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How SMEs develop ICT-based capabilities in response to their environment

Past evidence and implications for the uptake of the new ICT paradigm

Paolo Neirotti, Elisabetta Raguseo and Emilio Paolucci
Department of Management and Production Engineering, Politecnico di Torino, Torino, Italy

Abstract

Purpose – The adoption of Information and Communication Technology (ICT) in small and medium enterprises (SMEs) has some peculiarities that may depend on the combined effect of size and the competitive environment. The purpose of this paper is to use a contingency approach to explore how SMEs develop organizational capabilities through ICT investments in response to environmental conditions.
Design/methodology/approach – A survey on 284 SMEs in Italy was conducted and data were analyzed with regression models for testing seven hypotheses on the environmental influence on the development of ICT-based capabilities and the role played by firm size.
Findings – The results show that the environment influences the development of such capabilities in a different way, depending on size. Within munificent environments, ICT-based capabilities are more diffused among larger SMEs, whereas under environmental complexity, this pattern is inverted, with larger SMEs exhibiting a more limited deployment of ICT in support of both their internally and externally oriented processes. Under environmental dynamism medium-sized firms tend to develop more internally oriented ICT capabilities, but fail in reporting superior capabilities for managing external relationships.
Originality/value – This paper contributes to understand the relationship between the environment and ICT investments in SMEs. Since the combined effect of size and the competitive environment may influence considerably the ICT investments in SMEs, this study investigates the organizational responses with respect to how SMEs use ICT to address their external environment. This focus provides a contribution to understand the challenges that SMEs are facing in the current technological and market environment, where changes in the ICT paradigm raise the level of complexity and dynamism and bring changes in competition levels that leave few resources for growth to SMEs.

Keywords SMEs, Environment, Capabilities, Contingency approach, Industry 4.0
Paper type Research paper

1. Introduction

Information systems (IS) research has made significant strides in illustrating the impact of the environment on Information and Communication Technology (ICT) strategies. Some gaps remain in understanding organizational responses with respect to how small and medium enterprises (SMEs) use ICT to address their external environment. The academic challenge for IS scholars lies in the fact that most of the knowledge pertaining to the relationship between the environment and ICT investments has been developed in relation to large enterprises (e.g. Dale Stoel and Muhanna, 2009; Xue *et al.*, 2012) and is not fully applicable to SMEs. This gap is critical for our understanding of ICT usage in SMEs for three reasons. First, compared to their larger counterparts, SMEs are more constrained by their external environment and are more vulnerable to the availability of resources in the environment (Pfeffer and Salancik, 1978). To mitigate this effect, innovation support policies at the European level (e.g. the Horizon 2020 framework program, to name the most recent one) have traditionally put great emphasis on sustaining the process of "digitalization" of SMEs.

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However, these measures have not favored a broad diffusion of ICT solutions and new ICT-based practices among SMEs (Eurostat, 2014). The limited effect of public funding measures can be in part explained by the lack of a deep understanding of how SMEs' needs and difficulties in using ICT change in response to their external environment. Second, firms' needs and the challenges they face in developing organizational capabilities from the use of ICT primarily depend on conditions of the environment such as the level of dynamism in technology and market conditions, the complexity (i.e. the heterogeneity of inputs) and the munificence (i.e. the growth opportunity in the market and the availability of resources) existing in their industries. Third, size influences the coping mechanisms that firms enact to respond to their environments (Lawrence and Lorsch, 1967). Within the SME category, which for European classifications includes firms in the range 10-250 employees, coping mechanisms can change significantly given the wide diversity of resource endowments and behaviors in strategic positioning and organization design that can exist in this size range.

Based on these arguments, in the study we contend that SMEs' needs and challenges in adopting and integrating ICT into their organizational processes depend on the combined effect of size and the competitive environment (Terziovski, 2010). To this end, we reconcile the resource-based view and contingency perspective to identify the effects that the environment has on the organizational capabilities that SMEs develop through ICT use. While contingent studies on ICT have, thus, far illustrated the performance effects of the types of capabilities developed through ICT under different environmental contexts, there is limited theoretical discussion and empirical illustration of the barriers that SMEs face in investing in ICT under different environmental conditions. This approach has the potential to enrich our understanding of the factors hindering the use of ICT within SMEs. Little is known about this point since the view taken by early studies on ICT use was aggregate and simply focused on the adoption of systems (e.g. Dibrell *et al.*, 2008), or it was based on a narrow scope of functional capabilities (e.g. Kmieciak *et al.*, 2012). Consequently, a broad view on how ICT usage can affect SMEs' capability portfolio can provide a more comprehensive understanding in the following directions: how SMEs can cope with their external environment by adopting ICT to improve their organizational processes; how they can take advantage of an increasingly pervasive and complex range of technologies that since the 2010s support manufacturing and logistics processes, marketing relationships, and product innovation.

This study is an attempt to cover these issues through two questions:

RQ1. How does the environment affect ICT usage in SMEs?

RQ2. How does size influence the relationship between the environment and ICT usage?

We study ICT usage by drawing on the concept of ICT-based capabilities, which refers to the contribution that ICT resources makes to the creation or improvement of firms' organizational processes. We investigate this topic using a multi-industry sample of 284 Italian SMEs by focusing upon the changes ICT creates in four areas: production, administration, product development, and marketing and customer relationship management (CRM).

Understanding how and when SMEs develop ICT-based capabilities in response to their external environment can provide useful indications on how they are able to deal with the environmental changes that have characterized western countries in the 2010s. Specifically, our focus on dynamism, complexity and munificence as relevant variables of the competitive environment reflect the forces that have shaped the most the recent external context of SMEs. On one the hand, after 2011 SMEs have dealt with a lower amount of resources due to the economic crisis and the banking credit crunch. On the other hand, the increased pervasiveness of a new bunch of digital technologies like Internet of Things (IoT), big data, simulation approaches based on high-performance computing applied to manufacturing processes (where they have been renamed with terms like "industry 4.0" or smart manufacturing) and to

services have increased the dynamism and the complexity of their market and technological environment (Schröder, 2017). These technologies have also enabled the rise of new market mechanisms like sharing economy and servitization, which are now increasing competitive pressures, altering market equilibria, and changing industry structure. These changes are reflected in an increased dynamism and complexity for SMEs in sectors like retail, hospitality, industrial machineries, textile, etc. By shedding light on how SMEs used ICT in the second half of the 2000s to respond to dynamism, munificence, and complexity, the paper aims to draw some general indications about their capability to use ICT in the current period, where complexity, dynamism in technological and market conditions and prolonged limited munificence are visible in many industries. In other words, by observing the previous paradigm of ICT-based innovation, related to IS in an overall "simpler" competitive environment – the one between 2005 and 2008 – we draw some indications about SMEs' readiness to deal with a more complex and dynamic technological and business environment, where new digital technologies can revolutionize manufacturing processes, market relationships, and business models in many sectors. In so doing, we can provide a support for policy makers and managers to understand why under circumstances of increasing technological complexity and uncertainty and limited private financial resources SMEs may fail in adopting and using correctly emerging digital technologies.

2. Theoretical background

This section illustrates how SMEs' internal and environmental conditions can influence the development of capabilities through IS usage. In order to evaluate this influence, we applied the research framework shown in Figure 1.

2.1 A contingency view of ICT-based capabilities

To exploit organizational opportunities, firms must find a proper fit among their competitive environment, size, organizational structure, and strategy (Lawrence and Lorsch, 1967). The environment encompasses factors related to production technologies, the institutional forces influencing firms' strategies, and the competitive regime. In this study, we limit the external environment to those aspects of competitive regimes that influence firms'

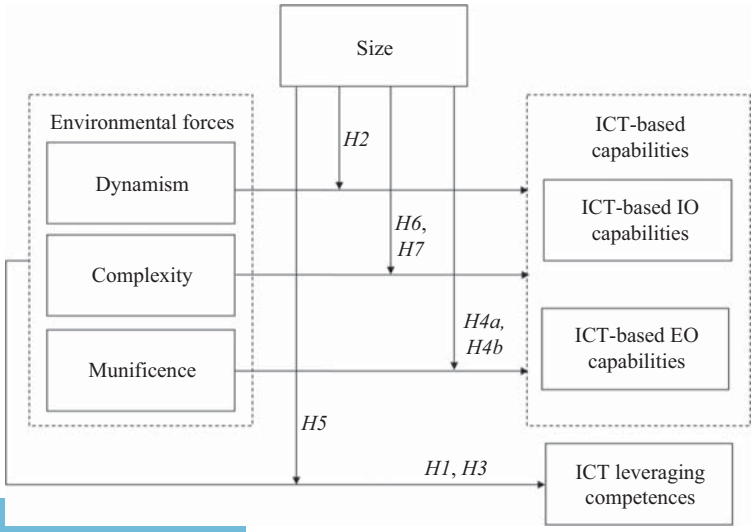

Figure 1.
Research framework

information-processing needs (Galbraith, 1974) and access to external resources (Pfeffer and Salancik, 1978). Past studies have collapsed these aspects into three dimensions: dynamism, munificence, and complexity (e.g. Dess and Beard, 1984; Keats and Hitt, 1988). Dynamic (i.e. turbulent) environments show continuous change in market and technology conditions. Munificent environments create resource and growth opportunities for firms. Complexity captures the heterogeneity of an environment, like the number of different market segments with varied characteristics and needs that firms can serve (Keats and Hitt, 1988). According to information-processing theory (Galbraith, 1974), environments that are dynamic, munificent, and complex require firms to process more information concerning market and technology conditions (Dale Stoel and Muhanna, 2009).

