RBGN REVISTA BRASILEIRA DE GESTÃO DE NEGÓCIOS
© FECAP

ISSN 1806-4892
e-ISSN 1983-0807

Capabilities and Innovative Performance in the Brazilian Agricultural Machinery Industry

Received on:
02/08/2021
Approved on:
11/12/2021

Responsible Editor:
Prof. Dr. Flávio Macau

Evaluation process:
Double Blind Review

Reviewers:
Guilherme Brittes Benitez;
José Cabral; Tobias Parente

Estêvão Passuello Ruffoni[1]
Fernanda Maciel Reichert[1]

Abstract

Purpose – This study identifies how Brazilian agricultural machinery manufacturers combine different capabilities to innovate. This industry has the potential to increase productivity in agriculture, a sector that is notably relevant in Brazil, one of the main food and agricultural commodities producers in the world.

Theoretical framework – Firms were approached through the lens of a four innovation capabilities model (development, operations, management and transactions). Previous research about innovation in the machinery and equipment industry was examined in depth to support the results obtained.

Design/methodology/approach – To identify the combinations of innovation capabilities, the fuzzy-set QCA (comparative qualitative analysis) technique was applied. Data were collected through a survey, conducted with 103 Brazilian companies.

Findings – Agricultural machinery manufacturers innovate through two combinations of capabilities: development, operations and management (DC*OC*MC), or operations and transactions (OC*TC). Innovation emerges when excellence in manufacturing is complemented by improvements in existing products and in managerial processes (DC*OC*MC), or in negotiation skills and commercialization processes (OC*TC).

Practical & social implications of research – Previous research had already identified that the machinery and equipment industry of emerging economies is focused on production-related enhancements. However, the present study demonstrates that this is not sufficient for firms to innovate. As a practical implication, we indicate two paths for agricultural machinery companies to achieve high innovative performance.

Originality/value – Research about innovation in the machinery and equipment industry generally aims to only understand how firms develop new products and production processes. This study fills a gap by approaching this industry through broader lenses, demonstrating the relevance of new managerial and transactional process development for these firms.

Keywords: Innovation, innovation capabilities, machinery and equipment industry, agricultural machinery, fsQCA.

1. *Federal University of Rio Grande do Sul, School of Administration, Department of Administration Sciences, Porto Alegre, Brazil*

How to cite:
Ruffoni, E. P., & Reichert, F. M. (2022). Capabilities and innovative performance in the Brazilian agricultural machinery industry. *Revista Brasileira de Gestão de Negócios*, *24*(2), p.275-293. https://doi.org/10.7819/rbgn.v24i2.4168

Revista Brasileira de Gestão de Negócios

https://doi.org/10.7819/rbgn.v24i2.4168

1 Introduction

The machinery and equipment industry plays a key role in economic development (Magacho & McCombie, 2017), so much so that machinery acquisition is a widely applied indicator of innovation activity in firms (Dutrénit et al., 2019; Goedhuys & Veugelers, 2012). Given the potential of this industry to promote economic progress, this study aims to identify how Brazilian agricultural machinery firms use their capabilities to achieve high innovative performance.

Technological advances in machinery and equipment provide considerable productivity gains, being associated with the fourth stage of the industrial revolution, Industry 4.0 (Frank et al., 2019) and Agriculture 4.0 (Wolfert et al., 2017). Productivity in agriculture is crucial to the world-wide food supply, especially due to increasing demand and the impact of climate change on growing conditions (Food and Agriculture Organization of the United Nations, 2017). This makes the agricultural machinery industry particularly relevant for a sustainable future, even more so in Brazil, one of the largest producers of food and agricultural commodities in the world (Vieira & Fishlow, 2017).

Generally, studies of innovation in machinery and equipment industry have sought to understand how new products (Acha et al., 2004; Dan et al., 2018) or new production processes (Asadi et al., 2019; Forrester et al., 2010) are developed. Servitization – the incorporation of services into products, which can lead to product, organizational or commercial innovations – has also been explored in this industry (Baines et al., 2019). A less representative set of studies has focused exclusively on organizational innovations, especially new project management methods for equipment development (Hobday, 2000).

However, important gaps remain in the literature. It would be useful to know the extent to which product, process, organizational or commercial innovations relate to innovative performance in the machinery and equipment industry. In other words, how do firms in this industry combine different innovation types to thrive?

As firms must develop their capabilities to innovate (Figueiredo et al., 2020; Lall, 1992; Teece, 2018), and because each innovation type is a consequence of a specific capability (Francis & Bessant, 2005; Guan & Ma, 2003; Janssen et al., 2016), an innovation capabilities approach was applied in this study. Agricultural machinery firms were analyzed using a four innovation capabilities model – development (product innovation), operations (process innovation), management (organizational innovation) and transactions (commercial innovation) (Zawislak et al., 2012).

The results obtained provide theoretical, practical and methodological contributions. The present research identifies that operations capability alone is unable to ensure high innovative performance, complementing previous studies, which have suggested that machinery and equipment manufacturers, in emerging economies, only focus on production processes innovations (Hobday & Rush, 2007; Kiamehr et al., 2015). To innovate, firms combine operations with development and management capabilities (DC*OC*MC), or with transactions capability (OC*TC). Therefore, besides developing new production processes, agricultural machinery firms also seek to improve their products, managerial methods, and commercial procedures. To help identify these combinations of capabilities, we employed an emerging analytical technique – fuzzy-set qualitative comparative analysis (fsQCA).

Including this introduction, the paper has five sections. Section 2 is divided into two subsections, where 2.1 reviews the literature on firms' innovation capabilities, and presents the innovation capabilities model, while 2.2 reviews the research on innovation in the machinery and equipment industry, particularly the specific features of the agricultural segment. Section 3 explains the research procedures adopted. Section 4 presents the results and discussions. Lastly, section 5 considers the implications of the findings, identifies the study limitations and suggests ideas for further research.

2 Theoretical background

2.1 Firm innovation capabilities

A firm's capability is a set of resources and routines related to the processes involved with product development, manufacturing, and commercialization, as well as with the business management (Dosi et al., 2004). According to Teece (2007), dynamic capabilities are able to sense a market change and adapt the firm to it by acquiring and reconfiguring routines and resources, a process through which innovation emerges (Teece, 2018).

There is considerable research into firms' capabilities driven by technological innovation – i.e., capabilities to develop new products or new production processes

(Figueiredo et al., 2020; Lall, 1992; Zhou & Wu, 2010). Service development can be considered within this same set of studies, since services are defined as intangible products (Janssen et al., 2016). Other studies adopt a broader approach, also considering firms' capabilities to innovate in business and marketing strategies, as well as in managerial and transactional processes (Francis & Bessant, 2005; Guan & Ma, 2003; Lawson & Samson, 2001).

This study applies the innovation capabilities model put forward by Zawislak et al. (2012) because it synthesizes these earlier approaches while maintaining a broad perspective. According to Zawislak et al. (2012), all firms have four capabilities, with each one being associated with a specific innovation type: development (product innovation), operations (process innovation), management (organizational innovation) and transactions (commercial innovation).

Development capability concerns a firm's resources and routines related to product development (Zawislak et al., 2018). It consists in procedures that aim to monitor, absorb, create and incorporate new technologies in products (Lall, 1992; Nagano et al., 2014; Zhou & Wu, 2010). Hence, this capability results from incremental improvements in existing products, such as quality or design enhancements, to the development of new ones, with new technological features and functionalities (Figueiredo et al., 2020).

