XXI SemeAd
Seminários em Administração

novembro de 2018
ISSN 2177-3866

The agtech companies: a new element for innovation ecosystem in agriculture

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Agradecimento à orgão de fomento:
Agradeço ao CNPQ pela bolsa de mestrado concedida

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1- INTRODUCTION

The agriculture is a millenarian activity that promote food and fostering business. The shift from a natural ecosystem to a new one led by production of food occurred ten thousand years ago, in Neolithic period, when humans started to grow plants and domesticate animals (Mazoyer & Roudart, 2006). Currently, farmers focus more on making and selling of agricultural products than on producing their own food and therefore the path of technological improvements and innovations in agriculture is higher than before. According to Evenson (1974), agricultural innovations typically affect one or more of the following areas: crops, animals, growing population growth and environmental change conditions, implements and management practices.

In order to investigate the innovation processes within a given area, it is crucial to learn about its drivers, motivations by which different actors decide to engaged in it, also about those factors and elements which initiated that processes. Particularly in the agriculture, external factors such as population growth and environmental restrictions are recognized as the drivers of change (Van Der Veen, 2010). In this direction, both population growth and adaptation to climate conditions presumes an increase in efficiency of agricultural production that can be translated into productivity.

While external changes in agriculture are more explicit, the dynamics of internal changes not always are prominent. Nowadays, the process of structural change in agriculture is closely linked to what happens in industry and services. As in the manufacturing sector, the growth of agricultural production occurs through adoption of new technologies, focused on increasing the productivity and cost reduction.

According to FAO (2009), the same unit of agricultural area that fed two individuals in 1960 was able to feed 4 people in 2010, but 2050 the world population may reach more of 9 billion people. Similarly, crop and meat consumption is growing in a number of emerging countries (Dutia, 2014). In addition, there is the phenomenon of "industry convergence", where sectors beyond the traditional fiber or food industries, such as bioenergy, bio-based plastic sector and pharmaceutical industry are using agricultural raw materials (Boehlje, Roucan-Kane & Broring, 2011).

These factors contribute to enhancement of final demand for crop-production and push the necessity to a new increase in agricultural productivity. This represents a current challenge for agriculture, as global constraints such as arable land and available water resources may limit the agricultural output more than ever before. Thus, agtech companies aim to develop some of the new resource-saving technologies to improve food production in the medium and long term without making irreparable damage on natural resources.

Considering the power of new high technologies, a question that arises is: how high technologies can collaborate to overcome these challenges? The increasing phenomenon of new hardware, software or biotechnology companies is changing the way by which the agricultural products are grown and distributed. These companies adopt technology as a key differentiating point for providing unique solutions to different agricultural processes. The companies with this feature are named "agtechs".

This new element of the agribusiness innovation ecosystem emerges as a hope that may challenge the traditional ways of food production by proposing innovative solutions. Thereby, these solution can reduce considerably the quantity of resources required to produce the same agricultural output. The innovations and high technological intensity products developed by knowledge-based companies in agriculture can address major problems faced by people such as environmental pollution, inefficiency, as well as help to achieve more sustainable resource use. It can create opportunities for small and medium enterprises, for example to develop new services and tools for food production.

It is essential to state that agtechs alone are not able to guarantee the proper solution of world food necessities: there is a need of another agents that will foster the agtech development and growth. Despite the importance of agtech companies there is a lack of definitions for that type of company, but still the researchers was able to find a proper agtech concept definition. For that reason, the present study adopts Mikhalov, Reichert, Pivoto (2018) perspective, who argue that agtechs are high technological intensity new ventures operating within agribusiness field.

In this article, the main actors and their roles within agtech innovation ecosystem will be described. The present paper aims to answer the following research question: which are the actors of agtech ecosystem and what are their roles? To that end, some of the characteristics of agtechs to be considered are location, actors, size, direction of action, financial resources.

