 Data analysis

Shortly after interviewing and visiting the firms, we wrote visit reports on each company Later, a short summary of the reports with the most relevant data from à larger report were written. Then, content analysis (Bardin, 1977) including three different phases, was performed. First, the researchers codified data on AC according to Zahra and George's (2002) capabilities model.

During the second phase, aiming to refine subcategories of AC capabilities used to compose main interview script researchers, an inductive cross-case analysis took place. the acquisition capability included: knowledge sources knowledge fields; technology trend monitoring; market data collection; data collection by employees; assimilation capability included recognition of external knowledge and new of opportunities, knowledge sharing; transformation capacity comprises information storage and creation of new knowledge; exploitation capacity comprises difficulties in new product development (NPD), role of employees in NPD and strategies used by the agtech to overcome resource constraints and environmental uncertainty.

The compilation and categorization of data on the academic background of agtech's employees were performed by using an adaptation of Frascati Manual typology (OECD, 2007)[4].

Finally, all data from interviews was analyzed according to previously cited categories. By triangulating data from visit reports, documental research and non-participant observations were able to discover how, in fact, analyzed agtech use their AC to create innovation. In total, information from raw data and processed data was stored through sixty nine different text and media files.

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

[4] 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 à created category of "Exact and technological sciences".

5. Results

Company A is an academic spinoff founded by a meat science Phd researcher in 2013. During his pos-doctoral studies the CEO A saw an opportunity to apply the state-of-art scientific knowledge to the market commercialization and opened à agtech within Esalq incubator facilities.. The owner A had no entrepreneurial experience before starting the company.

Company C was founded by an agribusiness entrepreneur in 2013. Back then he had more than ten years of entrepreneurship experience and Msc degree in agricultural sciences. In the 1990s he enrolled in the Msc program in precision agriculture at Esalq, which was the first institution to offer this program in Brazil. Later he started an agribusiness consultancy company and later the necessity to use ICT appeared. Finally, CEO C decided to get rid of all his business and to focus on digitalization of agriculture only.

Agtech A created à software and hardware based solution that allows cattle farmers and cattle slaughterers to better trade their products. It captures information on livestock, such as animals' feed and weight during the biological life-cycle, farm's expenditures as well as market prices information and then suggests the optimal selling date in terms of highest profit margin. Agtech C uses software-as-a-service (Saas) digital platform that connects farms to its suppliers.

Table 2
Characteristics of analyzed agtechs

Characteristics	**Company A**	**Company C**
Age (years)	5	5
N. founders	1	2
N. employees	30	30
Organizational structure	Matricial	Marketing, operations, technology and administrative department
Solution for	Animal production	Crop production
Value chain position	Downstream	Upstream
Financial sources	Owners resources, venture capital, Private equity, direct sales, services for large companies, public R&D support	Revenue, public R&D support
Total investment received (US $)	Over 1 million	Over 1 million
Started to raise revenue	Less than 1 year	More than 1 year

5.1 Acquisition AC

Both companies have wide knowledge base[5]. For instance, agtech À count with à total of thirty eight academic degrees, including three academic specializations, seven Msc, six Phds and two postdoctoral academic degrees. Five of its employees are undergraduate students. Agtech C counts forty academic degrees, including ten Msc and two Phds. In the case of agtech À (30) and Agtech C (31) the majority of degrees come from either agricultural or technological sciences.

Such a high-profile workforce together with à number of organizational practices allows the agtechs to absorb wide range of science based and market based knowledge Both agtechs rely on the use of the world's most reliable knowledge databases to map seek to map the

[5] 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, if, for instance an employee with Bsc degree in animal science and Msc degree in IT, it was counted as one Bsc in exact and technological science and one in agricultural sciences

scientific and technological state-of-art knowledge useful for companies' value generation. CEO A explains that: "*our main search tools are Elsevier, journals, CAPES journal portal...we also search à lot of information in Web of Science and Google Patents*". R&D supervisor C argues that: "*articles comprise 90% of my information sources".*

When the access to specific study is not accessible through a traditional database, less formal data sources are used. 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*".