Operations capability refers to a firm's resources and routines related to increasing the efficiency of production processes (Reichert et al., 2016). It encompasses process engineering activities (Lall, 1992; Figueiredo et al., 2020), and the production planning, programming, control and execution (Hopp & Spearman, 2021). Consequently, this capability results in new manufacturing procedures, shop floor layouts, production scheduling methods, or quality control systems, which generate lower production-related costs, and higher operational efficiency (Moldner et al., 2020).

Management capability describes a firm's resources and routines related to increasing the efficiency of managerial and decision-making processes (Zawislak et al., 2018). It involves developing new business strategies and models (Bonazzi & Zilber, 2014; Lawson & Samson, 2001), and implementing new management systems (Fierro Moreno et al., 2015), such as ERP (Enterprise Resources Planning) software (Sedera et al., 2016). Therefore, this capability results in a more effective use of human, material and financial resources (Lee et al., 2017).

Transactions capability concerns a firm's resources and routines related to improving transactions with the market, encompassing procedures aimed at developing brands, prospecting customers, product sales and distribution (Guan & Ma, 2003; Kamboj & Rahman, 2017), as well as procedures to search, select and assess suppliers (Li et al., 2016). Thus, this capability results in new marketing and supply chain strategies, and new commercialization and purchase processes (Francis & Bessant, 2005; Zawislak et al., 2012).

To shed light on the combinations of capabilities that lead agricultural machinery manufacturers to achieve high innovative performance, the next section looks at studies focused on innovation in the industry.

2.2 Innovation in the machinery and equipment industry

According to the Organisation for Economic Co-operation and Development (2016), the machinery and equipment industry invests significant amounts in research and development (R&D) activities. Considering the different segments, investments range from 6% of annual revenue, in transport equipment companies, to 30%, in aircraft manufacturers. The agricultural machinery firms invests around 7% of its revenue in R&D (Organisation for Economic Co-operation and Development, 2016), which permits a high level of technological innovation.

The development of new machinery and equipment can increase the productivity of several user industries and is fundamental for technological progress (Magacho & McCombie, 2017). Recently, the incorporation of software, hardware and artificial intelligence into machines has led to increased automation, precision and efficiency for user industries, characterizing a new stage of industrialization, the so-called Industry 4.0 (Muller et al., 2018) and Agriculture 4.0 (Wolfert et al., 2017).

Incremental improvements to products, such as in machinery aesthetics (Dan et al., 2018) and equipment modularization, have also been highlighted by studies. Product modularity enables mass customization – the offering of customized products while maintaining scale economies, obtainded through the design of a few modular components that can be assembled into a wide range of final products (Asadi et al., 2019; Trentin et al., 2015). Mass customization can be characterized both as product and process innovation, because when products are modularized, it simplifies production planning and control and reduces setup times (Qi et al., 2020).

Frequently in the agricultural machinery segment, a single company often manufactures a range of different products, such as tractors, planters, fertilizers, harvesters and several types of implements (e.g., plows and brush cutters). As the demand for these products varies along the year, according to the farming calendar (Vian et al., 2013), mass customization can offer an important competitive advantage for these firms.

According to Acha et al. (2004), machinery and equipment frims tend to be driven more by innovations in processes than in products. This occurs mainly in emerging economies, because product development activities are generally limited to the replication of equipment designed by head offices located abroad (Dosi et al., 2004; Galhardi & Zacarelli, 2005; Hobday & Rush, 2007; Reichert & Zawislak, 2014). In the Brazilian agricultural machinery companies, product development activities tend to focus on adapting equipment to the local soil and climate characteristics (Toledo & Simões, 2010). Brazilian companies are also strongly oriented towards improving production processes by implementing lean manufacturing techniques (Forrester et al., 2010).

Nonetheless, innovation in the machinery and equipment industry is not restricted to a technological driver. Some studies have explored how firms in the industry optimize managerial processes, especially those involved in project management, aiming to reduce the high development costs and lengthy time to market periods typically seen in equipment design (Acha et al., 2007; Hobday, 2000).

Another innovation type frequently explored in this industry is servitization – the incorporation of services into products. Because it requires firms to change several routines, from product development to sales processes, servitization can result in product, organizational and commercial innovations (Baines et al., 2019). Regarding the machinery and equipment industry, the service packages offered to users range from simple complements, like technical support services, to more complex additions, such as R&D services (Jovanovic et al., 2019).

For Frank et al. (2019), R&D services offered by machinery and equipment firms aim to improve the clients' products throught customized enhnancements in the equipment, and generally are offered as an add-on to machines designed with software and hardware embedded to collect, store and analyze production data, technologies that are necessary for its provision (Frank et al., 2019). R&D services are defined as an advanced service, in which the greatest potential for innovation via servitization resides (Sjödin et al., 2016).

Althought the literature on innovation in the machinery and equipment industry has explored the effects and characteristics of different types of innovation, there is a need for a more integrated approach. The four innovation capabilities model – development, operations, management, and transactions – can provide broader and deeper insights into how agricultural machinery firms articulate these innovation types to achieve higher performance. The next section presents the methodological procedures adopted in this study.

3 Methods

To identify the combinations of capabilities that allow firms to achieve high innovative performance, the fuzzy-set qualitative comparative analysis (fsQCA) technique was applied. FsQCA, like the crisp-set (csQCA) and multi-value (mvQCA) techniques, is based on Boolean algebra (Ragin, 1987), and has been gaining visibility in management research (Roig-Tierno et al., 2017). According to Parente and Federo (2019), there are three requirements to apply QCA techniques: configurational perspective, causal complexity and case knowledge.

While the configurational perspective assumes an outcome can result from a combination of causes, causal complexity suggests different combinations can lead to the same outcome (Cheng et al., 2013). Considering this, QCA identifies the combinations of patterns that must be present for a given outcome to occur (Fiss et al., 2013). At supposing that high innovative performance can be achieved through different combinations of capabilities, the QCA approach fits well with both the firm capabilities theory and the research objective. So much so that, in management literature, QCA techniques have often been adopted to identify combinations of firms' innovation capabilities (Ganter & Hecker, 2014; Reichert et al., 2016; Sjödin et al., 2016).

According to Rihoux (2006), the fsQCA technique is particularly well suited to large samples, where there is less need for case knowledge, since it enables generalizable results. For Pappas and Woodside (2021), fsQCA provides scholars with two options: I) identify patterns among a few cases and explore them through a deep case knowledge; or II) identify general patterns across many cases, where fsQCA can be an alternative to traditional statistical approaches based on correlations, such as regression analysis (Vis, 2012). Like several other studies, here we have adopted the second option (Gaspar et al., 2020; Leischnig & Kasper-Brauer, 2015; Tho & Trang, 2015).

3.1 Data collection

A survey questionnaire was applied to collect data (Appendix). Firms' capabilities and innovative performance were measured by 5-point Likert scale variables, while categorical variables were utilized to identify firms' complementary characteristics, for example, annual revenue and number of employees. All the variables are based on the Zawislak et al. (2012) innovation capabilities model, and have already been applied in previous studies (Reichert et al., 2016; Ruffoni et al., 2018).

