

# Dynamic capabilities and high-tech entrepreneurial ventures' performance in the aftermath of an environmental jolt

## 1 Introduction

Teece and colleagues (1997, p. 516) define dynamic capabilities (DCs) as “the firm’s ability to integrate, build and reconfigure internal and external competences to address rapidly changing environments”. Thus, DCs reflect the “capacity of an organization to purposefully create, extend or modify its resource base” (Helfat et al. 2007, p. 4).<sup>1</sup>

Over the past decades, numerous contributions have investigated the relationship between DCs and firm performance, concluding that the performance benefits of DCs are not automatic (see Fainshmidt et al. 2016 for a meta-analysis of these studies), but depend on diverse contingencies. In particular, taking direction from Teece et al. (1997), this literature has mainly focused on the effects of environmental contingencies on the DC-performance relation<sup>2</sup>. Some studies have shown that economic (Fainshmidt et al. 2016) and institutional conditions (Dunning and Lundan 2010) influence the performance benefits of DCs; other studies have investigated the effects on the DCs–performance relationship of environmental dynamism<sup>3</sup> (Karna et al. 2016) and competitive turbulence (Danneels 2012; Wilden and Gudergan 2015). In general, prior research on how the environment shapes the DCs-performance relationship has (implicitly) assumed “system stability”, namely a condition where environmental changes are gradual and not disruptive. Instead, scholars have ignored the case of discontinuous

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<sup>1</sup> DCs are based on a complex bundle of skills, processes, routines, organizational structures, and decision rules (Teece 2007). Eisenhardt and Martin (2000, p. 1106) propose a somehow different view, suggesting that, in high-velocity environments, DCs consist in “simple, experiential, unstable processes that rely on quickly created new knowledge and iterative execution to produce adaptive, but unpredictable outcome”. While the two perspectives relies on different assumptions and theoretical underpinnings, we agree with Peteraf and colleagues (2013, p. 1407) in considering them as largely complementary, in spite of their different views on the nature of DCs. We also concur with Peteraf et al. (2013) that “regardless of the level of market dynamism or the nature of dynamic capabilities, dynamic capabilities may enable firms to attain a sustainable competitive advantage in *certain conditional cases*” (see also Di Stefano et al. 2014). In this study, we address this over-arching issue in the specific case of the occurrence of an environmental jolt.

<sup>2</sup> An exception is in Wilden et al. (2013), who study how the effect of the use of DCs on firms’ competitive advantage depends on firms’ internal organization.

<sup>3</sup> Environmental dynamism is “the amount and unpredictability of change in customer tastes, production or service technologies, and the modes of competition in the firm’s principal industries” (Miller and Friesen 1983, p. 233).

environmental changes. This is a relevant literature gap. As the punctuated equilibrium model explains, long periods of system stability are punctuated by short periods of fundamental, discontinuous changes (e.g., Gersick 1991; Tushman and Romanelli 1985); these changes pose profound dilemmas to both managers and entrepreneurs, who are called to react to the disruption of their business environment.

The present paper makes a step in filling this gap by analyzing the relationship between DCs and firm performance in the aftermath of *an environmental jolt*. An environmental jolt is an unanticipated and disruptive change that causes a shock on both demand and supply sides (Chakrabarti 2015), makes firms lose suddenly their environmental fit (Meyer et al. 1990), but also opens new opportunities for value creation which were not there before (Sine and David 2003; Liu et al. 2007). By analyzing the effect of DCs in the aftermath of a discontinuous change, we offer valuable insights to managers and entrepreneurs on how to respond to this change.

We conduct our analysis focusing on high-tech entrepreneurial ventures.<sup>4</sup> Considering these firms adds relevance to our work. Indeed, when a jolt occurs, firms have an incentive to use their DCs to change their resource configuration and achieve a novel fit with the environment (Helfat et al. 2007: 7). Such an incentive is especially strong for high-tech entrepreneurial ventures. Because of their young age and (generally) small size, these firms tend, on one side, to be seriously hurt by jolts (see e.g., Bradley 2015). On the other side, they enjoy a flexibility advantage over their larger and more established counterparts (Ahuja and Lampert, 2001). In particular, high-tech entrepreneurial ventures are not exposed to inertia and matching problems (Schilke 2014), which hamper effective resource reconfiguration. However, using DCs for reacting to a jolt is far from simple for high-tech entrepreneurial ventures. In general, the use of DCs engenders substantial costs (Winter 2003, p. 1247), while the occurrence of a jolt exacerbates the well-known financial constraints of these firms (Carpenter and Petersen 2002; Hall, 2002). Basing on these arguments above, we argue that the (supposedly few)

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<sup>4</sup> High-tech entrepreneurial ventures are young, privately held, typically small, and growth-oriented firms that engage in innovative behaviors (Carland et al. 1984, DeSantola and Gulati 2017), and operate in high-tech industries. Scholars generally consider these industries as the most prominent example of a high-velocity environment.

high-tech entrepreneurial ventures that manage to overcome these obstacles and use their DCs achieve superior performance in the aftermath of the jolt. We also expect these beneficial effects to be especially apparent for relatively *smaller* ventures, which are the most exposed to financial constraints, but enjoy a stronger flexibility advantage in changing their resource configuration as they are less constrained by their extant resources.

We develop our analysis focusing on two DCs, i.e., the *new product development* and *internationalization capabilities*, which prior research has recognized as extremely important for the performance of high-tech entrepreneurial ventures in periods of stability (e.g., Deeds et al. 2000; Sapienza et al. 2006; Knight and Cavusgil 2004; Cavusgil and Knight 2015). Specifically, we define the *new product development capability* (hereafter: new product development DC) as ventures' ability to integrate, build and reconfigure resources and (first order) competences that are needed for the development of new products and services. Likewise, we define the *internationalization capability* (hereafter: internationalization DC) as ventures' ability to integrate, build and reconfigure resources and (first order) competences that are needed for the internationalization of the markets where ventures sell their - existing and new - products and services.<sup>5</sup>

We argue that using these DCs – separately and especially in combination – has positive effects on high-tech entrepreneurial ventures' performance in the aftermath of a jolt, because it allows these firms to renew their configuration of market- and innovation-related resources, thus realigning the resource configuration with the radically changed environmental conditions. In particular, using these DCs, high-tech entrepreneurial ventures may cope with the drops in demand, which environmental jolts typically cause, and capture the new opportunities for value creation generated by jolts. As we discuss in the following, jolt transforms customers' needs: by using the new product development DC, high-tech entrepreneurial ventures can generate innovative products to match these new needs, thus

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<sup>5</sup> In principle, high-tech entrepreneurial ventures may internationalize their operations by making greenfield foreign direct investments and by acquiring firms located in foreign countries. However, the literature on “born global” firms agrees that export to foreign markets is the most important internationalization channel for these firms (see again, e.g., Sapienza et al. 2006; Cavusgil and Knight 2015).

contrasting the drop in demand. Moreover, by using the internationalization DC, high-tech entrepreneurial ventures can contrast the drop in demand in their domestic market and, eventually, in their traditional foreign markets by winning new customers in foreign markets where they were not present before the jolt.<sup>6</sup> Lastly, in line with the idea that flexibility inversely relates to size, we expect the beneficial effects of the new product development and internationalization DCs to be larger for relatively smaller ventures.

