# Big data value and financial performance: an empirical investigation

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## Abstract

Firms automatically and continuously capture a high amount of digital data through social media, RFID tags, clickstreams, smart meters, manufacturing sensors, equipment logs, and vehicle tracking systems. However, empirical evidence on the effects of the generation of these digital data on firm performance remains scarce in the Information Systems and Management literature. Therefore, from a dynamic capability perspective, this paper examines whether companies' ability to leverage digital data, which we call their Digital Data dynamic capability, leads to better financial performance, and whether there are moderating effects on this relationship. In order to achieve these goals, the following research questions are addressed: 1) To what extent do firms that develop Digital Data dynamic capabilities achieve better financial performance? 2) To what extent do organisational and industry-related environmental conditions moderate the relationship between a firm's Digital Data dynamic capability and financial performance? We empirically test our hypotheses through partial least square modelling using a financial database and a survey of sales managers from 125 firms. We find that the development of Digital Data dynamic capability provides value in terms of firm financial performance and that the moderating effects are influential: under high levels of dynamism and munificence in younger firms, the relationship is stronger. Overall, this study evaluates the potential business value of firm digital data use and addresses a lack of empirical evidence on this issue in the Information Systems literature. We discuss two managerial implications. First, managers should pay more attention to digital data phenomena and to ways of leveraging value creation opportunities. Second, managers must evaluate their environmental and organisational characteristics when business opportunities from digital data are taken into account.

## Keywords

Big Data; Digital Data dynamic capability; firm financial performance; environmental conditions; organisational conditions.

# 1 Introduction

The foundational research on technology-based initiatives has examined how these initiatives sustain a competitive advantage while creating new competitive opportunities (Bradley et al., 2013; Chen et al., 2012; Sallam et al., 2013). Research on the business value of Information Technology (IT) has characterised the past two decades by focusing on patterns of theoretical development and on empirical findings (Melville et al, 2004). Recent studies have focused on particular IT artefacts to manage data-related problems related to business practices and strategies and, in particular, the Big Data trend (George et al., 2014; Lynch, 2008; Mayer-Schönberger & Cukier, 2013; Orlikowski & Scott, 2015; Watson, 2014). Big Data is the umbrella term for this evolving trend. Recent research suggests that Big Data is a driver of business success across a wide range of industries (McAfee & Brynjolfsson, 2012). Organisations are investing considerable resources in Big Data initiatives in search of value creation opportunities (Chen et al., 2012) to drive their digital business strategies (Bharadwaj et al., 2013) and allow them to make better informed business decisions (Eastburn & Boland Jr., 2015). Digital data (DD) are at the very foundation of this Big Data trend. Every day people generate DD through tweets, clicks, videos and the plethora of sensors that are embedded in their devices (Kietzmann et al., 2013). Furthermore, instruments and machines such as smart meters, manufacturing sensors, equipment logs, and vehicle tracking systems automatically and continuously generate DD. When firms use radio frequency identification (RFID) technologies to track items along a supply chain, they produce DD, and when customers follow a link to a website, they also produce DD. Piccoli and Watson (2008) explain how Caesars-Harrah's Entertainment (the largest casino firm in the United States) uses its well-known Total Rewards loyalty points system to collect extensive data on its customers' gambling behaviours by providing customers with cards that link names to transactions, and that allow Caesars-Harrah's to monitor behaviour over time. Armed with this infrastructure for collecting customer data, Caesars-Harrah's can extract value from data and then tailor the gaming experience to each customer.

We propose that the digital nature of data constitutes a fundamental characteristic of data itself. DD have unique properties that we do not find in physical infrastructures (Kallinikos et al., 2010). Moreover, DD are so easily shared, replicated, and combinable that they present tremendous reuse opportunities (Lynch, 2008). Finally, DD are at risk of various forms of obsolescence (Lynch, 2008), requiring organisations to leverage them promptly. Some firms such as Procter & Gamble, General Electric, and Cisco have successfully accelerated their decision-making processes thanks to DD (Bharadwaj et al., 2013).

These unique characteristics have contributed to the exponential growth of DD (Kallinikos et al., 2010), and such growth requires the use of new organisational approaches and specific research streams. "*Businesses appear to be on the cusp of a data-driven revolution in management. Firms capture enormous amounts of fine-grained data on social media activity, RFID tags, web browsing patterns, consumer sentiment, and mobile phone usage, and the analysis of these data promises to produce insights that will revolutionise managerial decision-making*" (Tambe, 2014, p. 1452). These fine-grained data play an additional economic function: generating wishful content and unwitting meta-data surrounding main content (Kallinikos et al., 2010; Orlikowski. 2015).

Organisations face enormous challenges when accessing, processing, and analysing such massive quantities of data (Bharadwaj et al., 2013). Indeed, many firms are overwhelmed by enormous amounts of fine-grained data. Firms that are not overwhelmed by these data still face significant management challenges (e.g., during recruitment) (Tamble, 2014). This recent data-driven revolution can offer firms opportunities to make prompt and accurate decisions based on readily available DD (McAfee & Brynjolfsson, 2012; Piccoli & Watson, 2008).

Because of this rapidly changing environment, we expect Information Technology (IT) capabilities to manage DD to be a key feature of successful businesses. The notion of IT capability refers to the deployment of IT-based resources while leveraging the value of other resources and capabilities (Bharadwaj, 2000). The capability perspective highlights the importance of a firm's internal resources to evaluations of its competitive advantage (Eisenhardt & Martin, 2000; Wernerfelt, 1984), particularly in today's fast-paced environment (Banker et al., 2006). Understanding the effects of IT resources and capabilities on firm performance remains a central issue in the Information Systems (IS) and management literature (e.g., Benitez-Amado & Walczuch, 2012; Galy & Sauceda, 2014; Melville et al., 2004; Mithas et al., 2011; Wang et al., 2013). Although several researchers have attempted to understand the role of IT capabilities on organisational performance (e.g., Chen et al., 2014), and more specifically on firm financial performance (e.g., Dale Stoel & Muhanna, 2009; Kim et al., 2011; Mithas et al., 2011; Neirotti & Raguseo, 2012; Neirotti & Raguseo, 2016), there are little empirical data on whether firms that develop DD dynamic capabilities enjoy better financial performance.

Even less explored is the role of environmental and organisational variables in the relationship between the development of such IT capabilities and a firm's financial performance. Therefore, in this study, we consider the moderating effects of such variables. The industry-related environmental effects considered are the level of munificence and the dynamism of the environments where firms do business. Industry-related environmental effects constitute a critical contextual variable with respect to the impacts of IT (Li and Richard Ye, 1999), dynamic capabilities (Eisenhardt & Martin, 2000; Gligor et al., 2015) and, at their intersection, IT capabilities (Chen et al., 2014; Dale Stoel & Muhanna, 2009). A coherent configuration that matches internal mechanisms with exogenous variables could help firms achieve superior levels of performance (Burns & Stalker, 1994; Thompson et al., 1992).

Processes of environmental dynamism appear to constitute a critical dimension of a firm's external environment, representing degrees of instability and change in a firm's environment. In highly dynamic environments, upper managers experience much more uncertainty or are presented with a dearth of information related to the current state of the environment, to the potential impact of such developments on their firms and to strategic options accessible to them (Li & Richard Ye, 1999). In addition, environmental munificence appears to be an important dimension that should be taken into account. It refers to the availability of resources in an environment. These two dimensions thus represent external challenges facing a firm. In this context, investments in IT and in IT dynamic capabilities may serve as an effective way to provide timely and relevant information to upper managers and to thus reduce levels of uncertainty (Li & Richard Ye, 1999).

When examining organisational effects, firm age and size are two variables that can affect the ways in which firms invest in IT and in IT dynamic capabilities. More specifically, firm size and age characteristics can change the degree to which certain postures, structures, and tactics boost a firm's performance under different strategic missions (Covin et al., 1994).

