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The effect of interlocking directorates on mergers and acquisitions in Brazil

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Abstract

This study investigates the effect of interlocking directorates on national and international mergers and acquisitions (M&A) in Brazil. Based on a sample of 153 large Brazilian firms in a time series (2000–2015), and using network techniques and regression analysis, this study addresses the hypothesis: board interlocking reduces the asymmetry of information in M&A, leading companies with a greater number of ties (degree centrality) to be more likely to participate in M&A. The results show that firms that have a larger number of ties with other firms through board interlocks (higher degree centrality) are more likely to perform M&A. Other network measures (closeness, eigenvector, betweenness, and structural holes) have no significant impact on the likelihood to participate in M&A. This study examines the impact of board interlocking on firms' propensity to undertake M&A while controlling for financial, corporate governance, and country-level governance variables in the explanatory model. This paper also contributes by identifying the determinants of M&A performed by companies headquartered in emerging countries such as Brazil, a major participant in M&A processes at the international level.

Keywords Interlocking directorates · Mergers and acquisitions · Country-level governance · Brazil · International level · Regression analysis

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1 Introduction

Why are some firms more likely to participate in mergers and acquisitions (M&A) than others? Many factors are considered when a firm decides to undertake M&A, from the maximization of market power and gains from economies of scale to acquiring knowledge, gaining access to funding, and a reduction in the cost of capital (Brigham and Daves 2014; Gaughan 2015; Lee et al. 2018; MacNab and Worthley 2013; Stankevičienė et al. 2014). In all motivating factors, access to information from other firms is present and becomes a critical element in the board of directors' decision to initiate M&A. Interlocking directorates (or board interlocking)—corporate ties formed when directors sit in several boards—are channels that contribute to the selection and filtering of relevant information (Burt 1997; Podolny 1994), and reduce costs related to the board's access to information (Nahapiet et al. 1998).

Therefore, board interlocking constitutes a device that can provide information on the experiences of other companies with M&A. During M&A, board members can use information gained while serving on other boards regarding the politics of negotiation, relationships with investment banks, and regulatory aspects. Board members can access information concerning similar acquisitions in the past and learn from mistakes and successes (Beckman and Haunschild 2002). More importantly, board interlocking can be a means of providing information about companies for potential acquisition, enabling the goals of the operation to be more efficiently identified, and substantially reducing research costs (Bruner, 2016). In addition, a firm can make more attractive acquisitions given the reduction in the asymmetry of information, transaction costs and adverse selection problems associated with target company opportunistic behavior (Akerlof 1970; Myers and Majluf 1984; Zhang 2016). M&A is often related to the level of industry shocks (Harford 2005; Mitchell and Mulherin 1996), and interlocking directorates can facilitate obtaining important information regarding new conditions within the segment and whether they involve regulatory changes (Andrade et al. 2001), or technological innovation (Andrade and Stafford 2004). This can lead, for example, to a firm's better positioning during periods that are conducive to M&A.

The aim of this paper is to test the relationship between interlocking directorates and M&A, specifically to find out whether board interlocks have a significant effect on a company's propensity to undertake M&A at national and international levels. When connections among directors of multiple firms are absent, the cost of information gathering on, selecting, and screening the most important firms is higher (Burt, 1997; Darmadi and Gunawan 2013; Nahapiet and Ghoshal 1998; Zhang 2016). In contrast, the presence of directors connected with other firms within the corporate network can mitigate selection problems and reduce the asymmetry of information (Sparrowe et al. 2001; Tsai 2002). Under this focus, based on a sample of 153 Brazilian firms in a time series (2000–2015), and using network techniques and regression analysis, we address the hypothesis: board interlocking reduces the asymmetry of information in M&A, leading companies with a large number of ties (degree centrality) to be more likely to participate in M&A.

Our case study is particularly relevant because Brazil, the largest economy in Latin America and an illustrative example of an emerging economy, has triggered a wave of M&A this century thanks to the growth of national business groups and large investments abroad (Pires-Alves et al. 2019). For example, JBS, a meat processing company, reported to be a central node in the corporate network of interlocking directorates by previous studies (Cárdenas 2015), has become the largest meat packer in the world after acquiring companies in Brazil and abroad, such as Swift Armor (Argentina), 50% of Inalca (Italy), Swift (United States), Tasman (Australia), 64% of Pilgrim's Pride (United States), Rigamonti (Italy) and Seara (Brazil).

Several studies have investigated aspects of the real and financial factors involved in M&A (Ahern et al. 2015; Erel et al. 2012; Forssbæck and Oxelheim 2011; Loukianova et al. 2017). However, the most recent studies have not addressed the impact of board interlocking in terms of a firm's propensity to undertake M&A while addressing financial and corporate governance variables in the adopted model (Agrawal and Knoeber 2012; Fraser and Zhang 2009), and the characteristics of the countries in which target companies are located (Moctar and Xiaofang 2014; Verma and Sharma 2014), which can directly affect M&A.[1] This study aims to contribute by filling this gap in the research, particularly in light of the current situation, in which emerging countries have come to play a significant role in the global economy, with Brazil being a major participant in M&A processes. This study also considers the limited research that empirically analyzes the determinants of M&A performed by companies headquartered in emerging countries (Fornes and Butt-Philip 2011; Holtbrügge and Kreppel 2012; Pusterla and Goldstein 2010; Yang 2015) and includes country-level variables which have not yet been investigated in similar studies.

This article is organized into five sections, including this introduction. Section 2 presents the theoretical and empirical bases regarding the relationship between board interlocking and the propensity to perform M&A. Section 3 details the methodological procedures that we have adopted in this study. The results are presented in Sect. 4. Finally, in Sect. 5 we outline our final considerations.

2 Theoretical and empirical platform

A core issue in the corporate governance literature is the nature of networks among corporations. Corporate networks in general and board interlocks in particular have been shown to affect firm processes and outcomes, see Caiazza and Simoni (2019) for a review. Unlike other corporate ties such as joint ventures, and supplier-customer relationships, board interlocks involve the top decision-makers in firms, ensure face-to-face meetings, two-way communication, and configure relatively stable structures

[1] Evidence of the impact of these macro-environmental variables on M&A can be observed in the finance and economics media. According to *The Economist* (The Economist 2016), the M&A announced in the first 9 months of 2016 amounted to US$ 2.5 trillion, 24% less than during the same period in 2015—the first decline in 3 years. The main reasons discouraging potential buyers were the vote of Britain to leave the European Union, uncertainty regarding the US presidential elections, and a decrease in raising capital.

(Knoke 2018). The two major perspectives to viewing board interlocks, as a managerial phenomenon and a sociological anchor, also involve two focuses of interest: the firm's position, and the entire network structure. The dominant perspective in management studies, based on the resource dependence theory, theorizes that firms reduce uncertainty and mitigate the risk of business activities by connecting with the boards of other companies. These studies focused on node-level centrality measures to explain firm behavior (Kopoboru et al. 2020). From a more sociological perspective, board interlocks are mechanisms used for the social cohesion of business elites. Therefore, the main interest lies in the whole network configuration shaped by the set of board interlocks (Mizruchi 1996). Here, network-level measures such as density have been used to understand corporate networks. Peng and Wang (2019) pointed out that the network-level dimension of board interlocks is underexplored in terms of understanding M&A processes despite the vast literature on the drivers of M&A. Although both perspectives are complementary, a relative lack of integration has prevailed when analyzing the impacts of board interlocking. Yet, even though these two perspectives have motivated an extensive number of studies, few studies address the two together. We attempt to integrate them by incorporating node-level centrality and network-level cohesion measures to investigate the role of board interlocking on M&A.