The upcoming sections are organized as follows. In section 2, the innovation and ecosystems' literature is briefly described. Section 3 describes the method and data used to answer the research problem. Section 4 shows the achieved results. In section 5, the paper discusses the results of the proposed analysis. Section 6 concludes the paper with some perspectives.

2- INNOVATION AND ECOSYSTEMS

The conceptual background is divided in two parts. First, it contextualizes the innovation literature and particularly the agribusiness innovation. Second, theory on ecosystems is presented.

2.1 Agribusiness innovation

Innovation, the word that originally came from the Latin "innovare", which meant "to make something new" represents the core renewal process in any organization (Bessant, 2003). In a modern science, after an original economic definition by Schumpeter (1912), this phenomenon was studied, from different perspectives, by Rogers (1962), Nelson and Winter (1982), Rosenberg (1982), Teece (1997) and many other scholars.

Historically, the agribusiness innovation occurred within four technology types: biological, chemical, mechanical and managerial (Evenson, 1974). More recent review of

Ogundari and Bolarinwa (2018), through metanalysis of 154 studies, divided the agricultural technological innovations adopted in emerging countries in five types: modern varieties, mechanization, pest control, natural resource management, integrated farming. However, with the scientific advances of the last decades, information and communication technologies (ICT) allowed a set of new solutions for agricultural sector. Among them it can be highlighted big data analysis (Kamilaris, Kartakoullis, Prenafeta-Boldu, 2017), smart farming techniques (Wolfert, Ge, Verdouw, Bogaardt, 2017), unmanned aerial systems (Zhang and Kovacs, 2012), even biotechnological improvements. Likewise, it is essential to argue that digital technologies had important impacts in linking farmer to its markets by reducing the transaction costs and thus increasing efficiency and stimulating innovation within the sector (Deichmann, Goyal, Mishra, 2016).

Outside of agribusiness innovation, there are some other innovation typologies. For instance, Tidd, Pavitt and Bessant (2008) stated that innovations can be divide in four types: product, process, position and paradigm. Table 1 links Tidd' et al. (2008) perspective to the main agricultural innovation in XXI century.

Innovation type	Examples within agribusiness	Applied technology
Product	CRISP, farm management softwares, next generation farms, biomaterials	Biotechnology, TIC, diverse, diverse
Process	Biological pest control, predictive analytics, IoT, Drones and robotics	Biology and Microbiology, ICT, manufacturing
Position	Marketplace platforms	ICT
Paradigm	Nano-clay for water retention, Nano capsules as fertilizers, Nano-sensors for plant health monitoring; vertical farming	Nanotechnology; Biotechnology…

Table 1. Innovation type, technology applied and example within agribusiness sector
Source: Tidd et al. (2008), Dutia (2014), Parisi et al. (2015) and CBinsights (2017), Nature Biotechnology (2017)

Thus, farm management softwares and next generation farms represent a product innovation. There are also process improvements through the use of drones and robotics, internet of things (IoT) and predictive analysis through softwares and big data. The farmers position improvements are frequently allowed by ICT appliances, for instance, marketplace platforms help to create a direct communication channel between farms or farmers and its final consumers, without previous necessity of geographical proximity. Finally, use of nanotechnologies may be considered a paradigm innovation, as this type of technology is still a minor technology within agricultural activities, due to reduced scalability of provided solutions (Parisi et al., 2015).

Concerning the new businesses operating within agriculture, the study of Gray, Boehlje, Amanour-Boadu and Fulton (2004) posit the importance of new value-added ventures in agriculture. Gao and Zhang (2014) analyzed innovation capabilities of "agricultural high-technology enterprises", but the criteria of companies' selection and the main activities of each group of the companies were not specified. Similarly, Wang and Wen

(2014) conducted a research on drivers value offered by agricultural high-tech enterprises, and cited, among others, high input and high-yield among its characteristics.