The survey was carried out among Brazilian agricultural machinery firms between August and October of 2018. All the companies contacted were listed in the FIERGS (Industries Federation of Rio Grande do Sul) catalog, which consists exclusively of companies based in the state of Rio Grande do Sul. Although this may represent a bias, since only one of the 26 Brazilian states is contemplated, Rio Grande do Sul concentrates important companies in this industry (Confederação Nacional da Indústria, 2020), characterizing a relevant proxy for Brazil.

To begin the data collection process, the companies were first contacted by telephone to schedule an interview with representatives in decision making positions – owners, CEOs or managers – because people in these positions usually have a broad perception of the firm's dynamic. Then, on the scheduled day, the interviewer called again and sent the questionnaire by email, so the respondent could follow it during the interview. From 187 companies in the agricultural machinery segment, 106 questionnaires were answered. As one observation was registered four times due to a system failure during the collection, three repeated questionnaires were excluded. With 103 validated questionnaires, the response rate was 55%.

Based on annual revenues ranges (Banco Nacional de Desenvolvimento Econômico e Social, 2019), 16.5% of the firms in the sample are micro companies (revenue less than or equal to R$ 360 thousand), 59% are small (revenue between R$ 360 thousand and R$ 4.8 million), 16.5% are medium (revenue between R$ 4.8 million and R$ 300 million), and 8% are large (revenue above R$ 300 million). Hence, micro and small companies represent 75% of the sample. The respondent profile is: industrial manager (43%); owner (31%); engineering coordinator (13%); manager of other departments, such as administrative, financial, human resources, logistics, marketing or sales (8%) and; CEO (5%).

3.2 Data analysis

The influence of the measurement method on variance was assessed with Harman's single-factor technique. Using the Statistical Package for the Social Sciences (SPSS) software, all Likert scale variables for innovation capabilities and innovative performance were fixed into a single factor, which explained 31.3% of the total variance. This value indicates a low measurement method impact, and does not compromise the results (Tehseen et al. 2017).

As previous studies have demonstrated the convergence and validity of the variables utilized in this study, through exploratory factor analysis (Reichert et al., 2016; Ruffoni et al., 2018), convergent validity was analyzed solely to ensure they conformed with the data obtained. Using the Smart Partial Least Square 3.0 (Smart PLS 3.0) software, a formative model was elaborated to measure the Cronbach's Alpha of each construct (Gaspar et al., 2020; Sjödin et al., 2016). Since a Cronbach's Alpha greater than 0.700 was obtained for all constructs (Table 1), the convergence can be considered acceptable (Hair et al., 2014). None of the variables were disregarded to obtain these values.

Having tested the method impact and convergent validity, data analysis was carried out with the fsQCA 3.0 software. According to Ragin et al. (2017), fsQCA considers each causal condition (capabilities) and the outcome (innovative performance) to be sets, and observations (firms) as set members. Basically, the combinations of causal conditions necessary for the outcome are determined by the degree to which observations belong to the intersection areas among the causal condition sets and the outcome set, as well as by the percentage of observations in these intersections (Ragin et al., 2017).

To determine to what extent an observation belongs to a set, data must be calibrated according to a fuzzy scale that varies from 0.05 to 0.95 (where: 0.05 = observation does not belong to the set; 0.50 = it partially belongs; and 0.95 = it fully belongs) (Ragin et al., 2017). As each construct was measured by the mean of its variables (specified in the Appendix), and the variables were

Table 1
Analysis of convergent validity

Construct	Type	Number of Variables	Cronbach's Alpha
Development Capability (DC)	Causal Condition	7	0.771
Operations Capability (OC)	Causal Condition	9	0.789
Management Capability (MC)	Causal Condition	7	0.836
Transactions Capability (TC)	Causal Condition	6	0.743
Innovative Performance (IP)	Outcome	3	0.926

measured using a 5-point Likert scale, the construct values also range from 1 to 5. Therefore, following Cheng et al. (2013), Leischnig and Kasper-Brauer (2015) and Tho and Trang (2015), calibration was carried out through direct correspondence between the Likert and the fuzzy scales (where: 1 = the observation does not belong to the set; 3 = it partially belongs; and 5 = it fully belongs).

With the data calibrated, fsQCA assembles a truth table, listing all possible combinations of causal conditions for the outcome, of which there are 16, since there are four conditions ($2^4 = 16$). To validate the truth table, combinations without allocated observations (Kuehn et al., 2017) and those with a raw consistency below 0.900 were eliminated. For Ragin et al. (2017), combinations with a raw consistency below 0.800 means the observations allocated to them have a low degree of membership (belonging), affecting the consistency of the final solution.

Once the truth table is validated, fsQCA generates three solutions: complex, parsimonious and intermediate. The intermediate solution was considered, because it is the most easily interpretable (Ragin et al., 2017). To support the results, descriptive statistics techniques were applied, such as frequency and percentage (Hair et al., 2014).

4 Results and discussions

The solution obtained from fsQCA can contain several combinations of causal conditions, and is evaluated using indicators of consistency and coverage. For Hsiao et al. (2015), consistency indicators measure the interdependence between the solution and the outcome, similarly to statistical correlation, while coverage indicators measure the explanatory power of the solution, resembling the R^2.

FsQCA evaluates a solution measuring the degree to which observations belong to each combination of causal conditions (**consistency**), and to all combinations of the solution (**solution consistency**). FsQCA also assesses the percentage of observations covered by each combination (**raw coverage**), and by all combinations of the solution (**solution coverage**). Moreover, FsQCA measures the **unique coverage** – the percentage of observations that are covered by only one combination of the solution, that is, which are not covered by multiple combinations (Ragin et al., 2017).

A causal condition can be said to be necessary – when it must be present for the outcome to occur – or sufficient – when it is able to cause the outcome alone (Ragin et al., 2017). Table 2 details the analysis of necessary causal conditions, while Table 3 specifies the analysis of their sufficiency.

For a causal condition to be necessary, its consistency must be greater than or equal to 0.900 (Carraro et al., 2019; Sjödin et al., 2016). Some researchers are more flexible in this regard, considering a threshold of 0.800 (Schneider et al., 2010). Thus, Table 2 demonstrates that the four capabilities can be considered necessary for high innovative performance. Even though the consistency of the development capability is below 0.900, it is above the 0.800 threshold.

Table 3 indicates that none of the causal conditions are sufficient because they must be combined with each other for the outcome to occur (Ragin et al., 2017). To consider a combination of causal conditions valid, its consistency and raw coverage values must be greater than 0.850 and 0.250, respectively (Rihoux & Ragin, 2008). Likewise, the solution's consistency and coverage must be greater than 0.750 and 0.250 (Woodside, 2013). Table 3 shows that all these cutoffs are met.

Therefore, Brazilian agricultural machinery firms innovate through two combinations of capabilities: DC*OC*MC (development, operations and management capabilities) or OC*TC (operations and transaction capabilities). The presence of the operations capability in both combinations suggests firms that tend to increase their operational efficiency (Moldner et al., 2020), reinforcing the perception that machinery and equipment manufacturers from emerging economies focus on production process

Table 2
Analysis of necessary causal conditions

Causal Conditions	Outcome: Innovative Performance (IP)	
	Consistency	Coverage
Development Capability (DC)	0.897	0.892
Operations Capability (OC)	0.934	0.889
Management Capability (MC)	0.948	0.886
Transactions Capability (TC)	0.961	0.880

Table 3
Analysis of sufficient causal conditions

Causal Conditions		Outcome: Innovative Performance (IP)	
		I	II
Development Capability (DC)		●	
Operations Capability (OC)		●	●
Management Capability (MC)		●	
Transactions Capability (TC)			●
Consistency		0.906	0.902
Raw Coverage		0.873	0.920
Unique Coverage		0.009	0.057
Overall solution consistency	0.898		
Overall solution coverage	0.929		

Note. ● = Causal condition must be present for the outcome to occur.

innovations (Acha et al., 2004; Kiamehr et al., 2015). However, high innovative performance is not achieved through operations capability alone.