This study thus serves as an attempt to address the above-mentioned research gap by answering the following research questions: 1) To what extent do firms that develop DD dynamic capabilities achieve better financial performance? 2) To what extent do organisational and industry-related environmental conditions moderate the relationship between DD dynamic capability and financial performance? In examining these research questions, we tested five hypotheses by combining data gathered from a survey of 125 Western European firms and from the AIDA Bureau Van Dijk database, which contains financial data on various firms.

## 2 Theory and hypotheses

### 2.1 Dynamic capability contributions to firm performance

Our research is based on dynamic capability theory (Augier & Teece, 2009; Peteraf et al., 2013; Teece et al., 1997), which is grounded in the resource-based view of firms (Barney, 1991). Dynamic capability theory has been employed in several fields to evaluate the efficient use and competitive advantage implications of specific firm resources (e.g., entrepreneurship (Rumelt, 1987), culture (Barney, 1986), and organisational routines (Winter & Nelson, 1982). The resource-based view has been used in the IS literature to theoretically ground studies on firm-level competitive advantage and on its sustainability (Nevo & Wade, 2010; Wade & Hulland, 2004), and it remains a central issue (e.g., Benitez-Amado & Walczuch, 2012; Galy & Sauceda, 2014; Melville et al., 2004; Wang et al., 2013).

The resource-based view highlights the importance of a firm's internal resources defined as the "*assets and capabilities that are available and useful in detecting and responding to market opportunities or threats*" (Wade & Hulland, 2004, p. 109). In today's fast-paced environment, organisations must adapt to or create market changes and develop dynamic capabilities. A dynamic capability is "*the ability to sense and then seize new opportunities and to reconfigure and protect knowledge assets, competencies, and complementary assets with the aim of achieving a sustained competitive advantage*" (Augier & Teece, 2009, p. 412). This adaptability has been identified as a way to increase customer value (Sambamurthy et al., 2003) and is considered particularly advantageous in fast-paced technological environments (Banker et al., 2006).

Firms use dynamic capabilities to identify and react to opportunities and threats in several ways (Dosi et al., 2000; Mithas et al., 2011). First, dynamic capabilities can improve the speed, effectiveness, and efficiency of organisational processes through which firms operate, resulting in cost reductions (Mithas et al., 2011; Tallon, 2008). Second, dynamic capabilities can positively influence a firm's capacity to understand and relate to customers and their changing requirements, expectations and preferences. This better customer relationship generates revenue-enhancing opportunities ( Mithas et al., 2011). Third, dynamic capabilities can positively affect firm financial performance by allowing firms to seize new opportunities and to develop new processes, products, and services based on performance data (Mithas et al., 2011; Zou et al., 2003). Fourth, dynamic capabilities generate new sets of previously unavailable decision options and thus allow for greater contributions to firm financial performance, (e.g., increased revenues or profits). Accordingly, dynamic capabilities can extend existing resource configurations and thus develop entirely new sets of decision options that improve a firm's processes and product performance (Eisenhardt & Martin, 2000). Apple Inc. serves as a good example of a firm with strong dynamic capabilities in many domains that have enabled it to recognise weaknesses of existing MP3 players, mobile telephones, and laptops and to surpass them with the iPod, iPhone, and iPad, thereby profiting from these products.

Although several researchers have attempted to determine the role of dynamic capabilities in organisational performance and more specifically in firm financial performance (e.g., Dale Stoel & Muhanna, 2009; Kim et al., 2011), there is little empirical evidence on whether firms that develop DD dynamic capabilities achieve higher levels of financial performance (Mithas et al., 2011).

### 2.2 DD dynamic capability contribution to firm financial performance

In our study, we define DD dynamic capability as the ability to seize new opportunities in DD through a four-fold organisational process that involves 1) "Choosing IT" (CIT) to generate and capture data unobtrusively in digital form; 2) "Integrating IT" (IIT) into the appropriate business processes; 3) "Managing digital data" (MDD) that are produced; and 4) "Reconfiguring" (REC) business processes, competencies or assets based on internal and external conditions. DD dynamic capability has also been empirically explored and supported by a preliminary case study (Prescott, 2014).

We theorise about DD capability as a dynamic capability for two complementary reasons. First, DD dynamic capability involves the ability to deploy new configurations of operational processes, assets or competencies relative to the competition. Second, DD dynamic capability involves dynamically reconfiguring and protecting existing combinations of assets and competencies to adapt to changing environmental conditions (Pavlou & El Sawy, 2006). These reconfigured and protected assets include IT and DD. The degree to which an ineffective organisational process related to DD can be reconfigured into a more promising process that matches its environment and that is better, faster, and less expensive than the competitors' processes determines the capability's dynamic quality (Eisenhardt & Martin, 2000).

Antecedents to DD dynamic capability are sensing, learning, integrating and coordinating capabilities (Pavlou & El Sawy, 2013). These capabilities facilitate the identification of opportunities for generating and leveraging DD. Our definition of DD dynamic capability takes advantage of these antecedents to seize opportunities presented by DD. Taking into account the four different ways of using dynamic capabilities to identify and react to opportunities and threats, DD dynamic capability can accelerate organisational and selling processes, advance knowledge on customer behaviour through analysis (e.g., data on their buying behaviours), present new services based on DD analysis, and support new decisions based on available DD. For example, a solution designed by Boeing, an American multinational corporation that designs, manufactures, and sells aircraft, highlights the potential link between DD and a firm's financial performance (Nolan, 2012). Boeing continues to expand its technology-based solutions to support commercial aircraft operators with regard to maintenance management issues. Boeing's solution mainly involves providing operators with DD for hangar maintenance through a secure online delivery system and time-critical problem solving at the gate through portable maintenance computers. These DD products and services help operators increase productivity, reduce technical operational costs, maximise available flying time and boost financial performance (Nolan, 2012). Based on these arguments and examples, DD dynamic capabilities can positively contribute to a firm's financial performance. Therefore, we formulate Hypothesis 1 as follows:

***H1***. *The higher the degree of DD dynamic capability is, the higher a firm's financial performance will be.*

## 2.3 Moderating effects on the relationship between DD dynamic capability and firm financial performance

We formulate four hypotheses in this section regarding the moderating effects of environmental and organisational variables on DD dynamic capability and firm financial performance. A moderator is a variable that affects the direction and/or strength of the relationship between an independent and dependent variable (Baron & Kenny, 1986). We consider factors that are involved in industry-related environmental and organisational effects as moderator variables. More specifically, we consider levels of munificence and dynamism in environments where firms do business, as these are critical contextual variables with respect to IT impacts. In considering organisational effects, we use firm age and size indicators as moderator variables given their impact on the ways in which firms invest. These moderators are used extensively in IS studies (e.g., Venkatesh et al., 2012).

### *2.3.1 The moderating effect of environmental dynamism*

Environmental dynamism refers to the rate of instability in an industry, i.e., changes in customer preferences and the pace at which firms develop new products and technologies (Dale Stoel & Muhanna, 2009). The literature shows that environmental dynamism moderates business performance (Lumpkin & Dess, 2001; Teece et al., 1997). Environmental dynamism constitutes a central factor in dynamic capability development. It is in fast-paced environments that organisations must constantly adapt to or create market changes with dynamic capabilities emerging as a result (Teece et al., 1997).

Response time is particularly essential when firms operate in dynamic environments, as significant and unpredictable changes in customer tastes, production levels, service technologies and modes of competition are found in such environments (Bechor et al., 2010). Therefore, the ability to respond to such environmental changes is even more critical for firms that operate in settings of increasing global competition. When firms are slow to respond, they may miss opportunities or be pre-empted by competitors (Bhatt et al., 2010). Conversely, firms that respond quickly to customer changes may often realise long-term performance benefits.

Given the advantages of DD dynamic capability, we expect firms in dynamic environments to achieve better financial performance using DD that are immediately available, and that can be managed and reconfigured to suit firm needs and strategies. For example, DD may provide organisations with insight into customers' expressed and latent needs, and this may result in reshaped strategies and increased revenues.

Based on these considerations, we expect that firms that develop high levels of DD dynamic capability achieve higher levels of financial performance under high levels of environmental dynamism.