We test our hypotheses on a sample of 340 Italian high-tech entrepreneurial ventures facing the consequences of the global crisis that began in 2008. This crisis is an environmental jolt in the form of a severe economic downturn, characterized by a sharp and unexpected decline in demand in all Western countries (OECD 2010). The demand drop coupled with deteriorating conditions in financial markets and led to a severe credit crunch (see, e.g., Ivashina and Scharfstein 2010; Garcia-Appendini and Montoriol-Garriga 2013), which exacerbated high-tech entrepreneurial ventures' difficulties in raising external capital (Cowling et al. 2012; Lee et al. 2015). Because of adverse environmental conditions, these firms experienced steep declines in performance during the 2009-2010 period (Criscuolo et al. 2014; Cowling et al. 2015).

Our work, which belongs to the limited stream that analyzes DCs in the context of entrepreneurial ventures (Zahra et al. 2006), is - to the best of our knowledge - the first study to examine the DCs-performance relationship in the aftermath of a jolt, an unexpected, but rather common, environmental contingency. In addition, our paper extends our knowledge on complementarities among DCs (Song et al. 2005; Gruber et al. 2010; Peteraf et al. 2013).

## **2 Background and hypotheses**

### **2.1 The role of the environment in the DCs-performance relationship**

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<sup>6</sup> Environmental jolts tend to have a limited geographical scope. The terrorist attack of September 11, 2001 primarily affected the U.S. airline industry (Ito and Lee 2005). Similarly, the Asian financial crisis of 1997 had limited demand consequences in Western countries (Claessens et al. 2003). Even when the geographic scope of the jolt is wider, as occurred with the 2008 global crisis, there always are markets that are somehow less affected (in that case, the Chinese and Indian markets, see section 3.1 for more details).

Most of the studies that examine how environmental conditions influence the DCs–performance relationship focus on the environmental dynamism caused by technological changes (Fainshmidt et al., 2016). In line with Teece et al.’s (1997) contention that DCs pay off in situations in which changes in technology are large and frequent, several studies find that DCs lead to superior performance in highly dynamic environments (see Pezeshkan et al. 2016, for a review of the empirical evidence). Instead, in stable environments, using DCs to reconfigure the resource base entails unnecessary costs as firms can achieve superior performance simply by relying on their ordinary capabilities (Drnevich and Kriauciunas, 2011).

Instead, other studies observe that the routinized and highly patterned behavior inherent in the use of DCs is at odds with highly dynamic environments characterized by marked unpredictability and volatility. Along this line of reasoning, Schilke (2014) shows that DCs related to alliance management and new product development are most beneficial at the intermediate levels of environmental dynamism.<sup>7</sup> The author argues that in highly dynamic environments, firms face two problems in using DCs. First, they may suffer from an *inertia problem* as they generally prefer to stay on the beaten path and engage in local adaptation; inertia may prevent the resource reconfiguration that is necessary to maintain environmental fit. Second, a *matching problem* may arise. Even if firms substantially and rapidly alter their resource base, they may select a new resource configuration that poorly fits the new environmental conditions because they mistakenly treat such conditions as similar to those encountered in the past.

Few studies consider other environmental contingencies apart from dynamism. Wilden and Gudergan (2015) focus on competitive turbulence, which indicates the pace of competitive moves (i.e., entry, exit, and change in strategies) by firms in an industry. The authors find that technological and marketing DCs have positive effects on firm performance in environments with high competitive turbulence, whereas such DCs have negative effects in less competitive environments. Danneels (2012)

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<sup>7</sup> Stadler et al. (2013) offer additional evidence of a positive relationship between DCs and firm performance in the moderately dynamic environment of the upstream oil and gas industry.

obtains more nuanced results by examining how competitive turbulence shapes the relationships between marketing and research and development (R&D) DCs and firm performance. He finds that the effect of marketing DCs on firm performance is positive under stable and moderate competitive conditions, whereas the effect of R&D DCs is positive under volatile competitive conditions. Fainshmidt et al. (2016) explore the influence of a country's economic conditions, showing that the performance benefits generated by DCs are stronger in developing economies than in more developed ones. The work of Battisti and Deakins (2017) is close to the topic of this paper; indeed, it documents the positive role of DCs for the performance of small firms in the post-disaster environment caused by a series of earthquakes that occurred in New Zealand in the period from 2010 to 2011.

The DCs-performance relationship in the aftermath of a jolt is an under-researched topic. This is an important gap. Environmental jolts are major and unpredictable discontinuities that happen suddenly and at any time, in both stable and dynamic environments (Bradley, 2015). As we illustrate in the next section, jolts cause a shock on both the demand and supply sides and render firms' resource configurations abruptly obsolete. At the same time, they generate new and unanticipated opportunities for value creation that firms can capture if they manage to reconfigure suitably their resources. However, because of the deterioration of conditions in financial markets, firms encounter serious difficulties in building, adding and reconfiguring resources. Therefore, the question of whether the use of DCs in this context results in better performance is an interesting and unexplored issue.

## 2.2. The economic consequences of environmental jolts

Environmental jolts abruptly change the environment in which firms operate and to which they are adapted (Meyer et al. 1990). Examples of jolts are the burst of the Internet bubble in 2000, which disrupted the dynamic environment of the newly born Internet-service industry (Park and Mezias 2005), and the regulatory shifts in the Californian hospital and savings and loan industries in the early 1980s (Haveman et al. 2001), which at that time were stable environments. Other popular examples of jolts are the Asian economic crisis of the late 1990s (Wan and Yiu 2009) and the terrorist attack of September 11, 2001 (Goll and Rasheed 2011).

Although jolts are heterogeneous, they share some common features. As Chakrabarti (2015) notes, in the aftermath of a jolt, firms experience a sudden and dramatic decrease in demand for their current products. Such a decrease may result from adverse macroeconomic and/or political conditions - such as an economic crisis or a major terrorist attack - or from increased competition - such as a regulatory change that opens the market. Moreover, the author observes that jolts generally limit firms' access to external resources because of the high uncertainty that they generate. Therefore, it comes as no surprise that environmental jolts have highly disruptive effects on firm performance<sup>8</sup> as firms' resource configurations suddenly become unfitted with the abruptly and drastically changed environmental conditions (Meyer 1982).

On the other hand, in spite of the adverse consequences mentioned above, the radical environmental changes triggered by a jolt may open new unanticipated business opportunities that potentially can create substantial value for the firms that are capable to capture them. For example, in accordance with the view that environmental jolts can serve as catalysts for action, Sine and David (2003) show that the energy crises of the seventies created new opportunities for entrepreneurial actions. Similarly, Liu et al. (2007) illustrates how the diffusion of computer viruses in IT networks, by abruptly shifting customers' cognition, allowed a company (Trend Micro) to prosper, by introducing innovative anti-virus services.

The above discussion suggests that firms facing an environmental jolt must react promptly to avoid severe performance penalties and, ultimately, to survive and be successful (Haveman et al. 2001). In short, revolutionary transformations in the environment call for revolutionary responses (Chakrabarti 2015; Meyer et al. 1990).<sup>9</sup> Local adaptation, which may be effective when reacting to (small)

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<sup>8</sup> For example, after the terrorist attack on September 11, 2001, the U.S. airline industry reported a decline in demand of approximately 30% and billions of dollars in financial losses (Ito and Lee 2005). Similarly, the dot.com bubble that popped on March 11, 2000, caused losses of 5 trillion dollars in the market value of Internet companies between March 2000 and October 2002 (Gaither and Chmielowski 2006). As we show below, the 2008 crisis led to a major deterioration in firm performance in advanced countries.