Firms may turn to various forms of ICT as a means of addressing information-processing requirements in production control, supply chain management (SCM), and CRM. Contingent studies have also shown that environmental conditions influence firms' approach to IS planning (Xue *et al.*, 2008). Thus, the environment influences the need for and the value of the capabilities that firms can develop through ICT (Dale Stoel and Muhanna, 2009), and the competencies that firms must develop to manage ICT investments.

2.2 ICT-based capabilities: what they are

ICT-based capabilities are "complex bundles of ICT-related resources, skills and knowledge, exercised through business processes, which enable firms to coordinate activities and make use of the ICT assets to provide desired results" (Dale Stoel and Muhanna, 2009, p. 185). Firms develop capabilities in response to environmental stimuli and to their organizational characteristics.

In general, firms may develop two types of meta-capabilities from ICT (see Table I): "internally oriented (IO)" or "externally oriented (EO)" capabilities (Dale Stoel and Muhanna, 2009). IO capabilities are based on the use of ICT systems, such as Enterprise Resource Planning (ERP) solutions, to process information on firms' internal operations. These systems may assist managers with operational decisions that pertain to short-term horizons, and they may thus facilitate efficiency improvement and operation control through data integration across functions (Wade and Hulland, 2004). Despite the maturity of technologies like ERP, statistics indicate that practices and resources related to IO capabilities are still limited among SMEs. For example, in Italy, France, and Germany the percentage of SMEs adopting ERP systems ranged between 33 and 36 percent (Eurostat, 2014).

EO capabilities are based on the use of ICT to support innovation in business models, new product development activities, e-commerce initiatives, and CRM processes and to enable firms to respond to market changes. EO capabilities, thus, reflect the ability to use ICT to sense and process external market information. Firms with these capabilities should be, thus, more capable of reconfiguring their products, their business models, and their supply chain relationships (Borges *et al.*, 2009). More specifically, CRM systems are aimed to sustain firm efforts in market intelligence generation, and ICT systems supporting the NPD are crucial for market responsiveness and coordination with supply chain partners and shorter time-to-market in product innovation. As EO capabilities may also encompass the ability to run e-commerce initiatives, they can allow the cost of entering new market segments.

Despite the relevance of ICT-based capabilities, SMEs can pursue and achieve strategic agility even without the "wiring" of ICT. However, by supporting small firms' capabilities ICT can be crucial for their growth, thanks to the role that these technologies may have in the formalization of organizational processes and in lowering the cost of entry in new market segments.

Beyond the fact that SMEs may have a limited intention to invest in ICT, other factors explain why they may marginally develop ICT-based capabilities. With regard to IO capabilities, the implementation of ERP systems in SMEs can be difficult because of the lack of managerial experience on business process innovation (Malhotra and Temponi, 2010) and

	Internally oriented capabilities	Externally oriented capabilities
Nature	They support internal information processing by supporting cross-functional integration	They enable firms to respond to market changes and shifts in the needs of customers and suppliers in a timely manner by supporting external information processing
Organizational locus	Production planning and control processes (e.g. scheduling, inventory management) Administrative processes (e.g. billing, accounting, and payroll)	Sales and after sales processes Inbound and outbound logistics New product development processes Business planning
Business relevance	Cost Savings. They allow efficiency improvements (e.g. reduction in overhead costs, improvement in inventory turnover) and operation control through data integration across functions	Revenue growth. They provide greater strategic agility, supporting the pursuing of digital options (e.g. entering new geographical markets with limited investment)
Enabling established technologies	ERP systems	CRM, suites supporting product development processes, SCM, technologies for e-commerce
Enabling emerging technologies	Internet of Things (IoT) and Data analytics for predictive maintenance of machineries, real-time monitoring of machineries and production flows on the shop floor	IoT and Data analytics for real-time monitoring of the product-in-use, of the product and its raw materials in the supply chain
Degree of organizational complexity for their development in SMEs	Medium: Implementation of ERP systems in production planning and control requires changes in routines and tasks High: For IoT and Data Analytics	High: other preconditions are needed for their development (e.g. entrepreneurial orientation, top management team highly engaged in external information processing)

Table I.
ICT-based capabilities: key characteristics

the idiosyncrasy in SMEs in production management, which entail profound changes in their organizational routines and in some modules of their standardized ERP software.

Also ICT systems supporting firm's EO are difficult to implement for SMEs, given the tighter coordination in the definition of ICT standards they have to follow with supply chain partners (Chan *et al.*, 2012). As such, the deployment of ICT in EO organizational processes involves high levels of social complexity. Additionally, path dependence is more evident because the use of ICT in product development and CRM requires a pre-existing accumulation of IS supporting internal operations and information repositories containing customer profiles and transactions (Mithas *et al.*, 2012). In 2010s, the rise of a new wave of digital technologies like IoT and big data solutions has amplified the social complexity and the path dependence effects that characterize the accumulation of ICT resources. Apart from the obstacles due to the higher expenditures needed to invest in emerging technologies rather than in mature applications, deploying effectively IoT and big data solutions require a firms' capacity to use effectively and in an integrated information architecture established ICT-based solutions like ERP, CRM, and product suites for the product development process. Therefore, the technologies emerged in the 2010s may have raised the social, technological, and financial complexity in the accumulation process of ICT resources, thereby contributing to amplify the divide between SMEs and large enterprises in ICT usage and, consequently, in profitability and market shares.

2.3 ICT-leveraging competence as an antecedent of ICT-based capabilities

To foster their organization capabilities through ICT firms first need to invest financial and organizational resources in developing the competence to manage ICT projects and their life

cycle effectively. This precondition is denoted as ICT-leveraging competence (Pavlou and El Sawy, 2006) or, more generically, ICT capability (Wade and Hulland, 2004) Firms with these competencies have organized themselves and have committed part of their internal resources to leverage the business potential of ICT to a greater extent. As such, this competence consists of a managerial and a technical dimension. The technical dimension includes the acquisition of ICT resources (i.e. IS and infrastructure) and technical skills for maintaining the overall ICT infrastructure and the portfolio of IS. The managerial dimension is related to the way in which investments in ICT resources are selected and deployed and is founded on two components: the senior manager's ICT vision, as owners/managers' intentionality shapes the ways in which firms develop their capabilities; and the managerial practices used for establishing alignment between the planning of ICT investments and the business strategy and for allocating decision-making rights and accountability for ICT projects to the management team (Xue *et al.*, 2008). The managerial dimension of ICT-leveraging competencies can be based on different degree of formalization of roles and the managerial practices used for steering ICT projects, depending on the level of resources available to ICT in SMEs. For example, in information intensive settings, strategic planning should also include ICT-related issues and involve managers specialized in ICT decisions and a formalized planning process for investments in these resources. By contrast, in a small enterprise the alignment between ICT investments and business strategies may be based on centralizing ICT-related decisions in the hands of the CEO/owner.

2.4 The environment and ICT-based capabilities

Industry environment has significant impact on a firm's strategic actions (Dess and Beard, 1984; Keats and Hitt, 1988) and on the amount of resources available. In regard to ICT-related strategies, the environment can influence a firm's information processing needs. The level of dynamism, munificence, and complexity may also influence the "adjustment costs" that SMEs must sustain to adapt their organization to the deployment of ICT resources or to change certain modules of the implemented ICT systems to meet the requirements of running certain processes. For example, in a turbulent environment, firms are more likely to need more frequent changes in how ICT systems support processes even after their implementation. In complex environments, firms may need a more extended use of ICT systems as a liaison mechanism across functions than they do in a homogeneous environment because operations and product development may require the integration of more knowledge interdependencies that involve various departments, units, and partners in the supply chain. In munificent environments, SMEs might need to extend their ICT systems to new units or new ways of running processes that are required to realize business expansion.

2.5 The combined effect of the environment and size on ICT-based capabilities

Size can be a moderator of the relationship between the environment and a firm's strategic conduct (e.g. Dickson *et al.*, 2006). With regard to IS strategies, the moderating effect of size on the relationship between the environment and capabilities may be related to the influence of size on the costs and the barriers that SMEs face when deploying ICT. These factors could lead SMEs to use different coping mechanisms to address the challenges posed by their external environment. As synthetized in Table II, this diversity of responses to the environment in the context of ICT strategies is motivated by the fact that within SMEs, size is associated with differences in strategic positioning, in stages of the organizational life cycle, and in dimensions of the organizational structure that influence the implementation of ICT systems (Ramanathan *et al.*, 2012). Additionally, size reflects differences in the learning-related scale for ICT investments. Larger SMEs may be quicker in the learning-by-doing that moves from their competitive actions to ICT-based

	Small firms	Medium-sized firms
Strategic positioning (Wiklund *et al.*, 2009)	Market niches, especially in dynamic and complex environments Limited vertical integration and geographical scope	Higher level of vertical integration and geographical scope
Information-processing approaches (Galbraith, 1974)	Reduce information-processing needs	Increase information-processing capabilities by using self-contained units and more ICT
Organizational structure (Mintzberg, 1978)	Centralized Low formalization and standardization in organizational processes	More decentralized and departmentation in more units Greater coordination problems across units
Learning (Sambamurthy *et al.*, 2003; Barney, 1991)	A more reduced repertoire of competitive actions reduces the speed of learning	Learning-related scale effects due to a broader repertoire of competitive actions Higher levels of social complexity due to size and organizational structure may hinder innovation in organizational processes

Table II.
Mapping differences in strategy, organizational structure and learning within SMEs

capabilities because they usually have a broader repertoire of competitive actions from which they can make their ICT systems and organizational processes coevolve based on problems they may encounter in their ICT projects (Sambamurthy *et al.*, 2003). Therefore, medium-sized firms can better exploit learning-related scale effects because of the opportunity for quicker and more likely return on the required investment in learning how to deploy new ICT systems in their organizational processes.