Given the importance of M&A in the global corporate environment,[2] many researchers have studied the subject in recent years (Bena and Li 2014; Kalodimos and Lundberg 2017; Lee et al. 2018; Loukianova et al. 2017; Qian and Zhu 2017). A large body of research has emphasized the importance of interlocking directorates as a means of producing benefits in processes that precede M&A (Akerlof 1970; Beckman and Haunschild 2002; Bruner 2016). Cai and Sevilir (2012) have noted that improvements brought about by interlocking directorates to the flow of information and communication among companies can affect the acquisition premium and, consequently, the transaction price of a deal, and can also inhibit the entry of external competitors which do not have board interlocks with the company being acquired. Singh and Schonlau (2009) investigate the repercussions of interlocking directorates on the performance of business concentrations and infer that the post-merger financial performance of acquired companies with extensive connections between boards (i.e., high degree centrality) is significantly better than the performance of less connected (i.e., non-central) boards. They also note that networks of interlocking directorates could affect the decision to acquire, the choice of target companies, the payment method and the company's financial performance in regard to a merger.

These results are in line with evidence collected by Nawfal (2011), who has investigated the same problem in the Canadian market and found that when one or more directors are shared between companies that transact, higher cumulative abnormal returns occur in the target and acquiring company. In addition, directors

[2] The global recovery of foreign direct investment (FDI) was strong in 2015, with global FDI flows increasing by 38%, their highest level since the 2008 crisis. This is the main factor behind the global economic recovery, as the total value of cross-border M&A increased from US$ 432 billion in 2014 to US$ 721 billion in 2015 (Burksaitiene and Garskaite-Milvydiene 2017).

with many connections tend to use equity as a form of payment, particularly when the acquirer's stock value is unknown (Wu 2017). Thus, an acquisition is more likely to occur between two interconnected companies because offers made under these conditions have a higher completion rate (Wu 2017). Zhang (2016) has studied the impact of board interlocking on M&A decisions, differentiating between vertical, horizontal and mixed mergers. This empirical analysis shows that if two companies are connected and one decides to perform M&A, it is more likely that the other firm will become the target. Besides, when the acquiring company is from a different market sector than the target company, interlocking directorates affect M&A with a more significant effect in terms of vertical mergers than in terms of horizontal or mixed ones.

Overall, the evidence suggests that interlocking directors mitigate inefficiencies that arise from asymmetries of information in M&A. Interlocking firms are more likely to be selected as targets, particularly when there is greater asymmetry of information regarding the target firm, or when the acquirer is financially constrained. But M&A is not restricted to interlocking firms, i.e., targeted firms are not necessarily those to which the acquiring firm was interlocked prior to the acquisition. Large companies find some of the necessary resources to capture other businesses through board interlocks. For example, since early 2012 the Alibaba Group has shifted gears and moved from organic growth and partnerships to high-speed growth by M&A in complementary technology fields. It has been expanding in finance, healthcare, travel, cinema, and other sectors (Greeven et al. 2016). Yet, this accelerated growth movement has, at least in part, been supported by a deliberate strategy of filling the company's board with people from other companies to connect the firm with other clusters and sectors, such as venture capital firms (Jia and Winseck 2018). Therefore, board interlocks can provide both information about specific firms that can be targeted for acquisition and information about the business sector, business shocks, and regulation to perform more M&A (Beckman and Haunschild 2002; Bruner 2016).

In addition, prior studies have shown that factors exogenous to firms, such as legal and regulatory aspects and an industry's technological shocks, may affect M&A and also board interlocks (Braun et al. 2019; Mizruchi 2013). For example, in adverse crisis scenarios, like the 2008 Financial Crisis, companies may seek to strengthen ties with financial firms, which benefit both sides. Banks reduce uncertainties regarding the investment made in companies by holding a seat on the board, whereas non-financial firms use the financial leverage and know-how of banking executives to mitigate the effects of the crisis. We expect, therefore, an increase in the cohesion of the whole network after 2008, which could lead to a greater propensity to undertake M&A.

3 Methods

The objective of this study is to empirically test whether the centrality of firms in the network of interlocking directorates influences the likelihood that these companies will undertake M&A, focusing on deals made on the domestic and international

markets. In order to corroborate the results and the theoretical framework, we will also examine the effects of the whole network's cohesion and the country's characteristics on M&A.

3.1 Data collection and variables

Our results are based on a sample of 153 large publicly listed companies in Brazil. Data come from three different sources: (i) data on boards of directors of listed Brazilian companies obtained from the Brazilian Securities and Exchange Commission (Comissão de Valores Mobiliários—CVM); (ii) data on M&A deals extracted from Thomson Reuters; and iii) financial variables compiled in corporate financial statements from Bloomberg. Moreover, we include country-level variables from the worldview governance indicators (Kaufmann et al. 2011).

The variables listed in Table 1 constitute the model and are aggregated and presented in Table 2 according to their use in the estimates.

Having described the variables, we address issues related to endogeneity and robustness testing. Then, we describe the econometric model's identification strategy.

3.2 Endogeneity and robustness testing

The literature has noted endogeneity problems in corporate governance research (Wintoki et al. 2012). These problems are primarily due to self-selection characteristics or reverse causality (Kai and Prabhala 2007). The model proposed in this article does not contemplate instrumental variables or simultaneous equations (Black and Kim 2012). In addition, there is no robust theoretical background on endogeneity in relational variables, which are the type used in the estimates (Johnson et al. 2013). To mitigate the endogeneity problems of potential omitted variables (which can affect the decision to perform M&A and become a more integrated firm), regressions are estimated by ordinary least squares (OLS) with fixed firm effects, while controlling for possible omitted time-constant variables and considering the time series 2000–2015, as in previous M&A studies conducted in various contexts (Forssbæck and Oxelheim 2008, 2011). Several studies in the area only use probit model estimates for this purpose (Kogut 2012). However, this method is not completely robust because of possible correlations between the error and independent variables.

Therefore, in addition to the probit model and to avoid the described problem, this article uses equations estimated by the OLS panel, which can also be applied to estimates with binary dependent variables (in this case, undertaking M&A). As shown in the literature, the OLS model can control for fixed firm effects and therefore heterogeneity. Moreover, estimates that use the OLS model consider that the estimated errors are robust and clustered at the firm level (Chodorow-Reich and Falato 2017; Di Maggio et al. 2019; Miguel et al. 2004). In any case, probit estimates will also be maintained, thus satisfying the main econometric methods applied for this purpose, in line with the financial literature.

