Big data analytics (BDA) and degree of internationalization: the interplay between governance of BDA infrastructure and BDA capabilities

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Abstract

In order to face the challenges of internationalization and to cope more efficiently with the uncertainty of foreign expansion, firms are called to analyze an increasing amount of real-time semi-structured and unstructured datasets. In this sense, big data analytics (BDA) can become strategic in stimulating the international growth of small and medium-sized enterprises (SMEs). However, the specific relationship between BDA and internationalization has been analyzed fragmentarily within the mainstream literature. With the purpose of shedding light on this relationship, the authors drew on resource-based view (RBV) and collected data through a questionnaire directed to CEOs of 266 SMEs, receiving 103 responses. A quantitative analysis based on an Ordinary Least Squares (OLS) regression showed that the relationship between governance of BDA infrastructure and the degree of internationalization (DOI) is not significant, while the direct effect of BDA capabilities as well as the interaction term between BDA infrastructure and BDA capabilities are positive and significant. This suggests that the governance of BDA per se is not enough for enhancing internationalization in SMEs. On the contrary, this article points out the relevance of developing specific BDA capabilities and the existence of a positive interplay between governance of BDA infrastructure and BDA capabilities that can exploit the new knowledge coming from BDA in SME international growth.

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1 Introduction

In the last years, the increasing amount of data that companies have been called to process and their potential key role in making strategic decisions has attracted the attention of managers and scholars (De Mauro et al. 2018; Erevelles et al. 2016; Gnizy 2018; Lopez-Nicolas and Soto-Acosta 2010; Sivarajah et al. 2017). The conventional practices, based on the exploitation of structured, small, and centralized data, have been recently challenged by the development of innovative information systems able to simultaneously process different semi-structured and unstructured datasets (Bean and Kiron 2013; Kiron et al. 2013; Germann et al. 2014; Grover et al. 2018; Vera-Baquero et al. 2016). The process of extracting, generating, interpreting, and categorizing useful information through the compression of an enormous amount of data is nowadays also known as big data analytics (BDA) (Chen et al. 2013; Davenport 2012).

Despite the newness of BDA as a field of studies, several academics started focusing on how and to what extent BDA can lead firms to achieve competitive advantages (Amalina et al. 2019; Ren et al. 2019; Wang et al. 2018). Previous studies suggest that BDA can enhance the quality of decision processes (Kowalczyk and Buxmann 2015); agility (Ashrafi et al. 2019; Cheng et al. 2020; Gunasekaran et al. 2018; Rialti et al. 2020); organizational and/or supply chain performance (Akter et al. 2016; Gunasekaran et al. 2017; Mishra et al. 2018; Shokouhyar et al. 2020; Wamba et al. 2017a, b); innovation capabilities (Mikalef et al. 2019b); and value creation (Seddon et al. 2017). However, some key promises of BDA, such as internationalization, remain somehow unexplored (Ardito et al. 2019; Dam et al. 2019).

Actually, BDA could lead companies to explore and scan foreign markets, assess risks resulting from foreign expansion, and reduce the complexity and uncertainty of the environmental and strategic contexts (Gnizy 2018; Westhead et al. 2004). This could result in higher internationalization activity that would facilitate the growth of such firms (Bianchi and Wickramasekera 2016). This is typical and may be a key issue in SMEs' early-stage internationalization process and growth (e.g., Cui and Xu 2019). In order to shed light on the relationship between BDA and internationalization, we draw on the resource-based view (RBV). First, we conceptualize BDA infrastructure as a resource that can be superior, rare, difficult to imitate, and non-substitutable in the context of SMEs (Ferraris et al. 2019) and that can lead to greater performance in terms of foreign sales. Based on this, the first hypothesis of our study is that the governance of BDA infrastructure positively influences internationalization. We posit that this main effect, however, is not sufficient for creating a data-driven organization and for addressing rapidly-changing environments such as foreign markets (Rialti et al. 2019a). SMEs also have to identify the strategic and business values of BDA (Wang et al. 2018). Indeed, they need to develop skills and routines to transform big data into knowledge of greater value (Ferraris et al. 2017). These skills and routines enable firm-specific capabilities that cannot be readily assembled through markets and can become sources of a sustained competitive

advantage (Mikalef et al. 2019b). Therefore, the ability of an organization to collect, prepare, and analyze big data may make the difference, especially when the organization makes these processes difficult to imitate (Ferraris et al. 2019). Following this reasoning, we introduced a second hypothesis to test the impact of BDA capabilities on internationalization and a third hypothesis to test the interaction term between governance of BDA infrastructure and BDA capabilities.