Still, neither Gao and Zhang (2014) or Wang and Wen (2014) described the concept of agtechs. Dutia (2014) within a business report stated that “agtech” refers to emerging economic sector, which could meet the demands of increasing population pressures and necessity of more sustainable crop production. He also stressed that “agtech startups” are the companies that operate within the agricultural technology sector. Finally, Mikhailov, Reichert and Pivoto (2018) by compiling literature on new ventures within agriculture stated that agtechs are new ventures or startups that aim, by frequently proposing innovative solutions with the use of high-technologies, to improve agricultural crop production or to connect the farm to its stakeholders.

2.2 Ecosystems

In that context, new field of study had emerged - innovation ecosystems studies. Innovation ecosystems can be found across different sectors, industries and regions. In addition, a range of authors points out its’ importance for firms and regions competitiveness as well as for economic development (Adner, 2006; Jackson, 2011; Nambisan & Baron, 2013). Apart from the works already mentioned, the study of Samila & Sorenson (2010) points out the importance of ecosystems for supporting innovation and entrepreneurship. According to the authors, consistently with a perspective of innovation ecosystems, public funding of academic research and venture capital have a complementary effect in the creation of new firms and innovation.

One of the first perspectives on innovation ecosystems started to being introduced in 1980s and received the name of National Innovation Systems (NIS), term which Freeman (1988) defined as a set of public and private institutions that aim to import, modify and to spread the technology. Lundvall (1992), by other hand, states that NIS includes all parts of economic structure and institutional organizations which impacts the education, investigation and exploration. Edquist (2005) points out that an innovation system is a composition of two actors: organizations and institutions. The former include firms, universities, venture capital organizations as well as public agencies responsible for innovation. The latter are norms, routines, established practices, laws, that jointly determine the "rules of the game". Recent definition of Zoltan et al., (2017) points out that NIS settings of each country result from historic processes and path-dependency, social rules and beliefs, as well as from its’ interaction with national politics and institutional development over time.

The local innovation systems (LIS) is a proposition based on the understanding that innovation is all about continuous learning and learning does not occur in a socio-cultural vacuum. The innovation network is more likely to blossom in a restricted localized environment where all the socio-cultural characteristics of a dynamic milieu are likely to be found (Zoltan, Paquet, & De la Mothe, 1995). According to Zoltan, Paquet, & De la Mothe (1995), the opposition between local and national systems of innovation is rooted in the contrast between two dynamics: the bottom-up dynamics of networks and the top-down dynamics built on the centralized mindset.

The third approach and quite recent one is an entrepreneurial ecosystem approach, which Nambisan & Baron (2012) argue to be important context for entrepreneurship. The entrepreneurial ecosystem approach surged mainly during last five years, and so there is no widely shared definition (Stam, 2015). Hence, according to Mack & Mayer (2015), "it consists of interacting components, which foster new firm creation and is associated with regional entrepreneurial activities".

Still, among range of theories applied in order to comprehend innovation ecosystems it can be found one more - a Triple Helix approach (Etzkowitz & Leydesdorff, 2000), which states that university can play an important role in enhancing innovation in the knowledge-based societies. For Etzkowitz and Leydesdorff (2000), the Triple Helix perspective differs from a National Innovation Systems (NIS) perspective, which points a firm as a leading agent in innovation, as well as from "Triangle model of Sabato (1975) - the one that gives a privilege position to the role of the State. Figure 1, shows the Triple Helix model according to Kimatu (2016).

Also according to Etzkowitz & Leydesdorff (2000), Triple Helix can have different configurations concerning university-industry-government relations. For instance, there is a "laissez-faire" model, in which each agent is considered to have quite independence, and also an static model, in which state incorporate both university and industry. Recently, the Triple Helix model has been transformed into the Quad Helix model, due to a number of innovation studies that revealed a strong importance of civil society in the interaction between university, industry and government (Kimatu, 2016).

Adner (2005) argue that currently ecosystem strategies are being deployed in a number of sectors and industries. Whilst leading exemplars tend to come from high-tech settings (e.g. Intel, Nokia, SAP), diverse industries such as financial services, basic materials, and logistics provision are constantly engaging in these strategies (Adner, 2005). Once implemented strategy is successful, ecosystem can allow firms to create value that no single firm could have created alone (Adner, 2005).