Table 1 List of variables

Variable (abbreviation)	Description
Dependent variable	
Acquisition (Acq)	Dummy variable: equal to 1 if at least one acquisition was made by company *i* or a subsidiary in year *t* in target country *k*, and zero otherwise
Financial variables	
Leverage (Lev)	Total debt/total assets for company i in year $t-1$
Cash flow (Cflow)	Free cash flow/total assets for company i in year $t-1$
Return on assets (ROA)	Earnings before interest and tax (EBIT)/total assets for company i in year $t-1$
Firm-specific variables	
Firm size (Size)	Logarithm of total assets for company i in year $t-1$
Intangibles (Intang)	Intangibles/total assets in time $t-1$ for company i
Inventories (Ivent)	Inventories/total assets in time $t-1$ for firm i
Network variables	
Degree (Degr)	Number of ties for firm i in year $t-1$
Closeness (Closen)	Sum of the shortest paths between firm i and every other in the network in time $t-1$
Betweenness (Betwee)	Number of these shortest paths that pass through the vertex for firm i in time $t-1$
Eigenvector (Eigenv)	Measure of the influence for firm i over the others in $t-1$
Structural holes (Holes)	Number of non-redundant ties of firm i in total number of ties (n) in $t-1$
Density (Den)	Proportion of ties in a network relative to the total number possible in $t-1$
Country-specific variables[a]	
Accountability (Acc)	The target country's score on a "voice and accountability" index (see Kaufmann et al. 2011) observed in year *t*; a higher index value indicates more democracy. Data: WGI
Stability (Stab)	The score of the target country on a "political stability" index (see Kaufmann et al. 2011) observed in year *t*; a higher index value indicates lower political risk. Data: WGI
Government (Gov)	The target country's score on a "government effectiveness" index (see Kaufmann et al. 2011) observed in year *t*; a higher index value indicates higher effectiveness. Data: WGI
Regulatory quality (RegQ)	The target country's score on a "regulatory quality" index (see Kaufmann et al. 2011) observed in year *t*; a higher index value indicates greater government capacity to formulate and implement sound policies and regulations that permit and promote private-sector development. Data: WGI
Laws (Law)	The target country's score on a "rules and laws" index (see Kaufmann et al. 2011) observed in year *t*; a higher index value indicates higher judicial integrity. Data: WGI
Corruption (Corrup)	The target country's score on a "control of corruption" index (see Kaufmann et al. 2011) observed in year *t*; a higher index value indicates greater control. Data: WGI
Military expenditure (Mil)	Military spending by target country *k* in time *t* obtained as % of GDP. Data: Stockholm International Peace Research Institute and World Bank
GDP (GDP)	Target market size: Domestic product growth of target country *k* at time *t*, in millions. Data: World Bank

Table 1 (continued)

Variable (abbreviation)	Description
Income per capita (Inc)	National product growth of target country *k* in time *t* divided by the population of country *k*. Data: World Bank
Population (Pop)	Population size of country *k* in time *t*. Data: World Bank
Transparency (Trans)	Country's score on Transparency International's Corruption Index (CPI) observed in year ***t***; a higher index value indicates less corruption. Data: transparency.org
Tax rate (Tax)	Total tax rate (% of commercial profits) of country ***k*** in time ***t***. Data: OECD

[a]Location and internalization variables. The dependent variable as well as the financial and specific firm variables were collected from Thomson Reuters Eikon™. WGI = World Governance Index. *Variables calculated according to the mathematical method described by Freeman (1978).

Table 2 Identification and description of the variables as they appear in the model

Variables	Description
Acq_{ikt}	It is a binary variable that represents the occurrence of mergers and acquisitions performed by firm ***i,*** targeting any country ***k***, in year ***t***
P_{it-1}	Represents the positioning of company ***i*** in the network in year $\boldsymbol{t-1}$
F_{it-1}	Represents the characteristic financial aspects of firm ***i*** in year $\boldsymbol{t-1}$
O_{it}	Represents traditional variables owned by firm ***i*** in year ***t***
L_k	Represents location-specific factors for the host country ***k***
I_k	Represents specific factors of internalization for the host country ***k***
C_{ikt}	They are control variables that can vary between firms, in time, or between countries
δ_t	They are year dummies that seek to capture macroeconomic conditions that uniformly influence the probability of firms making acquisitions in a given year (alternatively, we use macroeconomic variables rather than time dummies)
f_i	They are fixed effects of the firms that capture the unobserved heterogeneity (invariant in time) of each company
ε_{ikt}	It is a random error term

Regarding simultaneity, such as the decision of a particular firm to increase debt or perform M&A, firm-level variables will be estimated with a lag. Thus, these variables become "predetermined". Recent evidence suggests that companies with better standards of corporate governance, with emphasis on the characteristics of the board of directors and investments in social capital, show better results during periods of financial crisis (Lins et al. 2017; Lins et al. 2013; Nguyen et al. 2015). Therefore, we will conduct an additional model robustness test to overcome endogeneity and simultaneity issues. Then, we will perform estimates with the results for the pre- and post-2008 international financial crisis series, noting the influences of this exogenous event on the results, particularly in terms of networks.

3.3 Identification strategy

The identification strategy is an important part of the study, given the wide range of statistical tools and variables that could be considered in the model (Bowen et al. 2016). As in other financial studies, this study's dependent variable is whether M&A was undertaken (Forssbæck and Oxelheim 2008, 2011). To test the research hypothesis, the undertaking of M&A within or outside the firm's host country is regressed against the corporate network indicators (i.e., degree, closeness, betweenness, eigenvalues, structural holes and network density), firm financial characteristics, and a set of traditional relevant ownership, location and internalization (OLI) country-level variables.

The five network variables are those commonly used in corporate governance studies because they make it possible to evaluate the position of a particular company's board in a corporate network (Fracassi and Tate 2012; Johnson et al. 2013; Kim 2005; Larcker et al. 2013). The initial premise is that a board may be well connected if it has a relatively high number of communication or resource-exchange channels, which would confer more opportunities for the board, and access or alternatives compared to other boards. This concept is measured by degree centrality, which represents the number of ties of a particular company with other firms in terms of shared board members (Freeman 1978).

Mathematically, the degree centrality of a vertex $v$for a particular graph $G := (V, E)$ with $|V|$ vertices and $|E|$ edges is defined as follows:

$$C_{D(v)} = \deg(v) \tag{1}$$

Calculating the degree centrality for all nodes in a graph gives $\Theta\left(V^2\right)$ in a representation of the graph's dense adjacency matrix, and for the edges, gives $\Theta(E)$ in a sparse matrix representation. Therefore, the definition of centrality at the node level can be extended to the entire graph. We let v^* be the node with the highest degree centrality in graph G, and $X := (Y, Z)$ is connected to node $|Y|$ that maximizes the following quantity (with y^* being the node with the greatest degree centrality in X). Thus, we have (2):

$$H = \sum_{j=1}^{|Y|} \left[C_D(y^*) - C_D\left(y_j\right)\right] \tag{2}$$

Correspondingly, the degree centrality of graph G is as in (3):

$$C_D(G) = \frac{\sum_{i=1}^{|V|} \left[C_D(v^*) - C_D\left(v_i\right)\right]}{H} \tag{3}$$

Thus, the value of H is maximized when graph X contains a central node to which all other nodes are connected (i.e., a star graph), and in this case, $H = (n-1).((n-1)-1) = n^2 - 3n + 2$.