The logics that SMEs may follow in using ICT can reflect two alternative approaches to information processing (Galbraith, 1974). Specifically, SMEs may reduce their information-processing needs by narrowing their range of products and their supplier and customer base, or they may increase their information-processing capacity by enhancing their lateral forms of communication through ICT. This second alternative allows firms to have greater decentralization. Small firms might more likely to select the first alternative given their limited resources, whereas medium-sized could be more oriented toward decentralization, as they are typically characterized by greater formalization in the organizational structure, which is required for preventing a decentralized organization from being out of control.

3. Hypotheses

3.1 Dynamism

Dynamism may lead firms to increase their internal information-processing capacity with ICT to cope with changes in volume, product mix, customer requirements and the opportunities or threats produced by technological change, which operates with amplified frequency in dynamic environments (Galbraith, 1974). In this vein, approaches like simulation based on high-performance computing or rapid prototyping support firms in dealing with uncertain system-level requirements by increasing their information-processing capabilities in assessing the product or process performance under different design scenarios.

Given the higher information-processing needs experienced by firms under dynamism, it may influence the approach used by firms in planning ICT investments. Specifically, dynamism forces organizations to make quick and frequent decisions to allocate ICT resources to functional areas (Xue *et al.*, 2008). For example, changes in the technical specifications of new software may cause incompatibility and integration problems in IS. Changes in competition and the emergence of new technologies can force the IS department

to reprioritize investment projects. Changes in customer needs require new products and changes in organizational processes that sometimes require modifications of existing systems. Therefore, a dynamic environment requires greater managerial consideration of ICT-related issues in strategic planning that SMEs may enact with different organizational mechanisms depending on their size. Larger SMEs may appoint a specialist manager to address ICT investment decisions and may extensively involve this role in communication with other managers. For smaller firms, owners and CEOs must dedicate a part of their time to ICT-related decisions. Hence, we may expect what follows:

H1. Environmental dynamism is positively associated with ICT-leveraging competencies in SMEs.

Although dynamism may entail more structured decision processes for ICT investments, it may hinder the deployment of ICT in SMEs' organizational capabilities since ICT introduces a high formalization and standardization in organizational processes that can be detrimental to a firm's agility in an unstable environment. Therefore, in stable environments, firms are better positioned to use effectively new ICT in their organizational processes, even if they might show a more limited ICT-leveraging competence. IS literature views ICT as a mechanism to increase firms' strategic agility, but it recognizes that to achieve this condition, firms need to develop an entrepreneurial orientation and managerial practices to ensure the co-evolutionary adaptation of their IS and organizational processes (Sambamurthy *et al.*, 2003). Because medium-sized firms can better exploit learning-related scale in assimilating IS into organizational processes than their smaller counterparts, they are better positioned to make the coevolution of their ICT systems and organizational processes possible in response to external changes.

Therefore, dynamism may be associated with a more limited development of ICT-based capabilities in smaller enterprises (Lu and Ramamurthy, 2011). Smaller enterprises may have more limited capabilities to use ICT for internal information processing for two reasons. First, in a turbulent environment, small firms may achieve operational flexibility without the "wiring" of ICT because decision-making processes and communication facilitated by their simple organizational structure. In this regard, prior research illustrates that in a dynamic environment, firms may reduce the amount of information to be processed through "frugal" approaches such as simple visual card systems for production and inventory control, or through operational strategies based on small lot sizes and reduced product mix (Flynn and Flynn, 1999). As such, SMEs may have a lower advantage in investing in technologies like ERP or IoT solutions that increase information processing on the shop floor and in the warehouses (Matthias *et al.*, 2017).

Second, in unstable environments, ICT systems are likely to be in a state of constant flux (Merrifield *et al.*, 2008). This may hinder the use of ICT to improve internal efficiency, as standardized ERP packages for production management are "non-malleable" in supporting changes in business processes (Raymond and Croteau, 2006). Thus, even a marginal adaptation of ERP systems to changing operating conditions requires expensive consulting services. This lack of flexibility may be critical for smaller enterprises given their lower endowments of expertise and resources to invest in the evolution of their ICT systems. Emerging technologies like cyber-physical systems are more flexible since they support the self-optimization of machines to changing quality and efficiency requirements, but they entail a level of financial investments in sensors, new generation machineries, executive manufacturing systems, and information quality that will be long been not affordable for SMEs (Lee *et al.*, 2015).

Further, even if they adopt ICT systems under high turbulence, smaller firms can be less able to use them effectively when they decide to implement these resources in their internal operations. Firms experiencing environmental turbulence tend to increase centralization in

decision-making processes (Wang, 2001), which usually leads to a poorer use of internal information. Centralization as a response to environmental turbulence can generate difficulties in internal information processing through ERP systems or IoT solutions. This type of problem can be more likely in smaller firms, given their organizational culture based on the centrality of the owner.

These arguments suggest that SMEs may follow different approaches in addressing dynamism because a limited scale makes the deployment of ICT for internal information-processing activities and the related learning processes too expensive to smaller firms. Hence, we expect what follows:

H2. SMEs' size positively moderates the relationship between environmental dynamism and IO ICT-based capabilities, with larger SMEs being more likely to develop such capabilities under conditions of high dynamism.

The effect of size in explaining SMEs' use of ICT in support of EO capabilities in turbulent environments is more ambivalent. Although dynamism may be associated with a greater firm's intention to develop EO capabilities, ICT investments supporting external orientation involve a higher level of social complexity, path dependency, and learning. Under conditions of high environmental dynamism, both SMEs may encounter difficulties in using ICT to improve their external orientation. For example, Liao *et al.* (2003) found that SMEs in a turbulent environment place limited emphasis on acquiring and disseminating new and more information from the environment. For smaller firms, the limited emphasis on external information acquisition originates in the CEO/owner's focus on the internal operations and in ineffective communication channels between the sales area and the CEO. For medium-sized firms, the problem can lie in their more limited capacity to disseminate external information in internal coordination processes, since these firms often use some forms of divisional structure that hinder the internal coordination and dissemination of external knowledge from sales actives to product development and/or marketing processes (Battaglia *et al.*, 2015). Moreover, for medium-sized firms, sensing the market and processing external information is affected by a greater degree of uncertainty and ambiguity than it is for smaller enterprises because, for small firms, business models are often based on symbiotic and stable relationships with few large customers.

Consistent with SMEs' limited capacity for acquiring information from the environment, Wiklund and Shepherd (2003) found that environmental dynamism has a negative effect on SMEs' growth. In a similar vein, ICT investments have been found to be not beneficial to a firm's agility in responding to market changes (e.g. Xue *et al.*, 2012; Lu and Ramamurthy, 2011) because large ICT spending in the face of change reinforces existing underlying patterns and logics, which in turn leads to unintended rigidity in managerial routines (Gilbert, 2006). Another potential cause of rigidity due to ICT is that ICT tools may enhance broader environmental scanning and access to external information, which may lead to information overload and limit managers' ability to take timely actions.

In sum, if, on the one hand, dynamism may provide SMEs with a greater entrepreneurial orientation, on the other hand, the deployment of more ICT in these processes may not necessarily entail that these firms will develop greater strategic agility. Thus, we do not expect any direct effect of turbulence on EO capabilities, or any moderation effect due to size.

3.2 Munificence

Environmental munificence refers to the extent to which the environment can support firms in their endeavors to achieve sustained market growth. A munificent environment presents opportunities and slack resources for business expansion in existing and new markets (Keats and Hitt, 1988).

When market demand is growing, firms are more willing to invest in the development of new resources and capabilities because they perceive greater opportunities for receiving returns on them. In SMEs, munificence may, thus, favor ICT investments because of two effects. First, in these environments, SMEs encounter fewer financial constraints. Second, as munificence provides more opportunities for market expansion, SMEs may have a greater intention to adopt standardized and integrated ICT systems to formalize their organizational processes, enlarge their operations (Malhotra and Temponi, 2010) and support product innovation and collaboration with partners. For a growing SME, ICT can enable greater internal transparency, better coordination practices (Street and Meister, 2004), and a better use of external information. By contrast, in low-munificence industries, the stronger price competition may induce the majority of firms to focus their ICT adoption solely on improvements in internal efficiency (Dale Stoel and Muhanna, 2009) or may even block adoption of new solutions given the lack of resources for innovation. Arguments from an institutional view on the ICT adoption would suggest that under low munificence SMEs may more interested in adoption of IO ICT-solutions, since their implementation projects are less risky and can exhibit returns of easier access to bank debt as banks may take account of more formalized processes in rating their risk to provide credit to SMEs.

