ANTECEDENTS OF IT DYNAMIC CAPABILITIES IN THE CONTEXT OF THE DIGITAL DATA GENESIS

Claudio Vitari, Gabriele Piccoli,, Lapo Mola, Cecilia Rossignoli

ANTECEDENTS OF IT DYNAMIC CAPABILITIES IN THE CONTEXT OF THE DIGITAL DATA GENESIS

Vitari, Claudio, Grenoble Ecole de Management & Montpellier Research Management, 12 rue Pierre Sémard, 38000 Grenoble, France, claudio.vitari@grenoble-em.com

Piccoli, Gabriele, Università degli Studi di Sassari. Piazza Università 21, 07100 Sassari, Italy, gpiccoli@uniss.it

Mola, Lapo, Università degli Studi di Verona, Lungadige Porta Vittoria, 41, 37129 Verona, Italy, lapo.mola@univr.it

Rossignoli, Cecilia, Università degli Studi di Verona, Lungadige Porta Vittoria, 41, 37129 Verona, Italy, cecilia.rossignoli@univr.it

Abstract

Dynamic capabilities represent an important determinant of competitive advantage in turbulent environments. However, despite intense work in the area, the issue of the antecedents of dynamic capabilities remains poorly researched. Understanding the sources of dynamic capabilities would give organizations instruments to rationally improve their chance of gaining and sustaining competitive advantage. We contribute to the literature on information technology dynamic capabilities by focusing on three sources of dynamic capabilities: organizational processes, firm history and firm's assets.

We lay the theoretical and methodological groundwork for our explanation and empirically test our model by focusing on an emerging capability we term Digital Data Genesis (DDG). We define DDG as the dynamic capability of (1) choosing information technology to generate and capture data in digital form unobtrusively, (2) integrating the IT in the appropriate business processes, and (3) managing the digital data so captured .Our results show that the organizational processes of sensing and learning, the historical information dynamic capability, and the historical IT dynamic capability influence the DDG dynamic capability.

Keywords: IT dynamic capabilities, Dynamic capability, Antecedents, Digital Data Genesis.

This reseaerch is supported by the french region Rhône Alpes (http://www.rhonealpes.fr/)

1 Introduction

How to explain variations in competitive advantage between different business organizations is an evergreen question in the information systems, strategic management and organizational literatures (Zollo & Winter, 2002): among the different concepts developed to date, the notion of Dynamic Capabilities (DCs) promises to be particularly meaningful in turbulent environments, where changes are both complex and unpredictable(Mithas, Ramasubbu, & Sambamurthy, 2011; Pavlou & El Sawy, 2006; Rai, Patnayakuni, & Seth, 2006; Wunnava & Ellis, 2009; Zollo & Winter, 2002). But the Dynamic Capabilities research construct remains both debated and, at times, unclear, and the difficulty in addressing its origins and antecedents over time contributes to this confusion. The paucity of research that addresses this question directly is testament to the difficulties associated with studying research on the emergence of dynamic capabilities: if they really impacted organizational competitive advantage, the explanation of their sources would give organizations the instruments to improve their chances of building and sustaining competitive advantage: so research in this area is badly needed.

Early work in this area has proposed different approaches, which would benefit from being integrated and tested (Montealegre, 2002; Pavlou & El Sawy, 2006; Tanriverdi, 2005; Teece, Pisano, & Shuen, 1997; Zollo & Winter, 2002). We contribute to the emerging literature on the sources of DCs in turbulent environments by developing a model that integrates the roles of organizational processes, firm history and firm's assets as antecedents to dynamic capabilities, and adapt it to the Information Technology (IT) context in considering the multi-dimensional and enterprise-wide dynamic capability to leverage IT (Bharadwaj, Sambamurthy, & Zmud, 1999). We test the model in the context of an emerging IT DC that we term Digital Data Genesis (DDG).

This paper is organized as follows: §2 introduces the theoretical framework based on the resource-based view of the firm and formally defines the notions of DDG and DDG dynamic capability; §3 summarizes the literature on the sources of DCs; §4 describes our research model, its variables and hypotheses. §5 presents our research methodology and §6 shows our results which are discussed in §7, after which §8 draws conclusion highlighting the contributions of our research and suggesting future directions.

2 Theoretical framework

2.1 The Resource-based view

The resource-based view has been adopted in Information Systems research to theoretically ground studies on firm level competitive advantage and its sustainability (Nevo & Wade, 2010; Wade & Hulland, 2004). This perspective highlights the importance of the firm's internal resources for the evaluation of its competitive advantage (Eisenhardt & Martin, 2000; Wernerfelt, 1984). Resources are the "assets and capabilities that are available and useful in detecting and responding to market opportunities or threats" (Wade & Hulland, 2004) and , more specifically, "assets are defined as anything the firm can use in its processes for creating, producing, and/or offering its products (and/or services) to the market, whereas capabilities are repeatable patterns of actions in the use of assets to create, produce, and/or offer products (and/or services) to the market" (Sanchez, Heene, & Thomas, 1996; Wade & Hulland, 2004). Following the practice of the cross-disciplinary service science movement (Chesbrough & Spohrer, 2006), we label the group of products and/or services offered to the market by an organization as a 'bundle' (Kohli & Bharadway, 2007).

Resources that are valuable and rare can provide temporary competitive advantage, and the extent to which these resources are also inimitable, immobile and non-substitutable between firms explains the sustainability of that competitive advantage over time (Barney, 1991; Wernerfelt, 1984). While this

perspective pays considerable attentions to the firm's internal resources, it has the weakness of excluding the socio-economic environment beyond the firm's boundaries. Environmental conditions could change and make the firm's resources far less valuable (Leonard-Barton, 1992), so the resource-based view has had to be extended to better explain firm competitive advantage in turbulent environments (Eisenhardt & Martin, 2000).

2.2 Dynamic Capabilities

In turbulent environments, organisations need to constantly match or create market changes and DCs are "the firm's processes that use resources – specifically the processes to integrate, reconfigure, gain and release resources – to match and even create market change" (Eisenhardt & Martin, 2000). Thus DCs have the potential (Prieto & Easterby-Smith, 2006) to create, to evolve and to recombine internal existing resources to allow the firm to adapt to turbulent environments (Teece et al., 1997). This adaptability has been argued as offering improved customer value (Sambamurthy, Bharadwaj, & Grover, 2003; Wheeler, 2002), and is therefore especially required in fast-paced technological environments (Banker, Bardhan, Hsihui, & Shu, 2006; Schreyögg & Kliesch-Eberl, 2007; Teece et al., 1997; Zahra, Sapienza, & Davidsson, 2006).