We collected data through a questionnaire to the CEOs of 266 Italian SMEs, receiving 103 responses that were analyzed using Ordinary Least Squares (OLS) regression. Results suggest that in order to increase their internationalization activity, SMEs need to integrate the governance of BDA infrastructure with BDA capabilities, since BDA infrastructure alone does not show any significant direct impact.

This paper first contributes to the RBV theory by showing that BDA can lead to greater internationalization activity, unless SMEs combine their BDA infrastructure with superior, rare, difficult-to-imitate, and non-substitutable BDA capabilities (Ferraris et al. 2019). We show that the governance of BDA infrastructure does not directly affect SMEs' international growth while specific BDA capabilities do. Moreover, we point out the presence of positive interdependencies and the existence of a multiplicative effect when both the governance of BDA infrastructure and BDA capabilities are developed. Thus, our study also contributes by linking two emerging streams of research—BDA (Mikalef et al. 2019a, b; Rialti et al. 2019b; Wamba et al. 2017a, b) and SME internationalization (Dabić et al. 2020)—since the relationship between BDA and internationalization is still under-investigated by the mainstream literature.

This paper is organized as follows. Section 2 includes an overview of studies on BDA and the development of the hypotheses. In Sect. 3, the research design is described, explaining the set of methods and procedures used for collecting and analyzing data. Section 4 is dedicated to the results of the study, while in Sect. 5, the major findings are described. Finally, Sect. 6 is dedicated to conclusions and limitations, providing suggestions for further research.

2 Literature background

2.1 Big data analytics (BDA)

BDA is defined as a "holistic approach to managing, processing, and analyzing the 5 V data-related dimensions (i.e., volume, variety, velocity, veracity and value) to create actionable insights for delivering sustained value, measuring performance and establishing competitive advantages" (Wamba et al. 2017a). More specifically, these five dimensions refer to: volume (the quantity of data created every day grows exponentially), velocity (big data requires prompt and even faster responses), variety (sources of big data are many and relatively new), veracity (the data collected must be trustworthy), and value (extracting economic benefit from the available big data has enormous importance). Recently, the 5 V model has been extended to two other elements: (i) variability, which refers to the possible variations in data flow rate,

processing, and data sources, and (ii) visualization, which concerns the possibility of data analysts obtaining visual insights (Mishra et al. 2017; Seddon and Currie 2017; Wamba and Mishra 2017).

BDA is becoming a top trend in the debate of both academics and practitioners (Tian 2017) due to the competitive advantage it can bring to companies by not only providing patterns analysis but also the predictive likelihood of an event (Gandomi and Haider 2015; George et al. 2016). The opportunity to perform a novel, scalable, and dynamic data analysis has led the research stream on BDA to develop quickly (George et al. 2016).

The exploitation of big data can in fact have positive effects in several domains, such as customer relationship management, operational risk management, and overall firm operational efficiency and performance (Bresciani et al. 2018; Germann et al. 2014; Kiron et al. 2013; Mikalef et al. 2019b; Wamba et al. 2017a, b). The infinite amount of detailed information made available by BDA allows managers to be increasingly informed on the states of different business processes, such as supply chain, workforce performances, internal operations, and behavioral patterns of consumers (Bresciani et al. 2018; Dubey et al. 2018). An efficient BDA system produces deeper customer knowledge that goes beyond the traditional information-generation tools such as surveys and not only provide information about customers' choices but also about their unchosen alternatives, thus detecting their latent needs (Cortez and Johnston 2017; Watson et al. 2018). The previous literature has reported practical examples of how complex and huge amounts of data can be deployed for successful strategic decision-making and action-taking (George et al. 2016; Mazzei and Noble 2017). In the healthcare sector, for instance, machine learning algorithms for BDA could enable the discovery of patterns that anticipate specific diseases before they occur (Davenport et al. 2012). At the same time, BDA may help to create personalized treatment plans by combining genomic data and electronic medical records (Davenport 2014). Leading retail companies have already improved the customer experience by applying BDA to a variety of e-commerce needs, such as customer segmentation and targeting, fraud reduction, and just-in-time recommendations (Tweney 2013). The retailer Target Corporation, for instance, has developed a loyalty card to track customers' purchases and predict future buying trends. Another example from the retail sector is Amazon.com, which generates more than 30% of purchases from personalized purchase recommendations. BDA can also boost agility in manufacturing firms by providing real-time information so that they can act quickly and support the supply chain's activities, reaching the market with lowered costs and higher-quality products and services (Gunasekaran et al. 2018; Hofmann 2017).