To further explore each combination, Table 4 presents the firms' characteristics encompassed by their capabilities, such as product development triggers, average age of the industrial plant, managerial focus, pricing criteria, and recent improvements. Percentages were calculated considering the total number of observations in the sample (n = 103).

Table 4 demonstrates that process innovation happens mainly through improvements in manufacturing processes (44.7%) and equipment acquisition (30.1%). In most companies, the machinery used in production is, on average, 6 to 10 years old (59.2%), which can be considered new, since the average age of the Brazilian industrial park, considering different manufacturing sectors, is 17 years old (Instituto de Estudos para o Desenvolvimento Industrial, 2019). This focus on operations capability can also indicate a tendency to adopt lean production practices, such as SMED (Single Minute Exchange of Die), Kanban and Poka-Yoke, to reduce lead times, inventories, scrap and rework, in an effort to achieve operational excellence (Forrester et al., 2010).

The DC*OC*MC combination, although the presence of development capability, suggests firms only perform incremental enhancements to products, because the majority of improvements in this regard intend to reduce manufacturing costs or increase the quality of existing products (26.2% and 47.6%, respectively, totaling 73.8%), and are not much oriented to create new ones (24.3%). Furthermore, the development capability seems to be largely reactive to market needs, as product development is mostly triggered by factors external to the firms, such as compliance with legal requirements or consumer requests (9.7% and 46.6%, respectively, totaling 56.3%). Thus, it is probable that a considerable share of the approximately 8% of revenue invested in R&D activities by firms – a value similar to the 7% estimated for this industry by the Organisation for Economic Co-operation and Development (2016) – is applied to process innovations.

The presence of both development and operations capabilities indicates the application of mass customization principles, that is, the optimization of manufacturing processes through the design of modular products (Qi et al., 2020). Although some authors report the incorporation of mass customization practices in machinery and equipment firms

(Asadi et al., 2019; Trentin et al., 2015), more specific analyses are necessary to assume this.

The presence of management capability in the DC*OC*MC combination points to efforts to improve administrative procedures. Firms tend to focus its managerial activities on reducing costs, increasing efficiency or continuous improvement (81.3%). On the other hand, firms do little to implement new business strategies, with

Table 4
Analysis of innovation capabilities characteristics

Capability		Characteristic	%
Development Capability (DC)	Trigger for Product Development	Compliance with legal requirements	9.7%
		Consumers requests	46.6%
		Improvements of existing products	23.3%
		Increase of product portfolio	7.8%
		Invention	11.7%
		Missing	1.0%
		Total	**100%**
	Recent Product-Related Improvement	Reduction of manufacturing costs from existing products	26.2%
		Quality improvement of existing products	47.6%
		Development of new products, with higher added value	24.3%
		Missing	1.9%
		Total	**100%**
Operations Capability (OC)	Average Age of Industrial Plant	Up to five years	15.5%
		From six to 10 years	59.2%
		11 years and above	22.3%
		Missing	2.9%
		Total	**100%**
	Recent Production-Related Improvement	In manufacturing processes	44.7%
		Machinery and equipment acquisition	30.1%
		Changes in production system and layout	23.3%
		Missing	1.9%
		Total	**100%**
Management Capability (MC)	Managerial Focus	Cost reductions, efficiency increases, and continuous improvement	81.6%
		Goals achievement	13.6%
		Integration between areas and organizational change	4.9%
		Missing	0.0%
		Total	**100%**
	Recent Management-Related Improvement	In management systems and techniques	49.5%
		In business strategy	27.2%
		In organizational chart and job positions	13.6%
		In administrative infrastructure	8.7%
		Missing	1.0%
		Total	**100%**
Transactions Capability (TC)	Pricing Criteria	Determined by market	33.0%
		Determined by costs or mark-up	60.2%
		Determined by brand	6.8%
		Missing	0.0%
		Total	**100%**
	Recent Transactions-Related Improvement	In negotiation methods with consumers and suppliers	35.0%
		In price structure	18.4%
		In sales processes	26.2%
		In after sales processes	8.7%
		In distribution channels	10.7%
		In purchase processes	0.0%
		Missing	1.0%
		Total	**100%**

very few of them prioritizing organizational changes (4.9%). As the main changes in management take place in systems and techniques (49.5%), it appears that firms seek to adopt new, or upgrade their existing, managerial software (Sedera et al., 2016), such as ERPs (Enterprise Resource Planning), but mainly MRPs (Manufacturing Resource Planning), due the joint presence of operations capability. Moreover, the presence of development capability indicates that firms may also seek to optimize project management processes, in order to reduce costs and development times (Hobday, 2000).

By contrast, the OC*TC combination, given the presence of the transactions capability, indicates firms that focus on improving product commercialization (Kamboj & Rahman, 2017) through changes in sales (26.2%), after sales (8.7%), and distribution processes (10.7%), as well as in price structure (18.4%). However, little effort is made to enhance relations with suppliers (Zawislak et al., 2018), as the only item showing modifications in this regard was negotiation methodologies (35%). No firm indicated changes in its purchasing processes.

A transactions capability focused on consumers can lead to servitization, i.e., the addition of services to products (Baines et al., 2019). But, the absence of development and management capabilities in the OC*TC combination may suggest the incorporation of services that only involve changes in commercialization processes, such as technical assistance services, which merely complement the equipment (Jovanovic et al., 2019). Firms probably do not offer services that require technological modifications to the equipment and complex changes in the business model, strategy, and value proposition, like R&D services, which can improve users' products and processes (Frank et al., 2019). However, more specific studies about servitization in this industry are necessary to confirm this.

Again, regarding the OC*TC combination, firms tend to base their pricing criteria on internal costs (60.2%), rather than on prices imposed by the market (33%). This suggests they have strong bargaining power in relation to customers. The presence of both the transactions and operations capabilities indicates this bargaining power as sustained not only by negotiation skills, but also by short delivery times and high product quality, benefits of operational efficiency.

Table 5 synthesizes the results, indicating the main characteristics in each combination of capabilities that agricultural machinery firms must develop or improve to achieve high innovative performance.

The findings show that, while the operations capability is central to achieving high innovative performance, it is insufficient alone. Although equipment acquisitions on the technological frontier or the application of lean manufacturing practices, promote the development of new processes and lower production costs, they do not lead to innovation without other capabilities. To do so, firms choose between two paths: combining operations capability with development and management capabilities (DC*OC*MC), or with transactions capability (OC*TC).