***H2***. *The higher the level of environmental dynamism is, the higher the contribution of DD dynamic capability will be to firm financial performance.*

### *2.3.2 The moderating effect of environmental munificence*

Munificence refers to the extent to which opportunities exist and the degree to which an environment makes resources available to sustain growth (Dale Stoel & Muhanna, 2009; Rosenbusch et al., 2013). Munificent environments are characterised by growth in customer demands; thus, firms must be prompt in responding to customer needs (Xue et al., 2012). To the extent that munificence contributes to environmental uncertainty (Gligor et al., 2015), dynamic capabilities are necessary to obtain and sustain a competitive advantage in a highly uncertain environment (Teece et al., 1997). Thus, dynamic capabilities that make firms more attuned to customer demands positively contribute to the achievement of better firm financial performance (Dale Stoel & Muhanna, 2009).

The analysis and availability of DD may support more timely interactions with new opportunities (e.g., proposing new offers to customers). Such interactions may in turn reveal a variety of avenues for business expansion and profit. In short, we expect firm financial performance resulting from DD dynamic capability to be more pronounced in highly munificent environments. Therefore, we propose Hypothesis 3.

***H3***. *The higher the degree of environmental munificence is, the higher the contribution of DD dynamic capability will be to a firm's financial performance.*

### *2.3.3 Moderating effects of firm age*

Firm age refers to the number of years that a firm has been in business (Yli-Renko et al., 2002). Scholars have related firm age to firm financial performance through selection effects, learning-by-doing effects and inertia effects (Coad et al., 2013). These three factors can have opposite effects on firm performance and can interact with firms. In the case of DD dynamic capability, organisational inertia (e.g., Balasubramanian & Lee, 2008) has effect in fast-paced environments when dynamic capabilities are more suitable. Organisational inertial forces may render older firms less productive, as they can become increasingly inflexible, fitting in less with the changing business environment. Older firms may risk becoming rigid due to accumulating rules, routines, practices and structures (Autio et al., 2000), and they are not able to change as fast as their environments (Hannan & Freeman, 1984). Because organisations must constantly adapt to or create market changes in today's fast-paced business environment, older firms with accumulated rules, routines, practices and structures that function in slow-paced environments struggle more than younger firms do in converting their capabilities into financial performance. Based on these arguments, we expect that older firms may be less likely to promptly leverage DD dynamic capability and thereby achieve better financial performance. Based on these considerations, we propose Hypothesis 4.

***H4***. *The older the firm is, the lower the contribution of DD dynamic capability will be to firm financial performance.*

### *2.3.4 Moderating effects of firm size*

We use the number of employees as a proxy for firm size. Scholars have related firm size to firm financial performance through their resource bases, scale and scope economies, pre-emptive move capabilities, formalisation levels, decentralisation patterns, specialisation trends, and innovativeness levels (Eisenhardt & Martin, 2000; Kirca et al., 2011; Wagner et al., 2012).

These factors can have opposite effects on firm performance and can interact with firms. In the case of DD dynamic capability, we expect large organisations to struggle more in responding to changing conditions (Eisenhardt & Martin, 2000) and to thus be less innovative (Wagner et al., 2012). Such organisations tend to be associated with higher degrees of differentiation and formalisation, more decentralised managerial decision-making authority systems, higher levels of task specialisation, and more complex forms of communication. These characteristics may be indicative of high levels of bureaucracy in large firms, which limit the capacities of such firms to adjust effectively to rapid change. Consequently, DD dynamic capability may have a more significant effect on the financial performance of smaller firms because such firms should be characterised by higher levels of innovativeness. Thus, smaller firms may be more equipped to identify opportunities presented by DD and to recombine existing internal resources and data to adapt to changing environmental conditions (e.g., by collecting and producing additional DD). Furthermore, as organisational inertia may be related to manager inabilities to streamline long chains of command and control in large organisations, managers of small firms may be quicker to take advantage of new opportunities (e.g., the exploitation of DD). Therefore, we expect DD dynamic capability development to have a stronger effect on the financial performance of smaller firms.

***H5***. *The smaller the size of a firm is, the higher the contribution of DD dynamic capability will be to firm financial performance.*

To summarise, we present the conceptual framework for our hypotheses in Figure 1.

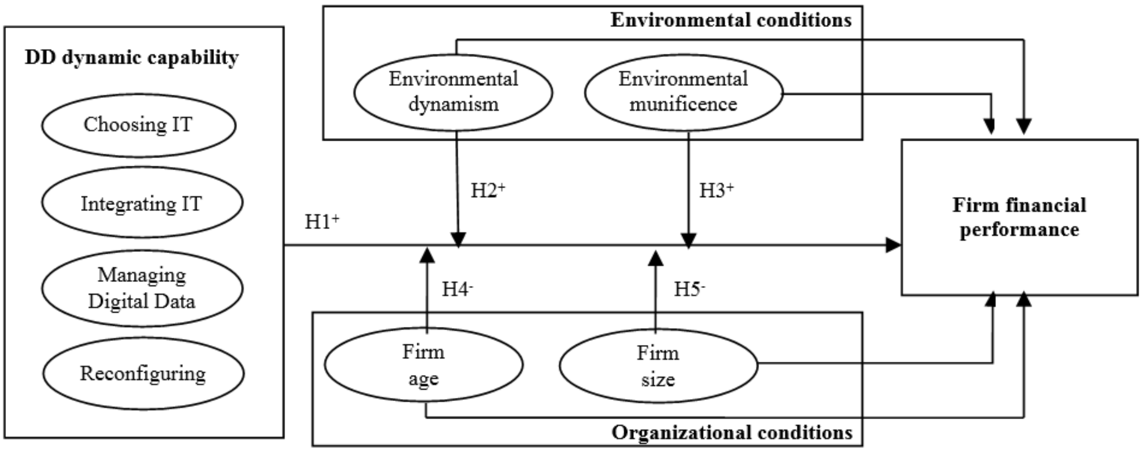


**Figure 1: Conceptual framework of the study**

# 3 Study design and method

## 3.1 Research design

We define a quantitative cross-sectional design to answer the research questions. In particular, we empirically propose to test our hypotheses through structural equation modelling (SEM). The logic beyond this choice is mainly related to the advantage of SEM in simultaneously testing the measurements and the structural models. In our case, SEM allows us to test multiple regression equations while avoiding the need to run multiple regression analyses when testing our entire model. We use a questionnaire-based survey distributed to firms located in Western Europe to provide the quantitative data required to run the SEM. The questionnaire-based survey gathers data on each variable in our conceptual framework. The operationalisation of the variables leverages the existing literature, an expert panel, the Q-sorting method and a case study. Finally, we supplement the results of this survey with firm financial data from the AIDA Bureau Van Dijk database. This database contains financial data on European firms.

## 3.2 Measurement

### *3.2.1 DD dynamic capability*

DD dynamic capability was operationalised as a reflective second-order construct based on four first-order components, CIT, IIT, MDD and REC, as discussed above. This approach is in line with previous research on dynamic capabilities (Setia et al., 2013) and with the IS literature (Ordanini & Rubera, 2010). DD dynamic capability is measured as a reflective construct (Coltman et al., 2008), as we hypothesise that this latent construct exists independent of its measurements (Borsboom et al., 2004; Rossiter, 2002). Moreover, we assume that the direction of causality between the construct and the indicators flows from the DD dynamic capability construct to the CIT, IIT, MDD and REC indicators. Finally, we assume that any change in this latent variable must precede variation in its indicators. Thus, this variable’s indicators share a common theme and are interchangeable. Consequently, for the sake of parsimony, we can reduce the number of items relatively safely without materially altering the content validity of the construct (Coltman et al., 2008).

More specifically, all the research variables that constitute DD dynamic capability were measured using multi-item Likert scales from 1 (not at all) to 7 (to a large extent) based on previous empirical research (Table 1), though this approach was not used for the CIT construct. The CIT construct measures firm capacities to select IT tools to unobtrusively collect valuable DD, but it has never been measured empirically. We thus tested the CIT construct empirically and directly through a pilot study. We began with four indicators identified in the literature (Williams, 2003) that have not been empirically tested. We recruited 35 managers from small, medium, and large firms in different industries in the US. Our four focal indicators were inserted among a set of 26 questions to reduce mono-method bias effects. The responses showed that the scale is reliable (Cronbach's alpha = 0.837).

