XXIV SEMEAD
Seminários em Administração
novembro de 2021
ISSN 2177-3866

GLOBALIZATION OF THE INNOVATIVE ACTIVITIES AND KNOWLEDGE ABSORPTION IN THE AGRICULTURAL BIOTECHNOLOGY SECTOR

RITA DE CÁSSIA ARANTES
UNIVERSIDADE FEDERAL DE LAVRAS (UFLA)

CRISTINA LELIS LEAL CALEGARIO
UNIVERSIDADE FEDERAL DE LAVRAS (UFLA)

RAFAELA MAIARA CAETANO
UNIVERSIDADE FEDERAL DE LAVRAS (UFLA)

MARIANE FIGUEIRA
UNIVERSIDADE FEDERAL DE LAVRAS (UFLA)

MANUEL ANIBAL SILVA PORTUGAL VASCONCELOS FERREIRA
UNIVERSIDADE FEDERAL DE LAVRAS (UFLA)

Agradecimento à orgão de fomento:
This study was funded by CNPq (National Council for Scientific and Technological Development).

GLOBALIZATION OF THE INNOVATIVE ACTIVITIES AND KNOWLEDGE ABSORPTION IN THE AGRICULTURAL BIOTECHNOLOGY SECTOR

1. INTRODUCTION

A common focus of research in the field of international business has been the possibility of subsidiaries of multinational companies (MNCs) to disseminate knowledge in host countries favoring local businesses that participate in collaborative relationships to generate innovation (Dunning, 1994; Buckley, Wang & Clegg, 2007; Buckley, Wang & Clegg, 2010). One aspect that extant literature has identified is how important knowledge absorptive capacity is. A company should have combinative capabilities to integrate, recombine and exploit knowledge resources (Sheng, 2017).

According to Sheng (2017), a company should have within its absorptive capability, the 'combinative capability', or the ability to integrate, recombine and exploit new available knowledge. Combinative capabilities can be defined as internal capabilities of a company that allow the coordination of available knowledge resources. Having in mind that companies do not have all the knowledge that they need to meet market demand, and according to Sheng (2017), companies cannot exploit their capabilities without resources, companies access knowledge from external sources to overcome natural limitations. Accordingly, to exploit knowledge, companies depend on their internal capabilities as well as knowledge derived from external sources. In that context, multinational firms can be seen as external sources of knowledge for firms in the host country, understood as 'local firms' in the present study, which can benefit from important knowledge resources. Due to their high levels of investment in research and development (R&D) and technology expertise, MNEs affect local firms, generating learning processes (Almeida, 2002).

The present study draws on understandings of previous studies on the importance of the internal capabilities of companies, as well as external sources of knowledge, and the role the combinative capabilities for creating competitive advantages (Sheng, 2017); the access to external sources of knowledge as crucial for innovation and overall performance of companies (Chesbrough, 2003; Gkypali et al., 2017); the understanding that the access to external knowledge allows companies to learn (Almeida, 2002); and the knowledge spillovers seen as powerful sources of value creation (Görg & Greenaway, 2004).

However, our understanding of the role of local firms' internal capabilities, or combinative capabilities of companies, in enhancing the exploitation of external knowledge resources remains limited. The importance of addressing this issue lies in the actual need for companies to rethink approaches whereby they can effectively exploit external knowledge and gain benefits. Kou, Wu and Lin (2018) highlight this need by arguing that prior knowledge accumulation alone does not necessarily increase the ability of a company to create knowledge. Thus, combinative capabilities apparently have a unique effect on knowledge exploitation.

On the other hand, Sakhdari (2016), when analysing the literature on absorptive capabilities, identified the need for further studies on the knowledge exploitation capabilities of companies, and called attention to the fact that the way through which environmental factors may affect knowledge absorption of firms remains unclear (Sakhdari, 2016). Therefore, we focus not only on assessing the effect of the internal capabilities, or combinative capabilities of local firms, upon their knowledge absorption efficiency, but also the effect of external sources of knowledge, and environmental conditions on the knowledge absortption efficiency of local firms.

We have conducted our research in the context of the Brazilian genetically modified seed sector. The genetically modified seed sector can be considered a knowledge-based sector

and largely consists of the partnerships between national and multinational companies. According to Amâncio (2011), this sector constantly requires innovations, and most innovations in the studied industry and/or commercialized in Brazil have been developed by large foreign multinationals. However, these subsidiaries seek partnerships in the country in order to access various technical knowledge resources, such as information on crops adapted to Brazilian climate and soil conditions, and combine them with existing resources, thereby generating new products and services, which are highly innovative and specific to the Brazilian market. Absorbing knowledge in the field of genetically modified seeds is a complex process and results from the cumulative knowledge of companies (Silveira, Borges, & Buainain, 2005). We used annual data on varieties of protected plants from five local companies (four public companies and one private company) from 2003 to 2017.

This study contributes to the knowledge-based literature, especially in the area of knowledge exploitation, which requires understanding the combinative capabilities of companies (Biedenbach, 2011). At the managerial level, our results may help managers of genetically modified seed companies understand the importance of partnering with MNEs. We also provide evidence that a favourable institutional environment enhances the performance of companies having in mind that public policies that promote a more credible corporate environment have implications for the strategies of multinationals which may positively impact local firms.