The resource-based view foresees a direct relationship between DCs and the firm's process performance (Ray, Barney, & Muhanna, 2004; Ray, Muhanna, & Barney, 2005; Zahra et al., 2006). However a firm's ability to deliver superior process performance in a competitive environment does not automatically imply it can achieve sustained competitive advantage, as several variables may intervene to prevent the latter (Kohli & Grover, 2008; Mithas et al., 2011; Ray et al., 2005). The acknowledgement of this interposition between single process outperformance and sustained competitive advantage shows the need to study DCs without employing organizational competitive advantage as dependent variable. Hence, in today's competitive environment, which is characterized by increasing IT diffusion, organizations need to be able to integrate new and established IT capabilities. The literature has documented a number of relevant DCs: our focus in this study is on an emerging dynamic capability called Digital Data Genesis (Piccoli & Watson, 2008).

2.3 Digital Data Genesis as a dynamic capability

DDG represents the naissance of digital data – it is a phenomenon (an observable fact or event) that involves the direct generation of new data in digital form, and takes place when information representative of a physical action, event or condition is created digitally concurrently with the event taking place: A classic example of DDG is a waiter taking an order at a restaurant table via a hand-held digital device – as the event occurs (the customer makes their choice) an informational representation of that event is generated. DDG thus enables real time digital representations of objects and events – so that these objects and events can exist as symbolic representations that can interact and be manipulated in the information space. We can define DDG dynamic capability as the three-fold organizational process of:

- Choosing IT to unobtrusively generate and capture data in digital form.
- Integrating the required IT into the appropriate business processes;
- Managing the digital data thus produced so it is accessible, accurate, complete and current.

The technology embedded in a DDG initiative may be emerging IT - a new technology not yet commercially viable (e.g., retinal implants for blind people) – or may be an enabling IT: an established technology used by a firm in an innovative application (e.g., RFID in gaming chips to track table play in a gambling context).

We theorize DDG as a dynamic capability for 2 complemetary reasons. First, it consists of deploying "new configurations of operational competencies relative to the competition" (Pavlou & El Sawy, 2006) - in other words, a firm with a DDG dynamic capability can identify opportunities for digital

data generation and for recombining internal existing resources and data to adapt to changing environmental conditions, through the collection and production of new digital data. Second, the DDG dynamic capability includes the dynamic reconfiguring of the existing combinations of resources for digital data generation (Pavlou & El Sawy, 2006): The degree to which an ineffective DDG process can be reconfigured into a more promising one that matches its environment, better, faster, and cheaper than the competition determines the capability's dynamic quality (Eisenhardt & Martin, 2000): the higher its degree of reconfigurability, the more dynamic the DDG dynamic capability is.

Note that the dynamic DDG capability is concerned with the unobtrusive generation, capture and management of digital data at the point of an event's occurrence - not with its actual use in, for example, analytical processes. The direct outputs of DDG are accessible, accurate, complete and current digital data, which can be exploited subsequently for analytical, decision making, monitoring and many other purposes, but these operations remain beyond the scope of this study on the antecedents of dynamic capabilities. Examples of DDG dynamic capabilities exist, such as the Harrah Corporation. For several years now, Harrah has systematically and repeatedly integrated new IT (such as computerized slot machines or RFID chips) to gain - unobtrusively, and always in new ways - valuable digital data on customers' behaviour at the Harrah's casinos and exploits these new data to improve its customers' profiles and to better reward customers.

3 Sources of Dynamic Capabilities

While several studies have investigated dynamic capabilities and their effects on competitive advantage (Montealegre, 2002; Pavlou & El Sawy, 2006; Tanriverdi, 2005; Teece et al., 1997; Zahra et al., 2006; Zollo & Winter, 2002), much less attention has been paid to their sources. We propose an integrative research model of the sources of dynamic capabilities, and chose to build it on the DDG dynamic capability because of its significance in fast-paced contemporary IT environments, and we build our understanding of those sources on those identified by Teece et al. (1997):

- The organizational processes of sensing, coordination, integration and, learning;
- The firm's assets, that define its strategic position;
- The firm's history, which accounts for the path dependent nature of its dynamic capabilities.

Together, these three theoretical sources can yield a competitive advantage that is based on the performance of the organizational processes, exploits the firm's assets and is grounded in its history, and were leveraged by Montealegre (2002) in an early empirical case study which highlighted actions firms could take to develop their dynamic capabilities. This study revealed the organizational processes of sensing, coordination, integration and learning emerged as the most important sources of DCs - by contrast, a firm's assets and history played only a marginal, supporting role. Other scholars have since theorized that learning mechanisms are the main independent variable influencing dynamic capability development (Zollo & Winter, 2002), and thus the main organizational process source of DCs. Tanriverdi (2005) combined firm assets and organisational processes in a model of DC development. IT infrastructures (one type of firm assets), and IT management processes (part of firms' organisational of sensing, coordination, integration and learning processes) have been noted as particular DC sources of firms' dynamic capabilities, and a further theoretical contribution from Zahra et al., (2006) confirms the role of firm organizational processes in DC development, proposing the processes of coordination, selection and combination were as the main organizational processes that enable a firm to build up its DCs. Their theoretical model also proposed that environmental turbulence decreases the performance of a firm's existing DCs, and hence sources new DCs to replace obsolescent capabilities. Pavlou & El Sawy (2006) measure the impact of IT leveraging competence on the development of a firm's DCs. They propose this competence - the ability to use IT functionalities effectively - as the only independent variable, with the organizational processes of coordination, integration and learning acting as mediators between it and DCs.

In summary, all three types of sources of DCs have been studied separately by different authors, although to different extents - so that the lack of a comprehensive research model including all three represents the most significant outstanding gap in the research: our main contribution is to address this lack by designing and testing a comprehensive research model of the sources of DC which combines three sources identified in the literature.

4 Research model

Our research model integrates and organizes previous literature around Teece et al.'s (2007) three-fold classification of the sources of DC: organizational processes, firm's assets and firm history. We argue that these processes are responsible for the emergence of DDG dynamic capability. The following section and Figure 1 our hypothesized relationships and presents our variables.

4.1 Organizational Processes

The organizational processes of sensing, learning, coordinating, and integrating can be the source of DCs when the opportunity or need arise (Kogut & Zander, 1996; Maritan, 2007; Pavlou & El Sawy, 2006; Zahra et al., 2006): sensing relates to understanding the environment and identifying market needs and opportunities; learning concerns developing new thinking and generating new knowledge to enhance existing resources; coordinating is about allocating and mobilizing resources, assigning tasks and synchronizing firm activities; while integrating concerns developing new patterns of interaction to face environmental changes or market evolutions, and implementing the resulting operational competencies configurations. We hypothesize these organizational processes as valid for the specific dynamic capability we are studying. The organizational processes of sensing, learning, coordinating and integrating are each expected to positively impact the DDG dynamic capability - in other words companies with effective organizational processes in these areas will be better able to choose new IT, integrate it and manage the data the new system produces. So:

H1: The organizational process of sensing has a positive and direct impact on DDG dynamic capability.

H2: The organizational process of learning has a positive and direct impact on DDG dynamic capability.