An efficient BDA system can also have a positive impact on internationalization processes. As pointed out by Gnizy (2018), informational processes are part of the exploratory ability of those firms that will compete internationally, since exporters possessing relevant information would be more likely to consider opportunities from foreign markets. BDA offers relevant advantages when compared with traditional information systems by providing data on customers and markets that are geographically and culturally distant through the exploitation of data that are not typically available in firm-level datasets. In this regard, the presence in international markets

requires timeliness to cope with the volatility attributable to intense competitiveness (Watson et al. 2018; Westhead et al. 2004); furthermore, the real-time data offered by BDA enable faster and more effective market analyses than traditional technologies, tackling real-time uncertainties typical of international operations (Gnizy 2018). Extracting value in real time from operational data provides companies with the opportunity to make well-informed and effective decisions on which foreign markets are worth investing in and which are not, according to the related opportunities and threats arising from external trends and changes (Bumblauskas et al. 2017; Jin et al. 2015).

2.2 Hypotheses development

Over the last decades, the ability to internationalize through exports has become a competitive necessity for a large variety of companies. Global markets are no longer exclusively the playing field of multinational corporations since the removal of imposed barriers and recent technological advances in manufacturing, transportation, and communications have enabled SMEs to move from local to foreign markets (Dabić et al. 2020) in order to increase survival prospects (Adomako et al. 2017; Dominguez and Mayrhofer 2017; Lee et al. 2012). Despite being often associated with growth (Filatotchev et al. 2009), internationalization processes are challenging because foreign markets are characterized by the existence of additional variables that are not present in domestic markets, increasing the risk of incurring non-linear and unpredictable changes that represent barriers to exploring new opportunities (Braganza et al. 2017; Leonidou and Theodosiou 2004). If SMEs want to increase their internationalization activity, they have to consider the uncertainty arising from several factors such as information asymmetry, geographical distance, and the difficulty both of enforcing contracts across borders and of ascertaining the capabilities of a foreign distributor (Freeman et al. 2006).

In such cases, the existing information cannot be considered sufficient and companies are thus called to develop new knowledge. Big data can provide real-time, detailed, and multi-source information to face this high uncertainty and to explore and scan the market, as well as to assess risks (Dam et al. 2019; Gnizy 2018).

To make use of big data, firms have to implement systems that require extremely large networked hardware architecture that rely on cloud storage and computing and that require extremely fast internet connections (Gandomi and Haider 2015). Infrastructural complexity is thus a problem but at the same time a resource, especially in SMEs (Ferrari et al. 2019). Hence, the governance of BDA infrastructure is an important enabling element of firm performance. Flexibility, transparency, and connectivity are essential when firms deal with uncertain business conditions such as hyper-competition, economic pressure, and globalization (Ferraris et al. 2018; Kim et al. 2012). In this case, the governance of a BDA infrastructure should facilitate team agility in developing necessary applications, creating effective information, facilitating data-sharing channels across business units, and launching systems that reinforce functional integration (Akter et al. 2016; Ashrafi et al. 2019; Kim et al.

2012). In this regard, it can be assumed that BDA infrastructure may help in facing the risks and uncertainty arising from export activities. Thus, the first hypothesis of this study is that:

H1 Within the context of SMEs, the governance of BDA infrastructure positively influences the degree of internationalization.

As aforementioned, the complexity of BDA methods can be problematic for SMEs, leading managers and employees to reject the implementation of these systems (Rialti et al. 2019a). In order to make everyone use complex technological systems, companies need to develop ad hoc BDA capabilities (Chen et al. 2012). According to Wang et al. (2018), we define BDA capabilities as the ability to acquire, store, process, and analyze large amounts of data in various forms and deliver meaningful information to users, allowing them to discover business values and insights in a timely fashion. BDA capabilities have undergone several conceptualizations. Wang et al. (2018), for instance, conducted a content analysis on 26 big data implementation cases in healthcare, identifying five BDA capabilities: analytical capability for patterns of care, unstructured data analytical capability, decision support capability, predictive capability, and traceability. Akter et al. (2016), instead, drew on the socio-materialism perspective (Orlikowski and Scott 2008; Kim et al. 2012) to present an entanglement conceptualization of three BDA capabilities—management, technology, and human, highlighting the importance of the complementarities between them for improving performance and sustained competitive advantage.