In a munificent environment, the greater opportunities for growth may lead firms to more frequently face decisions concerning the expansion of their operational units and their portfolio of IS applications and infrastructure. Munificence can, thus, increase an SME's dependence on ICT and can, thus, lead such organizations to invest in the resources and competencies that are needed to manage ICT investments, i.e., ICT-leveraging competencies. Moreover, as munificent environments favor decentralized structures (Mintzberg, 1978), a governance framework is needed for planning ICT investments and orchestrating the needs of different organizational subunits:

H3. Environmental munificence is positively associated with ICT-leveraging competencies in SMEs.

Although the development of ICT-based capabilities is expected to be more rapid in munificent environments, smaller enterprises may have not the capacity to improve their external orientation through such technologies at the same pace as their medium-sized counterparts. By investing less resources in ICT compared with their larger counterparts (Buonanno *et al.*, 2005), smaller enterprises cannot enter the virtuous circle in ICT investments that stems from faster learning due to past ICT projects (Mithas *et al.*, 2012).

Although small enterprises may often follow operational flexibility strategies more effectively than medium-sized firms, the scarcity of their slack resources and their focus on niche markets make them less agile in repositioning their market strategies (Chang and Hughes, 2011).

Additionally, environmental munificence may require larger SMEs to use ICT to introduce greater formalization and standardization, even in organizational processes that are IO like order management in sales, inventory management and purchasing in operations. An increase in formalization and standardization can occur because by addressing market growth opportunities, larger SMEs may face the need to standardize organizational processes and to replicate them across their units (Brynjolfsson *et al.*, 2007). Hence:

H4. SME's size positively moderates the effect of environmental munificence on the development of both IO (a) and EO ICT-based capabilities (b), with larger SMEs being more likely to develop such capabilities in situations of high munificence.

3.3 Complexity

Environmental complexity depends on both the number of different products that are offered by firms (Dale Stoel and Muhanna, 2009) or by the number of different technologies

that are embodied in the product. For example, firms specialized in industrial machineries face an increasing complexity in the moment their machines are equipped with new modules like sensors and embedded algorithms for their remote control and predictive maintenance. Because of the higher information-processing requirements that firms have in complex environments, in these settings, firms can use more decentralized and departmentalized organizational structures (Mintzberg, 1978) in teams or subunits, each of them being specialized in a single type of technology or output. For a complex product – like the above mentioned case of a machinery equipped with IoT sensors and software for remote control and maintenance – this may mean for the company to introduce new competencies on electronics, software, user interfaces in the product development team and increasing the exchange of information and coordination in the development process (Porter and Heppelmann, 2015).

SMEs may react to environmental complexity with different coping mechanisms depending on their size. Smaller firms may reduce their information-processing needs by opting for a high level of specialization in market niches that are simple to understand and require a low level of horizontal and vertical decentralization. This simplifies the amount of customer requirements and technical specifications that the firm needs to handle.

For such firms, finding and developing specific market niches can be easier than in markets where demand is homogeneous. In Mintzberg's terms, smaller firms cannot address two dimensions of complexity simultaneously, i.e., in the environment and in their organizational structure. By contrast, since larger SMEs can afford a certain level of slack resources and asset redundancies, larger SMEs are more likely to respond to greater environmental complexity with product diversification or by enlarging the portfolio of the technological competencies embodied in their services or products. A broader product scope or a product embodying more technologies leads these firms to have greater bureaucratization (Gray and Mabey, 2005) and greater specialization in divisional structures.

It can be expected that the greater information-processing needs that are associated with environmental complexity may lead SMEs to adopt ICT to a larger extent, especially in support of external information processing and the internal liaison mechanisms used to coordinate work across units. In this regard, prior research indicates that in complex environments, firms are more likely to use ICT in support of product innovation and market orientation (Xue *et al.*, 2012). SMEs tend to adopt ICT in support of product development, especially when they have to address complex product architectures, which demand that SMEs exhibit a higher level of coordination with customers.

The greater dependence on ICT in complex environments can lead firms to use more formalized practices to manage ICT investments (Xue *et al.*, 2008). Complexity may entail more problems involving data and IS integration and more complex prioritization mechanisms for selecting ICT investments, for the maintenance of existing ICT assets and for taking into account the needs of different subunits. Therefore, the higher tendency toward departmentation for medium-sized firms under environmental complexity should lead to a higher level of decentralization in ICT-related decisions to specialists in each subunit, thereby increasing the need for frameworks for planning ICT investments and sharing accountability and decision-making rights within the firm:

H5. SMEs' size positively moderates the impact of environmental complexity on ICT-leveraging competencies, with larger SMEs being more likely to develop a high level of ICT-leveraging competencies in situations of high environmental complexity.

Despite a higher expected level of ICT-leveraging competencies in SMEs facing a complex environment, in these settings, the implementation of new ICT solutions may be more prone to failure given the larger number of actors and requirements that characterize these initiatives (Piccoli and Yves, 2005). Two types of arguments suggest that failures to transform the

adoption of ICT-based solutions in successful practices can be more likely for firms in complex environments, especially in contexts of more complex organizational structures, as is the case for medium-sized firms. First, Chan *et al.* (2012) found that in more complex and competitive environments, SMEs may encounter more problems in using supply chain collaboration tools effectively, as intense competition distracts them from learning how to deploy these new IS effectively in their organizational processes.

Second, larger SMEs, using a structural "departmentation" in subunits can less easily achieve the level of cross-functional integration in data and IS that is required for improving their IO capabilities (Gattiker and Goodhue, 2004). Consistent with these arguments, Xue *et al.* (2012) found that complexity negatively moderates the impact of ICT on firms' efficiency and internal orientation:

H6. SMEs' size negatively moderates the relationship between environmental complexity and IO ICT-based capabilities, with larger SMEs being less likely to develop such capabilities in situations of high environmental complexity.

A similar effect of size and complexity can exist with reference to EO capabilities. Although spatial disaggregation into small units that are located close to the customer may help firms to acquire customer knowledge and serve customer-specific needs (Daft and Lengel, 1986), under high complexity, disaggregation into a large number of units may hinder the knowledge exchange among a firm's units and the achievement of a shared understanding of market changes (Roberts *et al.*, 2012). This occurs since separate units tend to develop distinct cognitive frames of market dynamics and their integration into a unique vision is hampered by limited internal coordination and socialization. Consequently, in complex environments, larger SMEs – because of their tendency toward departmentation – may find it more difficult to develop and apply new knowledge to products, services, and other innovative units (Ethiraj, 2007). Furthermore, prior research indicates that complexity has path-dependent effects over time. As products become more complex, knowledge about interdependencies becomes more tacit (Cusumano and Selby, 1998) and firms experience a decline in their ability to manage the dependencies among the various product components. An increase in tacit knowledge thus makes it more difficult to effect change when change is needed. This potentially poses further difficulties in using ICT for product development and CRM processes because ICT systems allow the firm to process knowledge that comes in codified and explicit forms. Therefore, medium-sized firms can be weaker than their smaller counterparts because the latter – despite their limited investment in ICT systems – can be more capable than the former in using tacit knowledge effectively to improve their product's features. Integration of knowledge in tacit form is easier when firms use mutual adjustment (Mintzberg, 1978) as the main coordination mechanism and when location in a unique unit facilitates socialization among employees:

H7. SMEs' size negatively moderates the effect of environmental complexity on the development of EO ICT-based capabilities, with larger SMEs being less likely to develop such capabilities in situations of high environmental complexity.

4. Research methodology

4.1 Sample

The data used in this study were collected in a survey of SMEs in the Piedmont region of Italy between February 2009 and April 2009. Piedmont is one of the top three regions in Italy in regard to innovation and technology adoption at the firm level and SMEs show an aggregate aptitude to innovation that is comparable to the one existing in the most innovative regions in Germany, France, and the UK (Hollanders *et al.*, 2012).

We focused the survey on four industry groups: manufacturing, wholesale and retail trade, logistics and transportation services, and business services. We did not survey industries that use ICT in highly specific ways, such as multimedia, software, ICT services, and financial services. The firms that were surveyed had between 10 and 250 employees. Approximately 2,000 companies from the AIDA database were selected randomly and contacted by phone to identify the key respondents. We asked the respondents to indicate whether there was a position for the management of ICT (a chief information officer or the equivalent of such a role) within their companies. For companies that did not appoint a specialized ICT management role, we asked for the owner or the CEO. A total of 284 usable questionnaires were returned, for a redemption rate of 14.2 percent. The median value for firm size was 35 employees. A representative sample of 284 firms provided usable responses for the purpose of this study. Specifically, non-response bias was tested on the basis of size, industry type, and value added per employee. None of these comparisons revealed any sample bias.