Before collecting the main survey data, we consulted an expert panel composed of seven sales managers and two IT managers, and we used the Q-sorting method to adapt the chosen scales to our research context and to assess the content validity of the scales used. The expert panel proposed and validated adaptations of the items for each construct. Q-sorting involved four rounds of refinement before a threshold of 50 percent of attributions to the correct construct for each item was reached. One hundred and nineteen respondents (primarily employees of different organisations between 20 and 40 years of age and equally distributed between men and women) participated in the Q-sorting procedure.

With the exception of the CIT construct, all other variables were based on previous empirical research. IIT was adapted from the variable that measures capacities to integrate IT solutions into business processes (Bharadwaj et al., 1999). MDD was adapted from the information-management dimension of the information capability measurement scale (Marchand et al., 2002) so that we could measure capacities to manage DD. REC was adapted from the reconfigurability measurement scale (Pavlou & El Sawy, 2006) so that we could estimate the capacity to reconfigure DD dynamic capability. Each component of DD dynamic capability was compounded as the mean of the related items. The final construct, DD dynamic capability, was measured as a second-order construct by compounding the mean of the four components of DD dynamic capability. DD dynamic capability has been empirically explored and supported through a preliminary case study (Prescott, 2014).

Our measurement scales were subjected to a long and complex adaptation process involving the following: evaluation by an expert panel, Q-sorting, and a case study. On the one hand, for some variables, this process resulted in several adaptations. The process reveals the extent to which our final scales differ from the original scales. Is so doing, of the various adaptations available, the DD concept was referenced using the term “digital data generation”, as this version was the most comprehensible to our audience. On the other hand, this process highlights the importance of reducing the length of the survey instrument. Thus, for the sake of parsimony, we reduced the number of items used for each construct as much as possible. For some dimensions, we reduced the number of items to two. This decision was supported by the following considerations: (a) two-item Likert scales have been successfully used (Venkatesh & Davis, 2000); (b) the DD dynamic capability construct is reflective, and (c) we intended to replicate questions on these items for the sales and IT managers of each firm. In sum, Figure 2 depicts DD dynamic capability as a second-order construct emanating from the adaptation process.

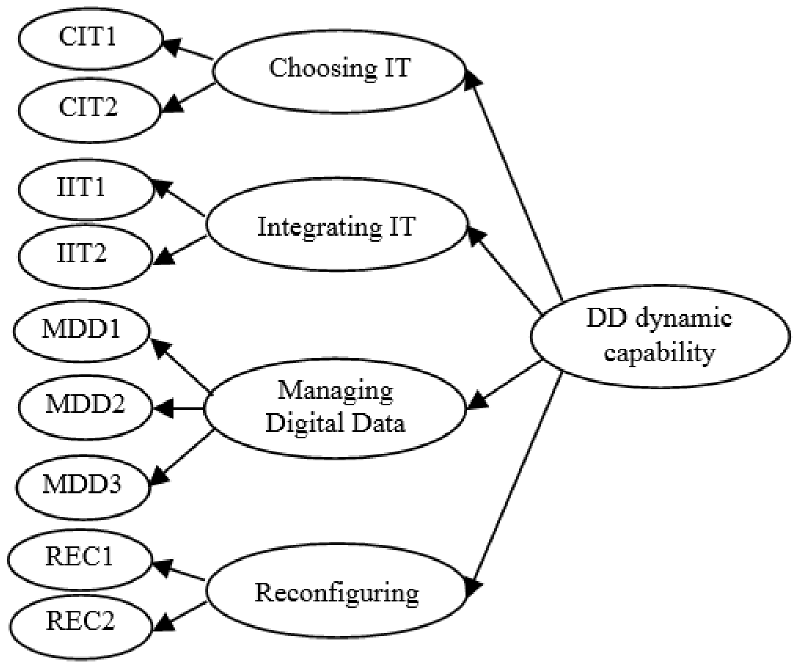


**Figure 2: DD dynamic capability as a second-order construct**

### *3.2.2 Moderating variables*

To operationalise the environmental context, we combined two approaches inspired by Dess and Beard (1984) and by Pavlou and El Sawy (2006). First, environmental dynamism was assessed in two complementary ways, thereby generating the Financial Environmental Dynamism (FED) and Perceived Environmental Dynamism (PED) variables. For the FED, we used AIDA Bureau Van Dijk databases, which contain firm and industry data defined at the three-digit Standard Industrial Classification (SIC) industry level (Johnson and Greening, 1999). Following Dale Stoel and Muhanna (2009), we measured environmental dynamism as variability in annual industry sales. For each sector, industry-level total sales for five years (from 2007 to 2012) were regressed on the year variable. Dynamism was measured as the standard error of the regression slope coefficient of annual industry sales divided by the industry mean for the five-year period. For the PED, we adapted the Environmental Turbulence construct applied by Pavlou and El Sawy (2006). We asked survey respondents to present their perceptions of environmental turbulence (precise statements are shown in Table 1) on a Likert scale of 1 (not at all) to 7 (to a large extent). We compounded a perceived variable on Environmental Dynamism with a financial variable on Environmental Dynamism to determine the robustness of our findings and to reduce mono-method bias effects.

Second, industry munificence was assessed using the AIDA Bureau Van Dijk databases. Using the same data on total industry sales revenues, environmental munificence (EM) was measured as the growth rate in annual industry sales over five years, which is measured as the regression slope coefficient divided by average industry sales. Third, to operationalise firm age (FA), we relied on data extracted from the AIDA Bureau Van Dijk databases (which includes the year of each firm’s establishment), and we calculated age as the difference between the year of the survey and the year of establishment (Yli-Renko et al., 2002).

Fourth and finally, firm size (FS) was constructed based on seven groups of employees (Table 2) (Bhatt & Grover, 2005; Fink & Neumann, 2007).

### *3.2.3 Firm financial performance*

We measured firm financial performance (FFP) using the return on sales (ROS), which we calculated by dividing net income by total net sales, both of which are available from the AIDA Bureau Van Dijk databases. To determine whether each firm's ROS was higher than the industry average (and therefore whether each firm was able to profit more from DD dynamic capability than its counterparts), we subtracted each firm's ROS from the average ROS of the firm's counterparts defined at the three-digit SIC industry level. We used ROS to measure FFP because this variable is strongly related to a firm's managerial capabilities (Kim et al., 2003). Thus, firm financial performance is measured as the difference between a firm's ROS and the industry's ROS to which the firm belongs.

### 3.3 Data collection

To test our hypotheses, we conducted a questionnaire-based survey between 2011 and 2012 that was distributed to firms located in Western Europe, and we supplemented the results of this survey with firm financial data from the AIDA Bureau Van Dijk databases. These databases contain basic financial data on European firms.

As dynamic capabilities are best measured at the organisational-process level (Li et al., 2009), we surveyed sales managers who were familiar with the entire sales process. When sales managers were not accessible, we surveyed sales directors and sales executives. We used this approach because sales departments tend to be more advanced in terms of DD initiatives relative to other firm departments, especially owing to their focus on customer relations (Piccoli & Watson, 2008). Similarly, we surveyed IT managers from the same organisations to reduce mono-method bias effects by presenting a subset of related questions on the final survey. This subset of questions was determined by the previously described expert panel composed of IT managers and sales managers. These experts converged on defining this subset, as they determined that the questions focused on topics that IT and sales managers are directly involved in. In turn, we avoided informant bias effects (Mills et al., 2010).

In this way, we compensated for the small number of items used to measure the CIT, IIT, REC and PED variables by asking the same questions of IT managers. With the same objective in mind, we also compensated for the small number of items employed to measure the PED variable using objective data from the AIDA Bureau Van Dijk database.