Even Kimatu (2016) states that in developing countries the interaction between universities, industries and government is almost nonexistent, some specific countries and industries represent an exception of the rule. It is essential to highlight that innovation ecosystem can model the economics of the complex relationships that are formed between actors or entities whose functional goal is to enable technology development and innovation (Jackson, 2011).

3- METHOD

The present study is an exploratory and descriptive research. The main topics for describing the agtech environment (location, actors and financial resources) were analyzed from the point of view of agribusiness innovation. The data were collected from a database (CB Insights 2017a) which provided specific information about agtech companies.

This database was chosen due to being one of the few databases that has information on agtechs' location and investment, as well as on investment entities. The information collected is publicly available and free. Likewise, the researchers decided to focus their analysis on companies located in the US (United States). In 2017 the country was ranked 4th according to Global Innovation Index (GEM, 2017) and additionally is the biggest world economy. Thus, it is possible to suppose that US offers a favorable environment for the new businesses emergency.

In addition, scientific papers, reports, and news that can collaborate in the characterization of the agtech environment were adopted (i. e. Dutia, 2014; Nature biotechnology, 2017) were analyzed. Taking into account that agtechs are emerging companies, it was adopted ecosystem perspective focusing also on agtechs' digital and other high technology solutions. The data gathering was carried out during November 2017, and in order to refine the selection database exclusion criteria were established according to Figure 1.

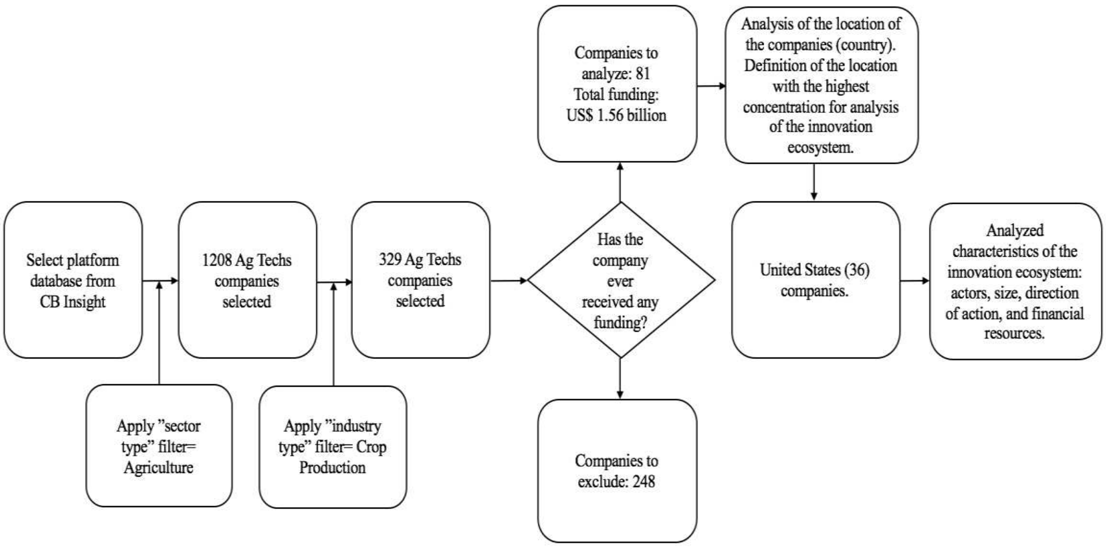

Figure 1. Phases of the research method adopted

Only companies that have already received some investment have been kept on the list of agtechs. This was done to ensure that the companies considered have already been perceived by investors as potential businesses.

After the refinement to keep only companies active in the Crop Production industry with investments already received, the focus was to verify which country had the highest concentration of agtechs. Completed this stage, the analysis was concentrated in companies established in the United States. In the next section, therefore, to achieve the research goal, the mechanisms, actors and their roles in the innovation ecosystem of the US agtechs will be described.