H3: The organizational process of coordinating has a positive and direct impact on DDG dynamic capability.

H4: The organizational process of integrating has a positive and direct impact on DDG dynamic capability.

4.2 Firm IT assets

Different kinds of assets - technological, complementary, financial, reputation, structural, institutional and market structure assets - can all be sources of new DCs (Teece et al., 1997). We theorize that IT assets the most significant type of asset antecedents of the DDG dynamic capability (Tanriverdi, 2005). IT assets are evidently co-specialized with several complementary assets, and eventually amalgamated into IT platforms, which make their building, management, reproduction, trading, and imitation difficult (Teece, 2007, 2011). Nevertheless, given that we consider DDG dynamic capability as grounded in IT-related and information-related processes of choosing IT, integrating IT, managing digital data and reconfiguring, we focus our notion of the antecedents of a firm IT DCs only on its IT assets.

There are two kinds of assets in the IT category: IT infrastructure and information repositories (King, Grover, & Hufnagel, 1989; Piccoli & Ives, 2005). IT infrastructure is "the base foundation of the IT

portfolio (including both technical and human assets), shared through the firm in the form of reliable services" (Broadbent, Weill, & St. Clair, 1999) or functionalities (Fink & Neumann, 2007; Pavlou & El Sawy, 2006; Zhu & Kraemer, 2005), and on which business applications and services can be built (Broadbent & Weill, 1997). IT infrastructures vary in reach and range (Piccoli & Ives, 2005): the reach measures the extent of the infrastructure's connectivity both within and outside of the firm, while its range measures the scope of services it can support. As these two factors increase, the IT infrastructure ability to act as a source of DCs also increases (Broadbent et al., 1999). With a development time estimated to be in the five- to seven-year range, the reach and range of the existing IT infrastructure influence the possibility and cost of integrating IT so as to gain valuable digital data unobtrusively, and hence being an antecedent of DDG dynamic capability.

For example, the French regional railway company TER Rhone-Alpes chose RFID cards and readers to generate and capture digital data about passenger flows on its train services. This initiative took place in 2008 after the liberalization of the rail service market and the first oil price peaks had increased train passenger numbers, challenging the company's passenger capacity limits. Passengers load their train passes and tickets onto their RFID card which they must then validate at an RFID card reader before being allowed to board the train. The digital data thus captured - which reflect the actual use of the railway service - are then used to adapt service frequencies and train capacities, thus both improving passenger satisfaction and ensuring full mobilization of the company's trains and helping plan its future rolling stock purchases. RFID cards and readers are the IT asset antecedents of TER Rhone-Alpes' DDG dynamic capability - and the company has progressively extended the reach of its IT infrastructure to deploy RFID card readers not just on its principal rail traffic routes, but through its secondary railways and on to its bus and tram services, in order to capture fuller and more sophisticated digital data about passenger flows.

The second category of IT assets are the information repositories, which are "collection(s) of logically related data, organized in a structured form, that [are] accessible and usable for decision-making purposes" (Piccoli & Ives, 2005). As far as Dynamic capabilities which depend on organized data require information repositories as antecedents (Piccoli & Ives, 2005), as do DDG dynamic capabilities . TER Rhone-Alpes exploited its information repositories on the sales of paper ticket and passes to establish the first train passes to be transferable onto RFID card and to be the first to equip railway stations with RFID readers.

Finally, IT infrastructure and information repositories are subjected to asset stock accumulation dynamics (Ingemar & Cool, 1989; Piccoli & Ives, 2005) as they become part of a company's IT asset stock over time, extending the pre-existing IT asset stock and becoming more valuable as the infrastructure's reach and range and the volume date held in its information repositories increase. The reusable portion of this stock can be leveraged in the future to create 'options value', and this accumulated IT asset stock, rich in reusable technologies and options, is an antecedent of the DDG dynamic capability. A substantial IT asset stock would represent an IT infrastructure capable of supporting the DDG dynamic capability's technical requirements, including compatibility between generated digital data and the existing IT infrastructure and storage to stock that data. Therefore, we respectively hypothesise that:

H5: the firm's IT infrastructure has a positive and direct impact on DDG dynamic capability.

H6: the firm's information repositories have a positive and direct impact on DDG dynamic capability.

4.3 Firm history

A firm's history explains its existing position, i.e. its current specific endowments in terms of technology, intellectual property, complementary assets and customer base, and its external relations with suppliers and complementors (Teece et al., 1997). At the same time, that history will influence the opportunities ahead for the firm, framing the path dependencies of the organization, the strategic alternatives available to it and the possible returns on them. Its current dynamic capabilities will

depend on its existing ones, which in turn will constrain newer options, because learning tends to be local and related to existing processes (Teece et al., 1997; Zahra et al., 2006). Thus, the antecedents of DDG dynamic capability are the most closely related historically existing DCs. Given that we consider that the DDG dynamic capability leverages are related to IT and to the information-related processes of choosing and integrating IT and of managing digital data, we hypothesize that IT dynamic capability and information dynamic capability are he DCs closest to the DDG dynamic capability.

IT dynamic capability is the multi-dimensional and enterprise-wide dynamic capability to leverage IT (Bharadwaj et al., 1999). The historical dynamic capacity to leverage IT will favour firm's IT personnel's ability to recognize the potential of emerging/enabling IT to generate and capture digital data. Good relationships between IT personnel and line management in integrating such IT within appropriate business processes is critical. The lack of IT dynamic capability would make the choice of which IT to integrate unclear, and could render later IT integration ineffective, so that digital data would be inaccessible or of poor quality, impeding its effective use.

In the case of Harrah, its IT managers and customer service managers realized very early on that a modern slot machine is a digital computer and worked together to develop a customer relationship management information system which could collect digital data on customers' behaviours at slot machines.

The concept of information dynamic capability is rooted in information theory (Shannon & Warren, 1949), and has been defined as the capacity to disseminate (Mathews & Healy, 2007), to apply and manage (Yoon, 2005), or to process (Lin, 2005) information. A historically developed dynamic capacity to manage information will enable the firm to manage digital data and so take advantage of its ability to generate data unobtrusively and in digital form - the inability to manage digital data would negate the value of data capture and integration.

Again in the case of Harrah, the company preferred digital data on guest preferences and transactions that it gained from slot machines to the unstructured information it received from its customer service staff. It can process the customer data collected from slot machines to profile gamblers and then disseminate these profiles throughout its different casinos.

Overall, we can hypothesize that:

H7: the historical IT dynamic capability has a positive and direct impact on DDG dynamic capability.

H8: the historical information dynamic capability has a positive and direct impact on DDG dynamic capability.