<sup>9</sup> Several studies have found that firms that undertake revolutionary changes are more likely to weather the storm caused by an environmental jolt. See, e.g., Haveman (1992) and Haveman et al. (2001) on the jolts triggered by major regulatory shifts in the early 1980s in the U.S. savings and loan and general hospital industries and Virany et al. (1992) on the jolts generated by breakthrough innovations in the microcomputer industry during the 1970s.

environmental changes in normal times, is indeed useless, if not detrimental, when an environmental jolt occurs (Lengnick-Hall and Beck 2005; Meyer et al. 2005). In this context, appropriate use of DCs may allow firms to rapidly change their resource configurations, regain environmental fit, and achieve superior performance. In the next section, we discuss the DCs-performance relationship in the aftermath of an environmental jolt in the case of high-tech entrepreneurial ventures.

### 2.3. The use of DCs and high-tech entrepreneurial ventures' performance in the aftermath of an environmental jolt

Although an environmental jolt is a challenge to any firm, such a challenge is particularly severe for high-tech entrepreneurial ventures. Being typically small, these ventures have limited slack resources for shielding against adverse environmental conditions; likewise, being new to the market, they lack established relations with customers, suppliers, and other resource providers. In other words, high tech entrepreneurial ventures suffer from the liabilities of newness (Stinchcombe 1965) and smallness (Bruderl and Schussler, 1990). Hence, the occurrence of a jolt severely threatens high tech-entrepreneurial ventures' survival, even more so as the weakness of these ventures in face of a jolt induces their pre-jolt partners — that provide them key resources (e.g., financial capital, distribution channels, testing facilities) —to abandon them and turn to more solid firms (Venkataraman and Van de Ven 1998).

On the other hand, the occurrence of an environmental jolt also offers high-tech entrepreneurial ventures new opportunities for value creation. We mentioned earlier that a jolt modifies the cognition of customers and generates new latent needs. Contrary to their larger and more established counterparts, high-tech entrepreneurial ventures do not suffer from the organizational pathologies (i.e. the familiarity, maturity and propinquity traps, see Ahuja and Lampert, 2001) that negatively influence the ability of these latter firms to design and implement the radical changes required to meet these changing customers' needs. Because of their flexibility, high-tech entrepreneurial ventures are in a better position to identify and exploit these new business opportunities.

In sum, high-tech entrepreneurial ventures have strong incentives to react to the occurrence of a jolt by using their DCs to achieve a novel resource configuration. They are also likely able to use their DCs more wisely than their established counterparts. Specifically, in using their DCs to react to a jolt, high-tech entrepreneurial ventures do not encounter the same severe inertia and matching problems that adversely influence the use of DCs of large established companies. First, contrary to these latter firms, high-tech entrepreneurial ventures usually do not make (or have not yet made) large specific investments in physical assets (e.g., Battisti and Deakins 2017) and do not have formalized internal structures (Sine et al. 2006), which renders them more flexible. Second, due to their young age and limited experience, high-tech entrepreneurial ventures do not run the risk of perceiving dissimilar situations as similar or mistakenly generalizing their experiences in past events. Hence, when using DCs to reconfigure their resources in the aftermath of a jolt, high-tech entrepreneurial ventures are more likely than established firms to select a novel resource configuration that matches the drastically changed environmental conditions, although this configuration is far from the pre-jolt one.

In this study, we focus attention on two DCs that, according to previous studies, are crucial for high-tech entrepreneurial ventures' performance: the new product development and internationalization DCs. The new product development DC (e.g., Deeds et al. 2000; Branzei and Vertinsky, 2006; Danneels 2008; Schilke 2014) consists in ventures' ability to add new resources and reconfigure their existing resources in the innovation domain (e.g., scientists and engineers, laboratory equipment), and to obtain access to the technological resources possessed by third parties (e.g., through technological alliances). This DC reflects ventures' desire of improving their capability of innovating their portfolio of products and services. The internationalization DC (e.g., Sapienza et al. 2006; Weerawardena et al. 2007; Prange and Verdier 2011; Khan and Lew 2018) consists in ventures' ability to add new resources and reconfigure their existing resources in the commercial area (e.g., brand, sales force, distribution channels), and obtain access to the commercial resources possessed by third parties (e.g., through commercial alliances). The internationalization DC reflects ventures' desire of improving their capability of exporting in new foreign markets where they were not present before, and expanding their sales in the foreign markets where they currently operate. We argue that, in the aftermath of a jolt, high-

tech entrepreneurial ventures can use their new product development and internationalization DCs to change their resource configuration, restore their environmental fit and obtain better performance.

As discussed in the previous section, one typical consequence of an environmental jolt is a large, sudden and unpredictable drop in demand (Chakrabarti 2015). One may expect that firms cope with this demand drop by streamlining their operations, laying off workers and eventually cutting costs by introducing process innovations. However, high-tech entrepreneurial ventures are unlikely to rely primarily on these actions. In comparison to their larger counterparts, these firms have less room for cutting costs, because of the small size of their operation and the key importance of the human capital embedded into highly skilled workers for value creation in high-tech industries. Moreover, high-tech entrepreneurial ventures typically rely more on product (and service) innovation than on process innovation as a key source of competitive advantage. Along this line of reasoning, previous studies (e.g., Cohen and Klepper 1996) document that the share of R&D expenses firms devote to process innovation (as opposed to product innovation) decreases with firm size, and is especially low in high-tech industries. Therefore, we expect that high-tech entrepreneurial ventures respond to the demand drop caused by the jolt by mainly relying on the development of new products and services. The reshaping of their product and service portfolio aims at both matching the transformed needs of their existing customers better than their current offering and winning new customers by providing a solution to the new (and so far unmatched) needs generated by the jolt. To this end, high-tech entrepreneurial ventures need to reconfigure their innovation-related resources, by boosting investments in product R&D, recruiting talented scientists and engineers and assigning technical personnel to new tasks.<sup>10</sup>

Another way through which high-tech entrepreneurial ventures can cope with the drop in demand caused by the jolt consists in the widening of the international scope of their sales by exporting into foreign markets that are less affected or are not affected at all by the jolt (see again footnote 6).

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<sup>10</sup> While investigating empirically the link between high-tech entrepreneurial ventures' use of the new product development and internationalization DCs and their performance during the 2008 global crisis, we will control for the cost cutting strategies eventually adopted by these firms for limiting the risk that the correlation we eventually detect is spurious. We thank one of the two anonymous reviewer for this suggestion.

Firms can pursue internationalization through different channels (e.g., export, greenfield foreign direct investments, foreign acquisitions, international alliances of technological or commercial nature), and with different objectives (e.g., expanding sales, getting access to unique natural or knowledge resources, cutting costs for instance through delocalization of labor-intensive productions activities). However, young and resource-constrained firms like high-tech entrepreneurial ventures, mainly rely on export to foreign markets, eventually combined with commercial alliances with foreign partners, with the aim of expanding the market for their products and services (Jones 1999; Sapienza et al. 2006; Cavusgil and Knight 2015). We thus expect that, to face the drop in demand in their domestic market (and, eventually, in their traditional foreign markets), high-tech entrepreneurial ventures rely on expanding exports. This move implies a reconfiguration of their market-related resources. Entrepreneurial ventures usually operate only in their domestic market or in few and proximate markets (Patel et al. 2018). By pursuing such a narrow international scope, these firms leverage their limited resources across closely related economic, institutional, and cultural contexts (Qian et al. 2013)<sup>11</sup>, but risk missing opportunities in distant (and thus loosely related) geographical markets (see again Patel et al. 2018). This cautious approach to internationalization is particularly worrisome when a jolt suddenly creates adverse demand conditions in the closely related markets in which high-tech entrepreneurial ventures operate. To succeed in foreign markets that are distant from the traditional ones, these ventures must use their internationalization DC to establish novel distribution channels, recruit new salespersons, and design suitable advertising, promotion, and pricing strategies.