Mikalef et al. (2018) carried out a systematic literature review and a research agenda. They identified three dimensions as antecedents of BDA capabilities (i.e., tangible, intangible, and human resources) building on Grant (1991). Their framework also invites future studies to analyze how BDA capabilities can enhance organizational-level capabilities.

Several studies have empirically tested the relationships between BDA capabilities and firm performance (Wamba et al. 2017a, b). Ferraris et al. (2019), for instance, found a positive relationship between BDA capabilities and firm performance in their analysis of a sample of 88 Italian SMEs. Moreover, they found that this relationship is mediated by knowledge management, highlighting that firms have to properly manage the knowledge emerging from big data to effectively create value. Wamba et al. (2017a, b) and Mikalef et al. (2020) tested the impact of BDA capabilities on firm performance, introducing, respectively, process-oriented dynamic capabilities and operational and dynamic capabilities as mediators. Similarly, Mikalef et al. (2019b) successfully tested the indirect impact of BDA capabilities on incremental and radical innovation capabilities, mediated by dynamic capabilities.

Despite the relevant number of studies addressing the relationship between BDA capabilities and firm performance, there is still a paucity of studies attempting to analyze the role that BDA capabilities can play in internationalization processes. The development of the right BDA capabilities is expected to reduce incorrect

analysis of business opportunities (White 2012) and to provide a competitive edge in the face of environmental uncertainty from foreign markets. So, the second hypothesis proposes that:

H2 Within the context of SMEs, BDA capabilities positively influence the degree of internationalization.

In order to effectively manage opportunities and threats from foreign markets, employees dealing with BDA should be capable of understanding, at least partially, the complexity of the infrastructure, the main methodologies of analysis, the potential effects on existing processes, and the potential outcomes of BDA (Côrte-Real et al. 2017; Rialti et al. 2019a). Indeed, the development of the right capabilities within a firm would reduce the risk of gathering and processing data of insufficient quality, avoiding false correlations by the time data are integrated with other data (White et al. 2012). This means that SMEs should develop a complex mix of superior, rare, and difficult-to-imitate capabilities to leverage the full potential of BDA infrastructure for export activities (Ferraris et al. 2019; Neubert 2018). Crucial aspects of internationalization such as exploring and scanning international markets, assessing country risks, and finding new partners to establish joint ventures risk not being effective if SMEs do not combine BDA hard resources with soft skills (Clark et al. 2018; Ferraris et al. 2019). Considering that investing in complex BDA infrastructures would represent a significant effort for SMEs, due to their resource constraints (Santoro et al. 2018), SMEs need to fully take advantage of their investments by leveraging their flexibility and agility to develop BDA capabilities, switching their organizational culture towards digitalization and teamwork and coping with adversity (Scuotto et al. 2017).

Based on these assumptions, we introduce an interaction term in our third hypothesis:

H3 Within the context of SMEs, there is an interplay between the governance of BDA infrastructure and BDA capabilities, resulting in positive interdependencies that lead to a higher degree of internationalization

3 Research method

3.1 The context of analysis—Italian SMEs and internationalization

The global economy has been shaping the environmental context surrounding companies, with the result that not only large corporations but also SMEs are now called to compete internationally (Adomako et al. 2017; Dominguez and Mayrhofer 2017; Santoro et al. 2019). Acknowledging the role of SMEs in enhancing employment, innovation, and economic growth in national economies (Amini 2004; Scuotto et al. 2017), many studies have investigated which factors may boost internationalization and what the consequences are in terms of performance (D'Angelo 2012; Hsieh et al.

2018; Musteen et al. 2010; Oehme and Bort 2015; Onkelinx et al. 2016; Reuber and Fischer 1997; Segaro 2012; Suárez-Ortega and Álamo-Vera 2005). More recently, scholars started focusing on how the recent technological advances have been influencing firms' internationalization (Bagheri et al. 2019; Lecerf and Omrani 2019; Mathews et al. 2016). In Italy, SMEs contribute to the backbone of the national productive system by employing 78.7% of the workforce and accounting for 68.1% of the value added. With regard to the manufacturing sector, the leading one in Italy, the analysis of data on direct exports indicates that Italian SMEs have sold 162.2 billion euros abroad, equal to 9.8% of national GDP and ahead of Spain by 5.7%, Germany by 4.1%, the United Kingdom by 2.0%, and France by 1.8% (Confindustria 2018; ISTAT 2017).