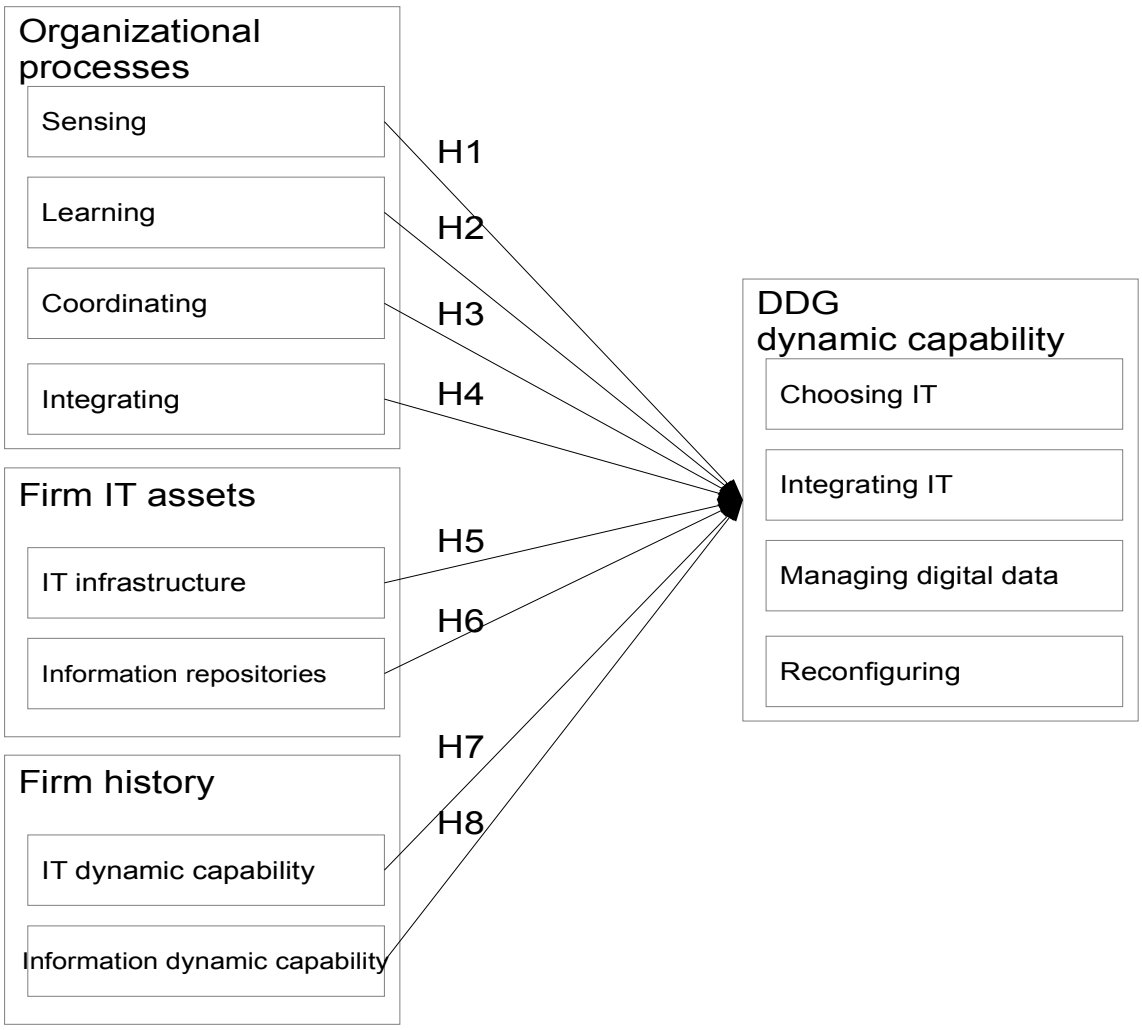

Figure 1. The research model.

5 Research design and methodology

Given that the best approach to measure DCs is at the organizational process level (Li, van Heck, & Vervest, 2009), our key informants were process managers in different companies. In particular, we selected sales managers as the sales department appeared as one of the departments more advanced in using DDG practices to improve customer relation (Piccoli & Watson, 2008). We adopted the survey method as our main source of empirical data so as to enable us to make a quantitative evaluation of the relationships between DDG dynamic capability and its antecedents. In practical terms, we organized phone interviews to fill our online questionnaire, querying the application of Customer Relationship Management at an affiliate of one of the authors to retrieve contact information about registered Sales managers in relationship with this affiliate.

We operationalized measurement scales that already existed and had been tested for all the model's operationalized all the constructs of the model, with one exception: the 'choosing IT' construct of DDG dynamic capability, which measures the ability to choose IT to collect valuable digital data unobtrusively. We could not find any previously-tested scale for this construct in the literature, so we

conducted preliminary testing via a pilot study. This pilot study started from four indicators which were available in the literature (Williams, 2003), but had never been tested empirically. We recruited 35 managers from SMEs and big enterprises in different industries in the United States to participate in the test, including the four indicators within a set of 26 other questions to reduce common method bias. Based on the 35 answers, the reliability of the scales satisfied the standard thresholds (Cronbach's Alpha = 0.837) and (for the sake of parsimony) the scale was then reduced to three items.

We employed already tested scales for all our other constructs and they were:

- Organizational process of sensing: effectiveness is reflected by an adapted market orientation measurement scale (Kholi & Jaworski, 1990; Pavlou & El Sawy, 2006).
- Organizational process of learning: learning effectiveness is measured by an adaptation of the absorptive capacity measurement scale (Cohen & Levinthal, 1990; Pavlou & El Sawy, 2006).
- Organizational process of coordinating: effectiveness evaluated by an adaptation of the coordination capability measurement scale (Malone & Crowston, 1994; Pavlou & El Sawy, 2006).
- Organizational process of integrating: effectiveness is estimated by an adaptation of the collective mind measurement scale (Pavlou & El Sawy, 2006; Weick & Roberts, 1993).
- Historical information dynamic capability: the dynamic capacity to manage information is measured by an adapted information capability measurement scale, along two dimensions: information management practices and information behaviors and values (Marchand, Kettinger, & Rollins, 2002).
- Historical IT dynamic capability: the measurement scale for the dynamic capability to leverage IT adapts the technical capability, the behavioral capability and business capability dimensions of the IT personnel capability construct (Fink & Neumann, 2007).
- Firm’s IT infrastructure: the scale is adapted from the IT infrastructure capability measure (Fink & Neumann, 2007).
- Firm’s information repository: this construct is reflected by the adaptation and unification of two different repository scales originally conceived (from the same model) for knowledge documents repositories and data repositories (Freeze & Kulkarni, 2005).
- DDG dynamic integrating IT capability: the scale used adapts the IT Business process integration category of the IT capability construct (Bharadwaj et al., 1999), to measure the ability to integrate IT in the business processes .
- DDG dynamic managing digital data capability's: the digital data managing scale adapts the information management dimension of the information capability measurement scale (Marchand et al., 2002), to measure the ability to manage digital data.
- DDG dynamic capability's reconfiguring: the adaptation of the reconfigurability measurement scale (Pavlou & El Sawy, 2006) estimates the potential to reconfigure DDG, and hence its dynamic nature.