Moreover, as the literature on transnational new product development capabilities emphasizes (e.g., Subramaniam and Venkatraman, 2001), high-tech entrepreneurial ventures that use their internationalization DC to expand their sales in new foreign markets, often must simultaneously and substantially innovate their product and service offering to adapt it to the needs of their new international customers. Indeed, customers' needs are in part uniform across markets, but also have

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<sup>11</sup> This also holds true in the case of the so-called born-global firms—i.e., ventures that initiate international business soon after their inception (Cavusgil and Knight 2015).

features that are idiosyncratic to individual local markets; thus, the needs of new international customers likely differ from those of ventures' current - domestic and international - customers. In line with this view, scholars studying entrepreneurial ventures' internationalization find that these firms capture the best growth opportunities in foreign markets if they leverage their ability to innovate (e.g., Filatotchev and Piesse 2009). In addition, exporting in foreign markets is naturally attractive for high-tech entrepreneurial ventures that reconfigure their innovation-related resources to introduce new products and services. Going international can enlarge the demand of these new products and services, if they are adapted to international customers' needs. In turn, to export into new foreign markets, high-tech entrepreneurial ventures need to be able to reconfigure their market-related resources. In sum, we expect that in the aftermath of a jolt, the performance benefits that high-tech entrepreneurial ventures gain from using their internationalization and new product development DCs are stronger when these firms use the two DCs *in combination*.

Although high-tech entrepreneurial ventures can improve their performance in the aftermath of a jolt by using – separately and especially in combination – their new product development and internationalization capabilities to reconfigure their innovation- and market-related resources, most ventures likely lack the financial and human resources to make the required changes in their resource configurations. Because of their young age, such firms have a limited track-record. Moreover, most of their assets are intangible and, thus, their value is difficult to assess. Lastly, high-tech entrepreneurial ventures oftentimes prefer not to disclose information on their innovative products and services to limit the risk of misappropriation. Hence, even in normal times, information asymmetries impede entrepreneurial ventures to attract external finance (Carpenter and Petersen 2002; Hall 2002) so that these firms finance their investments mainly through internal cash flows (Himmelberg and Petersen 1994). Similarly, high-tech entrepreneurial ventures can hardly attract skilled personnel (e.g., talented scientists and engineers, skilled salespersons, and seasoned managers). Candidate employees are indeed not inclined to accept the job offerings of high-tech entrepreneurial ventures because they have difficulties in judging whether such firms are reliable employers and offer good career prospects (Colombo et al. 2014; Vanacker and Forbes 2016). The occurrence of a jolt magnifies the

aforementioned difficulties: both external investors and candidate employees are concerned not only about high-tech entrepreneurial ventures' quality and business opportunities, but also about their ability to weather the storm. Furthermore, the decline in economic performance that generally accompanies a jolt makes it more difficult for high-tech entrepreneurial ventures to use internal cash flows to finance their investments in physical and human capital.

Based on the above discussion, we expect that in the aftermath of an environmental jolt, the few high-tech entrepreneurial ventures that use their new product development and internationalization DCs to change their resource reconfiguration achieve superior performance. This especially applies to ventures that use these two DCs in combination. Hypotheses H1, H2, and H3 follow.

*H1. In the aftermath of an environmental jolt, high-tech entrepreneurial ventures that use more of their new product development DC achieve superior performance.*

*H2. In the aftermath of an environmental jolt, high-tech entrepreneurial ventures that use more of their internationalization DC achieve superior performance.*

*H3. In the aftermath of an environmental jolt, high-tech entrepreneurial ventures that use their new product development and internationalization DCs in combination achieve superior performance.*

Finally, we argue that the strength of the positive association between the use of DCs by high-tech entrepreneurial ventures that face an environmental jolt and their performance depends on the ventures' size. Our idea is that the arguments supporting a positive DCs-performance relationship in this context especially apply to relatively *smaller* high-tech entrepreneurial ventures.

Clearly, smaller resource-poor high-tech entrepreneurial ventures find it more difficult than larger ones to use their new product development and internationalization DCs in the aftermath of a jolt. Even in normal times, smaller high-tech entrepreneurial ventures have particularly poor internal cash flow to finance their investments in physical and human capital; likewise, the aforementioned problems in attracting external finance and talented employees are particularly severe for these ventures. It is well-known that financial constraints increase as size decreases (Bertoni et al. 2010); micro

ventures are often unable to provide audited financial statements to external investors (Binks and Ennew 1996) and have very few assets to use as collaterals (Binks et al. 1992). Furthermore, candidate employees likely judge smaller high-tech entrepreneurial ventures more negatively than larger ones. Size is an inverse predictor of business failure (Watson and Everett 1996) and of the adoption of formalized human resource practices (Kroon et al. 2013). These aspects worsen the perception of uncertainty in career prospects and make smaller high-tech entrepreneurial ventures particularly unattractive as employers.

Nevertheless, we claim that the few smaller ventures that, despite the aforementioned difficulties, manage to use the two DCs under investigation here achieve greater performance improvements than their larger counterparts. A long scholarly tradition concurs that firms' flexibility inversely relates to their size (Penrose, 1955). Smaller high-tech ventures enjoy a flexibility advantage in comparison to larger and more established ventures, and use more wisely their new product development and internationalization DCs. Larger ventures possess more resources for engaging in innovation and entering into (new) markets; therefore, their first reaction to the occurrence of a jolt likely consists in reconfiguring their extant resources. For example, they may assign their employees to new innovation-related tasks or leverage their existing sales force and commercial partnerships to enter new foreign markets. However, it is questionable whether these extant resources are fungible enough to be used effectively in the very different environment forged by the jolt (see Li 2016 for a recent discussion on the role of resource fungibility for environmental adaptation). Conversely, smaller ventures, which possess very limited extant resources, have no choice but reacting to the jolt by adding new resources. As we mentioned above, these ventures find it difficult to add new resources. However, if they manage to do so, they likely choose the resources that best fit the novel environmental contingencies. For example, they hire new scientists and engineers whose skills are in line with their novel product development needs or open new suitable distribution channels in foreign markets that are less affected by the jolt.

Based on the arguments above, we formulate hypotheses H4 and H5.