4.2 Measures

The observation of ICT-based capabilities and environmental factors referred to the years before the survey, and thus took into consideration the second half of the 2000s. Capabilities were observed by taking into considerations' respondents evaluations on how in the four years preceding the survey ICT adoption contributed to improve their firms' key organizational processes. Environmental variables were measured considering industry-level data from the previous five years. Although simultaneity may impede a full assessment of the causal relationship between the environment and capabilities, three arguments suggest that the peril of simultaneous or inversed causality may be negligible. First, SMEs rarely have an influence over their environment. Second, ICT investments are relatively recent in Italian SMEs because of the limited supply of ICT systems for enterprise management in SMEs. Thus, SMEs are unlikely to have developed ICT-based capabilities before 2005. Third, the competitive attributes of most of the industries evolve following slow time dynamics. For example, a sector that reports stable competition patterns is unlikely to shift to more dynamic or munificent types of competition within a few years (Dess and Beard, 1984).

4.2.1 ICT-based capabilities. We distinguished among three types of ICT-based capabilities: production management and administrative capabilities (which are IO), product innovation, and market management. The last two outcomes can be considered as EO capabilities. Specifically, ICT-based production management and administrative capabilities refer to efficiency improvements that result from the role of ICT in improving inventory and production control and lead times in administrative processes such as invoicing and purchasing. These operational improvements are expected to reduce administrative overheads and the costs of goods sold.

The ICT-based new product development capability reflects the role of ICT in improving two attributes of the product development process: coordination among internal functional departments and with suppliers and customers, and managing the technical knowledge incorporated in documents of the engineering and design process. As such, this capability translates into a shorter time-to-market and high rates of product innovation.

The ICT-based market management capability refers to a better use of the resources and knowledge in sales and after-sales processes. As such, this capability translates into improvements in the knowledge of customer behavior and service levels in sales and after-sales activities as well as in better control and support for dealers and salesmen.

To operationalize these three types of capabilities using a five-point Likert scale, we asked the respondents to evaluate whether ICT had a significant effect on a series of items

that were related to the internal and external orientations of their firms. The respondents' assessments were based on the effects due to ICT that they had observed during the prior four years (between 2005 and 2008). We conducted a principal component analysis and a subsequent confirmatory factor analysis in Amos 16.0 to assess their measurement properties of the multi-item scales (see Table III). A second-order factor measurement model on market management and product development capabilities was developed to measure a firm's EO ICT-based capability. With a second-order factor, we were able to provide a more general interpretation of measurement scales and to offer a more parsimonious way to validate the hypotheses on the antecedents' ICT-based capabilities. The covariance among the two first-order factors was fully explained by the first-order factors' regression on the second-order factor.

In the econometric specifications, the factor scores of the capabilities were calculated as a weighted average of the items based on their factor loadings. For the EO capability, the loadings of the first-order factors served to compute the scores of these factors, which were in turn weighted by the loading of the second-order factor to arrive at a general measure of the EO ICT capability.

4.2.2 The environmental context. To operationalize the environmental factors, we followed the approach used by Dess and Beard (1984). Dynamism and munificence were measured using national accounting data from Istat, the Italian Bureau of Statistics. For each industry segment (defined at a three-digit level of NACE codes), the industry-level total sales for five years (from 2004 to 2008) were regressed on the year variable. The dynamism was operationalized as the variability in annual industry sales and was measured as the standard error of the regression slope coefficient of annual industry sales and was divided by the industry mean for the five-year period. Munificence was operationalized as the growth rate in annual industry sales, which was measured as the regression slope coefficient (the coefficient on the time variable) divided by the average annual sales over the five years' period (Dale Stoel and Muhanna, 2009).

We referred to two dimensions of complexity. The first one refers to the heterogeneity of the inputs (Dess and Beard, 1984), and was operationalized by using the input/output

Constructs	Loadings	Mean[a]	SD	Median
Production management and administrative capabilities ($\alpha = 0.696$; CR = 0.722; AVE = 0.467)				
Increased efficiency of administrative activities (i.e. simplification of payroll and accounting workflows)	0.662	0.216	1.012	0
Reduction in the costs of goods/services sold	0.778	0.511	1.017	1
Reduction in the costs of internal coordination and control	0.599	0.479	1.203	1
New product development capability ($\alpha = 0.803$; CR = 0.809; AVE = 0.516)				
Growth in the number of product/services delivered	0.735	−0.043	1.137	0
Reduction in the failure risks of new products	0.743	−0.667	1.117	0
Reduction in time-to-market for new products	0.752	−0.418	1.244	0
Increased collaboration with suppliers involved in product design and engineering	0.639	−0.188	1.308	0
Market management capability ($\alpha = 0.795$; CR = 0.837; AVE = 0.566)				
Increased knowledge of customer needs and purchasing habits	0.837	−0.025	1.164	0
Increased control of sales, including sales agents	0.859	0.014	1.240	0
Better support of sales employees and dealers	0.656	0.046	1.269	0
Improved delivery of after-sales services	0.629	0.107	1.263	0

Notes: [a]−2: completely disagree; +2: completely agree; 0: neutral

Table III. ICT-based capabilities: principal component analysis

concentration. The Istat input/output tables enabled us to calculate the concentration of each industry's inputs, which was measured as $C = \sum I_k^2/(I_k)^2$, where I_k is the euro volume of inputs from industry k. The complement to 1 of concentration C increases as the number of industries k supplying the inputs increases and as these inputs become more evenly distributed across the suppliers; thus, this value captures both the structural and distributive differences in complexity that may occur across industries. The second dimension refers to the concentration of industry outputs (where industry was defined at a three-digit level of NACE codes) and reflects the extent to which a large portion of an industry's input is supplied by large firms. It was measured through the Herfindahl index of concentration in the market shares of large enterprises. A small value of this measure reflects a trend toward dominance by fewer firms, making the environment less complex (Keats and Hitt, 1988). In order to validate the scale used for complexity, we conducted a principal component analysis on the complement to one of the two above-mentioned indicators of concentration. The pattern of factor loading supports the existence of a unique dimension of complexity. The standardized factor scores of this factor were used as a measure of complexity.

4.2.3 ICT-leveraging competence. Our measure of ICT-leveraging competence refers to four components (see Table IV). Two of these components pertain to a managerial dimension of how firms address the organizational and strategic implications of ICT investments. The two other components involve the technical dimension of how technology and technical skills on ICT are deployed in support of organizational processes.

With regard to the managerial dimension, the first component reflects SMEs' alignment between the ICT and business perspectives. We operationalized this component by asking companies whether there existed a position to manage ICT investments and business improvement programs simultaneously. The respondents were required to use a five-point Likert scale (1: strongly disagree; 5: strongly agree) to evaluate the degree of this role's involvement in: the selection of software packages for enterprise management and the definition of their business requirements; business strategy planning; and change management that is induced by ICT projects on business processes. These items had high loadings on a single factor (explaining approximately 90 percent of the variance of these measures).

	Range of scale	Mean	SD	Cronbach's α
1. ICT-business alignment				
In the firm ICT investments decisions are taken by a person who:				
1.1 is regularly involved in the selection of the IS to adopt and in the definition of their business requirements	1-5	2.687	1.633	0.970
1.2 regularly attends business planning meetings	1-5	2.377	1.447	
1.3 is charge of the continuous improvement of business processes	1-5	2.699	1.630	
2. CEO's ICT business vision				NA
2.1 Shareholders and/or the CEO consider ICT as a crucial asset for the firm's growth (Likert scale)	1-5	2.551	1.278	
3. Adoption of IS				0.559
3.1 SCM	0-1	0.053	0.224	
3.2 ERP	0-1	0.386	0.487	
3.3 CRM	0-1	0.159	0.366	
3.4 PDM/PLM	0-1	0.241	0.428	
4. ICT technical skills				NA
4.1 Percentage of ICT professionals in the workforce	0-1	0.066	0.224	

Table IV.
Construction of measure of ICT-leveraging competence

The second component of the managerial dimension refers to owner's and senior managers' perspectives on the role that is played by ICT in their firm's business strategies. This variable was operationalized by considering the extent to which the decisions of CEOs and/or shareholders to invest in ICT were related to business growth intentions and reflected the importance given to ICT as a crucial asset for business growth.

With regard to the technical dimension, the first component takes into consideration the adoption of four types of IS: ERP packages; CRM systems that support all of the sales cycle (from leads to after-sales services) and the analytics that relate to sales activities; product data management (PDM) systems that support collaboration, data and document management within the product development process; and SCM systems that support information sharing, collaborative production planning, and inventory management with external partners. The second component relates to ICT technical skills and was operationalized through the ratio of ICT professionals in the workforce. This measure reflects the variety of technical competencies that are related to the ICT that is available within a firm.

The correlations between these dimensions are positive and significant, and Cronbach's α for a multidimensional scale constructed from the individual variables is 0.503. This low value is because these measures are multidimensional in the sense that SMEs exhibit some dimensions of an ICT-leveraging competence independently of the others because the concept of ICT-leveraging competence, as it has been intended by the previous literature, is probably only partly applicable to SMEs. However, the value of Cronbach's α can be regarded as being satisfactory inasmuch as it is our measure of a new scale of ICT-leveraging competence for the specific case of SMEs. We constructed a scale from these measures using the sum of the standardized values of each dimension.