Second, it holds that a board can be well connected if it has relatively closer ties to external boards than others, making information or resource exchange faster for such a board (Larcker et al. 2013). This concept is measured by closeness centrality,

or proximity, which represents how easily or quickly a board can access another board via interconnected ties. Therefore, this indicator reflects the inverse of the average distance between one board and another (Freeman 1978). If we regard such considerations as a whole, it is apparent that proximity can be denoted as (4):

$$C(x) = \frac{1}{\sum_y d(y,x)} \tag{4}$$

where $d(y,x)$ is the distance between vertices x and y. However, when speaking of closeness centrality in general, the literature on networks refers to its normalized form, usually given by the preceding formula multiplied by $N-1$, in which N is the number of nodes in the graph. This adjustment is crucial to facilitate comparisons between nodes of graphs of different sizes.

The third consideration is that a board may be well connected if it is located on the paths of several other boards, making it a central board in the interconnection of firms and a key agent in terms of the exchange of information or resources. This concept is measured by betweenness (Freeman 1977), which represents how important a board is in the connection of other boards or how well situated a board is in terms of the paths of the network to which it belongs (Larcker et al. 2013). The indicator betweenness can be understood as (5):

$$C_B(v) = \sum_{s \neq v \neq t \in V} \frac{\sigma_{st}(v)}{\sigma_{st}} \tag{5}$$

where σ_{st} is the total number of shorter paths of node s to node t, and $\sigma_{st}(v)$ is the number of these paths that pass through v. Betweenness can be normalized by dividing it by the number of pairs of vertices that do not include v, which for directed graphs is $(n-1)(n-2)$ and for non-directed graphs is $(n-1)(n-2)/2$.

A fourth variable considered in the model is the eigenvector, or Bonacich alpha centrality, which evaluates the degree centrality of a node (in this case, the firm), taking into account the degree of hierarchization of relationships that compose the index (De Nooy 2011). Thus, the eigenvector is a refinement of degree centrality because having more direct connections is more influential when such ties can reach or influence a larger number of external boards (Larcker et al. 2013). That is, a board is well connected when its direct contacts are also well connected, which is measured by eigenvector centrality. Briefly, it holds that for a given graph $G := (V,E)$ with $|V|$ number of vertices, the adjacent matrix would be $A = \left(a_{v,t}\right)$. That is, $a_{v,t} = 1$ if vertex v is connected to vertex t, and $a_{v,t} = 0$ otherwise. This being the case, the relative centrality coefficient of the vertex, or eigenvector, can be defined as follows:

$$x_v = \frac{1}{\lambda} \sum_{t \in M(v)} x_t = \frac{1}{\lambda} \sum_{t \in G} a_{v,t} + x_t \tag{6}$$

where $M(v)$ is a set of neighbors of v, and λ is a constant. With a slight rearrangement, this expression can be rewritten in vector notation as the eigenvector equation $Ax = \lambda x$.

Structural holes are operationalized by measuring the effectiveness of ties, which measures the number of non-redundant contacts (i.e., effsize) in relation to the total number of ties, n, of company i (Burt 1992). Based on Borgatti's equation (Borgatti 1997), it holds that if a firm i has n contacts, then the non-redundant ties are evaluated by the expression $D_{alters} = \frac{2l}{n}$, where l is the number of links between n (*alters*). As D_{alters} indicates the total number of redundant ties, the non-redundant effsize connections are determined by the following notation: $n - D_{alters}$.

The final network variable is density (density), which refers to the whole network and is defined as the quotient of the number of ties in the network and the total number of possible ties. This variable makes it possible to analyze the level of cohesion in the corporate network in each year that constitutes the series (Schilling and Phelps 2007).

The financial variables used in the model are those generally used in financial research and include the leverage situation, cash flow and ROA (Almeida et al. 2017).

The firm-specific variables (i.e., size, intangibles and inventories) are also widely adopted in studies in this area and reflect the individual strengths of each firm, according to the Ownership, Location, Internalization (OLI) paradigm. Regarding OLI variables, it should also be noted that several theories have been advanced to explain why companies choose to undertake FDI (Buckley and Casson 1976; Hymer 1976). Another perspective known as the Eclectic Paradigm, whose foremost exponent is Dunning (Dunning 1977), has been widely used in studies on M&A (Forssbæck and Oxelheim 2008, 2011).

Dunning's (1977) results suggest that US companies with operations headquartered in the UK do not have the same level of productivity as firms headquartered in the US. Dunning's (1977) primary contribution lies in introducing the term OLI. His theory is based on condensing ownership, location and internalization into a triad that can explain productivity based on the assumption that a combination of these three factors is crucial to a firm's decision to pursue internationalization. Therefore, in addition to firm-specific variables, this study uses country-level variables in its estimates (Kaufmann et al. 2011), satisfying the OLI concept of ownership (O), location (L) and internalization (I). This insight can be denoted as (7):

$$Acq_{ikt} = \alpha + \beta_1 P_{it-1} + \beta_2 F_{it-1} + \beta_3 O_{it} + \beta_4 L_k + \beta_5 I_k + \pi C_{ikt} + \delta_t + f_i + \varepsilon_{ikt} \quad (7)$$

4 Analysis and results

Between 2000 and 2015, the Brazilian firms included in the sample undertook 317 acquisitions in different countries. The acquisitions predominantly occurred within the home country, while international operations accounted for only 14.83% of all M&A. The USA was particularly prominent in this context, with Brazilian companies performing 13 M&A operations there (Table 3).

Table 3 M&As by Brazilian firms between 2000 and 2015. Source: own elaboration

Target country	Freq.	Percent
Argentina	10	3.150
Australia	1	0.320
Brazil	270	85.17
Canada	2	0.630
Chile	2	0.630
China	1	0.320
Colombia	4	1.260
Dominican Republic	1	0.320
Germany	1	0.320
India	1	0.320
Mexico	2	0.630
Oman	1	0.320
Paraguay	1	0.320
Peru	1	0.320
Spain	1	0.320
Turkey	2	0.630
United Kingdom	1	0.320
Uruguay	2	0.630
USA	13	4.100
Total	317	100

The table presents M&As in alphabetical order, not by frequency. It considers all acquisitions performed nationally and internationally by Brazilian companies in the studied period and reveals a predominance of M&As in the domestic market (85.17%)

The first step of analysis consists of calculating descriptive statistics for the data. Table 4 shows the mean and standard deviation for the variables used in the study. This analysis reveals that the number of acquisitions increased in the sample, particularly starting in 2007, up from 2% to an average of 10%. Regarding ROA, it is possible to infer that earnings before interest, taxes, depreciation and amortization (EBITDA) remained constant and below 10% of total assets for the studied period, while total assets also did not exhibit substantial variation in the same time series. It can be observed that the average leverage increased from 30% at the beginning of the period to nearly 40% in 2015.