4- RESULTS

In order to better present the obtained results, this section is divided in two parts. In the first subsection the general information concerning the invested agtechs companies are presented. The second subsection includes data and description of agtech innovation ecosystems actors.

4.1 General information

According to CB Insights (2017b), both number of agtech investment deals[i] and disclosed funding is constantly growing in the last years. For instance, in 2013 forty one investment deals occurred with investment of US$ 57 million. In 2015, the number of investment deals raised to eighty two, with US$ 234 million invested. Finally, between january and november of 2017 one hundred forty seven investments occurred, and agtech companies received a total investment of US$ 735 million. In summary, since 2013 the global equity totalized US$ 1,5 billion across 453 investment deals (CB Insights, 2017b)

The profile of investment for 2016 and 2017 years showed that almost half of investment occurred during seed stage (51%, 48%), followed by Series

A (18%, 14%), and Series B (6%, 11%), respectively. Other types of investment represented 22% in 2016 and 23% in 2017. Among investment options grants showed to be a quite common option for agtech companies. For instance, Arable Lands, company specialized on predictive analytics for crop growth, received a total investment of US$ 6,7 million, and 11.2% of that was offered by National Science Foundation.

As indicated in the previous section, the database adopted has 81 companies. The characterization of the sample shows that these agtechs are distributed in 28 countries. In Figure 2, the country location of the companies in three concentration ranges of agtechs can be observed.

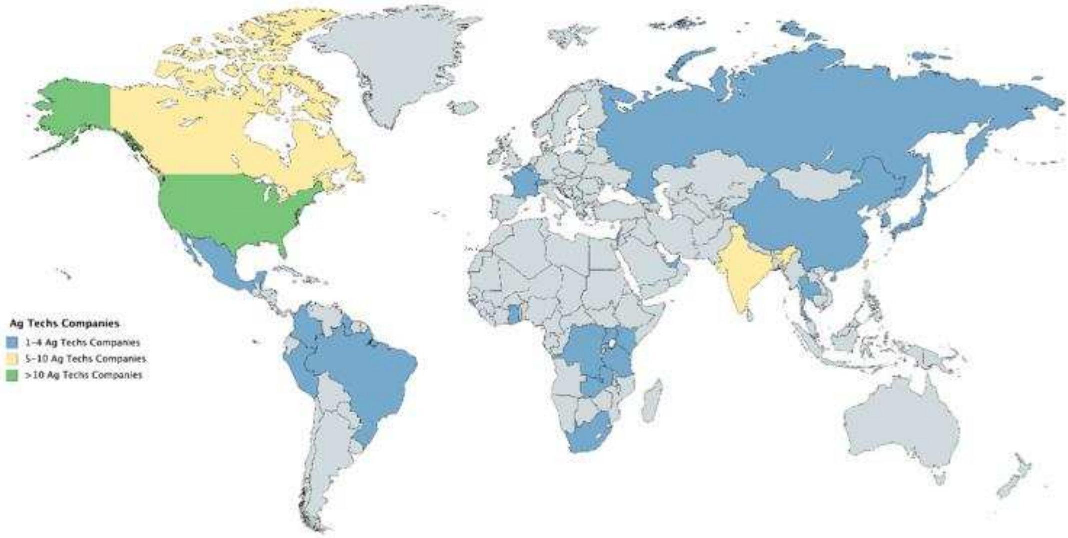

Figure 2. Distribution of agtech companies
Elaborated by the authors.

Most countries (25) have up to 4 agtech listed in the database adopted. Canada and India have between 5 and 10 companies and only the United States has more than 10 companies. In the case of the database used, the share for the United States (US) represents 44% of the total, which means 36 companies. Inside the United States, California State represents the highest concentration of agtech companies that already received funding, in a number of six. The second state with highest number of invested companies is New York (4) and Connecticut is the third (3).

It is important to point out that California is a hometown of *Silicon valley*, currently the most innovative ecosystem in the world. In this way, it becomes important to learn more about the agtech companies invested in the US and particularly in California. By other hand, the heartland region, which comprises biggest agricultural production of the US, especially corn (Dutia, 2014) is responsible for eight invested agtech companies.