We consulted three sources to ensure heterogeneity in the sample, thus ensuring a diversity of organisational sectors and sizes while facilitating the generalisation of our results. First, we surveyed 220 sales and IT managers using contacts from a Customer Relationship Management application maintained by a French business school. Most of these sales managers work in the Rhône-Alpes region, where the business school is headquartered. Second, we examined 402 organisations from the Piedmont region of Italy that had previously participated in an Italian engineering school's survey of the region. Third, we examined 370 organisations from Italy's Veneto region, all of which are members of the corporate syndicate in that region.

Our complete sample pool thus includes 942 organisations. We contacted organisations by telephone or email to request their participation. Data were collected primarily over the telephone or through face-to-face interviews, though a few respondents chose to answer autonomously by accessing an online questionnaire. In the latter case, three weeks after initial mailing, we sent a reminder postcard to sales managers that asked them to complete the survey if they had not previously done so. We also announced that we would provide the results of the study to those who had completed the questionnaire. A total of 202 questionnaires from different organisations (an overall response rate of 21%) were received. Such a high response rate is uncommon in survey research (Cycyota & Harrison, 2006). We discarded 24 questionnaires due to problems concerning missing data. As this study examines whether firms that develop DD dynamic capability enjoy better financial performance, we used only those questionnaires in which respondents indicated that they had launched DD initiatives. We thus excluded the 53 questionnaires wherein respondents indicated that they had launched no DD initiatives. We did not exclude firms from the study based on size or age, as the dynamic capability concept has proven useful in explaining organisational performance even for small entrepreneurial initiatives occupying early stages (Boccardelli & Magnusson, 2006; Gibcus & Stam, 2012). In the end, 125 questionnaires were completed by sales managers, 65 of which were also completed by IT managers from the same firms.

| **Construct** | **Item** | **Survey questions for sales managers** | **Survey questions for IT managers** | **Source** |
|---|---|---|---|---|
| *Choosing IT (CIT)* | CIT1 | Our sales personnel employ effective methods of digital data generation selection | Our IT personnel employ effective methods of digital data generation technology selection | (Williams, 2003) |
| | CIT2 | Digital data generation choices make their case for our sales process | Our IT personnel appropriately select digital data generation technologies | |
| *Integrating IT (IIT)* | IIT1 | The integration of digital data into firm processes renders our sales personnel more effective | Digital data generation technologies are seamlessly integrated into our sales processes | (Bharadwaj et al., 1999) |
| | IIT2 | Digital data generation is successfully integrated into our sales processes | Our IT personnel successfully integrate digital data generation technologies into our sales processes | |
| *Managing digital data (MDD)* | MDD1 | Our sales personnel effectively use digital data that they obtain | | (Marchand et al., 2002) |
| | MDD2 | Our sales personnel effectively process data obtained in digital form | | |
| | MDD3 | Our sales personnel effectively managing digital data that they obtain | | |
| *Reconfiguring (REC)* | REC1 | When our digital data generation methods must evolve, our sales personnel successfully manage their evolution | When our digital data generation technologies must evolve, our IT personnel successfully manage their evolution | (Pavlou & El Sawy, 2006) |
| | REC2 | When our digital data generation methods must evolve, our sales personnel effectively direct their reorganisation | When our digital data generation technologies must evolve, our IT personnel effectively direct their implementation | |
| *Perceived environmental dynamism (PED)* | PED1 | In our industry, the business environment changes unpredictably | IT tools change unpredictably | (Pavlou & El Sawy, 2006) |
| | PED2 | In our industry, customer preferences change unexpectedly | IT innovations are difficult to predict | |

***Note:*** *To collect data through the questionnaire, we clarified the meanings of the following terms: 1) "Digital data generation" involves the production or collection of data in digital form from their inception. Example: the use of a personal digital assistant (PDA) by a waiter in a restaurant to collect orders from customers and to deliver them to the kitchen represents a form digital data generation, whereas the use of a notepad and pen by a waiter to collect orders and to deliver them to the kitchen does not involve digital data generation. 2) "Effective" refers to the production of desired effects. We also asked respondents to provide examples of digital data generation methods employed in their firms to evaluate their understanding of the term.*

**Table 1: Survey items used to test the model**

### 3.4 Data analysis

We apply a structural equation modelling (SEM) technique to simultaneously test our measurement and structural model. SEM techniques allow us to test multiple regression equations simultaneously while avoiding the need to run multiple regression analyses when testing an entire model. Among the SEM techniques available, we use Partial Least Square (PLS) rather than covariance-based tools, as the PLS approach is "*the most accepted variance-based SEM technique*" (Gruber et al., 2010, p. 1342). Moreover, the PLS approach seems particularly useful when testing models that involve dynamic capabilities (Wilden et al., 2013), and particularly for models occupying early stages of development (Fornell & Bookstein, 1982) like our model. Finally, the PLS approach is more appropriate to use when one has access to only small sample sizes (Fornell & Bookstein, 1982), achieving higher statistical power levels than other statistical alternatives.

Of the statistical PLS software applications available, we employ SmartPLS 2.0 for our data analysis (Hair et al., 2011; Ringle et al., 2012). SmartPLS can accommodate reflective construct models, thus allowing us to use the PLS path modelling technique with reflective indicators to determine the validity and reliability of our data (Ringle et al., 2005). This application is also well equipped to address moderating relationships (Chin et al., 2003; Diamantopoulos et al., 2008). Moderating relationship modelling in SmartPLS involves adding moderating variables as direct relationships to outcome variables and calculating interaction variables based on predictor variables. Finally, the global fit measure of SmartPLS path modelling is evaluated by calculating the Goodness of Fit (GoF) score, as suggested by Tenenhaus et al. (2005), rather than fit indices of the covariance-based SEM (e.g., CFI, TLI, ILI, RMSEA).

## 4 Results

### 4.1 Respondent characteristics

Table 2 presents demographic features of the respondent sample. The firms surveyed covered four industry groups (Porat, 1977) and were nearly homogeneously distributed. The groups covered all nine employment ranges (one to more than 2,000 employees). Most groups included between 10 and 199 employees. Furthermore, most of the surveyed firms were between 11 and 20 years of age, with the oldest being 77 years of age. In terms of countries where the firms operate, the sample was balanced. Finally, sales manager respondents were primarily sales department directors, and IT manager respondents were primarily chief information officers.

| **Characteristics** | **Percentage** |
|---|---|
| *Industry* | |
| Traditional manufacturing | 32.8% |
| High-tech manufacturing | 19.2% |
| Material service | 25.6% |
| Information service | 22.4% |
| *Number of employees* | |
| 1 | 1.6% |
| 2 to 9 | 9.6% |
| 10 to 49 | 33.6% |
| 50 to 199 | 28.8% |
| 200 to 499 | 8.0% |
| 500 to 1999 | 10.4% |
| 2000 and more | 8.0% |
| *Firm age*[1] | |
| 1-10 years | 16.8% |
| 11-20 years | 34.4% |
| 21-30 years | 21.6% |
| 31-40 years | 14.4% |
| 41+ years | 12.8% |
| *Country* | |
| France | 60.0% |
| Italy | 40.0% |
| *Respondents - Sales managers* | |
| Business unit manager responsible for sales | 16.4% |
| Sales department director | 26.7% |
| Senior sales manager | 14.7% |
| Mid-level sales manager | 11.2% |
| Junior sales manager | 15.5% |
| Others | 15.5% |
| *Respondents - IT managers* | |
| Business unit manager responsible for IT | 13.8% |
| Chief Information Officer | 23.1% |
| Senior IT manager | 12.3% |
| Mid-level IT manager | 12.3% |
| Junior IT manager | 21.5% |
| Others | 16.9% |

**Table 2: Respondent characteristics**

## 4.2 Validity and reliability tests on the outer model measures

Table 3 examines convergent validity levels. Loadings of the measures on their respective constructs (derived through confirmatory factor analysis (CFA) ranged from 0.834 to 0.951. We consider these loadings to be satisfactory. The t-statistic of each factor loading was compounded to verify convergent validity. All factor loadings were found to be statistically significant, and all t-values were higher than the cut-off point of 1.980. We also found evidence of construct reliability, which measures scale stability based on an assessment of the internal consistency of items that measured the construct. All construct values were found to be greater than 0.707 (Fornell & Larcker, 1981).