Regarding the estimated descriptive statistics, the generation of operating free cash flow was negative starting in 2006, which indicates the need for companies to resort to internal and external funding sources. In addition, the average representativeness of intangibles in relation to total assets increased from 2% to 10%. Regarding country-level variables, the sample companies did not perform overseas acquisitions in the first years, from 2001 to 2003. After that period, less than 1% of companies performed acquisitions abroad. The Kauffman variables at the country level are only available from 2002 onward. Data for country income (i.e.,

Table 4 Mean and standard deviation of financial and network variables considered in the model. Source: own elaboration

Year	Aquisint	Deal	ROA	Size	Leverage	CashF	Intang	Holes	Invent	Closen	Eigenv	Degr	Betwee
2001	0	0.00,758	0.0346	19.17	0.308	−0.000207	0.0256	257.5	0.102	0.487	726.4	2034	152.6
	0	0.0869	0.176	1.992	0.398	0.0874	0.0296	440.0	0.0965	0.113	5010	2504	669.0
2002	0	0.00379	0.0247	18.83	0.323	0.0332	0.0211	143.3	0.108	0.481	547.0	3636	180.9
	0	0.0615	0.174	2.069	0.415	0.0918	0.0261	352.0	0.102	0.103	3371	6298	751.9
2003	0	0.0227	0.0508	18.92	0.300	0.0203	0.0138	256.2	0.116	0.498	531.4	3706	222.6
	0	0.149	0.184	2.109	0.405	0.127	0.0125	438.7	0.111	0.0953	3278	6249	839.7
2004	0.00379	0.0265	0.0714	19.08	0.275	0.00869	0.0325	284.5	0.132	0.567	296.7	3291	214.5
	0.0615	0.161	0.185	2.039	0.402	0.115	0.0832	453.3	0.126	0.0903	2451	4898	786.2
2005	0.0152	0.0303	0.0653	19.27	0.273	0.0136	0.0198	244.9	0.121	0.553	236.7	3094	237.3
	0.122	0.172	0.191	2.058	0.373	0.114	0.0320	431.9	0.117	0.100	2729	3999	743.7
2006	0.00379	0.0379	0.0656	19.58	0.281	−0.0257	0.0251	256.8	0.117	0.603	392.0	3312	219.2
	0.0615	0.191	0.167	1.994	0.376	0.135	0.0630	438.3	0.115	0.0976	2222	3984	807.2
2007	0.00379	0.110	0.0595	19.93	0.264	−0.0482	0.0332	230.6	0.113	0.591	1039	3702	224.5
	0.0615	0.313	0.170	2.033	0.337	0.140	0.0651	422.4	0.112	0.111	4590	4740	723.2
2008	0.0114	0.0947	0.0587	19.89	0.311	−0.0649	0.0567	264.3	0.117	0.708	1470	4084	239.5
	0.106	0.293	0.190	2.024	0.353	0.150	0.124	442.0	0.111	0.133	5611	4372	669.4
2009	0.00379	0.0606	0.0768	20.25	0.283	−0.0265	0.0985	271.8	0.0984	0.685	1507	3907	259.2
	0.0615	0.239	0.169	2.068	0.331	0.145	0.179	446.0	0.0935	0.123	5380	4373	732.2
2010	0.00758	0.121	0.0840	20.46	0.288	−0.0268	0.0915	343.2	0.0988	0.580	558.4	3450	205.3
	0.0869	0.327	0.144	2.023	0.345	0.128	0.172	476.1	0.0925	0.131	3141	4236	837.6
2011	0.00758	0.133	0.0728	20.50	0.304	−0.0364	0.0986	261.0	0.0991	0.637	712.2	3948	239.9
	0.0869	0.340	0.148	1.999	0.344	0.117	0.180	440.2	0.0908	0.165	3073	4654	821.0
2012	0.0227	0.114	0.0640	20.48	0.312	−0.0298	0.0868	245.3	0.0963	0.591	2272	4157	218.7
	0.149	0.318	0.164	1.994	0.325	0.119	0.162	431.2	0.0896	0.157	5365	5105	788.4

Table 4 (continued)

Year	Aquisint	Deal	ROA	Size	Leverage	CashF	Intang	Holes	Invent	Closen	Eigenv	Degr	Betwee
2013	0.0152	0.0871	0.0682	20.43	0.308	−0.0227	0.0904	272.5	0.0963	0.567	518.7	3735	210.3
	0.122	0.283	0.130	1.955	0.276	0.107	0.164	446.3	0.0916	0.145	2039	4303	736.9
2014	0.00758	0.0871	0.0614	20.35	0.356	−0.00678	0.0892	308.7	0.0979	0.695	105.6	3442	342.5
	0.0869	0.283	0.137	1.989	0.403	0.107	0.159	463.1	0.0928	0.151	888.4	3978	1022
2015	0.00758	0.0947	0.0431	20.00	0.387	−0.00251	0.0928	356.6	0.101	0.662	65.94	3313	310.2
	0.0869	0.293	0.144	2.045	0.436	0.107	0.157	480.2	0.0997	0.153	627.9	3656	853.8
Total	0.00732	0.0687	0.0615	19.89	0.306	−0.0234	0.0751	272.3	0.107	0.607	751.1	3566	236.2
	0.0853	0.253	0.164	2.099	0.368	0.125	0.149	444.8	0.103	0.147	3673	4553	794.7

Table 5 Mean and standard deviation of country-level variables. Source: own elaboration

Year	Acq	Stab	Gov	QReg	Law	Corrup	Tax	Inc	Mil	Trans	Dens
2001								3135	1.952	40	0.0100
								0	0	0	0
2002	0.390	0.284	0.0317	0.287	−0.303	0.0109				40	0.0130
											0
2003	0.389	−0.000696	0.186	0.313	−0.400	0.101	34			40	0.0130
	0	0	0	0	0	0	0			0	0
2004	0.508	−0.265	0.313	0.269	−0.132	0.307	34	9071	1.793	44.86	0.0120
	0.354	0.0305	0.656	0.582	0.689	0.683	0	144,86	0.879	12.85	0
2005	0.556	−0.337	0.374	0.455	0.0191	0.288	34.64	13,838	1.853	47.88	0.0100
	0.575	0.779	0.851	0.705	0.975	0.874	2.782	16,494	1.150	19.02	0
2006	0.396	−0.306	−0.249	−0.0759	−0.468	−0.167	33.70	5552	1.401	39.10	0.00900
	0.126	0.212	0.141	0.203	0.113	0.0761	1.337	836.6	0.218	1.912	0
2007	0.468	−0.334	−0.203	−0.0763	−0.455	−0.156	33.76	7154	1.391	39.41	0.0100
	0.0632	0.137	0.104	0.167	0.0584	0.122	1.704	482.2	0.227	1.918	0
2008	0.498	−0.282	−0.0402	0.103	−0.289	0.0107	32.30	10,028	1.452	41.28	0.0110
	0.250	0.284	0.370	0.314	0.447	0.410	5.477	7526	0.211	8.517	0
2009	0.503	0.166	−0.0251	0.131	−0.154	−0.0539	33	8564	1.538	41.38	0.0100
	0.147	0.151	0.340	0.429	0.400	0.387	4.274	447.7	0.237	6.642	0
2010	0.582	0.0155	0.0861	0.221	0.102	0.0941	33.94	13,708	1.613	42.66	0.00900
	0.202	0.119	0.428	0.464	0.493	0.406	1.703	8653	0.606	9.783	0
2011	0.511	−0.0849	−0.0506	0.213	0.0623	0.212	33.91	14,129	1.512	41.86	0.0100
	0.150	0.219	0.295	0.220	0.291	0.259	1.853	6207	0.538	7.663	0
2012	0.484	0.0631	0.0808	0.187	0.0446	0.0925	33.77	16,118	1.642	43.87	0.0100
	0.289	0.349	0.517	0.476	0.576	0.526	3.720	11,999	0.924	11.91	0

Table 5 (continued)