Below, Table 1 shows a list of all agtech companies located in the US that received investment, by total funding.

Company	Total investment US$	State	City
Materra Farming	93,46	California	Escondido
Green Earth Greens	23,75	California	Campbell
Divergence	23,3	Missouri	St. Louis
Hollandia Produce Group	22,28	California	Carpinteria
True Blue Berry Management	14,37	Michigan	South Haven
Gotham Greens	13,87	New York	Brooklyn
Freight Farms	12,25	Massachusetts	Boston
VeruTEK Technologies	9,35	Connecticut	Bloomfield
Blue Prairie Brands	6,95	Nebraska	Scottsbluff
Arable Lands	6,7	New Jersey	Princeton
Suntava	5,04	Minnesota	Afton
Front Range BioSciences	4,52	Colorado	Boulder
FarmedHere	4,45	Illinois	Chicago
Pista Land Company	4,1	Arizona	Bowie
Hop Head Farms	4	Michigan	Hickory Corners
Absorbent Technologies	3,1	Oregon	Beaverton
Four Season Farm	3	Connecticut	Suffield
Neu Seed	2,6	Idaho	Rexburg
Springworks Farm Maine	2,44	Maine	Lisbon
Edenworks	2,4	New York	Brooklyn
Advanced Growing Systems	2,38	Georgia	Alpharetta
Living Greens Farm	2,32	Minnesota	Prior Lake
Infinite Harvest	2,16	Colorado	Denver
Wayne E. Bailey Produce Company	2,05	North Carolina	Chadbourn
Uncommon Cacao	1,96	California	Berkeley
SunCliff	1,77	Washington	Seattle
Kultevat	1,65	Missouri	St. Louis
Global Village Fruit	1,52	Massachusetts	Cambridge
Atlantic Produce	1,51	Rhode Island	West Kingston
Riverland & Indian Sun	1,5	Connecticut	Westport
Phyto Management	1,39	DC	Washington
One Gro	1,32	Oregon	
Aquarius Cannabis	1,16	California	Woodland Hills
StelaGenomics	1,1	California	Santa Clara

Table 2. US agtech companies received investment according to total funding
Source: CB Insights (2017a)

According to the Table 1, the received investments by the US agtech companies varied from US$ 1,1 million up to US$ 93,46 million. In addition, among five biggest agtech investments, three occurred inside the Californian territory, totalizing US$ 139,49 millions in received investment. US responded for 18,3% of all funds received by world agtech companies, with California state responding for more than half (50,3%) of all funds received by US agtech companies.

4.2 Actors and their roles

In this section, main actors (investors, business accelerators and incubators, agtech companies, corporates, agencies, universities and entrepreneurs) of agtech innovation ecosystem are described as followed:

Investors:

Among investors that invested in agtech companies located in the US it can be find investment companies (e.g. DSM Venturing, Invest Nebraska), startup accelerators (e.g. Techstars), multinational corporations (e.g. Monsanto), angel investors, as it happened in case of Gotham Greens and government agencies (National Science Foundation). In this way, it can be observed the diversity of organizations investing in agtech companies.

In addition, it is important to point out that among 36 companies it was possible obtain the name of investors for 18 agtechs. For the others the identification is present as undisclosed angel investor and undisclosed investors. However, estimates indicate that in 2017, the number of unique investors represents more than 200 that made at least 1 investment in agtech, in general (all industries), which means 64% increase from 2016 already (CB Insights, 2017a).