2. LITERATURE REVIEW AND HYPOTHESES

While the notion that knowledge is one of the main resources for creating and sustaining competitive advantage is already widespread, the sources and forms of access to knowledge remain controversial (McBeath, & Ball, 2012; Almeida, Song, & Grant, 2002; Phene, & Almeida, 2008). For Almeida, Song and Grant (2002), firms accumulate knowledge through internal knowledge creation and external knowledge acquisition. Internal knowledge creation primarily involves internal R&D and the integration between people and companies (Caloghirou, Kastelli & Tsakanikas, 2004). External sources of knowledge are mainly used to complement internal knowledge (Caloghirou, Kastelli, & Tsakanikas, 2004) for the fact that companies do not have all the knowledge required to meet their demands. External knowledge sources, therefore, have been a powerful channel for value creation in global markets (Bunduchi, Yoruk, Crisan-Mitra, Slanta & Crisan, 2021).

Accordingly, alliances or partnerships can be a key source of external knowledge resources (Elia, Petruzzelli, & Piscitello, 2019; Xu & Zeng, 2021). The establishment of relationships with external organizations can be facilitated if the company has valuable knowledge for other agents (Phene & Almeida, 2008). Therefore, the internal stock of knowledge resources of the company attracts other organizations interested in acquiring or sharing knowledge. In this context, having valuable knowledge enables reciprocity in knowledge exchange and helps open channels, which facilitate inter-organizational knowledge flows (Phene & Almeida, 2008).

In turn, knowledge accumulation alone has not been enough for companies to innovate and gain competitive advantage (Kou, Wu & Lin, 2018). Companies also create new knowledge resources by internally recombining acquired knowledge (Phene & Almeida, 2008; Elia, Petruzzelli, & Piscitello, 2019). The innovative potential of this recombination process is associated with the ability of the company to effectively use knowledge sources within its innovation process, avoiding the risk of misusing resources (Messeni Petruzzelli & Savino, 2014) while establishing new connections between knowledge sources (Schilling & Green, 2011). Accordingly, value creation through innovation requires combining knowledge from the external world with knowledge from either the firm or other sources (Kogut & Zander, 1992).

Companies must access knowledge and apply it to generate new ideas and innovation; that is, they need combinative capabilities (Kogut & Zander, 1992). According to Kogut and Zander (1992), combinative capabilities are internal capabilities of a company that enable them to build new combinations of resources. In such a context, combinative capabilities represent the internal cognition mechanism of the firm as a response to external knowledge resources. Therefore, capabilities act as an internal filter that helps companies process new external knowledge (Sheng, 2019). In short, knowledge absorption by local firms depends on both, their internal capabilities, particularly combinative capabilities, as well as external resources.

2.1. Internal conditions for knowledge absorption: firms' combinative capabilities

Combinative capabilities were initially defined by Kogut and Zander (1992) as capabilities that lead a company to synthesize and apply current and new sources of knowledge. For Kogut and Zander (1992), new knowledge is not created through the abstraction of previous capabilities of the firm. Instead, new learning, including innovations, results from the combinative capabilities of the firm to generate new resources from existing knowledge. Combinative capabilities are, therefore, the intersection between the capacity of a company to exploit its knowledge and the untapped technological potential known as technological opportunity. Van den Bosch et al. (1999) differentiated three types of combinative capabilities: systems, coordination and socialization capabilities. These three abilities may hinder or facilitate the knowledge absorption process of the firm. Knowledge systems capabilities involve direction, policies, procedures and manuals, often used to integrate explicit (coded) knowledge. Knowledge coordination capabilities refer to multifunctional tasks and participation in decision-making processes. Knowledge socialization capabilities refer to the abilities of the firm to produce a shared ideology, which offers an attractive identity to members of the organization (Kogut & Zander, 1992; Van den Bosch, Volberda, & Boer, 1999; Savino et al., 2017). This argument highlights the importance of combining resources in the learning process given the importance of internal abilities. In addition, combinative capabilities can be either intra-organizational or inter-organizational, meaning that a company reconfiguring existing knowledge can use systems, coordination and socialization capabilities to absorb knowledge located within the firm, within the environment of its industry or within other related industry environments (Kogut & Zander, 1992; Van den Bosch et al.1999; Savino et al., 2017).

To evaluate the integration process of new knowledge, Van den Bosch et al. (1999) suggested that efficiency can be a pertinent indicator. The knowledge absorption efficiency refers to the way through which companies exploit and adapt internal and external knowledge. While combinative capabilities are related to the abilities of a company, the knowledge absorption efficiency refers to the results of knowledge integration. The knowledge absorption efficiency is based on the exploitation, refinement and of a company's knowledge (Van den Bosch et al.1999). Kuo, Wu and Lin (2018) have shown that prior knowledge accumulation is important for a firm's learning but does not necessarily affect the ability of the company to create new knowledge or produce innovation. We argue that the combinative capability plays a key role in the integration of knowledge resources. Combinative capabilities allow a company to conduct different activities and to exploit all the available knowledge resources (Cohen & Levinthal, 1990). Therefore, we argue that companies with higher levels of combinative capabilities tend to be more efficient in knowledge absorption.

Hypothesis 1: The ability of local companies to combine knowledge is positively related to their knowledge absorption efficiency.