Year	Acq	Stab	Gov	QReg	Law	Corrup	Tax	Inc	Mil	Trans	Dens
2013	0.396	−0.220	0.150	0.261	0.106	0.0793	32.91	17,413	1.609	45.09	0.0100
	0.573	0.537	0.611	0.572	0.652	0.657	3.463	16,759	0.697	13.59	0
2014	0.365	−0.0777	−0.0631	0.0440	0.00724	−0.279	32.91	13,911	2.033	41.57	0.00900
	0.355	0.311	0.344	0.331	0.382	0.373	5.107	9028	2.568	7.178	0
2015	0.391	−0.351	−0.113	−0.155	−0.150	−0.361	33.92	10,662	1.502	41.08	0.00900
	0.169	0.267	0.330	0.365	0.386	0.365	2.216	9534	0.562	6.928	0
Total	0.471	−0.139	−0.00381	0.120	−0.0948	−0.00820	33.53	12,187	1.591	42.09	0.0103
	0.281	0.337	0.423	0.411	0.486	0.454	3.231	9822	0.945	9.093	0.00130

Table 6 Consolidated descriptive statistics. Source: own elaboration

Variable	Obs	Mean	Std.Dev.	Min	Max
Aquis_int	3960	0.00732	0.0853	0	1
Deal	3960	0.0687	0.253	0	1
ROA	3462	0.0615	0.164	−0.823	0.449
Size	3480	19.89	2.099	13.39	25.84
Leverage	3480	0.306	0.368	0	2.827
CashF	2668	−0.0234	0.125	−0.670	0.308
Intang	2409	0.0751	0.149	−0.000788	0.703
Invent	3057	0.107	0.103	0	0.435
Degr	2561	3566	4553	0	51,000
Betwee	2561	236.2	794.7	0	8768
Closen	1806	0.607	0.147	0.216	0.750
Eigenv	2561	751.1	3673	−0	46,067
Holes	1806	272.3	444.8	0.0400	1000
Dens	3960	0.0103	0.00130	0.00900	0.0130
Acc	269	0.471	0.281	−1.581	1.496
Stab	269	−0.139	0.337	−2.032	1.030
Gov	269	−0.00381	0.423	−0.870	1.909
QReg	269	0.120	0.411	−0.957	1.797
Law	269	−0.0948	0.486	−0.997	1.765
Corrup	269	−0.00820	0.454	−1.007	1.888
Inc	264	12,187	9822	1452	67,653
Mil	264	1.591	0.945	0.418	13.51
Tax	268	33.53	3.231	10	40

per capita GDP) and military expenditure was also not available for 2002 and 2003, and the tax rate series starts only in 2003 (Table 5).

From a consolidated perspective, the country-level variables limit the estimates due to the reduced number of overseas acquisitions. In addition, within the sample panel, it is noted that international acquisitions were present in only 0.7% of company-year observations, while acquisitions in general accounted for 6% (Table 6).

The correlation matrix in Table 7 shows that an international acquisition has a weak but positive and significant correlation with companies with higher cash flow generation, which also applies to firms that have higher degree centrality, closeness and betweenness. Undertaking M&A also correlates negatively with the existence of structural holes. Complementarily, it is clear that international acquisitions are generally carried out in countries with lower tax rates and greater transparency, as well as having a positive correlation with all Kauffman indices and with the larger consumer markets (represented by income per capita). In light of Table 7, it should be noted that only the Kauffman variables exhibited a strong correlation, over 0.70. Therefore, multicollinearity is not a problem in the estimated model.

Table 7 Correlation matrix

	Aquis	Deal	ROA	Size	Laverage	CashF	Intang
Deal	0.3163*	1					
ROA	0.0341*	0.0651*	1				
Size	0.0912*	0.2015*	0.3651*	1			
Leverage	0.0292*	0.00730	−0.2783*	−0.0501*	1		
CashF	0.0298	−0.0363*	0.3212*	0.1660*	−0.0484*	1	
Intang	−0.0220	0.0425*	0.1334*	0.1859*	−0.00730	0.00610	1
Invent	0.00120	0.00540	−0.00250	−0.2232*	0.0104	−0.1195*	−0.3066*
Degr	0.0714*	0.2261*	0.1538*	0.4323*	0.00950	0.0255	0.0643*
Betwee	0.0717*	0.1720*	0.0910*	0.3009*	0.0176	0.0582*	0.00300
Closen	0.0400*	0.1186*	0.0744*	0.1934*	0.0466*	−0.0346	−0.00340
Eigenv	−0.00130	0.0914*	0.0454*	0.1426*	0.00530	−0.0119	0.0138
Holes	−0.0274	−0.0630*	−0.0675*	−0.2141*	−0.0185	−0.0637*	−0.00450
Dens	−0.0266*	−0.0927*	−0.0340*	−0.1858*	−0.0194	0.00490	−0.0726*
Tax	−0.3342*		0.1046*	−0.0575	−0.1411*	−0.0438	0.1171*
Trans	0.6003*		0.1531*	0.0914	0.1390*	0.1124*	−0.0661
Acc	0.1826*		0.1276*	0.0456	0.0473	−0.00760	0.00270
Stab	0.0880		0.1008*	0.1163*	0.0834	0.0784	0.0477
Gov	0.6463*		0.1813*	0.0852	0.1554*	0.1588*	−0.0617
QReg	0.6018*		0.1756*	0.1262*	0.1354*	0.1286*	−0.0451
Law	0.5416*		0.1498*	0.1674*	0.1436*	0.1636*	−0.0211
Corrup	0.5491*		0.1842*	0.1135*	0.1252*	0.0755	−0.0256
Inc	0.5376*		0.1659*	0.1195*	0.1643*	0.1169*	−0.00990
Mili	0.3619*		0.0816	0.0947	0.0912	0.1364*	−0.0535

	Invent	Degr	Betwee	Closen	Eigenv	Tax	Trans
Degr	−0.1522*	1					
Betwee	−0.0984*	0.6647*	1				
Closen	−0.00020	0.2383*	0.1303*	1			
Eigenv	−0.1187*	0.5181*	0.2680*	0.0886*	1		
Impos	−0.0161	0.0741	0.1209*	−0.0672	0.0573	1	
Trans	−0.0346	0.0345	0.0874	−0.0302	−0.0291	0.0662	1
Acc	−0.0513	0.0664	0.0923	−0.0360	0.0182	0.4085*	0.7386*
Stab	−0.0960	0.0615	0.0589	−0.0535	0.0934	0.1433*	0.6141*
Gov	−0.0322	0.0345	0.0832	−0.0644	−0.0332	0.0689	0.9428*
QReg	−0.0712	0.0478	0.0856	−0.0632	−0.0168	−0.0423	0.8511*
Law	−0.0786	0.0679	0.1356*	−0.0150	−0.00510	0.0718	0.9240*
Corrup	−0.0679	0.0625	0.0583	−0.0604	0.00460	0.0526	0.9200*
Inc	−0.0513	0.0706	0.1259*	−0.0154	−0.00290	0.1929*	0.8890*
D ~ Militar	−0.00910	−0.0204	0.0575	−0.00460	−0.0345	−0.2251*	0.4087*
Holes	0.0767*	−0.4880*	−0.1979*	−0.3301*	−0.1448*	0.0777	−0.0470
Dens	0.0502*	0.0168	−0.0242	−0.2143*	0.0167	−0.0355	0.0111