3.2 Data collection

The research involves data gathered from CEOs of medium-sized internationalized firms headquartered in Italy. We decided to focus only on medium-sized companies because small firms in Italy have very few resources to devote to complex, risky, and unfamiliar innovation activities abroad (Testa 2011). First, a total of 1000 medium-sized firms were randomly selected from the Amadeus database, a European database that has been used for many similar studies (e.g., Bresciani and Ferraris 2016). In line with the recommendations from the European Commission (2009), we selected medium-sized firms that have between 50 and 250 employees. Second, an email was sent to all the firms asking them to participate in the survey, along with further details on the study's purpose and other general information. A total of 266 firms responded positively (a response rate of 26.6%). Third, a questionnaire was sent to these firms starting in December 2017, with two reminders in March 2018 and October 2018. A final sample of 103 CEOs successfully answered our questions in the period February–November 2018. We had to discard some non-valid questionnaires because of lack of reliability on the answers, non-significant R&D abroad performed by the firms, and incomplete questionnaires.

Regarding the construction of the questionnaire, we asked questions related to our dependent variable after the questions about the independent variables in order to reduce the effects of consistency artefacts (Salancik and Pfeffer 1977) and to prevent respondents from understanding the relationship underlining our analysis, thus reducing the likelihood of a social desirability bias.

On average, firms in our sample have 156 employees, a turnover of €31 million, and operate in several sectors such as the electronics, engineering, software, and construction industries. The trading countries in which the firms mainly operate are the USA, Russia, and China, followed by some EU countries.

3.3 Variables used in this research

3.3.1 Main variables

Our two independent variables, governance of BDA infrastructure and BDA capabilities, are measured following previous BDA studies (e.g., Akter et al. 2016; Ferraris et al. 2018; Wamba et al. 2017a, b). Both variables were captured by six items. We used a 7-point Likert-type scale ranging from 1 to 7, where 1 corresponded to entirely disagree and 7 to entirely agree.

In order to build the dependent variable, internationalization activity, the authors obtain the ratio of foreign sales to total sales (FS/TS), which is in line with past studies (e.g., Tallman and Li 1996; Capar and Kotabe 2003; Ferraris et al. 2016), including both sales of foreign units and exportation. This measure has triggered some arguments in the literature on its validity and reliability (Ramaswamy et al. 1996). Alternative approaches were proposed by Sullivan (1994), who suggested a five-item multidimensional measure, and Hitt et al. (2006), who employed a sales-based entropy measure.

More recently, Dagnino et al. (2018) went beyond this approach by proposing a modified entropy measure based on the number of production plants that a firm has in each country in which it operates. However, because of data availability, and due to the fact that FS/TS is the measure most used in previous inquiries (facilitating valid cross-study comparisons of findings), the authors have opted for the FS/TS ratio. Moreover, since BDA capabilities may have a potential laggard effect in the international expansion outcomes (because being international is not an immediate reaction to the possession of certain new and superior capabilities), internationalization performances are likely to arise in the future. Thus, we asked the companies to report data for each year in the period 2015–2017, and we used the growth rate (%) of internationalization from the first to the last year of the period analyzed in order to assess our variable. All survey items are shown in Table 1.

3.3.2 Control variables

RandD intensity may influence the effective use of big data and the related capabilities, as well as the capacity to manage knowledge because, as suggested by Cohen and Levinthal (1990), individuals learn, or absorb, knowledge by associating it with their existing knowledge base. We measured R&D by measuring the expenditures by a firm on its research and development divided by the firm's total revenue. Like prior studies on SME internationalization (e.g., Zhang et al. 2012), we also controlled for high-tech vs. low-tech industries because high-tech SMEs may be able to learn more from BDA assets compared with more traditional SMEs (we used a dummy variable that takes the value of 1 for a high-tech and 0 for a traditional industry).