4.2.4 Size and control variables. Size was measured as the number of employees in logarithmic form. As control, we included firms' age (in logarithmic terms), human capital, the spatial disaggregation of sales and organizational units, and industry variables discriminating the first digit of the SIC industry codes. Human capital was measured using the average labor cost per employee. Spatial disaggregation was included as a dimension of complexity in the organizational structure that can affect the needs of ICT for internal coordination. Two dimensions of spatial disaggregation were considered: the number of operational units and the breakdown of sales in terms of geographical provenience. To this purpose, we distinguished between firms that are active mainly in the regional market of Piedmont from firms that sell their products in other Italian regions or abroad. Specifically, we included a dummy variable (i.e. "local firm") for discriminating firms where more than 90 percent of sales revenue stems from regional sales.

4.2.5 Instrument variables. The purpose of this set of variables was to account for potential endogeneity. We took into control: the geographical localization of the firm in a metropolitan area, the adoption of broadband internet connectivity with a download speed superior to 8 Megabit per second (in 2008, 67 percent of the firms in the sample had internet access with this characteristic), the use of training initiatives and other procedures on data and IS security made in the period under consideration in the survey. We discuss these variables in detail below.

4.3 Estimation method

We tested our hypotheses with a system of regressions involving the moderating effect of size on the relationship between environment and the two types of ICT-based capabilities. An instrumented equation was involved to account for the effect of the ICT-leveraging on ICT-based capabilities.

For both the structural and the instrument equations, we used a hierarchical approach for the regression analyses in order to assess the moderating effect exerted by SMEs' size

in the relationship between environmental variables and the ICT-related outcomes under consideration. To account for the suspected endogeneity in the ICT-leveraging competence, we performed a three-stage procedure. We predicted ICT-leveraging competence with the full set of exogenous control variables, industry dummies and their respective instruments.

Geographical localization of the firm in a metropolitan area was included for instrumenting ICT-leveraging competence in studying its effect on IT-based capabilities since SMEs located in metropolitan areas face better access conditions to the market of standardized ICT solutions and to the complementary consulting services related to their implementation. The supply of these technologies and services is usually concentrated in metropolitan areas than in rural areas. Also the supply of some infrastructural ICT resources such as mobile internet connection is more efficient in cities than in rural areas. Furthermore, localization in metropolitan areas favor knowledge spillovers between adopters and potential adopters that can influence the decision to adopt a certain technology. Information exchange and direct observation of the adoption of new technologies by others allow small businesses to improve on others' methods to manage ICT and may lead SMEs to develop better ICT-leveraging competencies respect to their counterparts in rural areas. There are, however, no *a priori* arguments that SMEs with operational units in metropolitan areas systematically accumulate more ICT-based capabilities, as the development IT-based capabilities depend on managerial abilities that do not necessarily characterize the majority of small business localized in cities.

The provision of training on standard operating procedures on data management and electronic security may reflect firms where ICT and data management have a greater salience for their business. However, being courses on data management and electronic security addressed to provide general purpose knowledge on data security and ICT, they are not expected to have any direct effect on the way ICT and data impact on the accumulation of ICT-based capabilities.

The instrumented values of the ICT-leveraging competence were used to estimate the two structural equations with the two ICT-based capabilities as dependant variables.

5. Findings

5.1 Descriptive statistics

Descriptive statistics (Table V) indicate that SMEs are more likely to develop IO than EO ICT-based capabilities as the score for IO capability was significantly higher than the score for the aggregate measure of EO capabilities. The mean values were 0.472 and −0.024, respectively (p-value of the Wald test for their difference < 0.001). SMEs that have developed EO capabilities were more likely to have developed also IO capabilities (Spearman correlation coefficient: 0.409, p-value < 0.01).

5.2 Regression results

As seen in Models 1 and 2 in Table VI, all the instruments are significant. ICT-based leveraging competencies are higher for firms located in metropolitan areas, with access to broadband internet connectivity and that have made training in ICT-related domains. The instruments had no residual partial effect on ICT-based capabilities, which suggests that they are robust.

5.2.1 The antecedents of ICT-leveraging competence. Size does not affect the level of the ICT-leveraging competence for SMEs (Model 1 and Model 2). Rather, ICT-leveraging competence is affected more by environmental variables than by size. Specifically, Model 1 shows that dynamism has a positive, albeit weakly significant, effect on the level of the ICT-leveraging competence, thereby giving weak support to *H1*.

	Mean	SD	Median	75th percentile	Min.	Max.
Dependent variables						
ICT-based IO capability	0.472	0.758	0.379	0.993	−2	2
ICT-based EO capability: aggregated measure (second-order factor)	−0.024	0.735	0.088	0.383	−2	2
ICT-based EO capability: product development capability	−0.183	0.819	0.000	0.333	−2	2
ICT-based EO capability: market management capability	0.154	0.882	0.250	0.760	−2	2
ICT-leveraging competence	0.005	3.051	0.009	1.714	−6.089	6.698
Focal independent variables						
Dynamism	0.065	0.041	0.062	0.085	−0.043	0.098
Munificence	0.017	0.014	0.016	0.031	−0.035	0.067
Complexity	0.007	1.587	0.269	1.437	−4.812	2.501
Size (logarithmic)	3.536	0.819	1.544	1.903	2.3	5.46
Control variables						
Age (logarithmic)	3.031	0.748	3.135	3.496	0	4.663
Human capital	37.907	12.357	37.000	44.000	18.000	96.000
Number of operational units	1.780	1.631	1	2	1	15
Local firms (i.e. firms only active in a regional market)	0.149	0.356	0	0	0	1

Table V.
Descriptive statistics

In a similar way, Model 1 highlights that environmental munificence has a positive and significant effect on the ICT-leveraging competence, thereby confirming *H3*. Model 1 also highlights that the effect of environmental complexity on ICT-leveraging competencies is negative, albeit non-significant, when only the first-order effect is taken into account. However, when the interaction effect between size and environmental complexity is taken into account (Model 2), there is evidence of a positive and significant coefficient for this interaction effect. Therefore, under contexts of greater environmental complexity, larger SMEs tend to develop a higher level of ICT-leveraging competencies, supporting *H5*.

5.2.2 First-order effects on ICT-based capabilities. Size had no significant effect on any of the types of ICT-based capabilities. As expected, firms with a higher level of ICT-leveraging competence have a higher level of both IO and EO ICT-based capabilities. With regard to the effects exerted by environment variables on ICT-based capabilities, it is worthwhile noticing that the first-order effects are not significant, except for munificence, which plays a negative effect on IO capabilities (Model 3). This negative effect is consistent with the more limited focus that firms in expanding markets have on improving their operational efficiency. As shown in the next section, environment effects become visible when its interaction with the size of SMEs is considered.

5.2.3 Moderation effects of size on the environmental influence on ICT-based capabilities. Model 4 takes into consideration the antecedents of IO capabilities and shows a positive and significant effect – albeit with a p-value between 5 and 10 percent – for the interaction between size and dynamism. Thus, under high environmental dynamism, larger SMEs exhibit a slightly higher level of IO capabilities than their smaller counterparts. This evidence provides a weak support to *H2*. It is worth noting that the effect of dynamism on EO capabilities is not significant, even when this effect is moderated by firm size (see Model 9). Therefore, there are no circumstances under which dynamism has effect on the extent of EO capabilities.

Model 5 on IO ICT-based capabilities shows a negative and non-significant effect due to the interaction between munificence and size. Therefore, *H4a* is not supported. By contrast, Model 10 on the degree of EO ICT-based capabilities shows a positive and significant

Table VI.
Regression models. Hierarchical approach for the hypothesized interaction effects