	Acc	Stab	Gov	QReg	Law	Corrup	Inc
Stab	0.5975*	1					

Table 7 (continued)

	Acc	Stab	Gov	QReg	Law	Corrup	Inc
Gov	0.6652*	0.5643*	1				
QReg	0.6201*	0.4922*	0.8889*	1			
Law	0.6860*	0.6356*	0.9079*	0.8835*	1		
Corrup	0.7275*	0.6076*	0.9119*	0.9128*	0.8831*	1	
Inc	0.6558*	0.6228*	0.9018*	0.8169*	0.9223*	0.8351*	1
Mili	−0.0572	0.1907*	0.4460*	0.4763*	0.4552*	0.3895*	0.4178*
Holes	−0.0489	−0.0136	−0.0409	−0.0632	−0.0438	−0.0909	−0.0261
Dens	0.0170	−0.0123	0.1087*	0.1359*	−0.1327*	0.1913*	−0.0443
	Mili	Holes	Dens				
Holes	0.0205	1					
Dens	−0.0418	−0.0624*	1				

*$p < 0.05$

The objective of the model estimated in Table 8 is to analyze the determinants of international acquisitions. When considering Equation I, only the eigenvector centrality was significant at 10% in determining the probability of a Brazilian company undertaking an international acquisition. Since the connection of a board depends on the connection of its direct ties, eigenvector centrality can be interpreted as an indicator that captures power and prestige. That is, a board can be well connected when it is perceived as prestigious and powerful, which awards it a special advantage in obtaining resources, information and favors. However, the coefficient does not have a high impact, and an increase of 1000 in the company's eigenvector is associated with a 0.3% decreased likelihood of performing an international acquisition.

In Eq. (3), considering only companies that made an international acquisition during the period, no network centrality measure was significant. In a robustness test that considered the international financial crisis of 2008, this variable was not significant in Equation V but had a 5% negative significance in Eq. (6). This outcome indicates that overseas acquisitions have tended to decrease in the post-crisis period. It is worth emphasizing that Eqs. (1), (3), (4) and (6) were estimated by an OLS panel with fixed firm effects, and I and III also have dummies for year, thus controlling for the heterogeneities of the firm and macroeconomic events. Eqs. (4), (5) and (6) have no year dummies because of the crisis variable.

Table 9 shows the estimated results for the model considering the implementation of an acquisition as the dependent variable regardless of whether it occurred inside or outside Brazil. The degree centrality was significant at 1% and had a positive coefficient, which indicates that an addition of one unit to this variable is associated with an increased likelihood of between 1.59% and 1.65%. This outcome represents a robust result between the probit and linear probability methods. Thus, firms with higher degree centrality are more likely to undertake M&A.

Table 8 Panel with OLS and probit models for determinants of international M&As. Source: own elaboration

Variables	(OLS) I	(PROBIT) II	(OLS) III	(OLS) IV	(PROBIT) V	(OLS) VI
ROA	0.0692 (0.0588)	5.073 (3.552)	0.217 (0.163)	0.0694 (0.0642)	3.346 (2.450)	0.601** (0.267)
Size	0.0105 (0.00848)	0.486* (0.277)	0.0128 (0.0174)	0.0147* (0.00792)	0.316* (0.183)	−0.0158 (0.0364)
Leverage	0.0179 (0.0371)	1.863* (1.037)	0.355* (0.210)	0.0177 (0.0338)	1.468** (0.730)	0.547** (0.235)
CashF	−0.0167 (0.0505)	−0.130 (2.274)	−0.181 (0.201)	−0.0202 (0.0513)	0.404 (1.707)	−0.263 (0.231)
Intang	−0.0488 (0.0317)	−9.870* (5.860)	−0.111 (0.0937)	−0.0384 (0.0270)	−6.387 (4.018)	−0.255* (0.136)
Invent	0.00985 (0.0798)	2.042 (3.835)	−0.334 (0.382)	0.0154 (0.0797)	1.204 (2.610)	0.124 (0.569)
Degr	2.79e−06 (2.86e−06)	0.000169 (0.000113)	3.68e−06 (4.69e−06)	2.86e−06 (2.89e−06)	7.44e−05 (7.02e−05)	3.04e−06 (1.04e−05)
Betwee	−3.91e−06 (1.18e−05)	−0.000280 (0.000294)	8.40e−06 (1.09e−05)	−3.34e−06 (1.21e−05)	−8.05e−05 (0.000197)	2.55e−05 (1.97e−05)
Closen	0.00766 (0.0160)	8.119 (25.93)	0.0285 (0.0833)	−0.0274 (0.0197)	−0.129 (1.645)	−0.146 (0.191)
Eigen	−3.20e−06* (1.72e−06)	−0.000226* (0.000130)	−7.05e−06 (4.91e−06)	−2.61e−06 (1.60e−06)	−6.66e−05 (5.45e−05)	−7.02e−06 (6.80e−06)
Holes	5.47e−06 (1.60e−05)	0.000101 (0.000714)	5.69e−06 (2.04e−05)	3.49e−06 (1.57e−05)	9.81e−08 (0.000518)	8.75e−06 (2.76e−05)
Tax			−0.0857*** (0.0141)			−0.0595*** (0.0130)
Trans			−0.0471** (0.0204)			−0.00858 (0.0190)
Acc			0.507 (0.461)			−0.751 (0.621)
Stab			0.0885 (0.144)			0.136 (0.108)
Gov			−0.517** (0.257)			0.160 (0.356)
QReg			−0.472*** (0.163)			−0.156 (0.115)
Law			−0.0149 (0.315)			0.0910
						(0.267)
Corrup			0.899*** (0.331)			0.199
						(0.221)
Inc			4.06e−05***			2.22e−05***
Mili			(8.20e−06) 0.472***			(7.58e−06) 0.213*

Table 8 (continued)

Variables	(OLS) I	(PROBIT) II	(OLS) III	(OLS) IV	(PROBIT) V	(OLS) VI
			(0.0923)			(0.118)
Dens		− 603.3 (0)		8.175 (6.078)	376.2 (265.2)	− 41.79 (32.11)
Crisis				− 0.00107 (0.0129)	0.293 (0.459)	− 0.205** (0.0846)
Constant	− 0.238 (0.173)	− 17.91 (20.27)	3.397*** (1.254)	− 0.374* (0.196)	− 14.89** (5.836)	3.001** (1.377)
Observations	1030	1030	142	1030	1030	142
R-squared	0.031		0.924	0.011		0.832
FIRM FE	YES	NO	YES	YES	NO	YES
YEAR Dummy	YES	YES	YES	NO	NO	NO
AIC	− 1449.714	177.0994	− 292.648	− 1450.51	182.7497	− 191.5034
Number of id	153	153	49	153	153	49

The financial variables within the firm were lagged in the first period with the goal of addressing simultaneity. Equations (3) and (6) also control for variables at the level of investment target country (the level of observation is reduced because the country-level variables only exist if an acquisition occurs during the period). As an alternative, the same equations were estimated using a probit model. However, these results are less robust because of the possible correlation between the error and the independent variables of the model. For the OLS models, the estimated errors are robust and clusterized at the firm level. Robust standard errors in parentheses ***$p<0.01$, **$p<0.05$, *$p<0.1$