In the DC*OC*MC combination, manufacturing excellence is complemented with incremental product improvement, and the optimization of management processes, especially those involved with product design and production planning, through software acquisition or upgrading. In the OC*TC combination, firms use their operational efficiency to improve their negotiation

Table 5
Main Characteristics of Capabilities Combinations for High Innovative Performance

Capabilities	Combinations	
	DC*OC*MC	**OC*TC**
Development Capability (DC)	• Adapts products to meet consumers' requests and legal requirements; • Improves the quality of existing products.	
Operations Capability (OC)	• Acquires technologically updated machinery; • Incorporates lean manufacturing practices.	• Acquires technologically updated machinery; • Incorporates lean manufacturing practices.
Management Capability (MC)	• Improves managerial processes; • Improves project management methods; • Acquires or upgrades managerial software.	
Transactions Capability (TC)		• Improves negotiation methods; • Improves sales, after sale and distribution processes; • Restructures the pricing method.

skills with customers, while enhancing their sales, after sales, and distribution processes, thus creating competitive advantages and restructuring their pricing procedures to increase profits.

5 Conclusion

It is important to understand innovation in the machinery and equipment industry due to its role in spreading technological progress to user sectors. Innovative agricultural machinery companies can support the development of more productive and sustainable processes, advancing agricultural producers towards Agriculture 4.0. This is partircullarly relevant in Brazil, one of the world's leading food and agricultural commodities producers. However, the literature on the machinery and equipment industry has lacked a broader approach towards innovation – a broad analysis of this industry's potential to generate new products, new processes, new management models and strategies, or new forms to negotiate with the market.

The study identified two combinations of capabilities that provide to agricultural machinery firms high innovative performance: DC*OC*MC (development, operations and management capabilities) and OC*TC (operations and transactions capabilities). These findings contribute to both academic and managerial fields. For scholars, the study opens up a new perspective on machinery and equipment manufacturers in emerging economies. Although previous studies have identified that firms in the industry tend to focus on process innovations, a result of operations capability, the present research shows that this capability alone is not enough for firms to achieve superior innovative performance. For managers, the findings show two paths for agricultural machinery firms to achieve high levels of innovation, thus companies can decide on the most suitable path for their businesses to succeed.

The findings also confirm the perception that Brazilian agricultural machinery frims concentrate on copying and adapting equipment designs developed abroad for local climates and soils. Although this strategy allows firms to innovate, a strategy focused on the development of totally new equipment might enable them to achieve world leadership, and even higher innovative performance. To offer significant productivity gains to producers, agricultural machinery manufacturers must establish R&D activities associated with the incorporation of software, hardware and artificial intelligence into the equipment. Otherwise, user industries may choose to acquire imported machinery to migrate to Agriculture 4.0, and Brazilian firms could lose competitiveness. The support of public policies that stimulate innovation is also important for this point.

This study has two limitations. First, the analysis only considers the firms' capabilities, and does not encompass the effects of other elements, such as geographical proximity, institutional contexts, or macroeconomic policies, on innovative performance. Second, although the sample is representative (with a response rate of 55%), it is restricted to one region of one country. Other Brazilian regions or other countries were not explored.

In future research, these two limitations can be overcome by adopting control variables and multi-group analysis. Moreover, in this study, fsQCA was applied to identify patterns across a large sample, with limited case knowledge. Future studies can apply fsQCA to identify specific patterns among a few agricultural machinery companies, and explore it based on deeper case knowledge. Lastly, future research could further the analysis of mass customization and servitization as innovation types in the machinery and equipment industry. These aspects are strongly associated with digital transformation, and transition of firms towards Industry 4.0. Although the findings suggest some elements of mass customization (DC*OC*MC) and servitization (OC*TC), more specific research are necessary to better explore these perceptions.

References

ACHA, V., BRUSONI, S., & PRENCIPE, A. (2007). Exploring the miracle: Strategy and management of the knowledge base in the aeronautics industry. *International Journal of Innovation and Technology Management*, *4*(1), 15-39. http://dx.doi.org/10.1142/S021987700700093X.

ACHA, V., DAVIES, A., HOBDAY, M., & SALTER, A. (2004). Exploring the capital goods economy: Complex product system in UK. *Industrial and Corporate Change*, *13*(3), 505-529. http://dx.doi.org/10.1093/icc/dth020.

ASADI, N., JACKSON, M., & FUNDIN, A. (2019). Implications of realizing mix flexibility in assembly systems for product modularity: A case study. *Journal of Manufacturing Systems*, *52*, 13-22. http://dx.doi.org/10.1016/j.jmsy.2019.04.010.

BAINES, T. S., BIGDELI, A. Z., SOUSA, R., & SCHROEDER, A. (2019). Framing the servitization transformation process: A model to understand and facilitate the servitization journey. *International Journal of Production Economics*, *221*, 1-16. http://dx.doi.org/10.1016/j.ijpe.2019.07.036.

Banco Nacional de Desenvolvimento Econômico e Social. (2019). *Quem pode ser cliente.* https://www.bndes.gov.br/wps/portal/site/home/financiamento/guia/quem-pode-ser-cliente/

BONAZZI, F. L. Z., & ZILBER, M. A. (2014). Inovação e modelo de negócio: Um estudo de caso sobre a integração do funil de inovação e o modelo Canvas. *Revista Brasileira de Gestão de Negócios*, *16*(53), 616-637. http://dx.doi.org/10.7819/rbgn.v16i53.1812.

CARRARO, R., MENESES, R., & BRITO, C. (2019). Combinação de categorias de práticas de controle de gestão para o alto desempenho de start-ups. *Revista Brasileira de Gestão de Negócios*, *21*(4), 861-878. http://dx.doi.org/10.7819/rbgn.v21i5.4022.

CHENG, C. F., CHANG, M. L., & LI, C. S. (2013). Configural paths to successful product innovation. *Journal of Business Research*, *66*(12), 2561-2573. http://dx.doi.org/10.1016/j.jbusres.2012.10.006.

Confederação Nacional da Indústria – CNI. (2020). http://perfildaindustria.portaldaindustria.com.br/estado/rs

DAN, S. M., SPAID, B. I., & NOBLE, C. H. (2018). Exploring the sources of design innovations: Insights from the computer, communications and audio equipment industries. *Research Policy*, *47*(8), 1495-1504. http://dx.doi.org/10.1016/j.respol.2018.05.004.

DOSI, G., FAILLO, M., & MARENGO, L. (2004). Organizational capabilities, patterns of knowledge accumulation and governance structures in business firms. *Organization Studies*, *29*(8), 1165-1185. http://dx.doi.org/10.1177/0170840608094775.

DUTRÉNIT, G., NATERA, J. M., ANYUL, M. P., & VERA-CRUZ, A. O. (2019). Development profiles and accumulation of technological capabilities in Latin America. *Technological Forecasting and Social Change*, *145*, 396-412. http://dx.doi.org/10.1016/j.techfore.2018.03.026.

FIERRO MORENO, E., CANTÚ MATA, J. L., MARTÍNEZ BELLO, J., & HERNÁN LÓPEZ, O. (2015). Predictores de la innovación administrativa: Funciones y métodos organizacionales en hospitales de México y de Colombia. *Revista Brasileira de Gestão de Negócios*, *17*(54), 806-821. http://dx.doi.org/10.7819/rbgn.v17i54.1820.

FIGUEIREDO, P. N., LARSEN, H., & HANSEN, U. E. (2020). The role of interactive learning in innovation capability building in multinational subsidiaries: A micro-level study of biotechnology in Brazil. *Research Policy*, *49*(6), 103995. http://dx.doi.org/10.1016/j.respol.2020.103995.