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9	Model 10	Model 11	Model 12
						Dependent variable.						
Independent Variable	ICT-leveraging competence	ICT-leveraging competence	IO ICT-based capabilities	IO ICT-based capabilities	IO ICT-based capabilities	IO ICT-based capabilities	IO ICT-based capabilities	EO ICT-based capabilities	EO ICT-based capabilities	EO ICT-based capabilities	EO ICT-based capabilities	EO ICT-based capabilities
Size	0.067	0.070	0.045	0.041	0.053	0.034	0.029	0.033	−0.003	−0.004	−0.010	−0.017
	(0.047)	(0.047)	(0.062)	(0.059)	(0.059)	(0.059)	(0.058)	(0.057	(0.057)	(0.056)	(0.057)	(0.057)
Dynamism	7.387****	7.859****	−3.197	−1.572	−0.880	−3.059	−3.134	−1.648	−1.595	−1.293	−2.526	−2.729
	(4.392)	(4.362)	(5.683)	(5.355)	(5.342)	(5.476)	(5.395)	(5.287)	(5.189)	(5.121)	(5.235)	(5.178)
Munificence	6.258*	6.091*	−8.537*	−8.232**	−7.737*	−9.045**	−9.120**	0.599	1.203	0.432	0.686	−0.452
	(2.779)	(2.753)	(3.669)	(3.084)	(3.161)	(3.155)	(3.101)	(3.40)	(2.989)	(3.030)	(3.016)	(3.057)
Complexity	−0.041	−0.055	0.001	−0.005	−0.013	0.019	0.018	0.050	0.044	0.039	0.059	0.059
	(0.053)	(0.053)	(0.067)	(0.050)	(0.049)	(0.052)	(0.051)	(0.062)	(0.049)	(0.048)	(0.050)	(0.049)
Size × Dynamism	–	–	–	11.422****	–	–	9.500	–	−0.774	–	–	–
				(6.483)			(5.902)		(6.301)			
Size × Munificence	–	–	–	–	−0.390	–	–	–	–	6.285*	–	6.531*
					(3.481)					*(3.011)*		(3.057)
Size × Complexity	–	0.090*	–	–	–	−0.141*	−0.119*	–	–	–	−0.070*	−0.080*
		(0.044)				(0.055)	(0.055)				(0.037)	(0.042)
ICT-leveraging competence	–	–	0.681**	0.524**	0.465*	0.679**	0.674**	0.356	0.433*	0.395*	0.516*	0.543**
			(0.228)	(0.199)	(0.193)	(0.213)	(0.199)	(0.218)	(0.193)	(0.185)	(0.204)	(0.194)
Age (log)	0.064	0.066	−0.091	−0.095	−0.094	−0.096	−0.099****	−0.127*	−0.149*	−0.153**	−0.151**	−0.155**
	(0.049)	(0.049)	(0.061)	(0.059)	(0.059)	(0.059)	(0.059)	(0.058)	(0.057)	(0.057)	(0.058)	(0.057)
Number of operational units	0.010	0.012	0.020	0.026	0.025	0.020	0.022	0.039	0.044****	0.044****	0.042	0.040
	(0.023)	(0.023)	(0.028)	(0.027)	(0.027)	(0.028)	(0.027)	(0.026)	(0.026)	*(0.026)*	(0.026)	(0.026)
Local business	−0.209*	−0.225*	−0.018	0.038	0.035	0.029	0.034	−0.015	−0.011	−0.014	−0.012	−0.014
	(0.104)	(0.106)	(0.136)	(0.134)	(0.139)	(0.102)	(0.132)	(0.116)	(0.125)	(0.126)	(0.126)	(0.126)
Human Capital	−0.001	−0.001	0.004	0.006	0.005	0.004	0.005	0.004	0.003	0.003	0.003	0.002
	(0.006)	(0.006)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.003)	(0.003)	(0.003)	(0.003)
Manufacturing Industry	−0.731	−0.728	0.251	−0.029	−0.052	−0.027	−0.016	0.269	−0.111	−0.122	−0.103	−0.103
	(0.502)	(0.495)	(0.642)	(0.102)	(0.100)	(0.102)	(0.101)	(0.594)	(0.099)	(0.096)	(0.098)	(0.096)
Information Intensive Industry	0.029	−0.014	0.033	0.055	0.062	0.103	0.091	−0.123	−0.099	−0.115	−0.079	−0.092
	(0.145)	(0.144)	(0.178)	(0.096)	(0.097)	(0.099)	(0.098)	(0.164)	(0.093)	(0.092)	(0.094)	(0.094)

(*continued*)

Table VI.

Independent Variable	Model 1 ICT-leveraging competence	Model 2 ICT-leveraging competence	Model 3 IO ICT-based capabilities	Model 4 IO ICT-based capabilities	Model 5 IO ICT-based capabilities	Model 6 Dependent variable. IO ICT-based capabilities	Model 7 IO ICT-based capabilities	Model 8 EO ICT-based capabilities	Model 9 EO ICT-based capabilities	Model 10 EO ICT-based capabilities	Model 11 EO ICT-based capabilities	Model 12 EO ICT-based capabilities
Broadband Internet	0.186*	0.155*	–	–	–	–	–	–	–	–	–	–
	(0.074)	(0.076)										
Metropolitan area 1 (Turin)	0.131*	0.123*	–	–	–	–	–	–	–	–	–	–
	(0.047)	(0.060)										
Metropolitan area 1 (Milan-Novara)	0.230*	0.238*	–	–	–	–	–	–	–	–	–	–
	(0.090)	(0.093)										
ICT training	0.289***	0.299***	–	–	–	–	–	–	–	–	–	–
	(0.074)	(0.074)										
Constant	0.310	0.331	0.385	0.529*	0.561*	0.562*	0.539*	–0.170	0.405****	0.415****	0.402****	0.418****
	(0.519)	(0.512)	(0.673)	(0.237)	(0.239)	(0.237)	(0.236)	(0.622)	(0.231)	(0.229)	(0.231)	(0.229)
R squared	0.182	0.197	0.123	0.170	0.165	0.142	0.151	0.211	0.171	0.183	0.170	0.177
χ^2	61.61	67.55	29.94	28.29	26.74	31.60	34.43	43.18	29.04	30.43	29.40	33.23
p-value	0.000	0.000	0.018	0.003	0.0050	0.001	0.001	0.000	0.002	0.0014	0.002	0.001

Notes: Industry dummies controlled at the first digit of SIC code. Parameters estimated followed by robust standard error in parentheses. *$p < 5$ percent; **$p < 1$ percent; ***$p < 0.1$ percent; ****$p < 10$ percent

interaction term due to size and munificence. In situations of high munificence, larger SMEs, thus, show higher degree of EO ICT-based capabilities. This result supports *H4b*.

Model 6 showed a positive – albeit not significant – effect for complexity on IO ICT-based capabilities but a negative and significant effect due to the interplay of complexity with size. Thus, complexity has a positive effect on ICT-based capabilities that are internally focused only for smaller SMEs. The larger the firm size, the less visible is the positive effect of complexity on IO capabilities (*H6* supported). It, thus, seems that in complex environments, small firms are more likely to improve their internal information processing capabilities through ICT.

Model 11 shows a positive first-order effect of complexity on EO capabilities and significant negative interaction between complexity and size (*H7* supported). In situations of high complexity, the firms that exhibit the higher endowment of ICT-based capabilities with an external focus are smaller firms. Instead, in complex environments larger SMEs tend to develop a level of EO capabilities that is comparable to the one developed by their peers in less complex environments.

In Model 7 and Model 12, we simultaneously tested the interaction effects resulted significant in the former model specifications confirming the results discussed above.

Table VII gives an overview of the results obtained and of their implications on the readiness that SMEs under contexts of complexity, dynamism and munificence may have in investing in the emerging digital technologies like big data and IoT. Specifically, the fact that in dynamic and complex environments firms show higher IT-leveraging competencies, but these conditions have no effect on their development of competencies, may suggest a situation of assimilation gap, as defined by Fichman and Kemerer (1999), namely, a situation in which the resources invested in ICT do not reflect in superior capabilities created through ICT.

5.3 Post hoc analysis

Our results show that for SMEs, developing capabilities from ICT use is also difficult under environmental situations in which it will be expected that the external forces would bring SMEs to develop such capabilities. The data in Table VIII are collected from the Italian Bureau of Statistics on a representative sample of SMEs and show that this situation has persisted in the 2010s. More specifically, these data are consistent with the general picture obtained from our analysis in the second half of 2000s. The presence of dynamism, technological complexity and lack of munificence is now extended to a higher number of sectors compared to the 2000s. Under these circumstances, we have shown that SMEs tend not to develop ICT-based capabilities. In this vein, data in Table VIII show that the diffusion of traditional ICT systems like ERP, CRM, SCM has not experienced an uptake between 2012 and 2016 among the different groups of SMEs in Italy. Also, the diffusion of ICT-based practices related to the new paradigm of connected products like the use of methods of data analytics obtainable from connected machineries or products is still in its infancy among SMEs. As such, the idea emerged by our analysis that even in environments with high information-processing needs SMEs develop limited capabilities from these technologies seem still valid with more updated data.

6. Discussion and conclusions

6.1 Discussion

We have combined a contingency and a research-based approach (Barney, 1991) to analyze how within SMEs size and the industry environment influence the development of organizational capabilities stemming from ICT adoption. This focus bridges a gap on organizational studies in SMEs by shedding light on how they use ICT as a coping

Table VII. Synthesis of the empirical findings and their implications for the emerging ICT paradigm

Environmental forces	Expected effects on ICT-based competencies and capabilities		Obtained effects				Implications for SMEs' readiness to the emerging ICT paradigm (IoT, big data, etc.)
	Earlier literature	Hypotheses	IT-LC	IO	EO	Conclusions	
Dynamism	Increased information processing-needs	Dynamism may lead to higher IO capabilities for larger SMEs (*H4*) and higher competencies for leveraging ICT resources (*H1*)	+		No effect	Dynamism does not lead SMEs to develop higher EO capabilities. Assimilation gap between investing on the competencies for leveraging ICT and the actual impact on capabilities	Difficult using data analytics and big data technologies to process information about demand, price, detect early signals of increased volatility
Munificence	Increased need of ICT to standardize and support managerial control under circumstances of business growth. More resources for ICT investments	Munificence may lead to higher capabilities and IT leveraging competencies	+	−	+ (M)	Medium-sized firms capitalize their investment in IT leveraging competencies through superior EO capabilities.	Readiness to the emerging digital technologies can be higher in munificent environment due to the higher availability of resources available and business opportunities to leverage these technologies
Complexity	Increased information processing-needs. Departmentation can make information integration more difficult → lower capabilities for larger SMEs under higher complexity	Complexity may lead to: (1) Higher capabilities, in smaller firms in particular (due to lower departmentation) (2) Higher IT leveraging competences (more complex planning of IT investments)	+	+ (S)	+ (S)	Complexity does not lead to higher capabilities for medium-sized firms, despite their higher IT leveraging competence. Departmentation and spatially dispersed units are an issue. Assimilation gap between investing on the competencies for leveraging ICT and the actual impact on capabilities	Difficult embodying industrial Internet of Things and big data inside products to make them smarter and connected as these technologies require even more complex and departmentalized organizational structures and product development teams