Table 9 Panel with OLS and probit models for M&A determinants (regardless of whether the merger or acquisition occurred in- or outside the country). Source: own elaboration

Variables	(OLS) I	(PROBIT) II	(OLS) III	(PROBIT) IV
ROA	−0.0162 (0.170)	0.395 (1.074)	0.0175 (0.166)	0.695 (1.040)
Size	−0.0148 (0.0330)	0.147* (0.0803)	−0.00194 (0.0277)	0.149* (0.0786)
Leverage	−0.0599 (0.0913)	0.108 (0.489)	−0.0845 (0.0914)	−0.0687 (0.521)
Flucx	0.0605 (0.117)	0.400 (0.843)	0.0456 (0.118)	0.408 (0.828)
Intang	−0.0829 (0.114)	−0.661 (0.685)	−0.0405 (0.0980)	−0.433 (0.664)
Invent	0.235 (0.302)	1.353 (1.230)	0.168 (0.288)	1.518 (1.219)
Degr	1.54e−05*** (5.85e−06)	9.08e−05*** (3.38e−05)	1.65e−05*** (6.03e−06)	0.000101*** (3.26e−05)
Betwee	−3.69e−05* (1.99e−05)	−0.000146 (0.000104)	−4.14e−05** (1.98e−05)	−0.000183* (0.000101)
Closen	−0.0371 (0.104)	0.103 (0.781)	−0.0543 (0.0797)	0.0501 (0.667)
Eigenvec	−4.30e−06 (3.18e−06)	−2.33e−05 (1.86e−05)	−4.25e−06 (3.20e−06)	−2.45e−05 (1.75e−05)
Holes	−8.16e−06 (3.53e−05)	5.48e−05 (0.000232)	6.99e−07 (3.44e−05)	8.79e−05 (0.000228)
Dens		−1175 (0)	2.759 (15.15)	3.910 (118.9)
Crisis			0.0405 (0.0367)	0.119 (0.209)
Constant	0.343 (0.667)	5.056*** (1.791)	0.0958 (0.572)	−5.720*** (2.085)
Observations	1030	1030	1030	1030
R-squared	0.031		0.016	
Number of id	153	153	153	153
Firm FE	YES	NO	YES	NO
Year Dummy	YES	YES	NO	NO
AIC	211.7227	694.1053	205.9576	686.9191

Equations (1) and (3) were estimated using an OLS panel with fixed firm effects because Eq. (1) includes dummies for year, thus controlling for heterogeneity of the firm and macroeconomic events. Equations (3) and (4) do not have year dummies because of the crisis variable. As in the previous estimate, the financial variables at the firm level were lagged by one period to address simultaneity. The equations do not have controls for variables at the investment target country level because when the variable has a value of 0, there are no observations at the country level. As an alternative, the same equations were estimated using a probit model. However, these results are less robust because of the possible correlation between the error and independent model variables. For the OLS models, the estimated errors are robust and clusterized at the firm level

This result is of substantial importance because it shows that through interlocking directorates, companies with a larger number of ties with other boards have an increased propensity to perform M&A in both the domestic and foreign markets. The other network measures were not significant (i.e., closeness, eigenvector, betweenness, structural holes and density).

5 Discussion and conclusions

A range of factors can motivate companies to undertake M&A, from economies of scale to reducing the cost of capital and numerous other elements that lead to the choice to concentrate activities and acquire other firms. However, the final decision to participate in M&A is made by the board of directors. Therefore, and in accordance with the evidence presented in the literature, the characteristics of this corporate governance body can exert an influence on M&A. Based on this assumption, our objective was to verify whether interlocking directorates reduce the asymmetry of information in M&A, meaning that firms that are more connected in the network (i.e., high degree centrality) are more likely to participate in M&A.

Basically, the results indicate that the number of ties that a firm has (i.e., degree), via the board of directors with other companies, affects its participation in M&A. Board interlocking influences positively the undertaking of M&A. This result is in line with similar findings in the literature (Cai and Sevilir 2012; Sparrowe et al. 2001; Tsai 2002; Wu 2017), which have emphasized that directors with high degree centrality in their networks can mitigate selection problems and make them less adverse, thus reducing the asymmetry of information in the context of M&A. Evidence in Brazil is particularly relevant because a comparative analysis of corporate networks in Latin America (Mexico, Chile, Peru, Colombia and Brazil) indicates a relatively low number of board interlocks in Brazil (Cárdenas 2016). Despite this fact, the few corporate interlocks in Brazil have played a critical role in company decision making regarding M&A. We have also shown that other network measures have no significant effect, including closeness, eigenvector, betweenness and structural holes.

Degree centrality takes into account the immediate ties that a node has. Therefore, degree is distinct from other centrality measures because it provides information about the local power of a node, whereas closeness, eigenvector and betweenness consider the position of the node regarding the entire network. Firms with high degree centrality may be members of highly cohesive clusters, so they get more redundant and in-depth information thanks to the trust achieved within clusters. Firms with a high betweenness centrality, on the other hand, act as a bridge between clusters, so they capture more heterogeneous information that passes through them. Firms with a high closeness and eigenvector centrality are closer to all other actors, so they must get more general information. The fact that only degree centrality is a significant determinant of M&A, and no other centrality measures, may suggest that interlockers can use multiple board membership to get redundant information about companies that can be targeted for acquisition at a national and international level.

The robustness test conducted in this study aimed to determine the existence of significant differences in the corporate network and centrality coefficients, observing the Pre- and Post-2008 Financial Crisis period. Although none of the other variables exhibited representative variance, the overall density of the network increased in the period after the onset of the crisis. This outcome indicates that the cohesion level of the entire network was higher after 2008. However, this observed higher density did not affect M&A processes. Future studies should keep on researching the effect of network-level characteristics on board decisions and M&A transactions to understand controversial facts. For example, studies across the world have shown that density has decreased significantly in national corporate board networks since the 1990s (David and Westerhuis 2014), but in parallel the number of M&A deals has increased since the first decade of the new century (IMAA 2020). To set a research agenda on board interlocking and M&A and to contribute to unsolved debates, further studies should also investigate the role played by a board's composition and functioning (Chen and Lai 2015), CEO-board power dynamics (Grinstein and Hribar 2004), the geographic or institutional distance between headquarters and affiliates (Ragozzino and Reuer 2006), and industrial diversification strategy (Di Guardo et al. 2019), especially in the phase after M&A decisions (Cai and Sevilir 2012; Renneboog and Zhao 2014).

From the point of view of the managerial implications of our results, we would like to highlight that according to Mizruchi (2013), the fragmentation of the network of interlocking directorates can help in the managing of crises. In this sense, the more the network of board members becomes thinner in structure, the easier it is for companies to survive and avoid being acquired. Furthermore, regarding investment decisions, well connected board members tend to be highly narcissistic and prone to overconfidence (Kruger and Dunning 1999). As a result, overconfident CEOs can underestimate the range of potential outcomes (Ben-David et al. 2013). Some CEOs, who overestimate the future return of their projects and therefore pay higher acquisition premiums, would be more likely to make 'bad' diversifying mergers in unrelated sectors (Malmendier and Tate 2005). Boards of directors are important because this is where ownership can be turned into control in terms of power and influence within the corporate environment.

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