*H4. The positive relationship between the use of new product development DC and ventures' performance is weaker for larger high-tech entrepreneurial ventures.*

*H5. The positive relationship between the use of internationalization DC and ventures' performance is weaker for larger high-tech entrepreneurial ventures.*

### **3 Sample and method**

3.1 The 2008 global crisis: an environmental jolt that deeply affected high-tech entrepreneurial ventures

The global crisis that began in the second half of 2008 is an ideal testing ground for studying the DCs–performance relationship in the aftermath of an environmental jolt. This crisis was a major and unexpected economic downturn of a severity not seen since the Great Depression of the 1930s. The origin of the crisis was the crash of the U.S. subprime mortgage market at the end of 2007 and the ensuing collapse of several major financial institutions in the fall of 2008 (most notably Lehman Brothers). The impact of these events on the real economy and the speed of international contagion from the U.S. to other advanced countries were largely unanticipated. In mid-2008, the Organization for Economic Cooperation and Development (OECD) was predicting simple slowdowns in gross domestic product (GDP) growth, which were expected to remain positive in most advanced countries (+1.1% in the U.S., +1.5% in Japan, +1.4% in the Euro area, and +0.9% in Italy; see OECD 2009). However, in 2009, GDP growth remained dramatically below these predictions in all advanced countries, plunging by -2.8 percent in the U.S. and by -5.5 percent in Japan and Italy (source: World Bank). Interestingly, despite the global nature of the crisis, its impact was much weaker in developing countries, and some countries remained almost unaffected. In 2009, real GDP growth was +9.2 percent in China and +8.5 percent in India (source: World Bank). These values are very close to or even higher than they were before the crisis.

Previous studies suggest that the global crisis severely hurt (high-tech) entrepreneurial ventures. Bartz and Winkler (2016) examine the growth performance of more than 10,000 small and medium-size enterprises (SMEs) in Germany. Their evidence indicates that the crisis was especially detrimental to young ventures. Similarly, Peric and Vitezic (2016) show that declines in firm sales during the global

crisis were more pronounced among smaller firms in Croatia. Using data from a sample of SMEs in the UK, Cowling et al. (2015) find that 40 percent of sample SMEs experienced a decline in employment during the crisis, and 50 percent experienced a decline in sales. Criscuolo et al. (2014) show that young SMEs experienced much sharper declines in net employment growth during the crisis than their older counterparts, although they were better able to generate new jobs during the pre-crisis period. Colombo et al. (2016) examine a sample of 140 Italian high-tech entrepreneurial ventures and find that the crisis interrupted the positive trend in sales between 2007 and 2008 (+7.8%). Between 2008 and 2009, sales decreased by an average of 5.4 percent, and 86 firms (i.e., 61.4% of the sample) registered sales reductions during this period.

In addition to a sharp decline in demand, the 2008 crisis brought about a deterioration of financial market conditions, leading to a severe credit crunch (Garcia-Appendini and Montoriol-Garriga 2013, p. 272; Ivashina and Scharfstein 2010). This lack of financing forced many firms to cut ongoing innovation projects (Archibugi et al. 2013, Paunov 2012), to reduce capital expenditures and marketing investments and to abstain from new hires (Campello et al. 2010). Again, high-tech entrepreneurial ventures were severely affected (Hud and Hussinger 2015; Paunov 2012). The credit crunch exacerbated the financial constraints that limit these firms' investment activities (Cowling et al. 2012; Lee et al. 2015). Because of banks' increased risk aversion and the higher credit risk of high-tech entrepreneurial ventures, these firms found obtaining adequate loans from banks even more difficult than in the precrisis period (EIB 2013). Similar reasoning applies to external equity financing because of the dearth of venture capital investment, especially in Europe. In this area, venture capital investment declined by 26.4 percent in 2009 (EVCA 2013). Finally, high-tech entrepreneurial ventures' deteriorating economic performance made relying on internal cash flows to finance investments very difficult.

### 3.2 Sample

We test our conjectures using a sample of 340 Italian high-tech entrepreneurial ventures extracted from the Research on Entrepreneurship in Advanced Technologies (RITA) directory. This directory is the

most reliable data source available on Italian firms that meet the following criteria: (i) being owner-managed when founded and remaining independent (i.e., not controlled by another firm); (ii) operating in high-tech manufacturing and service industries<sup>12</sup>, and (iii) being less than 25 years old.

To study the DCs–performance relationship of high-tech entrepreneurial ventures in the aftermath of the 2008 crisis, we collected information on the use of DCs through a survey administered to a subsample of the RITA entrepreneurial ventures between January and April 2012. Specifically, we focused on the 1,379 RITA firms that i) were founded not earlier than 1993 and not later than 2007 (i.e., at the beginning of 2008, immediately before the beginning of the crisis, they were 15 years old or less, and, when the crisis started, they had been in operations for at least 1 year), and ii) were still in operations as independent firms as of January 1, 2012.<sup>13</sup> Concerning this latter point, as we explain in the following, in our estimates we control for firm exit due to either acquisition or cease of operations (e.g., because of bankruptcy). For 938 RITA entrepreneurial ventures, we have longitudinal accounting data (source: AIDA database managed by Bureau van Dijk) including sales between 2007 and 2010. We administered the survey to these 938 firms. The survey questionnaire asked for information on the respondent firms’ internationalization and product/service innovation activities, which we used to develop measures of internationalization and new product development capabilities (see below). We sent the questionnaire to the personal email address of each Chief Executive Officer (or equivalent position) who had acted as the contact point with the team that developed the RITA directory. Research assistants cross-checked the responses and compared them with information obtained from the firms’ websites and other public sources. In the end, we collected 340 completed questionnaires (response rate: 36%).<sup>14</sup>

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<sup>12</sup> The RITA database covers the following industries: ICT manufacturing – computers; electronic components; telecommunication equipment; and optical, medical and electronic instruments – biotechnology, pharmaceuticals and advanced materials; aerospace, robotics and process automation equipment; software; Internet and telecommunication services; and R&D, engineering and other high-tech services.

<sup>13</sup> There is no agreement in the literature as to the age threshold beyond which a firm ceases to be considered an “entrepreneurial venture”. The thresholds used by the previous studies vary between 5 and 25 years. Here, we use a 15-year threshold. As a robustness check, we have repeated our estimates with a 10-year threshold. The results are reported in the section on robustness checks.

<sup>14</sup> As we conducted the survey four years after the environmental jolt under scrutiny, one may raise doubts about the reliability of our data. In particular, if the managers of sample ventures had changed in the 2008-2012 time

[Table 1 around here]

Table 1 presents the distributions across industries, geographical areas, age classes, and size (measured by employees and sales in 2007, the year before the beginning of the crisis) of the 340 sample firms. Most of the firms operate in software (25.3%) and ICT manufacturing (23.5%) and are located in the highly developed regions of Northwestern Italy (42.6%). The size distribution is highly skewed, with most firms having less than 10 employees (78.8%) and €2 million or less in sales (92.9%). Most firms are less than 10 years old (77.1%). No differences exist between the distribution of sample firms by industry, geographical location, sales and age and the corresponding distribution of the 938 contacted firms, as shown by the values of  $\chi^2$  tests ( $\chi^2(5)=11.2$ ,  $\chi^2(3)=3.4$ ,  $\chi^2(2)=1.2$ , and  $\chi^2(2)=6.3$ , respectively). There are also no notable differences between the distribution of the 212 early respondents that answered the survey in January or February 2012 and the 128 late respondents that answered in March or April ( $\chi^2(5)=3.0$ ,  $\chi^2(3)=2.7$ ,  $\chi^2(2)=0.2$ , and  $\chi^2(2)=0.7$ ). These findings indicate that nonresponse bias is not a serious concern in our study.