[1] To provide the company age statistics in the table below, we defined age ranges, but the variable used in the model was a continuous variable, as previously indicated.

The overall CFA indices are meritorious given that the Kaiser-Meyer-Olkin measure of sampling adequacy equals 0.804 and given that the Bartlett's Test of Sphericity gives a statistically significant Chi-Square of 760 (p-value = 0.000). We computed Harman's single factor test results to determine common method bias effects (Sharma et al., 2009). The results show that the first factor explains 44% of the variance, indicating a reduced risk of common method bias effects. We determined recommended levels for reliability (measured based on composite reliability and Cronbach's alpha) and the average variance extracted (AVE). Nunnally (1978) recommended using a value of 0.70 as a benchmark for modest composite reliability. Hair et al. (2006) recommended a Cronbach's alpha value of 0.70 as an acceptable threshold, and this value is generally applied in IS research (Armstrong et al., 2015). Bagozzi and Yi (1988) noted that AVE must be higher than 0.50. The composite reliability (CR) of all constructs ranged from 0.869 to 0.948, Cronbach's alpha values ranged from 0.707 to 0.909, and AVE values ranged from 0.769 to 0.900. These values are acceptable because they are higher than the acceptability threshold values. These results reveal the presence of convergent validity in the measurement model.

| Construct | Item | Loading | T-value | Mean | SD | CR | AVE | CA |
|---|---|---|---|---|---|---|---|---|
| *Digital Data dynamic capability (DDC)* | | | | | | 0.936 | 0.786 | 0.909 |
| | CIT | 0.869 | 38.189 | 5.076 | 0.959 | | | |
| | IIT | 0.843 | 64.584 | 5.351 | 1.004 | | | |
| | MDD | 0.948 | 155.429 | 5.049 | 0.947 | | | |
| | RIT | 0.883 | 99.952 | 4.594 | 1.064 | | | |
| *Choosing IT (CIT)* | | | | | | 0.926 | 0.861 | 0.839 |
| | CIT1 | 0.925 | 24.979 | 5.424 | 0.862 | | | |
| | CIT2 | 0.931 | 37.823 | 5.388 | 0.877 | | | |
| *Integrating IT (IIT)* | | | | | | 0.874 | 0.777 | 0.715 |
| | IIT1 | 0.907 | 30.963 | 5.149 | 1.117 | | | |
| | IIT2 | 0.854 | 11.330 | 5.552 | 1.156 | | | |
| *Managing digital data (MDD)* | | | | | | 0.922 | 0.798 | 0.874 |
| | MDD1 | 0.896 | 25.522 | 5.119 | 1.084 | | | |
| | MDD2 | 0.888 | 34.015 | 5.017 | 1.050 | | | |
| | MDD3 | 0.897 | 28.488 | 5.012 | 1.038 | | | |
| *Reconfiguring IT (REC)* | | | | | | 0.948 | 0.900 | 0.889 |
| | REC1 | 0.918 | 52.264 | 4.632 | 1.093 | | | |
| | REC2 | 0.834 | 10.895 | 4.555 | 1.156 | | | |
| *Perceived environmental dynamism (PED)* | | | | | | 0.869 | 0.769 | 0.707 |
| | PED1 | 0.918 | 3.324 | 4.275 | 1.849 | | | |
| | PED2 | 0.834 | 2.846 | 3.630 | 1.770 | | | |
| Criteria | | >0.707 | >1.980 | | | 0.600 | 0.500 | 0.700 |

*Note: SD = Standard Deviation; CR = Composite reliability; CA = Cronbach's alpha; AVE = Average variance extracted.*

**Table 3: Psychometric table of measurements**

Tables 4 and 5 show discriminant validity for our variables measured by Likert scales. The square root of average variance extracted for each construct was compared with correlations between each construct and the remaining constructs (Fornell & Larcker, 1981). Each construct shared more variance with its own measurement items than with constructs of different measurement items. We also used the cross-loading method to show that the measurement items load higher on their own constructs than on items of the other constructs, though the difference is small for MDD3. Therefore, discriminant validity was supported (Rahimnia & Hassanzadeh, 2013).

| | MDD | CIT | IIT | REC | PED |
|---|---|---|---|---|---|
| IIT1 | 0.695 | 0.556 | **0.907** | 0.642 | 0.018 |
| IIT2 | 0.633 | 0.546 | **0.854** | 0.551 | -0.018 |

| | | | | | |
|---|---|---|---|---|---|
| REC1 | 0.682 | 0.612 | 0.709 | **0.947** | -0.063 |
| REC2 | 0.702 | 0.592 | 0.585 | **0.951** | 0.031 |
| CIT1 | 0.663 | **0.925** | 0.577 | 0.615 | 0.112 |
| CIT2 | 0.650 | **0.931** | 0.581 | 0.563 | 0.095 |
| PED1 | 0.013 | 0.115 | -0.05 | -0.106 | **0.918** |
| PED2 | 0.080 | 0.074 | 0.074 | 0.113 | **0.834** |
| MDD1 | **0.897** | 0.691 | 0.623 | 0.621 | 0.017 |
| MDD2 | **0.888** | 0.690 | 0.649 | 0.673 | 0.100 |
| MDD3 | **0.894** | 0.807 | 0.655 | 0.602 | 0.000 |

**Table 4: Loadings and cross-loadings of the measured scales and their items for discriminant validity evaluation**

| | DDC | CIT | IIT | MDD | REC | PED |
|---|---|---|---|---|---|---|
| DDC | 0.886 | | | | | |
| CIT | 0.642** | 0.912 | | | | |
| IIT | 0.830** | 0.491** | 0.840 | | | |
| MDD | 0.822** | 0.533** | 0.611** | 0.918 | | |
| REC | 0.811** | 0.528** | 0.597** | 0.700** | 0.948 | |
| PED | 0.009 | 0.052 | -0.010 | -0.023 | 0.012 | 0.760 |

**The correlation is significant with a p-value of less than 0.01.

**Table 5: Correlations of the measured scales for discriminant validity evaluation, with square roots of the average variance extracted as diagonal elements**

To ensure that multicollinearity effects were not an issue, we computed the variance inflation factor (VIF) between each of the variables by running separate analyses for one variable as the dependent variable while using all other variables as independent variables. The VIF values ranged from 1.426 to 2.787. None of the VIF values reached the maximum level of 3.3 established by Diamantopoulos and Siguaw (2006). Thus, multicollinearity did not appear to be an issue. Furthermore, to determine mono-method bias risk levels, we jointly tested the reliability of the measures related to DD dynamic capability levels gathered through the questionnaires administered to the IT and sales managers. We found acceptable reliability levels that ranged from 0.6 to 0.825.

### 4.3 Structural inner model tests

The results of the SmartPLS structural model assessment are presented in Table 6. Inspired by previous IS research (Patnayakuni et al., 2006), we tested two models. One model was run without moderating effects, and the other model was run with moderating effects. The model that was run without moderating effects exclusively involved the direct effects of DD dynamic capability on firm financial performance (FFP) and generated an R-Square value of 15.1%. In this model, DD dynamic capability development has a significantly positive effect on FFP ($\beta = 0.166$; $t = 2.433$; $p = 0.016$). The complete model with all moderating effects has an R-Square of 20.5%. Therefore, the addition of moderation effects explained an additional 5.4% of the variance.

For the complete model, we evaluated the overall goodness value by calculating the Goodness of Fit (GoF) score as a global fit measure for PLS path modelling bounded between 0 and 1, as suggested by Tenenhaus et al. (2005). The GoF score of our model was 0.401. According to Wetzels et al. (2009), the GoF cut-off value for a model with medium effect sizes should be 0.25. Our model exceeded this value easily, indicating that our model fits well.