Before the main data collection we consulted an expert panel and used Q-sorting methods to adapt the scales chosen to our research context and to assess content validity. The expert panel involved seven sales managers who proposed and validated our adaptations of each constructs' items, while the Q-sorting involved four rounds of refinement before reaching, for each item, the threshold of 50% of attributions to the right construct (the final version is available in the Appendix). A total of 119 people (mainly employees in different companies), between 20 and 40 years old and equally distributed between men and women, participated in the Q-sorting procedure.

6 Results

We collected 117 questionnaires, but had to discard 26 because of missing data problems, leaving only 91 usable to test our research model, of which 50 referred to enterprises engaged in Digital Data Genesis, while 41 do not. The respondents were mainly sales department managers (27%), senior sales managers (15%), mid-level sales managers (14%) and business unit managers responsible for sales

(10%). A broad range of industries were represented and the participating companies were of a wide variety of sizes (See table 1).

Number of employees	Total	With DDG	Without DDG
1	4.67%	1.87%	2.80%
2 to 9	15.89%	8.41%	7.48%
10 to 49	27.10%	15.89%	11.21%
50 to 199	26.17%	9.35%	16.82%
200 to 499	9.35%	6.54%	2.80%
500 to 1999	5.61%	2.80%	2.80%
2 000 and more	10.28%	7.48%	2.80%
Total	100.00%	53.27%	46.73%

Industries	Total	With DDG	Without DDG
Construction	3.74%	3.74%	0.00%
Wholesale and retail trade	16.82%	10.28%	6.54%
Finance, Insurance	5.61%	4.67%	0.93%
Agriculture, food and beverage	3.74%	0.93%	2.80%
Manufacturing and mining	23.36%	11.21%	12.15%
B2B Services	27.10%	14.02%	13.08%
Communications, Electric, Gas, Sanitary Services, Public Administration and other services	16.82%	6.54%	10.28%
Total	100.00%	53.27%	46.73%

Table 1. The size and industries of participating companies.

We ran two chi-squared tests but revealed no statistically significant relationships either between the use of DDG and industry or between the use of DDG and company size. We ran a confirmatory factor analysis and deleted the following problematic variables and items:

- the organizational process of coordinating variable,
- the organizational process of integrating variable,
- the DDG dynamic capability integrating IT variable,
- one of the three items in the organizational process of sensing variable,
- one of the three items in the DDG dynamic capability's managing digital data variable.

In terms of collinearity analysis, our observations of the correlation matrix and our tolerance value computations highlighted no risk of multicollinearity, with the correlation coefficients lower than 0.9 and the tolerance values above 0.19. We used Cronbach's Alpha to measure reliability and found all values were over the 0.7 threshold. (See Table 2)

Construct	items	alpha
DDG dynamic capability's choosing IT	2	0.76
DDG dynamic capability's managing digital data	2	0.78
DDG dynamic capability's reconfigurability	2	0.84
Organizational process of sensing	2	0.74
Organizational process of learning	3	0.84
Historical information dynamic capability	3	0.85
Historical IT dynamic capability	2	0.80
Firm's information repositories	3	0.90
Firm's IT infrastructure	3	0.79

Table 2. The reliability Cronbach's Alpha.

We run a multiple discriminant analysis to explore differences across the independent variable values between those companies that did and didn’t employ DDG. The Box's M test, to assess the similarity

of the dispersion matrices of the independent variables between the two groups, was not significant (= 0.795), so we can confirm that the dispersions matrices do not differ between the two groups.

The discriminant analysis, applying the simultaneous estimation method, was significant at 0.02, the Wilks Lambda equalled 0.84, the chi-squared 15,041, the Eigenvalue 0.191. The canonical correlation coefficient equalled 0.401, which means that about 16% of the variance in the dependent variable could be accounted for by the discriminant analysis model. Of the six independent variables, only historical information dynamic capability, firm's IT infrastructure and firm's information repositories had significant (at 0.05) differences in group means (See Table 3), and the loadings were above the 0.4 threshold for identifying substantive discriminating variables. Thus, in the end, the companies with DDG had, on average, higher mean scores for these three independent variables.

	Group means		Test of equality of group means			Structure matrix
Independent variables	With DDG	Without DDG	Wilks'Lambda	F value	Signif.	Loading
Historical information dynamic capability	5.038	4.4175	0.929	6767	0.011	0.759
Firm's IT infrastructure	5.9412	5.2583	0.921	7665	0.007	0.808
Firm's information repository	5.6209	4.70	0.919	7881	0.006	0.819

Table 3. The multiple discriminant analysis model.

After the multiple discriminant analysis, we performed a multiple regression analysis on the companies with DDG between the remaining dimensions of DDG dynamic capability (Choosing IT, managing digital data, and reconfiguring) and the remaining independent variables (the organizational processes of sensing and of learning, the historical information dynamic and IT dynamic capabilities, and the firm's IT infrastructure and information repositories). We followed the backward method and executed, for the three dependent variables, the regressions on the different independent variables, which explained between 13% and 22% of the variance (See Table 4 and Figure 2). The relationships which were statistically significant (at the 0.05 and 0.001 levels) confirm that:the organizational process of sensing has a positive and direct impact on DDG dynamic capability's choosing IT (supporting H1),the organizational process of learning has a positive and direct impact on DDG dynamic capability's managing digital data (supporting H2)the organizational process of learning has a positive and direct impact on DDG dynamic capability's reconfiguring (again supporting H2)the historical IT dynamic capability has a positive and direct impact on DDG dynamic capability's choosing IT (supporting H7)the historical IT dynamic capability has a positive and direct impact on DDG dynamic capability's reconfiguring (again supporting H7)the historical information dynamic capability has a negative and direct impact on DDG dynamic capability's choosing IT (supporting H8)

On the other hand, the firm's IT infrastructure and information repositories do not significantly (at 0,05) explain any dimension of the DDG dynamic capability, so we find no support for H5 or H6.

Regression	Dependent variable	F	Signif.	Adjusted R^2	Independent variable	Hyp.	Beta	T-value	Signif.
1	DDG dynamic capability's choosing IT	13.467	***	0.428	Organizational process of sensing	H1	0.495	3.408	***
					Historical information dynamic capability	H8	0.395	2.604	0.012
					Historical IT dynamic capability	H7	-0.347	-2.658	0.011
2	DDG dynamic capability's managing digital data	19.484	***	0.425	Organizational process of learning	H2	0.497	3.952	***
					Historical IT dynamic capability	H7	0.285	2.050	0.046
3	DDG dynamic capability's reconfigurability	22.427	***	0.300	Organizational process of learning	H2	0.560	4.736	***

Notes : only the significant independent variables listed, Beta = standardized regression coefficient, ***= significant at the 0,001 level

Table 4. The regression model statistics.