Lastly, several control variables in the overall model were also used because they may impact business process performance: firm size (as measured using the natural logarithm of the number of employees); firm age (as measured using the natural logarithm of the number of years from the date of birth); and three geographical dummy variables in order to catch differences among the north, center, and south of Italy. Correlations among the variables are presented in Table 2.

Table 1 Survey items

Governance of BDA infrastructure (adapted from Akter et al. 2016; Ferraris et al. 2019; Wamba et al. 2017a, b) *Cronbach's alpha = 0.83*	All remote, branch, and mobile offices are connected to the central office for analytics
	Our organization utilizes open system network mechanisms to boost analytics connectivity
	Software applications can be easily transported and used across multiple analytics platforms
	Our user interfaces provide transparent access to all platforms and applications
	End-users utilize object-oriented tools to create their own analytics applications
	Applications can be adapted to meet a variety of needs during analytics tasks
BDA capabilities (adapted from Akter et al. 2016; Ferraris et al. 2019; Wamba et al. 2017a, b) *Cronbach's alpha = 0.81*	We continuously examine the innovative opportunities for the strategic use of BDA
	We perform BDA planning processes in systematic and formalized ways
	When we make BDA investment decisions, we think about and estimate the effect they will have on the productivity of the employees' work
	When we make BDA investment decisions, we consider and project how much these options will help end-users make quicker decisions
	In our organization, information is widely shared between business analysts and line people, or those who make decisions or perform jobs have access to all available know-how
	In our organization, the responsibility for BDA development is clear
Degree of internationalization (Tallman and Li 1996; Capar and Kotabe 2003; Ferraris et al. 2016)	Ratio of foreign sales to total sales (FS/TS)

4 Results

We tested the hypotheses using OLS regression analysis, and we present the results in Table 3. Model 1 represents the effect of the control variables only on internationalization activity. Model 2, on the other hand, is implemented to test the impact of the two independent variables (governance of BDA infrastructure and BDA capabilities) while in Model 3, the interaction terms are proposed to look at the interaction effect between the two independent variables. Model 1 has an R^2 of 0.14 (adjusted R^2 is 0.11) and an F-value of 5.28 ($p < 0.01$). Model 2 has an R^2 of 0.36 (adjusted R^2 is 0.33) and an F-value of 11.25 ($p < 0.001$). Model 3 has an R^2 of 0.40 (adjusted R^2 is 0.36) and an F-value of 10.53 ($p < 0.001$).

The outcomes of the empirical analysis indicate that BDA positively affects the international performance (in terms of foreign sales ratio) of medium-sized Italian companies. However, the analysis proves that only BDA capabilities positively and

Table 2 Correlations among key variables

	BDA capabilities	Governance of BDA infrastructure	Degree of internationalization	Firm size	Firm age	R&D intensity
BDA capabilities	1					
Governance of BDA infrastructure	0.413**	1				
Degree of internationalization	0.501**	0.208*	1			
Firm size	− 0.007	− 0.077	0.056	1		
Firm age	− 0.19	− 0.056	0.054	.265**	1	
R&D intensity	0.146	0.129	0.357**	0.028	− 0.129	1

* $p < .05$

** $p < .01$

Table 3 Results of the regression analysis

Variables	Degree of internationalization		
	Model 1	*Model 2*	*Model 3*
Governance of BDA infrastructure	–	− 0.01 (− 0.10)	− 0.11 (− 1.02)
BDA capabilities	–	0.50 (5.50) ***	0.54 (5.88) ***
Governance of BDA infrastructure x BDA capabilities	–	–	0.19 (2.09) *
R&D intensity	0.37 (3.88) ***	0.30 (3.60) ***	0.28 (3.30) **
Firm size	0.08 (2.18) *	0.02 (0.02)	− 0.12 (− 0.14)
Firm age	0.07 (0.49)	0.15 (2.13) *	0.19 (1.98) *
Geography_1 (1 = North of Italy, 0 = no)	0.04 (0.21)	0.05 (0.23)	0.07 (0.17)
Geography_2 (1 = Center of Italy, 0 = no)	0.05 (0.24)	0.04 (0.20)	0.05 (0.54)
Geography_3 (1 = South of Italy, 0 = no)	− 0.05 (− 0.46)	− 0.04 (− 0.32)	− 0.07 (− 0.49)
Industry (1 = high tech, 0 = low tech)	0.03 (0.31)	0.075 (0.79)	0.05 (0.54)

* $p < .05$

** $p < .01$

*** $p < .001$

directly impact internationalization (in model 2, the standardized coefficient is 0.50 with *t*-value of 5.55, $p < 0.001$), while the governance of BDA infrastructure that corresponds to our first hypothesis does not show any significant effects (see both Models 2 and 3).