Our results support Hypothesis 1: DD dynamic capability development has a significantly positive effect on FFP ($\beta = 0.175$; $t = 8.303$; $p < 0.001$). In addition, FED positively moderates the relationship between DD dynamic capability development and FFP ($\beta = 0.119$; $t = 2.237$; $p < 0.05$), supporting Hypothesis 2. EM has a positive moderating effect on the relationship examined (β = 0.142; t = 3.046; p < 0.010). Thus, Hypothesis 3 is fully supported. We found FA to have a negative moderating effect on the examined relationship (β = -0.095; t = 2.460; p < 0.05), substantiating Hypothesis 4. We did not find statistically significant support for Hypothesis 5 regarding whether size negatively moderates the relationship between DD dynamic capability and FFP (β = -0.015; t = 1.091; p > 0.100). To provide a graphical representation of the findings, Figure 3 shows interaction plots of the significant moderating effects tested through the PLS models. We also ran a SmartPLS model that included PED. The model confirms all of the previous results, thus increasing the robustness of our findings.

| Dependent variable<br>Independent variables | Hp | Firm financial performance | | |
|---|---|---|---|---|
| | | Beta (β) | t-value (t) | p-value (p) |
| *Direct effects* | | | | |
| DDC | H1 | 0.175 | 8.303 | <0.001 |
| FED | | 0.154 | 3.112 | 0.002 |
| EM | | -0.015 | 0.542 | >0.100 |
| FA | | 0.042 | 1.443 | >0.100 |
| FS | | -0.018 | 1.316 | >0.100 |
| *Moderating effects* | | | | |
| DDC x FED | H2 | 0.119 | 2.237 | 0.027 |
| DDC x EM | H3 | 0.142 | 3.046 | 0.003 |
| DDC x FA | H4 | -0.095 | 2.460 | 0.015 |
| DDC x FS | H5 | -0.015 | 1.091 | >0.100 |
| R-Square | | | 20.5% | |

**Table 6: Beta, t-value, p-value and R-square values of the structural inner model with and without moderating variables**

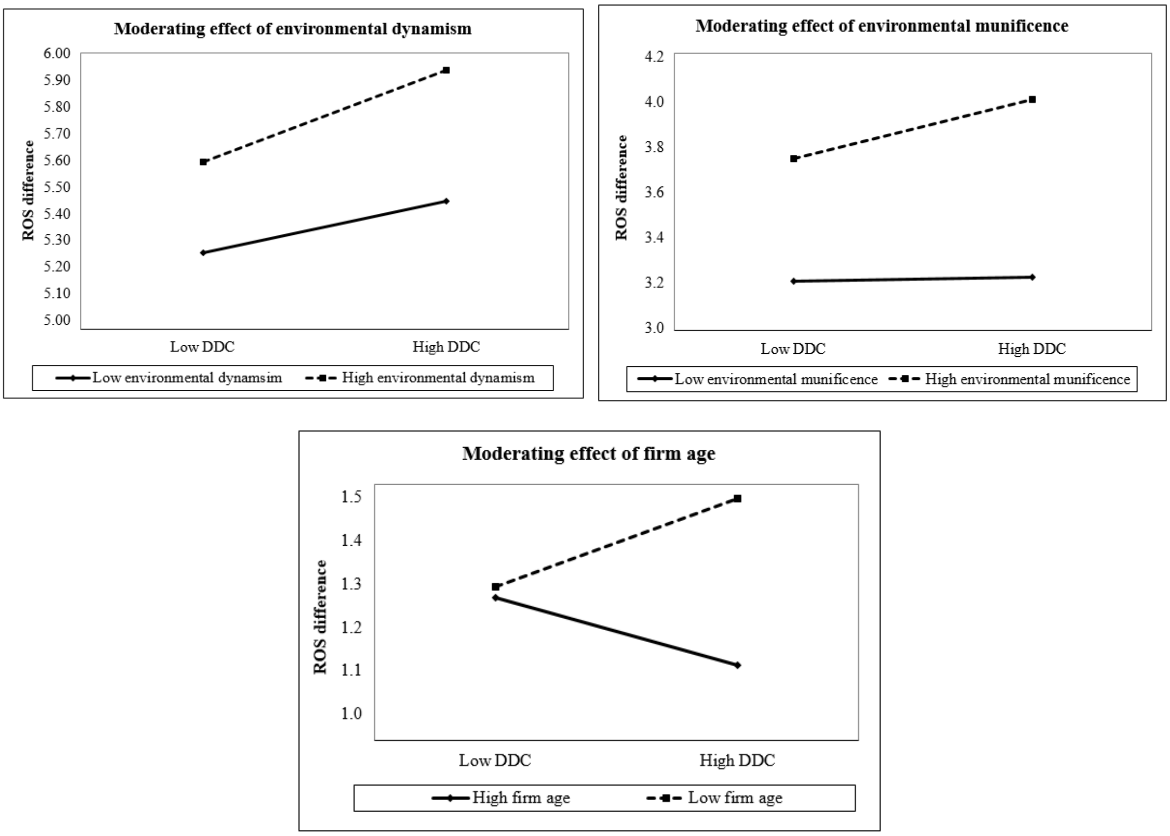


***Figure 3*: Interaction plots of the significant moderating effects**

# 5 Discussion and conclusions

## 5.1 Theoretical implications

Our results inform theories on the effects of a firm's capabilities on its performance, which constitutes a central issue in the information systems and management literature (e.g., Galy & Sauceda, 2014; Wang et al., 2013). In particular, we highlight the contributions of IT capabilities to financial performance through our examination of DD dynamic capability in a Big Data context. Unlike past studies that left several theoretical and empirical issues related to IT capability and its role in firm financial performance up for debate (Armstrong & Shimizu, 2007; Newbert, 2008), our study clearly illustrates the value of IT capability in relation to DD.

DD dynamic capability development has strategic ramifications. Our study supports the theory that dynamic capabilities are organisational abilities that may prove strategically important to successfully match or create market changes. We confirm previous research findings that such adaptability may generate improved customer value (Sambamurthy et al., 2003) and that dynamic capabilities are recommended for fast-paced environments (Banker et al., 2006). Firms may effectively develop dynamic capabilities to identify and react to opportunities and threats by extending, modifying, changing, and recreating ordinary capabilities (Dosi et al., 2000), which should ultimately positively affect firm financial performance.

Our theoretical definition of DD dynamic capability is supported empirically as a four-fold approach to organisational ability that involves selecting IT tools, integrating IT tools, managing digital data, and reconfiguring DD assets and competencies. DD dynamic capability contributes positively to firm financial performance, as the capacity to select and integrate IT tools while managing and reconfiguring digital data allows a firm to transform its assets, competencies, products and services while exploiting DD at higher levels. Thanks to DD, firms can develop new ways of understanding their environments and stakeholders' needs while reshaping their strategies according to changing tastes and preferences. In this way, firms can move closer to their stakeholders while lowering costs and/or increasing revenues, resulting in better financial performance. Higher levels of DD dynamic capability development can thus improve a firm's financial performance.

Moreover, the relationship shown in our model between DD dynamic capability and financial performance is not straightforward due to the effects of several moderating variables. The effects of three moderating variables that affect firm performance were confirmed in the DD dynamic capability context. DD dynamic capability is associated with slightly better financial performance, not only in terms of generating more dynamic and munificent environments but also in the case of younger firms. Our results suggest that when firms experience tremendous change and uncertainty in their products and markets, as in current environments, dynamic DD capabilities may offer value to firms by improving their financial performance.

Response time seems particularly critical when firms operate in dynamic environments due to significant and unpredictable changes in customer tastes, production and service technologies, and modes of competition (Bechor et al., 2010). DD dynamic capability can help firms respond to these environmental changes through the use of immediately available DD. Firms without DD dynamic capabilities are slower to respond and are likely to miss opportunities or to be pre-empted by competitors (Bhatt et al., 2010). In the end, the higher the degree of environmental dynamism is, the greater the contribution of DD dynamic capability is to financial performance. This correlation empirically reaffirms the essential importance of dynamic capabilities in turbulent environments. Additionally, in munificent environments, DD dynamic capability has a greater effect on a firm's financial performance. In fact, dynamic capabilities of DD improve firm speed in responding to customer needs (Xue et al., 2012), ultimately resulting in enhanced financial performance (Dale Stoel & Muhanna, 2009).