We acknowledge that, as is generally the case with survey data, the sample suffers from survivorship bias. Our study does not include firms that failed or were acquired by other companies between 2009 and 2011. The likelihood of failure is higher for ventures that perform poorly, while there is likely a positive relationship between firm performance and the fact of being targeted for acquisition. If using the two DCs under scrutiny had a positive effect on firm performance, the sample selection resulting from the exclusion of firms that failed or were acquired would lead to a downward bias in the estimate of this effect. However, as we have data on the 66 entrepreneurial ventures that were included in the RITA directory at the outset of the crisis, and they did not survive as independent firms until

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frame, the data we collected could be unreliable. Thus, we checked whether the respondents were already top managers of the sample firms at the beginning of 2008. To do so, we combined the individual information already stored in the RITA database with information retrieved through an online search, mainly conducted on the LinkedIn personal pages of the respondent managers. We could retrieve information about the respondent occupation in 2008 for 254 respondents (out of 340, i.e. 75% of the sample). 247 of these respondents (i.e., 97%) were already in the ventures' managerial ranks in 2008 and the remaining 7 respondents entered their firms in 2009. As the vast majority of the respondents were already venture managers when the global crisis started, we are confident that they provided reliable information about their ventures' reactions to the crisis.

January 1, 2012, we corrected for survivorship bias using Heckman sample selection correction (see below).<sup>15</sup>

### 3.3 Measures of internationalization and new product development capabilities

Generally, accepted measures of DCs are still lacking (Grant and Verona 2015; Laaksonen and Peltoniemi 2018). To measure the use of the internationalization and new product development DCs that high-tech entrepreneurial ventures employed in response to the 2008 crisis, we drew on work by Danneels (2008; 2012; 2016). The author focuses on marketing and R&D capabilities and measures second-order capabilities, a subset of DCs, which reflect a firm's ability to add new resources to its current resource base (Danneels 2012; 2016). He captures firms' marketing capability using eight items that assess the ability to identify and access new markets and R&D capability using six items that assess the ability to identify and incorporate new technologies. To consider the peculiarities of the context of our study, we departed from Danneels' approach with regard to the following aspects.

First, while Danneels considers only the addition of new resources, we also consider the firms' reconfiguration (i.e., extension and modification) of existing resources. In doing so, we more closely adhere to the definition of dynamic capabilities proposed by Teece (2007) and Helfat (2007). Second, while Danneels measures the *possession* of DCs, which does not automatically imply their use (Helfat and Peteraf 2009), we measure the *use* of DCs in response to the 2008 crisis. Indeed, we claim that it is the use of DCs, and not merely their possession, which allows new ventures to effectively cope with the crisis. Third, while Danneels resorts to self-reported *relative* measures, asking respondents to assess their firms' capabilities compared with those of their competitors (see, e.g., Schilke 2014, for a similar approach), we resort to *absolute* measures of the use of DCs. We use such measures because, as Grant and Verona (2015) observe, managers tend to have limited knowledge of competitors' abilities that are

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<sup>15</sup> Success bias might also affect survey data. Better-performing firms might be overrepresented in our sample because they might be more willing to provide information about themselves than their poorly performing counterparts. However, our sample includes several firms that were badly hurt by the crisis and experienced major declines in sales and/or employment. Hence, we are confident that our results are not severely affected by success bias.

not readily observable or subject to regular benchmarking. The difficulty of making comparisons with competitors is even more severe in our context. The 2008 crisis created an unstable scenario in which the boundaries of competitive landscapes were blurred. Thus, the firms had difficulties even in identifying competitors and could hardly judge what they were doing. Fourth, while Danneels refers to large firms (the average number of employees in his sample is 4,305), we focus on high-tech entrepreneurial ventures and thus had to adapt the items in our context. As we mentioned earlier, high-tech entrepreneurial ventures' R&D is mainly oriented to the development of new products and services. Therefore, we converted Danneel's six items assessing the ability to identify and incorporate new technologies (R&D capability) into four items to assess the extent to which high-tech entrepreneurial ventures modify their resource base to develop new products and services. Similarly, we changed Danneel's eight items assessing the ability to identify and access new markets (marketing capability) into five items capturing the modification of high-tech entrepreneurial ventures' resource base to export to new international markets.<sup>16</sup> Moreover, besides considering the addition of new resources, as Danneels does, we also consider the reconfiguration of existing ones. To this end, two of our items (one for each DC under scrutiny) accounted for changes in the roles and tasks of employees involved in either the commercialization of the firm's products and services in international markets or the development of new products and services.

The new questions and all the items, measured on five-point Likert scales, were included in a trial questionnaire and were pretested with three academic experts and three practitioners. Subsequently,

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<sup>16</sup> For instance, for the new product development capability, we replaced the item "*setting up of new types of manufacturing facilities and operations*" with the item "*developing new technological competences/resources*". For the internationalization capability, we replaced the item "*developing new advertising or promotion strategies*" with the item "*developing stronger brand reputation and/or better firm image in international markets*" (see Table A1 in the Appendix for the list of the items in our scale). It is worth to acknowledge here that to build the measure of internationalization DC we did not collect information about the foreign markets that respondent ventures considered when they reconfigured their internationalization-related resources. Hence, we do not know whether respondent ventures developed new resources/competences to operate in markets strongly affected by the crisis or in markets relatively less affected by the crisis (e.g., Asian markets). However, we think this is not a weakness of our measure. Indeed, several entrepreneurial ventures in high-tech industries sell products (and software) that are components of larger technological systems. In response to the drop in demand in their traditional markets, they may have reconfigured their resources so as to increase their sales to (large) Western firms, that manage to sell their products to Asian customers.

they were included in the survey questionnaire. Using the data collected through the survey, we developed two variables measuring entrepreneurial ventures' internationalization and new product development DCs through two separate principal components factor analyses (PCAs) on the items shown in Table A1 of the Appendix. The first PCA reduced the five items used to capture the respondents' internationalization capability to a single factor, *InternationalizationDC*. Similarly, the second PCA reduced the four items that captured the respondents' new product development capability to a single factor, *ProductInnovationDC*. Table A1 shows that both factors have eigenvalues well above the recommended 1.0 cutoff point (Pedhazur 1997), and all the items exhibit high loadings (>0.6) on their respective factors. The reliability of the resulting scales is good, as reflected in the high values of Cronbach's alpha (0.913 and 0.795 for *InternationalizationDC* and *ProductInnovationDC*, respectively).

To further assess the validity of the DC scales, we followed the procedure proposed by Danneels (2016). First, we tested the *convergent* and *discriminant validity* of our scales, i.e., we assessed whether the various items considered in the scales were closely associated with the DC to which we assigned them and not associated with the other DC. Second, we assessed the *nomological* validity of our DC measures, i.e., the degree to which our constructs relate to other theoretically connected constructs in a way that is consistent with a priori expectations. We report on how we conducted these tests in the Appendix (see also Table A2).

3.4 The use of DCs and the performance of high-tech entrepreneurial ventures after the 2008 crisis: descriptive evidence

[Table 2 around here]

Table 2 presents descriptive statistics on the use that the 340 sample ventures made of their internationalization and new product development DCs in response to the crisis. To ease the interpretation of the results, in the table, we report the mean of the item scores relating to the two standardized factors that measure the DCs under consideration. The mean value of the new product development DC is significantly higher than the mean value of the internationalization DC (t-

test=12.30, significant at 1%), reflecting the reliance of high-tech entrepreneurial ventures on product (and/or service) innovation and their reluctance to go abroad. The table also shows differences in the use of the two DCs across industries, geographic locations, and ventures' size and age classes. Specifically, we found statistically significant differences across industries and size classes. Manufacturing ventures were far more active than service ones in using the internationalization DC in response to the crisis. The same holds true for larger ventures (in both sales and employees) compared to smaller ones. Ventures with more employees also used the new product development DC more intensively than smaller ventures.