FISS, P., SHARAPOV, D., & CRONQVIST, L. (2013). Opposites attract? Opportunities and challenges for integrating large-n QCA and econometric analysis. *Political Research Quarterly*, *66*(1), 191-234. http://dx.doi.org/10.1177/1065912912468269e.

Food and Agriculture Organization of the United Nations – FAO. (2017). *The state of food and agriculture: Leveraging food system for inclusive rural transformation.* http://www.fao.org/3/a-i7658e.pdf

FORRESTER, P. L., SHIMIZU, U. K., SORIANO-MEIER, H., GARZA-REIS, J. A., & BASSO, L. F. C. (2010). Lean production, market-share and value creation in the agricultural machinery sector in Brazil. *Journal of Manufacturing Technology Management*, *21*(7), 853-871. http://dx.doi.org/10.1108/17410381011077955.

FRANCIS, D., & BESSANT, J. (2005). Targeting innovation and implications for capability development. *Technovation*, *25*(3), 171-183. http://dx.doi.org/10.1016/j.technovation.2004.03.004.

FRANK, A., MENDES, G. H. S., AYALA, N. F., & GHEZZI, A. (2019). Servitization and industry 4.0 convergence in the digital transformation of product firms: A business model innovation perspective. *Technological Forecasting and Social Change*, *141*, 341-351. http://dx.doi.org/10.1016/j.techfore.2019.01.014.

GALHARDI, A. C., & ZACARELLI, S. B. (2005). Inovação e imitação tecnológica como estratégia competitiva. *Revista Brasileira de Gestão de Negócios*, *7*(17), 23-29. http://dx.doi.org/10.7819/rbgn.v7i17.32.

GANTER, A., & HECKER, A. (2014). Configurational paths to organizational innovation: Qualitative comparative analyses of antecedents and contingencies. *Journal of Business Research*, *67*(6), 1285-1292. http://dx.doi.org/10.1016/j.jbusres.2013.03.004.

GASPAR, R. M., HENRIQUES, P. L., & CORRENTE, A. R. (2020). Trust in financial markets: The role of the human element. *Revista Brasileira de Gestão de Negócios*, *22*(3), 647-668. http://dx.doi.org/10.7819/rbgn.v22i3.4072.

GOEDHUYS, M., & VEUGELERS, R. (2012). Innovation strategies, process and product innovations and growth: Firm level evidence from Brazil. *Structural Change and Economic Dynamics*, *23*(4), 516-529. http://dx.doi.org/10.1016/j.strueco.2011.01.004.

GUAN, J., & MA, N. (2003). Innovative capability and export performance of chinese firms. *Technovation*, *23*(9), 737-747. http://dx.doi.org/10.1016/S0166-4972(02)00013-5.

HAIR, J. F., BLACK, W. C., BABIN, B. J., ANDERSON, R. E., & TATHAM, R. L. (2014). *Multivariate data analysis.* London: Pearson.

HOBDAY, M. (2000). The project-based organisation: An ideal form for managing complex products and systems? *Research Policy*, *29*(7-8), 871-893. http://dx.doi.org/10.1016/S0048-7333(00)00110-4.

HOBDAY, M., & RUSH, H. (2007). Upgrading the technological capabilities of foreign transnational subsidiaries in developing countries: The case of electronics in Thailand. *Research Policy*, *36*(9), 1335-1356. http://dx.doi.org/10.1016/j.respol.2007.05.004.

HOPP, W., & SPEARMAN, M. (2021). The lenses of lean: Visioning the science and practice of efficiency. *Journal of Operations Management*, *67*(5), 610-626. http://dx.doi.org/10.1002/joom.1115.

HSIAO, J. P., JAW, C., HUAN, T. C., & WOODSIDE, A. G. (2015). Applying complexity theory to solve hospitality contrarian case conundrums. *International Journal of Contemporary Hospitality Management*, *27*(4), 608-647. http://dx.doi.org/10.1108/IJCHM-11-2013-0533.

Instituto de Estudos para o Desenvolvimento Industrial – IEDI. (2019). *A indústria do futuro no Brasil e no mundo.* https://iedi.org.br/media/site/artigos/20190311_industria_do_futuro_no_brasil_e_no_mundo.pdf

JANSSEN, M. J., CASTALDI, C., & ALEXIEV, A. (2016). Dynamic capabilities for service innovation: Conceptualization and measurement. *R & D Management*, *46*(4), 797-811. http://dx.doi.org/10.1111/radm.12147.

JOVANOVIC, M., RAJA, J., VISNJIC, I., & WIENGARTEN, F. (2019). Paths to service capability development for servitization: Examining an internal service ecosystem. *Journal of Business Research*, *104*, 472-485. http://dx.doi.org/10.1016/j.jbusres.2019.05.015.

KAMBOJ, S., & RAHMAN, Z. (2017). Market orientation, marketing capabilities and sustainable consumption: The mediating role of sustainable consumption and competitive advantage. *Management Research Review*, *40*(6), 698-724. http://dx.doi.org/10.1108/MRR-09-2014-0225.

KIAMEHR, M., HOBDAY, M., & HAMEDI, M. (2015). Latecomer firm strategies in complex product systems (CoPS): The case of Iran's thermal electricity generation systems. *Research Policy*, *44*(6), 1240-1251. http://dx.doi.org/10.1016/j.respol.2015.02.005.

KUEHN, D., CROISSANT, A., KAMERLING, J., LUEDERS, H., & STRECKER, A. (2017). Conditions of civilian control in new democracies: An empirical analysis of 28 'third wave' democracies. *European Political Science Review*, *9*(3), 425-447. http://dx.doi.org/10.1017/S1755773916000011.

LALL, S. (1992). Technological capabilities and industrialization. *World Development*, *20*(2), 165-186. http://dx.doi.org/10.1016/0305-750X(92)90097-F.

LAWSON, B., & SAMSON, D. (2001). Developing innovation capability in organizations: A dynamic capabilities approach. *International Journal of Innovation Management*, *5*(3), 377-400. http://dx.doi.org/10.1142/S1363919601000427.

LEE, R., LEE, J., & GARRET, T. (2017). Synergy effects of innovation on firm performance. *Journal of Business*

Research, *99*, 507-515. http://dx.doi.org/10.1016/j.jbusres.2017.08.032.

LEISCHNIG, A., & KASPER-BRAUER, K. (2015). Employee adaptive behavior in service enactments. *Journal of Business Research*, *68*(2), 273-280. http://dx.doi.org/10.1016/j.jbusres.2014.07.008.

LI, X., WU, Q., HOLSAPPLE, C. W., & GOLDSBY, T. (2016). An empirical examination of firm financial performance along dimensions of supply chain resilience. *Management Research Review*, *40*(3), 254-269. http://dx.doi.org/10.1108/MRR-02-2016-0030.

MAGACHO, G. R., & MCCOMBIE, J. S. L. (2017). A sectoral explanation of per capita income convergence and divergence: Estimating Verdoorn's law for countries at different stages of development. *Cambridge Journal of Economics*, *2018*(42), 917-934. http://dx.doi.org/10.1093/cje/bex064.

MOLDNER, A. K., GARZA-REYES, J. A., & KUMAR, V. (2020). Exploring lean manufacturing pratices´ influence on process innovation performance. *Journal of Business Research*, *106*, 233-249. http://dx.doi.org/10.1016/j.jbusres.2018.09.002.