Particularly interesting is the interaction effect between the two independent variables. Along with the procedures for testing interaction effects suggested by Aiken and West (1991), the independent variables were standardized before creating the multiplicative terms, thus reducing possible distortion caused by strong correlations between the interaction term and its components. Model 3 presents the consequences of the interaction effect between governance of BDA infrastructure and BDA capabilities on internationalization activity. The results indicate that the interaction term is positive and significant ($\beta = 0.20$, $t = 2.18$, $p < 0.5$).

Concerning the control variables, one of the variables employed in the different regressions (R&D intensity) significantly explains a part of the variance in the internationalization performance (see all models). Moreover, firm age positively influences internationalization performance in our sample ($\beta = 0.22$, $t = 2.54$, $p < 0.5$). Surprisingly, firm size as well as industry do not show significant results in this analysis. Moreover, there are no significant differences in the geographical locations of firms and thus no difference between north and south Italy.

5 Discussion and contributions

The purpose of this study is to analyze the impact of BDA on internationalization within the context of SMEs. More specifically, we consider two variables related to BDA, namely governance of BDA infrastructure and BDA capabilities. They were

both expected to play key roles in our development of the hypotheses. We tested single and joint effects of these two distinguished concepts, finding that governance of BDA infrastructure does not influence internationalization activity, while BDA capabilities do. Moreover, an interesting result emerges in this study when the interaction term enters into the regression model, showing a positive and significant interaction effect between governance of BDA infrastructure and BDA capabilities.

The results of this study indicate that the complexity in terms of hardware architecture and infrastructure that BDA requires may represent a challenge for SMEs that needs to be tamed by developing specific ad hoc capabilities (Ferraris et al. 2019; Rialti et al. 2019a). Thus, the findings highlight the importance of management capabilities in extracting value from big data, reinforcing previous studies attributing the importance to the various processes in which data are collected and analyzed (Ferraris et al. 2019; McAfee et al. 2012). The speed at which companies are called to operate and the uncertainty they have to face in foreign markets highlight the necessity of aligning the overall organization, spreading a big data-driven culture not just confined to the "expert" level (Bullini Orlandi and Pierce 2019; Frisk and Bannister 2017; Mikalef et al. 2019a, b). This means changing processes and routines according to the necessity of dealing with a large number of unstructured datasets (Rialti et al. 2019a). Top managers would have the opportunity to validate positions that were previously supported by common sense, practical experience, or received wisdom (Ferraris et al. 2018; Gupta and George 2016), whereas employees should incorporate big data-specific skills to increase their familiarity with complicated computer-science analytics methods (Barton and Court 2012; Shah et al. 2012). Although the literature has reported several examples of big data success (Davenport 2014), the systematic adoption by companies is still sparse (Braganza et al. 2017). However, if SMEs are able to exploit their agility to leverage the full potential of BDA, they will gain a competitive advantage in their strategic decisions related to internationalization, with a positive impact on foreign sales. Since SMEs are usually less formalized than large companies, it is important that these processes be driven by managers who will play a key role in promoting the development of BDA-related capabilities (Ferraris et al. 2018).

This study intersects with and provides contributions to different streams of research. First, it contributes to the RBV (Barney 1991, 2001) in the specific domain of information systems (Wade and Hulland 2004) by providing new knowledge on the role that the governance of BDA infrastructure and BDA capabilities can play in enhancing SME internationalization activity. More precisely, we point out that BDA, in order to stimulate higher internationalization performance, should combine a flexible, transparent, and reliable infrastructure with specific superior, rare, difficult-to-imitate, and non-substitutable BDA capabilities. This would help democratize, contextualize, investigate, and implement big data comprehension in a proper way (Anwar et al. 2018; Zeng and Glaister 2018) to deal with the unpredictability of foreign markets by exploring and scanning opportunities as well as assessing potential risks more effectively.