2.2 External conditions for knowledge absorption: external resources and macroeconomic factors

Most companies search for knowledge outside their organizational boundaries. The reason for expanding boundaries, in general, can be summarized in the search for new resources (Elia, Petruzzelli, & Piscitello, 2019). Companies can rely on different external sources of knowledge, such as customers, suppliers, universities, research centres and competitors. Through strategic alliances, companies exchange resources and develop new abilities (Xu & Zeng, 2021). Therefore, strategic alliances or partnerships have been shown to play a key role in company competitiveness (Contractor & Lorange, 2002; Xu & Zeng, 2021).

MNCs, usually, partner with companies in the host country (local companies) (Ferraris, Santoro & Dezi, 2017), and as suppliers of knowledge to local companies, MNCs can transfer technology and knowledge, generating innovations and leveraging the productivity of local firms (Phene & Almeida, 2008). We argue that the high R&D levels of MNCs impact the knowledge absorption efficiency of the local company, considering the type of knowledge that is at stake in the relationship. MNCs, as a source of external knowledge, differ from others in that they have specific advantages resulting from their intangible assets and constant investment in R&D (Caves, 2007). Therefore, MNCs have superior knowledge of product and process technologies and of organizational and marketing practices (Blomstrom & Kokko, 1998). We also postulate that local firms benefit from partnerships through knowledge that spills over, or the so called spillovers. Knowledge spillovers, particularly tacit knowledge, might impact local firms' productivity increase (Görg & Greenaway, 2004).

Hypothesis 2: The R&D of a partnering multinational company is positively related to the knowledge absorption efficiency of local firms.

Empirical evidence demonstrates that the environmental conditions of the host country of a company may affect its competitiveness (Wokoun, Pělucha, Krejčová, Kouřilová, & Šumpela, 2013). In addition, literature has also shown that specific country factors, such as environmental conditions, also result in differences in learning levels between companies (Thoenig & Verdier, 2010). The environmental context also affects some company choices (Yang & Mallick, 2014). The degree of turbulence in a host country may restrict foreign investment and affect company decisions regarding new investments. We argue that understanding the environmental context specific to the host country might help understand multinationals' capabilities and knowledge exploitation approaches.

For instance, contagious outbreaks of optimism or pessimism can amplify the economic cycle and these outbreaks can be autonomous and disconnected from reality, becoming quantitatively important for fluctuations in business cycles (Pigou; 1929; Keynes, 1936). Thus, we suggest that greater uncertainty in the institutional environment causes local companies to invest less in R&D. In addition, MNCs may become more resistant to establishing alliances with those local firms.

Hypothesis 3: A better environment conditions in the host country of a local firm is positively related to its knowledge absorption efficiency.

3. METHODOLOGY

We tested our hypotheses in the context of the Brazilian genetically modified seed sector that is considered a knowledge-based sector, consisting of partnerships between national and multinational companies. This sector has an R&D network guided by the leadership of public

institutions and universities with the participation of national and multinational corporations (Silveira, Borges, & Buainain, 2005). It is worth mentioning that Brazilian agriculture is recognized for its high level of technology and the potential in increasing productivity and production in the country (Pivoto et al. 2018), although most innovations of the Brazilian seed sector are introduced by multinational companies (Dal Poz, 2006). The sector is particularly unique because product development involves a series of stages and specificities, in addition to several actors that participate in this process, making this activity even more complex (Teles & Fuck, 2019).

The process of developing an agricultural biotechnology product can be divided into five stages: 1- event (trait) identification/generation; 2- crop transformation; 3- field efficacy tests; 4- regulatory approval; and 5- commercial stage (McElroy, 2004).

In the Brazilian context, biotechnology companies develop quality events/traits for insertion into production vehicles (seeds) that should be adapted to soil and climate conditions, usually germplasms (pure seeds) developed in Brazil.

Identifying different types of companies operating in R&D and in the seed multiplication system in Brazil, Zylberstyajn et al. (1998) highlighted that multinational companies, in charge of biotechnology R&D, establish contracts with local companies involved in plant cultivar R&D, developing germ cells adapted to Brazilian conditions. Typically, these companies also conduct activities related to regional variety adaptation. The companies receive the new events in seeds that are used in the first crosses. Then, they can multiply these seeds for multiple uses and use the seeds resulting from crosses to develop new transgenic varieties that can be applied to different regions in the country. The development of these innovations by local companies requires distinct capabilities, including the ability to combine knowledge and to apply it to innovate.

This empirical scenario provides a natural experiment to study the phenomenon of efficiency of knowledge absorption, not only for the fact that there is the need for constant innovation in this sector but also the fact that most agricultural biotechnology innovations are developed by large foreign companies seeking partnerships in the country to access several knowledge resources specific to the Brazilian market. To remain competitive, national companies must, therefore, understand the nuances of the innovation process in the sector and evaluate the results of these partnerships. Knowledge absorption in the agricultural biotechnology field is a complex process and results from the cumulative knowledge of companies (Silveira, Borges, & Buainain, 2005).

3.1 Data collection and sample

Our sample consists of Brazilian companies of the genetically modified seed sector that have registered seeds in the National Register of Cultivars (*Registro Nacional de Cultivares* – RNC). We identified 26 Brazilian companies and institutions that registered innovations from 2003 to 2017. Most of these companies and institutions had few innovation registrations, with long time lapses between registrations. To understand the phenomenon of the efficiency of knowledge absorption, of these 26 companies, we selected those that had the largest datasets. Following this criterion, five local companies (four public companies and one private company), were selected from 2003 to 2017, totalling 75 observations.