Table 3
Acquisition AC

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

Market data collection is not an easy task for agtechs À and C, as the lack formal information sources of agriculture is common for emerging economies. CEO C explains that: *"agricultural sector in Brazil is à sector that lack information...we do not have à lot of official statistics"*. In order to overcome the difficulties related to obtaining reliable market data from international sources, such as Food and Agriculture Organization (FAO). Companies also gather information by contacting clients and industry specialists, taking part in meetings and conferences, use internet-based sources such as blogs, thematic websites and online discussion groups, as well as Agtech Valley ecosystem.

Both companies upgrade the knowledge base of its employees by encouraging them to engage in continuous education through graduate studies to pay attention to their intellectual capital and HR.

5.2 Assimilation AC

As shown at Table 3, informal communication plays a crucial role in promoting internal knowledge sharing. As the agtechs' members come from different knowledge background, particularly in the case of agtech A, knowledge sharing requires an intense effort in aligning the cognitive structures: "*the way of transmitting the information it goes through a dialogue and goes through a way of analyzing the information* " (CEO A).

Employees not only share daily information, but also seek to learn from each other, particularly à knowledge outside of employees' skills. MM C explains that: *"we managed to extract a lot of cool information when we worked together with the support team.* Individual learning effort and education background contribute to ease the process of learning.

Table 3

Assimilation AC

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

As shown at Table 11, companies A and C do it in a different way. While agtech À strongly departs from data, agtech C seeks to strictly follow the strategic planning, even it also uses large amount of data for new opportunities identification. 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*".

5.3 Transformation AC

Both companies store information and create new knowledge in a similar way (Table 4). The software platform is important particularly for information storageThey also generate internal reports related to technical and commercial issues. For instance, in agtech C there is à specific position which is responsible for, among others, managing bureaucratic issues of grant applications: *"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).

Table 4
Transformation AC

	Company A	Company C
Information storage	Internal reports	Internal reports
	Project documentation	Project documentation
	Software platform	Software platform
Creation of new knowledge	Learning spaces	Learning spaces
	Project development	Project development
	Learning-by-doing	Learning-by-doing

Source: elaborated by the authors

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 given activity requires cumulative long-term learning. "*There is an intrinsic knowledge to people who code (software), this knowledge has a lot to do with core code, so when the more the individual code (software), the more it develops"* (CEO A).

A crucial tool for creation of new knowledge by both agtechs refers to taking part of learning spaces, both internally and externally. Particularly for agtech À, project development is crucial internal learning space:.*"Everyone who participates in that project, who are part of our team, study, evaluate, understand, improve, and so we generate new knowledge"* (CEO A).

In terms of external learning spaces, Agtech Valley environment, as it allows to exchange ideas and experience with Thus, agtechs À and C take part of environments such as Esalq business incubator, Pulse Hub, Innovation Mill where the access new ideas as well as experience of other companies.

5.4 Exploitation

Perhaps, the most important aspect of AC is the ability to transform the new created knowledge into innovation. However, that's not such a simple task. Due to high technological and business uncertainty sometimes agtechs frequently don't count with reliable information. CEO C points that: "*you are not sure of the future, you do not know if what you are doing is going to work*".

Particularly agtech A experience pressures for delivering working projects according to deadlines and requirements imposed by investors. CEO À argues that: "*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*".

In order to overcome these difficulties, agtech C focuses on following the strategic planning and on rapid decisions based on information gathered along the way. Agtech A seeks to learn quickly during the NPD process and counts with adhoc advisors, who also take decisions on innovation (Table 5).

Table 5
Exploitation AC

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

Agtech À seeks to diversify its investments sources. Additionally, it also balances between incremental and radical innovation. CEO À argues: "something disruptive (solution) is difficult to develop, but you know that it tends to guarantee.. in the long run. Something incremental, is what will pay your bills in the short term, so you need to have the two things... otherwise you do not do the business to stand"

Both companies recognize the importance of human capital for NPD. 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"*.