This study also contributes to BDA studies and to SME internationalization studies. The relationship between these two emerging streams of research has great potential despite being overlooked so far. Previous studies addressing BDA and BDA

capabilities have in fact analyzed their impact on firm performance and competitive advantage, but they have omitted considering internationalization as a possible measure of performance. Akter et al. (2016), for instance, included customer retention, sales growth, profitability, and return on investment as measures of firm performance. Wamba et al. (2017a, b) instead integrated financial performance with market performance of the firm (e.g., success rate of new products, market share, and new market entry). Anwar et al. (2018) went one step further and considered the non-financial performance as well, such as customer satisfaction, employee satisfaction, and product/service quality. We contribute to shedding light on the possible impact of BDA in the field of SME internationalization that increasingly represents an important element of performance for SMEs in hyper-competitive and globalized economies (Bianchi and Wickramasekera 2016; Dabić et al. 2020; Ferraris et al. 2019).

This study produces relevant insights for companies. In fact, SMEs, during their internationalization process, have to deal with the so-called liability of smallness (Santoro et al. 2018; Zahra 2005; Zhou et al. 2007) and liability of foreignness (Ferraris 2014; Ferraris et al. 2016). BDAs can help to address these problems and increase the effectiveness of international activity in SMEs, such as exploring and scanning international markets, assessing country risks, and finding new partners to establish joint ventures or to invest in foreign direct investments. However, SMEs have limited financial and human resources compared with bigger firms, and investments must be adequate to prevent SMEs from draining resources without producing value for the company. The findings of this work suggest that investing in the governance of BDA infrastructure to enhance internationalization activity may not create value for SMEs, unless they devote efforts to developing BDA capabilities. Indeed, SMEs should invest in BDA infrastructure while increasing management capabilities in order to facilitate change in organizational culture towards more data-driven companies. Moreover, SMEs should also be able to make use of big data to better manage their human resources, increasing efficiency and optimizing costs, especially by monitoring the local teams that are operating overseas and trying to increase their satisfaction. To increase their BDA performance, SMEs should be open to learning from the success of more mature and larger organizations that have already implemented efficient systems of business analytics and BDA.

6 Conclusion

Today, the ability to adapt rapidly within the global market is no longer limited only to large companies but also to SMEs that want to achieve long-term survival (Adomako et al. 2017; Bresciani 2017; Cerrato and Piva 2012; Dominguez and Mayrhofer 2017). Leveraging resources in different geographic areas with different market conditions could allow firms to more easily capitalize on market imperfections, gaining higher returns on their investments (Ferraris 2014; Lu and Beamish 2001). Although the role of information in facilitating export processes has already been acknowledged by previous studies (Chabowski et al. 2018; Fletcher et al. 2013; Kiron 2013; Rialti et al. 2018; Theodosiou and Katsikea 2013), there is still a paucity of studies that analyze the effect of BDA and their related capabilities on SME

internationalization. In this study, the authors have investigated the impact of the governance of BDA infrastructure and BDA capabilities on internationalization by using OLS regression analysis based on data gathered from 103 Italian SMEs. The results show that BDA capabilities have positive and significant impacts on internationalization activity, while governance of BDA infrastructure does not reveal any direct influence. Moreover, the most interesting result of this study is the significant and positive combined effect of BDA infrastructure and BDA capabilities, highlighting the importance of simultaneously integrating these two BDA-related dimensions.

There are some limitations and some possible further developments based on this study. First, the sample is limited to only the Italian context; it may be useful to take different samples from different contexts, countries, and cultures in order to derive wider and deeper implications. Second, this study considers the relationship between governance of BDA and internationalization by introducing BDA capabilities as the moderator. However, the relationship between BDA and internationalization can be affected by other organizational variables. Further studies could include other moderators in the research model. Moreover, internationalization is a complex phenomenon based on multiple phases or sub-phases. A possible future development of this work may be to investigate not only the DOI but also the international processes of SMEs, analyzing, for instance, whether BDA are more critical in exploring and scanning international markets, assessing country risk, or finding potential partners to establish joint ventures or to invest in foreign direct investments. Third, the research model does not consider costs for implementing BDA (e.g., large amount of time, privacy concerns) and does not consider learning mechanisms that people who use BDA may experience. Future studies should consider these aspects and test non-linear relationships such as inverted U-shaped or more complex relationships (e.g., for the relationships' internationalization performance, cf. Bresciani and Ferraris 2015; Ferraris et al. 2016). Moreover, another interesting further step may be focusing on analyzing which logics and institutional pressures hamper the adoption of BDA among SMEs beyond traditional cost–benefit analyses (Arendt 2008; De Bernardi et al. 2019).

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