We used data from the national cultivar registration system to track the number of registered cultivars and approved events/genes (genetically modified crops approved for sale) by local companies. The data used were compiled from the Ministry of Agriculture, Livestock and Food Supply (*Ministério da Agricultura, Pecuária e Abastecimento* – MAPA) database and from the Espacenet patent search database on Biotechnology and Applied Microbiology (Class C06) for companies of the Innovation System of Transgenic Plants (*Sistema de Inovação de*

Plantas Transgênicas). Patent documents have been deemed useful for studying innovation and its implications (Almeida & Kogut, 1999; Jaffe, Trajtenberg, & Henderson, 1993; Phenne & Almeida, 2008). Similarly, Brazilian cultivar registrations are also considered key documents because they make it possible to infer about technological influences and the success of a specific invention (Jaffe, Trajtenberg, & Henderson, 1993; Amâncio, 2011) by providing comprehensive data, such as the name of the inventor and partner (if any), geographical location, date of the registration request and technical information regarding the invention, including the elite event with the gene of interest in the applicant's report, in addition to the cultivar. For example, for a corn cultivar, an applicant (national company) reported using a gene from a multinational company (MON89034 and NK603, TC1507: transgenic corn resistant to insects of the Lepidoptera order and tolerant to the herbicides glyphosate and ammonium glufosinate (TC1507 x NK603). Therefore, the source of the biotechnology company could be traced, in addition to assessing the history of the event after its patent.

3.2. Variables

To assess the effect of the internal capabilities, external sources of knowledge, as well as environmental conditions that influence the knowledge absorption efficiency of local companies in the presence of a multinational corporation we developed a dependent variable termed efficiency of knowledge absorption (EFKA). Efficiency was evaluated as the way in which local companies exploit knowledge acquired from external sources and, after combining it with existing knowledge, transform it, generating new possibilities (Van de Bosh, 1999). The variable was constructed by investigating the portfolio of cultivar registrations and measured by analysing the number of different regions of the local company and the number of cultivars registered by the local company. Based on these data, we developed an indicator that expresses the EFKA, using the following formula:

$$EFKA = 1 - \frac{\sum_{i=1}^{n} NDC_t}{\overline{RAd_t}}$$

where *EFKA* is the expected efficiency of knowledge absorption; *NDC* corresponds to the number of different cultivars used by a local company, at a specific time *t*, and *RAd* is the median of the number of regions to which the cultivar was adapted in the home country by the local company at a specific time *t*. The objective was to determine the multinationals' efficiency in adapt each cultivar for different regions in the country. For example, if a local company registered 1 different cultivar in the Brazilian system for 4 Brazilian regions, its EFKA index is 0.75.

Independent variables

Combinative capabilities: Combinative capabilities were evaluated as the extension of knowledge integration that expresses the breadth of knowledge used by the local company over time,

$$CC = \frac{\sum_{i=1}^{n} NDC_{t-3}}{\overline{\overline{NDC}_{t-3}}}$$

where CC stands for combinative capabilities; *NDC* corresponds to the number of different cultivars used in the last three years by the local company divided by the media *NDC* registered by the local company at *t-3 year*. The idea is to capture the number of registered cultivars

developed through partnerships in the period with MNCs that show the local company combinative capability to integrate its internal knowledge with the multinationals' knowledge.

R&D investment: represent the amount of investment from MNC in R&D in t -1 year. Data were collected from the multinational companies' annual reports. For most studies, R&D expenditure in the agricultural sector is only one of the inputs that can derive innovation. (Manogna, Mishra, & Sinha, 2020), particularly high in biotechnology industry. As MNCs invest more in R&D, the local companies will tend to reap more benefits through spillovers.
AgGDP: represent the environment conditions in the local company country. To measure these conditions, we used the deflated gross domestic product of agriculture (AgGDP) as share of total GDP. The higher is the AgGDP, better the perception of the country's institutional environment for the agriculture investors, and the greater is the propensity for local and multinational companies to make new investments.

Instrumental variables

The experience of the local company was calculated based on the age of each company. Forés and Camisón (2008) noted that the experience of a company affects its knowledge absorption capabilities. The experience of local companies likely affects the EFKA.

The *cultivar* variable was calculated based on the number of cultivars that the local company deposited. In most years, companies have deposited more than one cultivar for each gene acquired. Therefore, we chose to sum up the deposited cultivars. We hope that the efficiency of the local company will be greater the greater the number of cultivars deposited for each adaptation region.

The *gene* variable represents genetically modified crops approved for sale by local companies.

The *Patents* variable represents the number of existing MNC patents in the t year and was evaluated as the quality of knowledge that the MNC shares with local companies through its partnerships.

The *adaptation region* variable represents the number of regions in which the cultivars have adapted. We hope that the greater the number of regions, the greater the efficiency of the local company.

The *crop* variable represents the type of related crop (soybean, corn or cotton).

3.3 Estimation models

To assess the role of companies' combinatorial capabilities in increasing the exploitation of external knowledge resources, we used panel data analysis by fixed or random effects via the Generalized Moments Method (GMM).