Business accelerators and incubators:

There is a number of MNC from agribusiness field starting to participate in the agtech accelerators. For instance, according to CB Insights (2017b), the 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 involved with “Cultivation corridor” and “Iowa AgriTech Accelerator”. In addition, Syngenta, the MNC specialized in seeds and chemicals for agriculture, take part on “AgTech accelerator” and LandLakes, agribusiness and food company, in “Techstars”. Both “Cultivation corridor” and “Iowa AgriTech Accelerator” are located in Iowa state. In addition, the AgTech Accelerator is located in North Carolina. “Radicle”, by other side, is located in San Diego, California, and focuses exclusively on agtech and food startups for investment. In this way, there are at least two accelerators working specifically with agtech activities inside what Dutia (2004) called as states of “heartland” of agricultural production in the US. It is important to highlight that “heartland” is a hometown of a number of universities working in agribusiness field. California state, from other hand, has at least one specific agtech business accelerator.

Agtech companies:

As previously pointed out, California is the state with highest number of invested companies. They invested agtech companies are: Acquarius Cannabis, with US$ 1,16 million of investment, branding company in the legal medical and recreational cannabis industry in the U.S. The company is on a mission to professionalize the legal cannabis industry by creating a portfolio of consistent, pesticide-free cannabis brands. The Green Earth Greens, with US$ 23,75 million of funding is a company which produces fresh vegetables year-round in organically certified farms. The company's practices and processes set new standards of sustainability, food safety and conservation of critical resources. As other example, Hollandia produce group, with investment of US$ 22,28 million, specialized in greenhouse-grown vegetables. In contrast, Materra farming, with investment of US$ 93,46 million aims to produces animal feed.

Among California invested companies there is a biotechnology firm, Stelagenomics, an originally Mexican company which enables a rational, eco-friendly control of weeds and use of fertilizers in modern high-yield agriculture. It developed Stelight, a platform for weed control based in the use of phosphite that achieves sustainable high-yield agriculture for any transformable crop without the use of herbicides, and received investment of US$ 1,1 million. Uncommon Cacao, firm that received US$ 1,96 million in investments, focuses on work with cacao farmers and responsible exporters, aiming to be a trusted supply chain partner.

Corporations:

As pointed by CB Insights (2017b) report, in the last years it can be observed growing interest of multinational companies in both investing or acquiring agtech companies. Particularly in the US market, the participation of corporations in the agtech investment increased from 5% in 2013 to 24% in the period from January to October of 2017 (CB Insights, 2017b). In addition, only at 2017 two agtechs were acquired respectively by *John Deere* and *DuPont* for more than US$ 300 million. The agtech company acquired by the former, *Blue river technology*, is specialized in smart agricultural machinery and equipment, and the acquisition payment was of US$ 305 million. The *Granular*, acquired by the latter, was specialized in farm management software and the payment was of US$ 305 million. Finally, in 2013 Monsanto acquired Climate corporation in a deal of US$ 1,1 billion, currently the biggest agtech company acquisition.

In addition, in the US between 2013 and november 2017 California state was responsible for the 31% of number of agtech acquisitions, followed by Massachusetts, Missouri and Illinois, each one representing 7% of total deals (CB Insights, 2017b).

Agencies:

As pointed out by CB Insights (2017b) report, between 2013 and november of 2017 agtech companies received thirty nine financings with a total amount of US$ 20,2 million through the grants conceded agencies. Among them it can be found such agencies as National Science Foundation, King Baudoin Foundation. Considering that part of agtech companies are located in Science parks and business incubators and work at the edge of the scientific knowledge of the food and agribusiness sector, this grants can be considered not just as interaction between third sector and industry, but also an interaction between either independent agencies or government and R&D sector.

In addition to identified actors, it is absolutely must to point out such actors as entrepreneurs who created the agtech companies and the universities. Once many agtech business operate within high technological intensity sectors, the proper knowledge base is required. Therefore, the universities start to play crucial role in providing proper knowledge inflows for agtech companies to work with. In addition, the entrepreneurs themselves usually have Bachelors or Masters degree, or are still undergraduate students, and thus they may apply the knowledge obtained from the universities to their businesses.