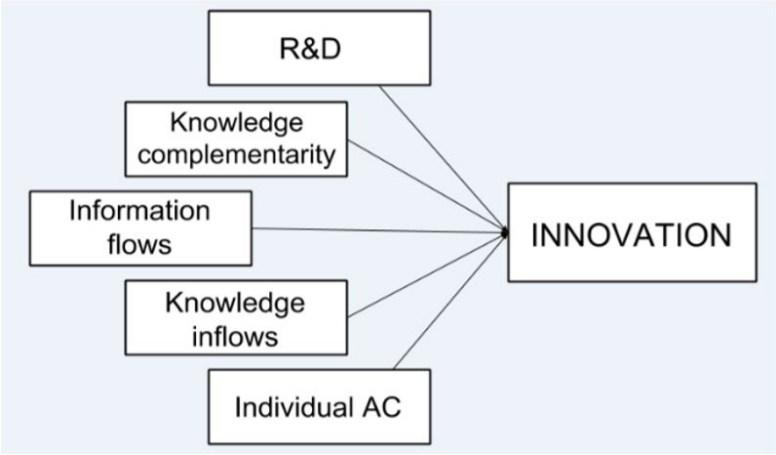
Both companies are managed by visionary leaders. They set ambitious goals that drive their whole effort into innovation: *"we will change the way people (value chain elements) trade their assets (meat products)"* (CEO A). CEO C argues that: "*Mckinsey reports place agriculture*

as the least digitized 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.

5.5 Results summary

Figure 1
Key aspects of AC that enable innovation in analyzed agtechs



6. Discussion

As observed from the case-studies, the way that agtechs A and C use AC to innovate is quite similar to those that academic literature, which are intense R&D activities (Cohen & Levinthal, 1990), knowledge inflows (Murovec & Prodan, 2009), strong individual AC and knowledge complementarity and information flows within (Cohen & Levinthal, 1990; Zahra & George, 2002). Both companies also showed very strong intellectual capital. To overcome the informational constraints, companies diversify their information sources. They gather large quantities of formal and informal information from science-based and market-based sources. Many of these resources are publicly-available and cost-free, however, it's required to have proper relations to access these resources as well as proper knowledge base in order to get use of 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. 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. 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.

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). However, analysed companies are able to, at least partially, to overcome these constraints by diversifying its financial sources. Particularly for R&D investments, which are the most risky investment (Mansfield, 1991), agtechs seek to use non-refundable public applied research grants.

Here, 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 Agtech Valley also showed to be an important element of innovations of agtechs, thus, it can be supposed that the analyzed companies know how to use the innovation environment on their benefits. Altogether, these strategies allow to the agtechs to be able to surf on the technological turbulences and market uncertainties.

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. Hence, the pattern of technical change in agribusiness sector, previously dominated by large companies, maybe shifting towards innovation developed by small companies, that is, agtechs.

7. Conclusions

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.

AC antecendents such as internal R&D, knowledge inflows from market and science-based actors, and individual AC of employees do improve companies' AC, which is in line with academic standpoint of view of AC (i.e Cohen & Levinthal, 1990; Engelman et al., 2017; Murovec & Prondan, 2009; De Zubielqui et al., 2016). Also, knowledge complementarity and rapid information dissemination within the companies were identified as important factor for enabling innovation in agtechs, which is in line with Cohen and Levinthal (1990) and Zahra and George (2002).

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. Thus, even being the oldest economic sector, agriculture is being able to attract knowledge intensive and high-tech sectors to solve its current difficulties. It is crucial to add that the present study shows that, in theorethical terms, innovation and agricultural academic literature can be linked with each other.

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 there is an emerging modification 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.

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. Due to lack of literature on AC in new ventures and startups, 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.

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.

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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