Panel data models combine time series data with cross sections and their basic representation can be expressed as:

$$y_{it} = b_0 + b_1 x_{1it} + b_2 x_{2it} + \ldots + b_k x_{kit} + a_i + u_{it} \quad (1)$$

where, y_it is the dependent variable (knowledge absorption efficiency); x_it represents a set of explanatory variables; a_i is the unobserved effect and indicates the specific effects of units that do not vary over time and u_it the idiosyncratic (individual) error term, where the subscript i indicates i = 1, 2, ..., N units and t represents t = 1, 2, ..., T time periods.

Panel data models support static and dynamic form. However, fixed and random effects models do not deal with the problem of endogeneity, not respecting one of the conditions of the linear regression model (Baltagi, Bratberg & Holmås, 2005). Therefore, we use the GMM,

which has two important assumptions: i) lagged dependent variable is added to the model as an explanatory variable, adding a dynamic character to the model; ii) instrumental variables, in first differences, are used to solve the econometric problems in the sample data (Larcker & Rusticus, 2010).

Also according to Baltagi, Bratberg and Holmås (2005), the dynamic model can be expressed as:

$$y_{it} = a + b_1 y_{it-1} + b_1 x_{1it} + b_2 x_{2it} + \ldots + b_k x_{kit} + v_i + u_{it} \quad (2)$$

It is important to emphasize that in this model the Cov (v_i, y_(it-1)) ≠ 0, thus, the above equation is transformed by calculating the first differences.

$$(y_{it} - y_{it-1}) = b_1(y_{it-1} - y_{it-2}) + b_2(x_{it} - x_{it-1}) + \ldots + b_k(x_{it} - x_{it-1}) + (u_{it} - u_{it-1}) \quad (3)$$

So:

$$\Delta y_{it} = (b_1 \Delta y_{it-1} + b_2 \Delta x_{it} + \Delta u_{it}) \quad (4)$$

Baltagi, Bratberg and Holmås (2005) adds that through this procedure it is possible to eliminate the individual error, v_i, which is the cause of endogeneity.

Therefore, we propose the following model:

$$EFKA_{it} = \alpha_i + \beta_1 EFKA_{i,t-1} + \beta_2 CC_{i,t} + \beta_3 R\&D\_MNC_{i,t} + \beta_4 AGGDP_{i,t} + u_{i,t} \quad (5)$$

Where: i: companies; t: years; α_i: specific regression term; u: Residuals from the regression. EFKA represents the company's knowledge absorption efficiency; CC represents the company's combinatorial capacity; R&D_MNC represents the level of investment in R&D by the multinational; AGGDP represents the degree of turbulence in the local business environment.

Regarding the diagnostic tests to test the consistency of the models, some tests based on Arellano and Bond (1991), Arellano and Bover (1995) and Blundell and Bond (1998) were performed. The Arellano-Bond test tests the hypothesis of no second-order serial correlation in the error term. The Hansen test is a test of restrictions, whose null hypothesis indicates that the instruments are valid. The Sargan test also analyzes the validity of instruments. Finally, the Hansen Difference test tests whether the level instruments are valid and not correlated with the differential equation error term. The results of these tests will indicate the suitability of the modeling in this investigation.

4. RESULTS

The Table 2 e Table 3 outlines the descriptive statistics and correlations. The results show that the combinative capabilities of local companies, on average, are negative. In general, companies have a low absorption of knowledge.

Table 2. Descriptive Data Statistics

Variable	Mean	Median	Maximum	Minimum	Std. Dev.	Jarque-Bera	Probability	Observations
EFKA	-1,09	-0,25	0,80	-11,00	2,18	328,26	0,00	75,00
CC	2,92	1,73	37,00	0,00	4,98	2724,88	0,00	75,00
R&D_MNC	246,40	1,73	780,00	1,10	279,91	8,64	0,01	75,00
AGGDP	5,91	5,92	6,15	5,72	0,15	5,32	0,07	75,00
GENE	1,00	1,00	4,00	0,00	0,93	33,13	0,00	75,00
CULTIVAR	4,39	3,00	23,00	0,00	4,92	54,88	0,00	75,00
CROP	0,77	1,00	2,00	0,00	0,53	0,43	0,81	75,00
REGION	39,84	47,14	100,00	0,00	29,03	5,06	0,08	75,00
PATENT	3,61	3,84	4,01	0,00	0,98	449,71	0,00	75,00
EXPER	27,60	32,00	46,00	2,00	13,05	7,14	0,03	75,00

Source: Search Results

Considering the correlation between the efficiency and combinative capabilities variables (Table 3), we propose that the companies with greater combinative capabilities are more efficient in knowledge absorption.