MULLER, J. M., BULIGA, O., & VOIGT, K. I. (2018). Fortune favors the prepared: How SMEs approach business model innovation in Industry 4.0. *Technological Forecasting and Social Change*, *132*, 2-17. http://dx.doi.org/10.1016/j.techfore.2017.12.019.

NAGANO, M. S., STEFANOVITZ, J. P., & VICK, T. E. (2014). Caracterização de processos e desafios de empresas industriais brasileiras na gestão da inovação. *Revista Brasileira de Gestão de Negócios*, *16*(51), 163-179. http://dx.doi.org/10.7819/rbgn.v16i51.1426.

Organisation for Economic Co-operation and Development – OECD. (2016). *OECD taxonomy for economic activities based on R&D intensity* (OECD Science, Technology and Industry Working Papers). Paris: OECD Publishing. http://doi.org/10.1787/18151965.

PAPPAS, I., & WOODSIDE, A. (2021). Fuzzy-set qualitative comparative Analysis (fsQCA): Guidelines for research practice in information systems and marketing. *International Journal of Information Management*, *58*, 3-23. http://dx.doi.org/10.1016/j.ijinfomgt.2021.102310.

PARENTE, T. C., & FEDERO, R. (2019). Qualitative comparative analysis: Justifying a neo-configurational approach in management research. *RAUSP Management Journal*, *54*(4), 399-412. http://dx.doi.org/10.1108/RAUSP-05-2019-0089.

QI, Y., MAO, Z., ZHANG, M., & GUO, H. (2020). Manufacturing practices and servitization: The role of mass customization and product innovation capabilities. *International Journal of Production Economics*, *228*, 2-10. http://dx.doi.org/10.1016/j.ijpe.2020.107747.

RAGIN, C. C. (1987). *The comparative method: Moving beyond qualitative and quantitative strategies.* Los Angeles: University of California Press.

RAGIN, C. C., PATROS, T., STRAND, S., & RUBINSON, C. (2017). *User's guide to fuzzy-set/qualitative comparative analysis.* Tucson: University of Arizona.

REICHERT, F. M., & ZAWISLAK, P. A. (2014). Technological capability and firm performance. *Journal of Technology Management & Innovation*, *9*(4), 20-35. http://dx.doi.org/10.4067/S0718-27242014000400002.

REICHERT, F. M., TORUGSA, A. N., ZAWISLAK, P. A., & ARUNDEL, A. (2016). Exploring innovation success recipes in low-technology firms using fuzzy-set QCA. *Journal of Business Research*, *69*(11), 5437-5441. http://dx.doi.org/10.1016/j.jbusres.2016.04.151.

RIHOUX, B. (2006). Qualitative comparative analysis (QCA) and related systematic comparative methods: Recent advances and remaining challenges for social science research. *International Sociology*, *21*(5), 679-706. http://dx.doi.org/10.1177/0268580906067836.

RIHOUX, B., & RAGIN, C. C. (2008). *Configurational comparative methods: Qualitative comparative analysis (QCA).* Los Angeles: Sage Publications.

ROIG-TIERNO, N., GONZALEZ-CRUZ, T. F., & LLOPIS-MARTINEZ, J. (2017). An overview of qualitative comparative analyses: A bibliometric analyses. *Journal of Innovation & Knowledge*, *2*(1), 15-23. http://dx.doi.org/10.1016/j.jik.2016.12.002.

RUFFONI, E., D'ANDREA, F., CHAVES, J., ZAWISLAK, P., & TELLO-GAMARRA, J. (2018). R&D investment and the arrangement of innovation capabilities in Brazilian manufacturing firms. *Journal of Technology Management & Innovation*, *13*(4), 74-83. http://dx.doi.org/10.4067/S0718-27242018000400074.

SCHNEIDER, M. R., SCHULZE-BENTROP, C., & PAUNESCU, M. (2010). Mapping the institutional capital of high-tech firms: A fuzzy-set analysis of capitalist variety and export performance. *Journal of International Business Studies*, *41*(2), 246-266. http://dx.doi.org/10.1057/jibs.2009.36.

SEDERA, D., LOKUGE, S., GROVER, V., SARKER, S., & SARKER, S. (2016). Innovating with enterprise systems and digital platforms: A contingency resource-based theory. *Information & Management*, *53*(3), 366-379. http://dx.doi.org/10.1016/j.im.2016.01.001.

SJÖDIN, D. R., PARIDA, V., & KOHTAMÄKI, M. (2016). Capability configurations for advanced service offerings in manufacturing firms: Using fuzzy-set qualitative comparative analyses. *Journal of Business Research*, *69*(11), 5330-5335. http://dx.doi.org/10.1016/j.jbusres.2016.04.133.

TEECE, D. (2007). Explicating dynamic capabilities: The nature and microfoundations of (sustainable) enterprise performance. *Strategic Management Journal*, *28*(13), 1319-1350. http://dx.doi.org/10.1002/smj.640.

TEECE, D. (2018). Dynamic capabilities as (workable) management systems theory. *Journal of Management & Organization*, *24*(3), 359-368. http://dx.doi.org/10.1017/jmo.2017.75.

TEHSEEN, S., RAMAYAH, T., & SAJILAN, S. (2017). Testing and controlling for common method variance: A review of available methods. *Journal of Management Sciences*, *4*(2), 142-168. http://dx.doi.org/10.20547/jms.2014.1704202.

THO, N. D., & TRANG, N. T. M. (2015). Can knowledge be transferred from business schools to business organizations through in-service training students? SEM and fsQCA findings. *Journal of Business Research*, *68*(6), 1332-1340. http://dx.doi.org/10.1016/j.jbusres.2014.12.003.

TOLEDO, J. C., & SIMÕES, J. M. S. (2010). Gestão do desenvolvimento de produto em empresas de pequeno e médio porte do setor de máquinas e implementos agrícolas do Estado de São Paulo. *Revista Gestão e Produção*, *17*(2), 257-269. http://dx.doi.org/10.1590/S0104-530X2010000200004.

TRENTIN, A., FORZA, C., & PERIN, E. (2015). Embeddedness and path dependence of organization capabilities for mass customization and green management: A longitudinal case study in the machinery industry. *International Journal of Production Economics*, *169*, 253-276. http://dx.doi.org/10.1016/j.ijpe.2015.08.011.

VIAN, C. E. F., ANDRADE Jr., A. M., BARICELO, L. G., & SILVA, R. P. (2013). Origens, evolução e tendências da indústria de máquinas agrícolas. *Revista de Economia e Sociologia Rural*, *51*(4), 719-744. http://dx.doi.org/10.1590/S0103-20032013000400006.

VIEIRA Fo., J. E. R., & FISHLOW, A. (2017). *Agricultura e indústria no Brasil: Inovação e competitividade*. Brasília: Ipea.

VIS, B. (2012). The comparative advantages of fsQCA and regression analysis for moderately large-N analyses. *Sociological Methods & Research*, *41*(1), 168-198. http://dx.doi.org/10.1177/0049124112442142.

WOLFERT, S., GE, L., VERDOUW, C., & BOGAARDT, M. J. (2017). Big data in smart farming: A review. *Agricultural Systems*, *153*, 69-80. http://dx.doi.org/10.1016/j.agsy.2017.01.023.