## **4 Econometric analysis and results**

### 4.1 Specification of the econometric models

The dependent variable in our econometric models is the relative sales growth during the 2008-2010 period, measured by the difference in sales between 2010 and 2008 divided by sales (plus 1) in 2008<sup>17</sup>.

The main explanatory variables are our measures of the new product development and internationalization DCs. The model specification also includes the following controls: the relative sales growth of the focal venture during the pre-crisis 2007-2008 period (*SalesGrowth<sub>0708</sub>*); the venture size at the end of 2008 as captured by the logarithm of sales (plus 1) winsorized at 2 percent (*LnSales<sub>08</sub>*); venture age in 2008 (*Age<sub>08</sub>*); and five industry dummies (*DICTManufacturing*, *DBioPharma*, *DOtherManufacturing*, *DInternet* and *DSoftware*, with other high-tech services being the reference category). We estimated the model using ordinary least squares (OLS).

As mentioned in section 3.2, the use of survey data implies potential survivorship bias that may influence the relationships that we investigate here. Some unobserved factors may be correlated with both firms' exit because of failure or acquisition between the beginning of the crisis and the launch of our survey (i.e., January 2012) and firms' sales growth during the 2008-2010 period. One correction for

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<sup>17</sup> The relative sales growth was winsorized at 2% to limit the impact of outliers. The results without winsorization are similar to those shown here and are available from the authors upon request.

possible survivorship bias that is widely used in the literature on firm growth is the inverse Mills ratio approach (Heckman, 1979). Among the 1,379 RITA entrepreneurial ventures that were active and independent at the outset of the crisis, 53 ventures failed and 13 were acquired between 2009 and 2011. Hence, we estimated a bivariate Probit model of venture exit during the 2009-2011 period because of either failure or acquisition. We used the following independent variables: venture age and sales in 2008 (*Age<sub>08</sub>* and *LnSales<sub>08</sub>*, respectively), a dummy equal to one for manufacturing ventures and zero for service ones (*DManufacturing*), two geographic area dummy variables (*DNorth* and *DSouth*) and the average firm failure rate in the 2009-2011 period in the province where the focal firm was located (*FirmFailureRate*, source: Eurostat). Table A3 of the Appendix shows the results of the estimates. Based on the estimates, we used the standard formula (Wooldridge 2002, p. 522) to compute two inverse Mills ratio factors for the 340 entrepreneurial ventures included in our sample relating to the probability of ceasing operations during the 2009-2011 period (*InverseMillsRatioFailure*) and the probability of being acquired in the same period (*InverseMillsRatioAcquisition*). We included them as additional controls in the model specification.

## 4.2 Results

Tables 3 and 4 report the descriptive statistics and correlation matrix of the explanatory and control variables. An inspection of the variance inflation factors (VIFs) indicates the absence of severe multicollinearity problems in our model. The mean VIF is 2.76, with a maximum VIF of 6.40. These values are, respectively, below 5 and 10, the thresholds most commonly used to identify multicollinearity issues (O'Brien, 2007)<sup>18</sup>.

[Tables 3 and 4 about here]

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<sup>18</sup> Originally, our models included also controls for the geographical area where the focal firm was located. Specifically, we included three dummies for geographic areas (*DNorthwest*, *DNortheast* and *DSouth*, with being located in the center of Italy acting as the reference category) and, as an alternative, the GDP per capita in the firm region (source: Eurostat). In both cases, the additional controls were highly correlated with the inverse Mills ratio factors; thus, the models did not pass the VIF test on multicollinearity. Hence, we deleted the geographic controls. As a check for robustness, we also estimated the models including the geographic controls and deleted the two inverse Mills ratio factors. The results (available from the authors upon request) are in line with those reported below.

Tables 5 and 6 report the results of the estimates of the econometric models. The models in Table 5 test the effect of the use of the internationalization and new product development DCs on high-tech entrepreneurial ventures' relative sales growth in the aftermath of the 2008 crisis, while the models in Table 6 show how ventures' size at the outset of the crisis (measured by sales) moderates these effects.

[Table 5 about here]

Let us first focus on Table 5. Model 1 includes only the controls. *SalesGrowth<sub>0708</sub>* has a negative coefficient, indicating a negative association with the post-crisis growth rate. However, the coefficient is only slightly significant in this model and not significant in the remaining models in the Table. Conversely, *InverseMillsRatioAcquisition* has a positive coefficient, significant at the 1%. This latter result indicates that, as expected, in our sample, unobserved factors that render a high-tech entrepreneurial venture a more attractive acquisition target are positively associated to the venture's relative sales growth during the 2008-2010 period. In models 2 and 3, also *LnSales<sub>08</sub>* exhibits a significant negative coefficient, indicating that, during the 2008-2010 period, smaller ventures exhibited higher relative sales growth than their larger counterparts.

In Model 2, we insert the two explanatory variables. Hypotheses H1 and H2 predict that the more high-tech entrepreneurial ventures use the two DCs under consideration the better their growth performance will be. Our results support these predictions: the coefficients of both *InternationalizationDC* and *ProductInnovationDC* are positive and significant at 5%. The economic magnitudes of these performance effects are also sizable. A one-standard deviation increase in *InternationalizationDC* and *ProductInnovationDC* is respectively associated with an increase of the sales growth rate between 2008 and 2010 equal to 11 and 7.3 percentage points, respectively.

In Model 3, we insert the interactive term between the two explanatory variables to check the performance impact of using the two DCs in combination. Contrary to Hypothesis H3, the coefficient of the interactive term *InternationalizationDC*×*ProductInnovationDC* is positive but not significant at conventional confidence levels, thus suggesting that using the two DCs in combination does not lead to greater sales growth than using them in isolation.

[Table 6 about here]

To test H4 and H5, in the models of Table 6, we insert the interaction terms between the two DC measures and venture size at the end of 2008, measured by *LnSales08*. In Models 1 and 2, we insert only one interaction term per model, then, in Model 3, we insert the two interaction terms together. The estimates of Models 4 and 6 indicate that venture size negatively moderates the effect of *InternationalizationDC* on ventures' growth performance. In both models, *InternationalizationDC* has a positive coefficient, while its interaction term with *LnSales08* has a negative one, and both coefficients are significant at conventional confidence levels. Moreover, the F-tests reported at the bottom of the table indicate that the null hypothesis that the coefficients of *InternationalizationDC* and *InternationalizationDC*×*LnSales08* are jointly null cannot be rejected at conventional confidence levels. The negative moderating effect of venture size on the positive relationship between the use of the internationalization DC and relative sales growth is also of great economic magnitude. Based on the estimates of Model 4, when *LnSales08* is set at one standard deviation below the mean value, a one standard deviation increase in *InternationalizationDC* results in a 20.6 percentage points increase of the sales growth rate. The increase is only equal to 2.9 percentage points when *LnSales08* is set at one standard deviation above the mean value. We thus conclude that, in line with Hypothesis H5, the positive association between sales growth and use of the internationalization DC in response to the crisis is much stronger for smaller ventures.