Table 3. **Correlation of variables**

	EFKA	CC	R&D_MNC	AGGDP	GENE	CULTIVAR	CROP	REGION	PATENT	EXPER
EFKA	1,00									
CC	0,16	1,00								
R&D_MNC	0,10	-0,22	1,00							
AGGDP	-0,07	0,37	-0,78	1,00						
GENE	-0,56	0,15	-0,40	0,48	1,00					
CULTIVAR	-0,80	-0,07	-0,29	0,30	0,77	1,00				
CROP	-0,45	0,30	-0,32	0,38	0,84	0,70	1,00			
REGION	-0,07	0,34	-0,38	0,48	0,59	0,48	0,77	1,00		
PATENT	0,09	0,10	0,17	-0,34	-0,13	-0,07	0,03	0,08	1,00	
EXPER	-0,21	0,18	-0,26	0,33	0,32	0,35	0,28	0,19	-0,12	1,00

Source: Search Results

Before estimating the efficiency models, stationarity tests were performed for the series used in this work. The ADF GLS tests were performed; PP – Phillips Perron and KPSS – Kwiatkoswski-Phillips-Schmidt-Shin. According to the tests, all variables were stationary, so there was no need to perform their first difference.

It is relevant to perform some diagnostic tests before proceeding with the analysis of short and long term estimates of ARDL models. Hansen's J Test is a constraint test whose null hypothesis is that the instruments are valid. It is verified by the probability of the Jstatistic that the null hypothesis is not rejected, that is, the instruments used in the regression are valid (Table 4)

Another diagnostic test is that of endogeneity. The null hypothesis is that the explanatory variables are exogenous. Due to the probability of the Hansen Difference, the null hypothesis is not rejected (0,4711), that is, there is no endogeneity problem in the model. Therefore, Table 4 shows the final research model.

Table 4. Relationship between Efficiency in Knowledge Absorption and Combination Capabilities

Dependent Variable: Efficiency of knowledge absorption (EFKA)				
Variable	**Coefficient**	**Std. Errror**	**T-Statistic**	**Probabillity**
EFKA(-1)	0,229955	0,137832	1,668369	0,1000
CC	0,315910	0,107018	2,951935	0,0044*
R&D_MNC	0,022276	0,007404	3,008830	0,0037*
AGGDP	29,70120	10,28353	2,888230	0,0052*
Number of observations: 75				
J Statistic: 5,164747				
Prob (J Statistic): 0,522864				
Durbin-Watson: 1,415831				
Instrument rank: 11				

Significance of variables: * (at 1%); ** (at 5%) and *** (at 10%). Instruments in first differences: CULTIVAR; GENE; EXPER; PATENT; CROP; REGION; EFKA
Source: Search Results

The knowledge combinative capabilities of local companies is significant. Hypothesis 1 is supported, with a positive and significant coefficient; as such, the enhanced combinative capabilities of local companies elevate the EFKA. Furthermore, as explained above, to ensure the dynamic character of the model, the variable EFKA was lagged and was shown to be statistically significant and positive. This means that the efficiency of knowledge absorption in t is influenced by the efficiency in past times, that is, in t-1.

Hypothesis 2 is also supported, with a positive coefficient for the R&D level of the MNC partner.

Hypothesis 3 is also supported. The variable AGGDP, the proxy for the perception of the institutional environment, was also significant and positive. This corroborates our supporting our assumption that the EFKA of local companies is partly explained by macroeconomic factors of the host country.

5. DISCUSSION

Evidence shows that the combinative capabilities of a company can provide competitive advantages (Sheng, 2017), but several implications and the potential of the combinative capabilities of companies for knowledge exploitation remain poorly understood (Sakhdari, 2016). Based on prior evidence, we suggest that combinative capabilities play a key role in the integration of knowledge resources (Kou, Wu & Lin, 2018). Kou, Wu and Lin (2018) demonstrated that companies innovate not only by accumulating but also by combining knowledge. Therefore, while knowledge accumulation is important for company learning, knowledge accumulation alone does not necessarily affect the ability of the company to create new knowledge.

We highlight the potential of combinative capabilities for local companies. As local companies enhance their knowledge combinative capabilities, their EFKA tends to increase. Based on previous studies, we suggest that having rare resources is important for attracting external sources of knowledge (Phene & Almeida, 2008; Kou, Wu & Lin, 2018), but the EFKA directly depends on the combinative capabilities of local companies. Therefore, companies must monitor their strategies to not only accumulate knowledge but also to exploit it, through combinative capabilities.

We also argue that the high R&D levels of MNCs affect the EFKA of local companies through the type of knowledge that is at stake in the relationship. We found a positive and

significant relationship between the EFKA of local companies and the R&D levels of MNCs. We suggest that the tacit knowledge that underlies the relationship between MNCs and local companies enhances the knowledge exploitation of local companies. Therefore, we argue that the efficiency of knowledge exploitation depends on the external sources of knowledge (Contractor & Lorange, 2002) and on the knowledge combinative capabilities of the companies as well (Caloghirou, Kastelli & Tsakanikas, 2004).

In terms of uncertainty in the institutional environment and EFKA, we found significant differences. This result demonstrates that the EFKA of local companies can be partly explained by macroeconomic factors of the host country. Thus, we argue that the degree of turbulence in the country may restrict foreign investment and affect the decisions of companies regarding new investments.

Study limitations and future perspectives

As in any study, this research is not without limitations. First, our sample is limited to Brazilian operating in the agricultural biotechnology sector, more specifically the genetically modified (GM) seed sector. In addition, companies were included in our sample based on data availability. Accordingly, our sample represents only a percentage of GM seed companies in the country. Our findings cannot be extended to all Brazilian companies in the biotechnology sector.