With respect to organisational conditions, scholars have linked organisational experience to organisational inertia (e.g., Balasubramanian & Lee, 2008). Our study supports this theoretical assertion, as the older a firm becomes, the more it will struggle to unlearn established organisational practices and to remain a dynamic organisation that can reconfigure processes. Such firms seem “locked out” of certain types of knowledge and are therefore less likely to leverage DD dynamic capability to manage business opportunities. This lower level of probability in turn limits DD dynamic capability contributions to the financial performance of older firms.

We were unable to confirm our hypothesis regarding firm size. This hypothesis stated that the smaller the firm is, the greater the contribution of DD dynamic capability will be to the firm’s financial performance, which is in line with previous research showing that large organisations struggle more in responding to changing conditions (Carnall, 2007). The results show that there is not a moderating effect of firm size. On the one hand, this absence of a moderating effect could highlight that the managers of all companies - whatever their size - understand, to the same extent, the importance of leveraging DD to create business value, and they similarly implement actions to take advantage of new opportunities. On the other hand, we could speculate that our hypothesis was not confirmed for empirical reasons. We posit that this lack of statistical significance may be partially due to our sample, which was largely composed of small- and medium-sized firms and only a few large firms. Moreover, large firms in Western Europe are relatively smaller than their typical counterparts in the US. Perhaps our sample included firms that were too small, even if the dynamic capability concept seems useful in entrepreneurial and small firm contexts (Boccardelli & Magnusson, 2006; Gibcus & Stam, 2012). Consequently, in opposition to what has been shown using various firm samples, DD dynamic capability development does not affect the financial performance of smaller firms to a greater extent than it does for larger firms.

### 5.2 Implications for practice

Our findings have important managerial implications. First, managers should be more aware of the opportunities presented by digital data and of their firms’ dynamic capabilities. Digital Data dynamic capability should be built into specific business processes to improve firm performance and possibly financial performance. We tested the effects of DD dynamic capability on sales processes because sales departments tend to be more advanced in terms of Digital Data initiatives relative to other firm departments, especially because of sales departments’ focus on customer relations (Piccoli & Watson, 2008). Nonetheless, we expect that other business processes can also take advantage of DD dynamic capabilities. Indeed, we recommend starting with a strategic initiative in order to directly appreciate the higher performance resulting from DD dynamic capability. In fact, we were able to show that firms that are able to integrate DD dynamic capabilities into specific business processes may increase their performance relative to their competitors. For example, data might be generated more effectively in digital form while simultaneously aiding the identification of real-time data patterns as they arise, as digital forms of data seem to improve their accessibility (Vitari et al., 2015).

We invite firms to not reduce Digital Data dynamic capability to a simple purchase of a new, trendy Big Data Information Technology. The choice of Information Technology is important, but it is only a component of Digital Data dynamic capability. The integration of adopted technology into the appropriate business processes, the management of the generated digital data and the ability to reconfigure an established business process to take advantage of a new, emerging opportunity are equally important. Moreover, managers should evaluate the specificities of the environments in which they operate. When operating under high levels of dynamism and munificence, and when firms are younger, managers should be more aware of potential firm performance gains that may be enjoyed through DD dynamic capability development.

Managers should realize that DD dynamic capability can be very beneficial if their firm competes in a highly unstable industry, with frequent changes in customer preferences or the rapid arrival of new products and technologies. In general, managers in dynamic industries experience much more uncertainty and a relative dearth of information related to the current state of the environment. In these cases, DD dynamic capability can directly reduce this uncertainty or lack of information by facilitating access to additional data. If a firm does not engage in such an industry, the effort of building a new DD dynamic capability could be less beneficial.

Similarly, if a firm competes in a market offering a large variety of growth opportunities, DD dynamic capability can be very well suited, as managers would have an additional lever to provide prompt responses to customer demands. DD dynamic capability can grant a firm an advantage with regard to access to data about customers, and it can facilitate the transformation of customer data into a value proposition.

Finally, managers of older firms should consider overcoming the organisational inertial forces that often prevent older firms from exploiting the new business opportunities presented by digital data. Overcoming such forms of organisational inertia may involve creating largely independent start-ups that can profit from parent firm assets (e.g., financial assets) while also enjoying the benefits of small firms (e.g., flexibility) (Coad et al., 2013).

### 5.3 Limitations

First, our research is limited to the extent that we focused on generalizable aspects of different industries while ignoring their idiosyncratic features. For example, firms in different industries may use DD differently to achieve higher levels of financial performance. It is thus necessary to understand how DD are used differently across various sectors (e.g., in the hospitality industry, the retail sector or the banking sector). Such studies may provide insight into the effects and peculiarities of unique industry factors that extend beyond those examined in our study.

Second, we show that DD dynamic capability offers firms a small premium in terms of financial performance. We estimate a small premium because the sizes of the coefficients are small (Chin et al., 2003). This modest effect was justified when we contextualised the model in concrete, complex and mediated interactions that empirically exist between dynamic capabilities and organisational performance (Helfat & Winter, 2011; Mithas et al., 2011). Several opposing and diluting variables may interfere with our modelled direct relationship between DD dynamic capability and firm financial performance. However, our simplification and abstraction of reality does not compromise the central message that IT capability can have a positive (even if small) effect on performance (Piccoli & Lui, 2014).

Third, we could have considered additional items in examining the DD dynamic capability construct. We recognise that some variables are based on a small number of items, potentially compromising construct validity. Nevertheless, we attenuated this risk by building a reflective DD dynamic capability construct and by asking sales and IT managers to focus on several dimensions.

Fourth, the difference between two cross-loadings for the MDD3 item is small. As the MDD construct is based on three items, we estimate that this issue is less critical than it would be for a two-item scale. The other MDD3 cross-loadings and all the MDD1 and MDD2 cross-loadings present much higher and acceptable differences.

## 5.4 Conclusions

This paper theoretically contributes to the large debate on whether and how technology-based initiatives sustain competitive advantage (Bradley et al., 2013; Chen et al., 2012; Sallam et al., 2013). Indeed, among the possible technologies that can sustain a competitive advantage, the advent of Big Data opened up substantial debate around technologies used for generating, processing, and streaming digital data, as digital data are at the very foundation of this Big Data trend (George et al., 2014; Mayer-Schönberger & Cukier, 2013; Lynch, 2008; Orlikowski & Scott, 2015; Watson, 2014). We contributed to this debate because we argue that the digital nature of data constitutes a fundamental characteristic of data itself, with unique properties in terms of sharing, replication, combination and obsolescence.

From an empirical perspective, organisations face enormous challenges when accessing, processing, and analysing such massive quantities of digital data (Bharadwaj et al., 2013). Hence, we expected IT capabilities to manage digital data to be a key feature of successful businesses. Our review of the literature led us to conclude that there was little empirical evidence on whether firms that develop digital data dynamic capabilities enjoy better financial performance. Even less explored was the role of environmental and organisational variables in the relationship between the development of such IT capabilities and a firm's financial performance. Therefore, this paper contributed findings on how firms can leverage dynamic capabilities and digital data to achieve better financial performance and on the effects of organisational and industry-related environmental conditions on performance.

We showed that firms acquire a financial premium by levering their DD dynamic capability and that environmental munificence, dynamism and firm age moderate the relationship between DD dynamic capability and financial performance. Environmental dynamism and munificence appeared to constitute two critical dimensions of a firm's external environment. Under dynamic and munificent contexts, investments in DD dynamic capabilities served as a particularly effective way to provide timely and relevant information and, in the end, to improve firm performance. Similarly, when examining organisational effects, firm age was found to affect the ways in which firms invest in DD dynamic capability. Indeed, firm age influences the degree to which certain postures, structures, and tactics related to DD dynamic capability boost firm performance.

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