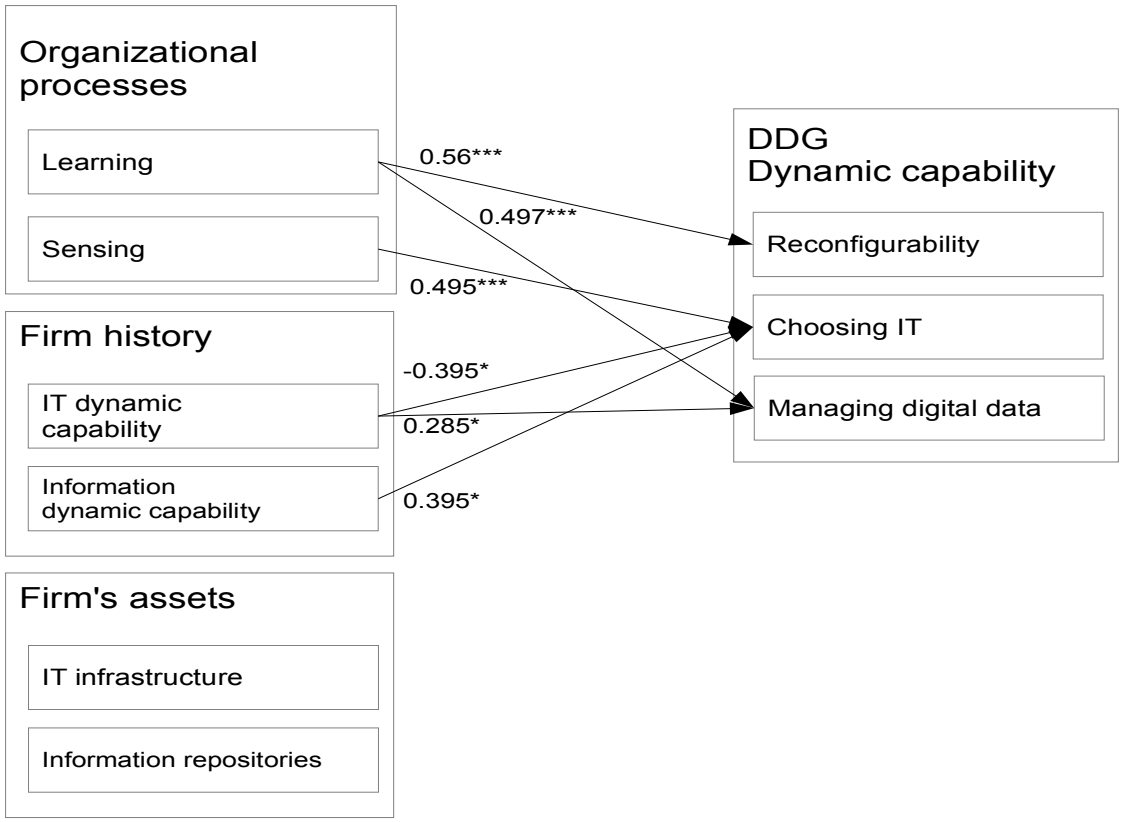

Figure 2. The regression model's statistically significant relationships (means significant at the 0.05 and *** at 0.001)*

7 Discussions

Preliminary, it's interesting to note that the results highlight the presence of DDG across company sizes and industries, without distinctions. This empirical evidence confirms our research design decisions since, a priori, we did not identify any particular company size or industry as adopting more DDG than any other and, as a consequence, included all companies, of any size and any industry, in our sample.

Beyond that, only about half of the sample employed DDG, which it allowed us to explore the role of the independent variables as antecedents for starting DDG. Significant differences exist between the groups of companies which did and did not employ DDG in terms of the historical information dynamic capability and firm's IT infrastructure and information repositories variables. For these variables, companies with DDG have higher means, implying that they have more effective information dynamic capabilities, more extended IT infrastructures and information repositories of longer standing than the companies without DDG. In terms of the historical information dynamic capability, those companies leveraging DDG had been, in the recent past, more effective in processing and exploiting information concerning Sales process performance and failures than those which did not. Regarding the firm's IT infrastructure, those companies with DDG had widened the range of their

information, communication and network technologies over time more than the others. Finally, considering information repositories, the companies with DDG owned information repositories which spanned over longer periods than those of the companies without DDG.

The organizational processes and the firm history influence the DDG dynamic capability of those companies that employed it, but firm assets did not, a finding which contrasts with those of previous research (Tanriverdi, 2005). In terms of organizational processes, we found that the sensing process influenced companies' effectiveness in choosing IT for DDG. More companies with DDG had personnel effectively observing customers' preferences and gathering feedback from partners about sales' plans, and more of them had effective methods for choosing IT for DDG solutions.

We also found that the organizational process of learning influenced the reconfiguring of the DDG dynamic capability and its capability to manage digital data, confirming the preeminent role of learning among the organizational processes. In practical terms, those personnel who are more effective in putting newly acquired knowledge into practice are also more effective in steering the DDG evolution and reorganization (i.e., its reconfigurability) and in handling (i.e. managing) the digital data that they obtained.

Considering the effects of firm history, the historical IT dynamic capability positively influenced the DDG dynamic capability of managing digital data but negatively impacted the DDG dynamic capability of choosing IT. This distinction between IT personnel and sales personnel can be at the origin of this opposed influence - a possible explanation could relate to the measurement of the historical IT dynamic capability in terms of the proven past effectiveness of a firm's IT personnel in developing and exploiting IT applications, and assessing the DDG dynamic capability of choosing IT by measuring sales personnel's effectiveness in choosing IT for DDG for their Sales efforts. The more the sales personnel perceive that the IT personnel exploit IT effectively, the less they think to be able to choose the IT for DDG. However, the same does not hold for the digital data management dimension, where sales personnel's perceptions that IT personnel are better at exploiting IT positively influences the perception that the sales staff's higher effectiveness in handling digital data. The historical information dynamic capability also influences the DDG dynamic capability - in particular, it positively influences the DDG dynamic capability of choosing IT: the more the Sales personnel have proven being, in the recent past, effective in processing information and the more the Sales personnel are effective in choosing IT for DDG.

Finally, the combined results of the multiple discriminant and regression analyses gives a more thorough picture of where significant relationships exist, and suggests that companies need a certain level of IT infrastructures and information repositories to start DDG. But once these thresholds are attained, further improvements in these firm assets bring no increased influence on the DDG dynamic capability. But the historical information dynamic capability is important for the launch of DDG initiatives, and remains important for development of DDG dynamic capabilities.

8 Conclusions

The literature proposes that DCs underpin organizations' competitive advantage in turbulent environments – yet their antecedents remain somewhat unexplained, and clarification would give organizations instruments to rationally improve their processes and indirectly increase their competitive advantage. We contribute to the emerging literature on the antecedents of the IT dynamic capabilities by proposing and testing a research model on DDG dynamic capability: the dynamic capability of (1) choosing IT to generate and capture data in digital form, unobtrusively, (2) integrating the IT in the appropriate business processes, and (3) managing the digital data so produced.