The second limitation of this study is that we have used only cultivar registrations as indicators of combinative capabilities. In making this choice, we recognize that our focus is restricted to the outcome of the process. We acknowledge that the abilities that compose combinative capabilities, i.e., systems, coordination and socialization capabilities, should be investigated using other data sources. Further studies could assess the effect of each combinative capability on the efficiency of knowledge exploitation by local companies. Such studies are important given the potential to scrutinize the capabilities of companies and their relationship with knowledge.

In conclusion, assessing the effect of local companies' combinative capabilities on their knowledge absorption efficiency is relevant for the contribution to the general theory of knowledge. This study advances the state of the art of the knowledge-based view, by separately investigating companies' combinative capabilities as enhancers of the knowledge absorption efficiency. Our findings indicate that the greater the combinative capabilities of companies, the higher their knowledge absorption efficiency will be. In addition, our results indicate that local companies' knowledge absorption efficiency also depends on the type of external knowledge. Local companies' knowledge absorption efficiency can be partly explained by macroeconomic factors of the host country.

References

Almeida, P., & Kogut, B. (1999). Localization of knowledge and the mobility of engineers in regional networks. *Management science*, *45*(7), 905-917.

Almeida, P., Song, J., & Grant, R. M. (2002). Are firms superior to alliances and markets? An empirical test of cross-border knowledge building. *Organization Science*, *13*(2), 147-161.

Amâncio, M. C. (2011). Sistema de inovação em plantas transgênicas no Brasil: estratégias para garantir a competitividade nacional neste setor. 207 p. *Tese* (Doutorado em Ciências Genômicas e Biotecnologia) - Universidade Católica de Brasília, Brasília.

Arellano, M., & Bond, S. (1991). Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. The review of economic studies, 58(2), 277-297.

Arellano, M., & Bover, O. (1995). Another look at the instrumental variable estimation of error-components models. Journal of econometrics, 68(1), 29-51.

Arellano, M., & Bond, S. (1998). Dynamic panel data estimation using DPD98 for GAUSS: a guide for users. Institute for Fiscal Studies, London.

Baltagi, B. H., Bratberg, E., & Holmås, T. H. (2005). A panel data study of physicians' labor supply: the case of Norway. *Health Economics*, *14*(10), 1035-1045.

Biedenbach, T. (2011). The power of combinative capabilities: facilitating the outcome of frequent innovation in pharmaceutical R&D projects. Project Management Journal, 42(2), 63-80.

Blomström, M., & Kokko, A. (1998). Multinational corporations and spillovers. *Journal of Economic surveys*, *12*(3), 247-277.

Buckley, P. J., Wang, C., & Clegg, J. (2010). The impact of foreign ownership, local ownership and industry characteristics on spillover benefits from foreign direct investment in China. In *Foreign direct investment, China and the world economy* (pp. 305-326). Palgrave Macmillan, London.

Buckley, P.J., Wang, C. and Clegg, J. (2007). The impact of foreign ownership, local ownership and industry characteristics on spillover benefits from foreign direct investment in China. International Business Review. Vol. 16. pp. 142-158.

Caloghirou, Y., Kastelli, I., & Tsakanikas, A. (2004). Internal capabilities and external knowledge sources: complements or substitutes for innovative performance?. *Technovation*, *24*(1), 29-39.

Caves, R. E. (2007). *Multinational enterprise and economic analysis*. 3rd edition, Cambridge, Cmbridge University Press.

Chesbrough, H. W. (2003). *Open innovation: The new imperative for creating and profiting from technology*. Harvard Business Press.

Cohen, W. M., & Levinthal, D. A. (1990). Absorptive capacity: a new perspective on learning and innovation. *Administrative Science Quarterly*, 1 (35): 128-152.

Contractor, F., & Lorange, P. (2002). The growth of alliances in the knowledge-based economy. International Business Review, 11(4), 485–502.

Dal Poz, M. E. S. (2006). Redes de inovação em biotecnologia: genômica e direitos de propriedade intelectual. 307 p. *Tese* (Doutorado em Política Científica e Tecnológica) - Universidade Estadual de Campinas, Campinas, 2006.

Dunning, J. H. (1994). Multinational enterprises and the globalization of innovatory capacity. *Research policy*, *23*(1), 67-88.

Elia, S., Petruzzelli, A. M., & Piscitello, L. (2019). The impact of cultural diversity on innovation performance of MNC subsidiaries in strategic alliances. *Journal of Business Research*, *98*, 204-213.

Ferraris, A., Santoro, G., & Dezi, L. (2017). How MNC's subsidiaries may improve their innovative performance? The role of external sources and knowledge management capabilities. *Journal of Knowledge Management*, *21*(3), 540-552.

Forés, B., & Camisón, C. (2008). La Capacidad de absorción de tecnología de conocimiento: factores determinantes internos y externos. *Revista Dirección y Organización. Nro. 36. 35*, *50*.

Gkypali, A., Arvanitis, S., & Tsekouras, K. (2017). Absorptive capacity, exporting activities, innovation openness and innovation performance: A SEM approach towards a unifying framework. *Technological Forecasting and Social Change*, *132*, 143-155.

Görg, H., & Greenaway, D. (2004). Much ado about nothing? Do domestic firms really benefit from foreign direct investment?. *The World Bank Research Observer*, *19*(2), 171-197.