5- DISCUSSION AND CONCLUSIONS

The purpose of this study has been to answer who are the actors of agtechs ecosystem and what are their roles starting from the choice of the country with the largest number of companies to serve as a point of analysis. The article data showed that among different states of the US, California state presents the highest number of both a tech companies deals and agtech companies raised funding. Considering that California is the far biggest agricultural GDP among fifty states of the country, with US$ 47,1 billion in crop cash receipts (CDFA, 2017) this results seems to be quiet coherent. In addition, the US and particularly ecosystem of California states seems to attract new entrepreneurs and ventures, due to identification of a number of agtech companies that received investment were not originally located at this place.

This paper contributes to the literature in two ways: The article presents the effort to compile data on the agribusiness environment with a focus on a new segment of actors that are agtechs considering the innovation ecosystem approach. Some of the findings of the article are similar to a number of previous studies. For instance, data showed that among agtech companies the most relevant funding source is angel investment. This result is supported by the tendency pointed out by Henton & Held (2013), who argued that, at least in Silicon Valley case, venture capitalist (VC) investment model tend to decline while angel investment, with advent of internet and speed communication, is constantly increasing, opening doors for smaller investors. In this way, it seems that the "new era of early-stage financing" (Henton & Held, 2013) already started for agtech companies as well.

Also, interaction between actor of innovation ecosystem are revealed by the data. For instance, government and non-governmental agencies enlarge the investment opportunities opened to agtech companies by offering financial resources through grants conceding. This mode of support and growth of the agtechs demonstrates the interdependence among the actors. Added to coevolution that binds them together over time, the ecological aspects are highlighted which supports Moore's (1993) proposition of the use of the ecosystem concept for management studies. And according to the analyzed data the growth of the agtech companies pulled and was pushed by the movement of other actors like investors, business accelerators and business incubators, corporates, and government.

The system approach refers to a delimited set of components (actors and organizations) which have interdependence between their components, yet they have independence from other systems (Von Bertalanffy & Rapoport, 1956). The condition of the state of California as the main location in number of agtech companies and number of investments received demonstrates the importance of the boundary issue. A feature discussed in studies such as (Gulati et al., 2012, and Valkokari, 2015) which indicate that the ecosystem boundaries could be traced via geographical scope (local vs. regional or national vs. global); temporal scale; or permeability (open vs. closed) and are seen to play a crucial role.

After discussing the aspects related to the ecosystem, attention must be paid to what is new. The discoveries and inventions can come from any individual, yet the condition of obtaining results and commercial recognition is necessary to characterize the innovation. Adopting digital technology (hardware and software) as key differential agtechs are changing the way agricultural production happens and is distributed. Similarly, the results support the Ogundari and Bolarinwa's (2018) perspective, as the listed agtechs focus on all phases of agricultural innovations.

Together, the companies analyzed in the study raised a total funding of US$ 1.56 billion. These values reinforce the condition of the use of the concept of innovation ecosystem in the study. According to Adner and Kapoor (2010), Ritala et al., (2013), and Overholm (2015) this approach has been adopted to describe profit-driven systems of innovation around focal companies, technologies and platforms. Likewise, it is crucial to argue that as innovation ecosystems tend to present idiosyncratic characteristics, it would be difficult to replicate the similar ecosystem in other geographical regions.

Besides these contributions, the study present some limitations. For instance, from one hand, as angel investment is quiet representative among agtech companies, and for other, this type of investment can be difficult to track (Henton & Held, 2013), the total amount of investment in agtech companies can be even higher than the amount identified by CB Insights tech market intelligence platform. The same is true as we analyzed disclosed investment, which, of course, can be a limitation of many other studies.

For future research, the authors suggest to conduct in-depth study of agtech companies ecosystems, with the use of in-place data collection. This alternative may reduce the amount of hidden data and may allow the interpretation of other information that is not available on the platform adopted in this study.

The practical implications of the study is that actors within ecosystem can improve their performances only through interaction and communication with each other. In addition, public policies can be shaped to the notion of innovation ecosystem as locus of interference. This strategy can promote benefits broadly comparatively if directed only at a specific industry. This notion is desirable in an economic activity such as agriculture, in addition to promoting economic development the production of food with less cost and more efficiency can benefit society more broadly.

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