WOODSIDE, A. G. (2013). Moving beyond multiple regression analysis to algorithms: Calling for adoption of a paradigm shift from symmetric to asymmetric thinking in data analysis and crafting theory. *Journal of Business Research*, *66*(4), 463-472. http://dx.doi.org/10.1016/j.jbusres.2012.12.021.

ZAWISLAK, P. A., ALVES, A., TELLO-GAMARRA, J., BARBIEUX, D., & REICHERT, F. M. (2012). Innovation capability: From technology development to transaction capability. *Journal of Technology Management & Innovation*, *7*(2), 14-27. http://dx.doi.org/10.4067/S0718-27242012000200002.

ZAWISLAK, P. A., FRACASSO, E., & TELLO-GAMARRA, J. (2018). Technological intensity and innovation capability in industrial firms. *Innovation & Management Review*, *15*(2), 189-207. http://dx.doi.org/10.1108/INMR-04-2018-012.

ZHOU, K. Z., & WU, F. (2010). Technological capability, strategic flexibility, and product innovation. *Strategic Management Journal*, *31*, 547-561. http://dx.doi.org/10.1002/smj.830.

APPENDIX – QUESTIONNAIRE

DEVELOPMENT CAPABILITY

Your company...	Strongly Disagree			Strongly Agree	
Designs its own products	☐1	☐2	☐3	☐4	☐5
Monitors the industry's latest technological trends	☐1	☐2	☐3	☐4	☐5
Uses formal project management methods (Stage-Gate, PMBOK, innovational funnel, …)	☐1	☐2	☐3	☐4	☐5
Adapts technologies in use to its own needs	☐1	☐2	☐3	☐4	☐5
Prototypes its own products	☐1	☐2	☐3	☐4	☐5
Develops products in partnership with Science and Technology Institutions	☐1	☐2	☐3	☐4	☐5
Launches its own products	☐1	☐2	☐3	☐4	☐5

What triggers product development (choose one option)?		
( ) Compliance with legal requirements	( ) Consumers' requests	( ) Improvements of existing products
( ) Increase of product portfolio	( ) Invention	

The most recent product-related improvements were (choose one option):		
( ) Development of new products, with higher added value	( ) Quality improvements of existing products	( ) Reductions of manufacturing costs of existing products

OPERATIONS CAPABILITY

Your company...	Strongly Disagree			Strongly Agree	
Formalizes production planning and control procedures	☐1	☐2	☐3	☐4	☐5
Maintains statistical control of processes	☐1	☐2	☐3	☐4	☐5
Uses up-to-date equipment, at the industry technological frontier	☐1	☐2	☐3	☐4	☐5
Maintains an appropriate materials inventory level for processes	☐1	☐2	☐3	☐4	☐5
Carries out productive processes as scheduled	☐1	☐2	☐3	☐4	☐5
Establishes a productive routine that does not generate rework	☐1	☐2	☐3	☐4	☐5
Delivers products promptly	☐1	☐2	☐3	☐4	☐5
Expands installed capacity whenever is necessary	☐1	☐2	☐3	☐4	☐5
Ensures that a process does not generate product returns	☐1	☐2	☐3	☐4	☐5

The most recent production-related improvements were (choose one option):		
( ) In manufacturing processes	( ) Machinery and equipment acquisition	( ) In production system
( ) In layout	( ) New industrial plant	

What is the average age (in years) of the machinery and equipment in use? _____.

MANAGEMENT CAPABILITY

Your company...	Strongly Disagree				Strongly Agree
Formally defines its strategic objectives annually	☐1	☐2	☐3	☐4	☐5
Integrates all areas with information technology	☐1	☐2	☐3	☐4	☐5
Standardizes and documents different work procedures	☐1	☐2	☐3	☐4	☐5
Updates its management tools and techniques	☐1	☐2	☐3	☐4	☐5
Maintains employees adequately trained for their job functions	☐1	☐2	☐3	☐4	☐5
Uses modern financial management practices	☐1	☐2	☐3	☐4	☐5
Includes social and environmental responsibilities on its strategic agenda	☐1	☐2	☐3	☐4	☐5

The company's main managerial focus is (choose one option):		
( ) Cost reductions	( ) Efficiency increases	( ) Continuous improvement
( ) Goals achievement	( ) Integration between areas	( ) Organizational change

The most recent management-related improvements were (choose one option):	
( ) In management systems and techniques	( ) In business strategy
( ) In the organizational chart	( ) In job positions and salaries
( ) In the board of directors and manager staff	( ) In administrative infrastructure (physical base and equipment)

TRANSACTIONS CAPABILITY

Your company...	Strongly Disagree				Strongly Agree
Conducts formal research to monitor the market	☐1	☐2	☐3	☐4	☐5
Imposes negotiating terms on its suppliers	☐1	☐2	☐3	☐4	☐5
Imposes its prices on the market	☐1	☐2	☐3	☐4	☐5
Imposes negotiating terms on its customers	☐1	☐2	☐3	☐4	☐5
Conducts surveys to measure customer satisfaction	☐1	☐2	☐3	☐4	☐5
Uses formal criteria for supplier selection	☐1	☐2	☐3	☐4	☐5

How is price determined (choose one option)?		
( ) By the competition	( ) By internal costs	( ) By consumers
( ) By the brand	( ) By mark-up	

The most recent transactions-related improvements were (choose one option):	
( ) In customer service	( ) In negotiations
( ) In sales channels	( ) In product distribution
( ) In pricing	( ) In purchase procedures
( ) In sales procedures	( ) In after-sales

INNOVATIVE PERFORMANCE

In your company...	Strongly Disagree				Strongly Agree
Net profit has grown continuously over the last 3 years	☐1	☐2	☐3	☐4	☐5
Market share has grown continuously over the last 3 years	☐1	☐2	☐3	☐4	☐5
Revenue has grown continuously over the last 3 years	☐1	☐2	☐3	☐4	☐5

GENERAL DATA

Approximate company annual revenue in last year (choose one option):	
( ) Less than or equal to R$ 360 thousand	( ) Between R$ 360 thousand and R$ 4.8 million
( ) Between R$ 4.8 million and R$ 300 million	( ) Above R$ 300 million

What percentage of annual revenue is invested in R&D (research and development)? _____

Financial support:
CNPq (*Conselho Nacional de Desenvolvimento Científico e Tecnológico*) and FAPERGS (*Fundação de Amparo à Pesquisa do Estado do Rio Grande do Sul*).

Conflicts of interest:
The authors have no conflict of interest to declare.

Plagiarism analysis:
RBGN performs plagiarism analysis on all its articles at the time of submission and after approval of the manuscript using the iThenticate tool.

Authors:
1. Estêvão Passuello Ruffoni, Master in Business, Federal University of Rio Grande do Sul (UFRGS), Porto Alegre, Brasil.
E-mail: epruffoni@hotmail.com
2. Fernanda Maciel Reichert, PhD in Business, Federal University of Rio Grande do Sul (UFRGS), Porto Alegre, Brasil.
E-mail: fernanda.reichert@ufrgs.br

Authors' contributions:
1st author: Definition of research problem; Development of hypotheses or research questions (empirical studies); Definition of methodological procedures; Data collection; Literature review; Statistical analysis; Analysis and interpretation of data; Critical revision of the manuscript; Manuscript writing.
2nd author: Definition of research problem; Development of hypotheses or research questions (empirical studies); Definition of methodological procedures; Literature review; Statistical analysis; Analysis and interpretation of data; Critical revision of the manuscript.