Jaffe, A. B., Trajtenberg, M., & Henderson, R. (1993). Geographic localization of knowledge spillovers as evidenced by patent citations. *the Quarterly journal of Economics*, *108*(3), 577-598

Keynes, J. M. (1936). The General Theory of Employment, Interest and Money (London, 1936). *KeynesThe General Theory of Employment, Interest and Money1936*.

Kogut, B., & Zander, U. (1992). Knowledge of the firm, combinative capabilities and the replication of technology. *Organization Science*, 3(3): 383-396.

Kuo, C. I., Wu, C. H., & Lin, B. W. (2018). Gaining from scientific knowledge: the role of knowledge accumulation and knowledge combination. *R&D Management*, *49*(2), 252-263.

Larcker, D. F., & Rusticus, T. O. (2010). On the use of instrumental variables in accounting research. *Journal of accounting and economics*, *49*(3), 186-205.

Manogna, R. L., Mishra, A. K., & Sinha, A. K. (2020). Does institutional ownership affect firms' international investments? empirical evidence from India. *Journal of Strategy and Management*.

McBeath A., & Ball, P. (2012).Towards a framework for transferring technology knowledge between facilities. *Strategic Outsourcing: an International Journal*, 5 (3): 213-231.

McElroy, D. (July, 2004). Valuing the product development cycle in agricultural biotechnology – what's in a name? *Nature Biotechnology*, 22 (7): 817-822.

Messeni Petruzzelli, A., & Savino, T. (2014). Search, recombination, and innovation: Lessons from the haute cuisine. Long Range Planning, 47(4), 224–238.

Phene, A., & Almeida. (2008). Innovation in multinational subsidiaries: the role of knowledge assimilation and subsidiary capabilities. *Journal of International Business Studies*, 39: 901-919.

Pigou, A. C. (1929). The monetary theory of the trade cycle. *The Economic Journal*, *39*(154), 183-194

Pivoto, D., Waquil, P. D., Talamini, E., Finocchio, C. P. S., Dalla Corte, V. F., & de Vargas Mores, G. (2018). Scientific development of smart farming technologies and their application in Brazil. *Information processing in agriculture*, *5*(1), 21-32.

Sakhdari, K. (2016). Absorptive capacity: Review and research agenda. *Journal of Organisational Studies and Innovation*, *3*(1), 34-50.

Savino, T., Messeni Petruzzelli, A., & Albino, V. (2017). Search and recombination process to innovate: a review of the empirical evidence and a research agenda. *International Journal of Management Reviews*, *19*(1), 54-75.

Schilling, M. A., & Green, E. (2011). Recombinant search and breakthrough idea generation: An analysis of high impact papers in the social sciences. Research Policy, 40(10), 1321–1331.

Sheng, M. L. (2019). Foreign tacit knowledge and a capabilities perspective on MNEs' product innovativeness: Examining source-recipient knowledge absorption platforms. *International Journal of Information Management*, *44*, 154-163.

Sheng, M. L. (2017). A dynamic capabilities-based framework of organizational sensemaking through combinative capabilities towards exploratory and exploitative product innovation in turbulent environments. *Industrial Marketing Management*, *65*, 28-38.

Silveira, J. M. F. J. da; Borges, I. C.; Buainain, A. M. (2005). Biotecnologia e agricultura: da ciência e tecnologia aos impactos da inovação. *São Paulo em Perspectiva*, São Paulo, 19 (2): 101-114.

Teles, G. C., & Fuck, M. P. (2019). Inovação e apropriabilidade sobre sementes de soja no Brasil. *Revista de Economia*, *39*(69).

Thoenig, M., & Verdier, T. (2010). A macroeconomic perspective on Knowledge Management. Journal of economic growth, 15(1), 33-63.

Van den Bosch, F., Volberda, H., & Boer, M. (1999). Coevolutionof firm absorptive capacity and knowledge environment. *Organization Science*, 10 (5): 551-569.

Wang, L., Li, S., & You, Z. (2020). The effects of knowledge transfer on innovation capability: a moderated mediation model of absorptive capability and network reliance. Journal of High Technology Management Research, 31(1), 100372.

Wokoun, R., Pělucha, M., Krejčová, N., Kouřilová, J., & Šumpela, V. (2013). Regional competitiveness from a macroeconomic perspective and within factors of the knowledge economy: a case study of the Czech Republic.

Xu, l., & Zeng, D. (2021). When does the diverse partnership of R&D alliances promote new product development? The contingent effect of the knowledge base. Technology in Society, 65, 101590.

Y, D. E., Bunduchi, R., Yoruk, E., Crisan-Mitra, C., Slanta, I., & Crisan, E. L. (2021). Pathways to innovation in Romanian software SMEs: exploring the impact of interdependencies between internationalization and knowledge sources. Journal of International Management, 27(4), 100874.

Yang, Y., & Mallick, S. (2014). Explaining cross-country differences in exporting performance: The role of country-level macroeconomic environment. International Business Review, 23(1), 246-259.

Zylbersztajn, D. et al. (1998). Perspectivas da aplicação da biotecnologia no Sistema Agroindustrial Brasileiro: o exemplo da soja Roundup Ready. In: Seminário Internacional Pensa de Agribusiness, 8., 1998, São Paulo. *Anais*... São Paulo: PENSA/USP, 1998. 1 CD-ROM.