The test of the model highlights the importance of all the three sources of dynamic capabilities - organizational processes, firm assets and firm history - but their impacts differ. Firms' historical information dynamic capability, present IT infrastructures and information repositories facilitate the launch of DDG, while their organizational processes of sensing and learning, historical information

dynamic capability, and historical IT dynamic capability positively influence the DDG dynamic capability: but their historical IT dynamic capability negatively influences the DDG dynamic capability of choosing IT.

Further research suggestions include extending the sample to improve the quality of the results even more, and the application of more sophisticated methods, such as Structural Equation Modelling. Interviewing IT as well as Sales managers would yield a complementary point of view and help reduce common method bias. Finally, repeating the interviews after a period would help confirm the dynamic nature of the DDG dynamic capability that is only measured in this study via the dimension of reconfiguring.

References

Banker, R. D., Bardhan, I. R., Hsihui, C., & Shu, L. (2006). Plant information systems, manufacturing capabilities and plant performance. MIS Quarterly, 30(2), 315–337.

Barney, J. B. (1991). Firm resources and sustained competitive advantage. Journal of Management, 17, 99–120.

Bharadwaj, A., Sambamurthy, V., & Zmud, R. (1999). IT Capabilities: Theoretical Perspectives and Empirical Operationalization. ICIS.

Broadbent, M., & Weill, P. (1997). Management by Maxim: How Business and IT Managers Can Create IT Infrastructures. MIT Sloan Management Review, 38(3), 77–96.

Broadbent, M., Weill, P., & St. Clair, D. (1999). The Implications of Information Technology Infrastructure for Business Process Redesign. MIS Quarterly, 23(2), 159–182.

Chesbrough, H., & Spohrer, J. (2006). A research manifesto for services science. Communications of the ACM, 49(7), 35–40.

Cohen, W. M., & Levinthal, D. A. (1990). Absorptive Capacity: A New Perspective on Learning and Innovation. Administrative Science Quarterly, 35(1), 128–152.

Eisenhardt, K. M., & Martin, J. A. (2000). Dynamic Capabilities: What Are They? Strategic Management Journal, 21(10/11), 1105.

Fink, L., & Neumann, S. (2007). Gaining Agility through IT Personnel Capabilities: The Mediating Role of IT Infrastructure Capabilities. Journal of AIS, 8(8).

Freeze, R., & Kulkarni, U. (2005). Knowledge Management Capability Assessment: Validating a Knowledge Assets Measurement Instrument. Hawaii International Conference on System Sciences.

Ingemar, D., & Cool, K. (1989). Asset stock accumulation and sustainability of competitive advantage. Management science, 35(12), 1504–1511.

Kholi, A., & Jaworski, B. J. (1990). Market-Orientation: The Construct, Research Propositions, and Managerial Implications. Journal of Marketing, 54, 1–18.

King, W. R., Grover, V., & Hufnagel, E. H. (1989). Using information and information technology for sustainable competitive advantage: Some empirical evidence. Information & Management, 17(2), 87–93.

Kogut, B., & Zander, U. (1996). What firms do? Coordination, learning, and learning. Organization Science, 7(5).

Kohli, A. K., & Bharadway, S. G. (2007). Rethinking customer solutions: from product bundles to relational processes. Journal of Marketing, 71, 1–17.

Kohli, R., & Grover, V. (2008). Business Value of IT: An Essay on Expanding Research Directions to Keep Up With The Times. Journal of the Association for Information Systems, 9(2), 23–39.

Leonard-Barton, D. (1992). The factory as a learning laboratory. Sloan Management Review,.

Lin, P. (2005). Learning with Information Capacity Constraints. Journal of Financial & Quantitative Analysis, 40(2), 307–329.

Li, T., van Heck, E., & Vervest, P. (2009). Information capability and value creation strategy: advancing revenue management through mobile ticketing technologies. European Journal of Information Systems, 18, 38–51.

Malone, T., & Crowston, K. (1994). The Interdisciplinary Study of Coordination. ACM Computing Surveys, 26(1), 87–119.
Marchand, D. A., Kettinger, W. J., & Rollins, J. D. (2002). Information Orientation: The Link to Business Performance. New York, USA: Oxford University Press.
Maritan, C. A. (2007). Dynamic Capability and organizational processes. Dynamic Capability. Malden, USA: Blackwell Publishing.
Mathews, S., & Healy, M. (2007). The internet and information capability reduces perceived risk of internationalisation; an australian SME perspective. International Journal of Organisational Behaviour, 12(1), 71–87.
Mithas, S., Ramasubbu, N., & Sambamurthy, V. (2011). How information management capability influences firm performance. MIS Quarterly, 35(1), 137–A15.
Montealegre, R. (2002). A Process Model of Capability Development: Lessons from the Electronic Commerce Strategy at Bolsa de Valores de Guayaquil. Organization Science, 13(5), 514–531.
Nevo, S., & Wade, M. (2010). The formation and value of IT-enabled resources: antecedents and consequences of synergistic relationships. MIS Quarterly, 34(1).
Pavlou, P. A., & El Sawy, O. A. (2006). From IT Leveraging Competence to Competitive Advantage in Turbulent Environments: The Case of New Product Development. Information Systems Research, 17(3), 198–227.
Piccoli, G., & Ives, B. (2005). Review: IT-Dependent Strategic Initiatives and Sustained Competitive Advantage: A Review and Synthesis of the Literature. MIS Quarterly, 29(4).
Piccoli, G., & Watson, R. T. (2008). Profit From Customer Data By Identifying Strategic Opportunities And Adopting The 'Born Digital' Approach. MIS Quarterly Executive, 7(3), 113–122.
Prieto, I. M., & Easterby-Smith, M. (2006). Dynamic capabilities and the role of organizational knowledge: an exploration. European Journal of Information Systems, 15(5), 500–510.
Rai, A., Patnayakuni, R., & Seth, N. (2006). Firm Performance Impacts Of Digitally Enabled Supply Chain Integration Capabilities. MIS Quarterly, 30(2), 225–246.
Ray, G., Barney, J. B., & Muhanna, W. A. (2004). Capabilities, business processes, and competitive advantage: choosing the dependent variable in empirical tests of the resource-based view. Strategic Management Journal, 25(1), 23–37.
Ray, G., Muhanna, W. A., & Barney, J. B. (2005). Information Technology and the Performance of the Customer Service Process: A Resource-Based Analysis. MIS Quarterly, 29(4).
Sambamurthy, V., Bharadwaj, A., & Grover, V. (2003). Shaping agility through digital options: reconceptualizing the role of information technology in contemporary firms. MIS Quarterly, 27(2), 237–263.
Sanchez, R., Heene, A., & Thomas, H. (1996). Introduction: Towards the Theory and Practice of Competence-Based Competition. Oxford, UK: Pergamon Press.
Schreyögg, G., & Kliesch-Eberl, M. (2007). How dynamic can organizational capabilities be? Toward a dual-process model of capability dynamization. Strategic Management Journal, 28, 913–933.
Shannon, C. E., & Warren, W. (1949). The mathematical theory of communication. Urbana, Illinois, USA: University of Illinois Press.
Tanriverdi, H. (2005). Information Technology Relatedness Knowledge Management Capability, And Performance Of Multibusiness Firms. MIS Quarterly, 29(2), 311–334.
Teece, D. J. (2007). Explicating Dynamic Capabilities: The Nature and Microfoundations of (sustainable) Enterprise Performance. Strategic Management Journal, 28(13), 1319.
Teece, D. J. (2011). Dynamic Capabilities: a Guide for Managers. Ivey Business Journal, 75(2), 29–32.
Teece, D. J., Pisano, G., & Shuen, A. (1997). Dynamic Capabilities and Strategic Management. Strategic Management Journal, 18(7), 509–533.
Wade, M., & Hulland, J. (2004). Review: The resource-based view and information systems research: review, extention, and suggestions for future research. MIS Quarterly, 28(1), 107–142.
Weick, K. E., & Roberts, K. . (1993). Collective mind in organizations : heedful interrelating on flight decks. Administrative Science Quarterly, 38, 357–381.