Notes: + (–): the environmental effect positively (negatively) impacts on the creation of the capability under consideration; + (M): the environmental effect positively impacts on the creation of the capability under consideration in medium-sized firms, more than in small ones; + (S): the environmental effect positively impacts on the creation of the capability under consideration in small-sized firms, more than in the medium-sized ones

Size (employees)		2012 (%)	2013 (%)	2014 (%)	2015 (%)	2016 (%)	Compound annual growth rate 2012-2016 (%)
10-49	ERP	17.45	23.56	33.66	32.23	32.97	13.6
	CRM	15.94	15.19	16.92	17.37	17.51	1.9
	SCM	19.10	–	14.33	11.31	–	–
	Data analytics on smart machineries/products/services	–	–	–	–	2.06	–
50-99	ERP	42.45	49.08	58.41	57.30	56.58	5.9
	CRM	28.10	23.32	27.22	26.26	26.53	−1.1
	SCM	20.74	–	21.19	16.60	–	–
	Data analytics on smart machineries/products/services	–	–	–	–	7.14	–
100-249	ERP	57.88	61.34	69.86	70.38	68.26	3.4
	CRM	28.75	31.06	31.08	27.93	30.45	1.2
	SCM	21.72	–	22.57	23.97	–	–
	Data analytics on smart machineries/products/services	–	–	–	–	10.66	–

Source: Italian Bureau of Statistics (data extracted from dati.istat.it. on March 20, 2017)

Table VIII. Diffusion of ICT resources and related practices among different layers of SMEs in Italy

mechanism to respond to the external environment. The study shows that size and environmental conditions have a limited direct influence on the patterns through which SMEs develop new capabilities through ICT use, but it is rather the combined effect of these factors that shape the development of their capabilities. At a general level, this result is consistent with previous studies that described that firm size is a moderator rather than an antecedent to the innovation process (Harmancioglu *et al.*, 2009). In this vein, our results show that between small firms, on the one hand, and their medium-sized counterparts, on the other hand, there is no a significant divide in their abilities to invest in ICT. This most likely occurs because each of them faces barriers to the use of ICT that are specific to their size and environment. Specifically, within munificent environments larger SMEs tend to develop a higher level of ICT-based capabilities compared to their smaller counterparts, whereas in industries with environmental complexity, this pattern is inverted, with larger SMEs exhibiting a more limited deployment of ICT in support of both their internally and EO processes than smaller firms. Therefore, based on these results for smaller firms the main barrier to ICT adoption can be the existence of cheaper alternatives to internal information processing (Flynn and Flynn, 1999), their limited resources for external information processing, and the limited learning-related scale in ICT adoption projects that is important for learning from occasional failures in ICT projects (Mithas *et al.*, 2012). By contrast, the paper suggests that the main barrier to ICT-based capabilities for larger SMEs is related to the complexity of their organizational structure (i.e. departmentation, spatial disaggregation), which in situations of environmental complexity hinders the use of ICT for an effective integration and use of market information (Ethiraj, 2007).

Our results show that barriers to ICT use are more evident also in dynamic environments. In this type of settings, SMEs tend to attribute a greater importance to ICT, given their higher level of ICT-leveraging competence, but fail to develop ICT-based capabilities. A similar pattern occurs in complex environments, where larger SMEs tend to develop more limited ICT-based capabilities despite their greater level of ICT-based competence. In this vein, our study captures the environmental conditions where difficulties in turning ICT adoption into greater capabilities are more evident. For what regards EO capabilities, our findings are consistent with prior research that show a more limited capability of using and integrating external information when SMEs increase in size and in the complexity of their organizational structure (Liao *et al.*, 2003). More in general, small

firms face more barriers in deploying ICT in their IO processes, since under situations of external turbulence ICT generates organizational inertia, because of the standardization of organizational processes, rather than being an enabler for operational flexibility and strategic agility, as described by part of IS research (e.g. Sambamurthy *et al.*, 2003).

These results – despite being obtained on empirical observations from the second half of the 2000s on the environmental conditions and type of IS supply available to SMEs – offer relevant indications to understand SMEs' capacity to take advantage from the current ICT paradigm. This paradigm is characterized by a broader and more complex range of technologies like IoT and big data having a pervasive field of applications in the internally and EO process of both manufacturing and service industries. In other words, the current wave of innovation in ICT and the changes in business practices enabled by the internet like sharing economy and servitization is increasing the level of complexity, competition and dynamism in the technological and market environment to which firms are exposed. This study has found that under these conditions SMEs had difficulties in developing capabilities from ICT that in the 2000s were already established and mature and on which industry recipes and best practices had already been developed and broadly diffused. The difficulties we documented in this paper were more evident in EO processes, which is the area in which the current wave of digital technologies offer more opportunities of innovation in customer relationships, business model and market logics. Our findings from the "past" can, therefore, offer insights to predict the "future", which may be characterized in many sectors by higher rate of industry exit for SMEs or by their progressive downsizing. In this regard, our study suggests that in increasingly dynamic and complex environments there is more advantage to become smaller, as firms can face lower information processing requirements and have less need for ICT. Obviously, this must be a problem for the competitiveness of nations like Italy characterized by a digital delay and higher prevalence of SMEs compared to other countries.

6.2 Implications and directions for future developments

For managers and ICT vendors, this study stresses the importance of developing ICT solutions and management frameworks that can offer a greater flexibility when SMEs must reconfigure their ICT systems and their organizational processes. Our research indicates that this competence can be particularly important in turbulent and complex environments in which our study found more cases of a limited development of ICT-based capabilities.

More broadly, our evidence on SMEs' limited use of ICT in support of external capabilities suggests that in more complex and dynamic settings this weakness could be more critical for their long-term survival, given the higher importance that these capabilities have in these environments. Also, our evidence on the limited use of ICT in support of their external capabilities may suggest that SMEs may fail to exploit the business potential of ICT diffusion. Indeed, prior research indicates that the adoption of ICT resource for internal orientation brings short-lived returns whereas the support of ICT to external orientation (i.e. in product development, CRM processes) is strategically more important as it may allow SMEs to expand operations into new markets and to reduce dependencies on existing domains (Sambamurthy *et al.*, 2003).

From a policy-making perspective, the paper highlights that small firms in environments that combine limited growth and high turbulence need the most managerial and financial support for a better use of ICT in support of their external relationships because of their weaknesses in developing ICT-based capabilities.

6.3 Limitations

The main limitation of the paper pertains is the fact that SMEs' organizational structures is not directly observed. Future studies should analyze the effect of SMEs' organizational

attributes, such as the degree of departmentation, over the development of ICT-based capabilities. Also, as we have extensively highlighted that our empirical observations date back to the second half of the 2000s. Future studies should assess the generalizability of our results to the current technological context, which is characterized by increased dynamism and complexity and prolonged lack of munificence for SMEs in many industries. In a similar way, future research should assess whether our results are replicable in other nations.

There are also some minor limitations. Data were collected from a single respondent. This approach may present fewer drawbacks for SMEs than for larger enterprises: owners and managers have typically cross-functional accountabilities in SMEs and are thus likely to be knowledgeable about ICT-related issues. Moreover, subjective scales may have some advantages in the consideration of SMEs because the lack of management control systems increases the difficulty of collecting data that pertains to "intermediate" performance indicators that could be used to examine the capabilities of a firm. Furthermore, our approach allows us to address the impact of ICT investments on some business processes that are scarcely quantifiable through quantitative and objective measures (Kohli and Devaraj, 2003).

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Further reading

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About the authors

Paolo Neirotti is currently working as an Associate Professor at the Politecnico di Torino, where he teaches Managerial Economics and Strategic Management. His research interests are in the field of the strategic use of information technology, management of information systems, and strategy and innovation. He is an

Author of several research papers published in international journals including *Industrial and Corporate Change*, *Information & Management*, *New Technology, Work and Employment*, and *Business Process Management Journal*.

Dr Elisabetta Raguseo is Assistant Professor at Politecnico di Torino. She won a Marie Curie research fellowship conducted at the Business School Grenoble Ecole de Management (France) during her post-doc research period. Her research and teaching expertise is in strategic information systems, use of advanced IT to support business activities, business economics and big data. Dr Raguseo is an Author of several research paper published in international journals including *Information & Management*, *International Journal of Technology Management*, *International Journal of Information Management*, *Computers and industrial engineering*, *New Technology, Work and Employment*, and *International Journal of Engineering Business Management*. Dr Elisabetta Raguseo is the corresponding author and can be contacted at: elisabetta.raguseo@polito.it

Emilio Paolucci is a Full Professor at the Politecnico di Torino, where he teaches Organizational Behavior and Management of Information Systems. He has around 60 journal publications that includes information systems, organizational change, knowledge, and technology management.