Wernerfelt, B. (1984). A Resource-based View of the Firm. Strategic Management Journal, 5(2), 171–180.
Wheeler, B. C. (2002). NEBIC: A Dynamic Capabilities Theory for Assessing Net-enablement. Information Systems Research, 13(2), 125–146.
Williams, M. L. (2003). Identifying the Organizational Routines in NEBIC Theory's Choosing Capability. HICCS. Hawaii.
Wunnava, S., & Ellis, S. (2009). IT Capability: A Moderator Model of Competitive Advantage. AMCIS 2009 Proceedings.
Yoon, C. Y. (2005). Measuring personal information competency for organizational computing. Annual Computer and Information Science International Conference.
Zahra, S. A., Sapienza, H. J., & Davidsson, P. (2006). Entrepreneurship and Dynamic Capabilities: A Review, Model and Research Agenda. Journal of Management Studies, 43(4), 917–955.
Zhu, K., & Kraemer, K. L. (2005). Post-Adoption Variations in Usage and Value of E-Business by Organizations: Cross-Country Evidence from the Retail Industry. Information Systems Research, 16(1), 61–84.
Zollo, M., & Winter, S. G. (2002). Deliberate Learning and the Evolution of Dynamic Capabilities. Organization Science, 13(3), 339–351.

Appendix: questionnaire

In order to collect consistent data among the different respondents, we request that you answer the following questions keeping in mind that:

- with the term 'enterprise' we refer to the smallest organizational unit, you work in, that is an autonomous business unit in its investment decisions.
- with the term 'Digital Data Generation' we refer to the production or capture of data, from its inception, in digital form. Example: the use of a Personal Digital Assistant (PDA) by the waiter of a restaurant to collect orders from the customers to the kitchen is Digital Data Generation, as opposed to the use of a note pad and a pen by the waiter to collect orders to the kitchen is not Digital Data Generation. Hence 'Digital Data Generation Technology' is the Information Technology that allows the production or capture of data, from its inception, in digital form. In the previous example, Personal Digital Assistant (PDA) technology is 'Digital Data Generation Technology' indeed, in the previous example, the note pad and the pen are not 'Digital Data Generation Technology'.
- with the term 'effective' we mean : 'producing the desired effect'.

Please rate your level of agreement with the following sentences, on a seven-point scale ranging from 1 to 7, where 1 refers to 'not at all' and 7 to 'yes, to a very large extent'.

Constructs	Items
Data Genesis capability: Choosing IT	Our Sales personnel have effective methods for the choices of Digital Data Generation
	The choices of Digital Data Generation make their case for our Sales process
Data Genesis capability: Integrating IT	Digital Data Generation is successfully integrated into our Sales process
	The integration, into our Sales process, of Digital Data Generation is effective
Data Genesis capability: Digital Data Management	Our Sales personnel effectively handle the digital data that they obtain
	Our Sales personnel effectively process the data that they obtain in digital form
	Our Sales personnel have effective methods for managing the Digital Data that they obtain
Data Genesis capability: Reconfiguring	When our Digital Data Generation must evolve, our Sales personnel successfully steer its evolution
	When our Digital Data Generation must evolve, our Sales personnel effectively lead its reorganisation

DDG dynamic capability: Choosing IT	Our Sales personnel have effective methods for the choices of Digital Data Generation
	The choices of Digital Data Generation make their case for our Sales process
DDG dynamic capability: Integrating IT	Digital Data Generation is successfully integrated into our Sales process
	The integration, into our Sales process, of Digital Data Generation is effective
DDG dynamic capability: Managing Digital Data	Our Sales personnel effectively handle the digital data that they obtain
	Our Sales personnel effectively process the data that they obtain in digital form
	Our Sales personnel have effective methods for managing the Digital Data that they obtain
Data Genesis capability: Reconfiguring	When our Digital Data Generation must evolve, our Sales personnel successfully steer its evolution
	When our Digital Data Generation must evolve, our Sales personnel effectively lead its reorganisation
Organizational processes : Sensing	Our Sales personnel effectively look for new business opportunities
	Our Sales personnel effectively observe customers' preferences
	Our Sales personnel effectively gather feedback from our partners
Organizational processes: Learning	Our Sales personnel put effectively into practice their recently acquired knowledge
	Our Sales personnel are effective in applying the new knowledge
	Our Sales personnel effectively employ the new knowledge about our customers
Organizational processes: Coordinating	Our Sales personnel effectively coordinate their different work activities
	Our Sales personnel set up a well-coordinated team
	Each member of the Sales department effectively coordinates with the rest of the Sales department
Organizational processes: Integrating	Each member of the Sales department effectively integrates his job with the others towards a collective result
	Each member of the Sales personnel promptly contributes in the collective solution of the Sales department's problems
	Each member of the Sales department is proactive in contributing to the collective output of the Sales department
Firm history: Information Capability	In the recent past, our Sales personnel have proven effective in processing information
	In the recent past, our Sales personnel have proven effective in exploiting information concerning our Sales performance
	In the recent past, our Sales personnel have proven effective in leveraging the information concerning our failures
Firm history: IT capability	In the recent past, our IT personnel have proven effective in developing IT applications
	In the recent past, our IT personnel have proven effective in exploiting IT
Firm's assets: IT infrastructure	The range of our communication technologies (e.g. Web sites, call centers, telephony) have widened over time
	The range of our information technologies (e.g. applications, software, servers) have widened over time
	The range of our network technologies (e.g. broadband, Intranet, Extranet) have widened over time
Firm's assets: Information Repository	Our information repositories span over a long period of time
	Our information repositories cover a long history of events
	Our information repositories have been long-standing