Conversely, the estimates of Models 5 and 6 indicate that venture size does *not* moderate the effect of the new product development DC on sales growth. In both models, the coefficients of the interactive term between *ProductInnovationDC* and *LnSales08* is not significant at conventional confidence levels.

To test the robustness of our findings, we performed some additional analyses. In the models reported in Tables 5 and 6 we limited the number of controls in the attempt to maximize the size of the sample. In the Models reported in Table 7, we insert two important additional controls: *CostCut0810* and *Liquidity08*. *CostCut0810* reflects the adoption by sample ventures of actions aimed at reducing costs. It is computed as the difference between the values of the sum of consumables and personnel costs divided

by firm sales in 2010 and 2008. A negative value of *CostCut<sub>0810</sub>* indicates that the focal firm cut costs in the crisis period. This cost reduction may have allowed this firm to slash the price of its products and services, thus stimulating demand. *Liquidity<sub>08</sub>* is computed as the 2008 value of the ratio between cash equivalents and total assets. It captures ventures' financial slack. Ventures with greater slack may be better positioned to implement actions (e.g., marketing actions) that stimulate demand. The balance sheet data used to build *CostCut<sub>0810</sub>* and *Liquidity<sub>08</sub>* were obtained from Orbis, the Bureau van Dijk's commercial database, and were available only for a subset of 217 ventures.<sup>19</sup> The results of the estimates including these controls are in line with those reported earlier. In particular, the coefficients of *Internationalization DC* and *ProductInnovationDC* are positive and significant, while the one of their interactive term is not significant. The magnitude of the effects of the two DC variables is slightly higher than the one estimated in Models 2 and 3. Interestingly, the negative and significant coefficient of *CostCut<sub>0810</sub>* implies that the high-tech entrepreneurial ventures that cut costs achieved superior growth performance in the aftermath of the crisis. *Liquidity<sub>08</sub>* has a positive coefficient, which is weakly significant in Model 9 and close to significance in the remaining Models. Hence, the evidence that the ventures with greater liquidity exhibited higher relative sales growth during the 2008-2010 period is weak.

[Table 7 about here]

Second, as we mentioned above, high-tech entrepreneurial ventures are young firms; however, there is no consensus as to the age threshold beyond which firms cease to be young. Therefore, we checked that our results are robust to changes in the age threshold used. Specifically, we repeated the estimations on the subsample that includes only the 262 firms that were 10 years old. The results (available from the authors upon request) are unchanged.

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<sup>19</sup> The distribution by geographic area and industry of these firms differs from that of the 340 ventures considered in the estimates reported in Tables 5 and 6. Therefore, when we included *CostCut<sub>0810</sub>* and *Liquidity<sub>08</sub>* in the list of controls we run the estimates using sampling weights. The weights denote the probability that each sample firm was included in the subset because of its location and industry of operation.

Third, we checked whether unobserved factors that simultaneously affect firm growth and the use of the two DCs or reverse causality drive our result. For instance, high-tech entrepreneurial ventures that expected greater reductions in sales following the 2008 crisis might have been more prone to use their DCs in response to the crisis. This reverse causality would make the OLS estimates inconsistent and downwardly bias the estimated coefficients of the DC variables. To consider the possible non-exogenous nature of the DC variables, we resorted to an instrumental variables (IVs) approach (Angrist et al. 1996) with two-stage least squares (2SLS) estimation. We carefully selected a set of four instruments. At the firm level, we used the ratio of R&D investments over sales and the ratio of commercial investments in international markets over sales of the focal venture in 2007 (source: RITA survey). We argue that these instruments capture well the extent of the firms' innovation and internationalization activities before the crisis. At the regional level, we use the share of R&D investments on GDP and the share of exports on GDP in the region in which the focal venture is located in 2007 (source: ISTAT) as proxies for local innovativeness and internationalization. The selected instruments respect the conditions of relevance and exogeneity as is respectively shown by the Kleibergen-Paap rk LM statistic for underidentification ( $\chi^2(3)=13.72$ ,  $p\text{-value}<0.05$ ) and by the Anderson-Rubin Wald test for overidentifying in presence of weak instruments ( $F(4, 285)= 0.66$ ,  $p\text{-value}=0.6213$ ); the Hansen J statistic for overidentification provides the same result:  $\chi^2(2)=2.314$ ,  $p\text{-value}=0.3145$ ). The Hausman endogeneity test (e.g., Wooldridge, 2002) for *ProductInnovationDC* and *InternationalizationDC* does not produce significant results ( $\chi^2(2)=3.633$ ,  $p\text{-value}=0.1626$ ), thus indicating that our DC variables are not endogenous in the sales growth model, possibly because the dramatic effects of the 2008 global crisis were largely unexpected, as was documented earlier.

#### 4.3 Additional analyses

To gain additional insights into the relationship between the two DCs under scrutiny and the growth of high-tech entrepreneurial ventures in the aftermath of the crisis, we looked at longer term effects of the use of the two DCs and checked whether the effects of *InternationalizationDC* and *ProductInnovationDC* differed between manufacturing and service firms.

[Table 8 about here]

In the models in Table 8, we use as the dependent variable the relative sales growth during the 2008-2012 period (*SalesGrowth<sub>0812</sub>*) so as to capture the long-term effects of using the new product development and internationalization DCs.<sup>20</sup> The coefficients of both *InternationalizationDC* and *ProductInnovationDC* are again positive and significant. The economic magnitudes of their effects are much greater than the ones illustrated above. A one-standard deviation increase in *InternationalizationDC* and *ProductInnovationDC* is respectively associated with an increase of the sales growth rate between 2008 and 2012 equal to 63 and 25.8 percentage points, respectively (vs. 11 and 7.3 percentage points between 2008 and 2010). The estimates of Model 13 indicate that greater venture size makes the positive relationship between the use of the internationalization DC and relative sales growth weaker also in the long term. This evidence is, again, in line with H5. In sum, these results show that the positive effects of the two DCs on ventures' growth were persistent and even reinforced over time. Moreover, the greater economic magnitude of the effect of *InternationalizationDC* suggests that, despite the peculiarities of high-tech entrepreneurial ventures made it more difficult and time consuming for these firms to reconfigure their internationalization-related resources in the aftermath of the crisis, as indicated by the low average value of *InternationalizationDC*, in the long term such reconfiguration had much more positive effects on growth than the reconfiguration of ventures' innovation-related resources.

[Table 9 about here]

In the models in Table 9 we run separate estimates for manufacturing ventures (Models 14 and 15) and service ventures (Models 16 and 17).<sup>21</sup> The positive and significant coefficient of

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<sup>20</sup> Two clarifications are required. First, the estimates run on a subset of 254 ventures, because sales in 2012 were not available for 86 sample ventures. Second, for the sake of synthesis, in Table 8 we did not report the estimates of the model including only the controls, nor we report the estimates of the models including the interactive terms that were not significant in Tables 5 and 6, namely *InternationalizationDC*×*ProductInnovationDC*, and *ProductInnovationDC*×*LnSales08*. The coefficients of these interactive terms are not significant also when we use *SalesGrowth<sub>0812</sub>* as the dependent variable.

<sup>21</sup> For the sake of synthesis, in Table 9 we reported only the estimates of the models including the controls plus i) the measures of the two DCs (Models 12 and 14), ii) the interactive terms between *LnSales08* and the internationalization DC for manufacturing ventures (Models 13) and between *LnSales08* and the new product development DC for services ventures (Models 15).

*InternationalizationDC* and the non-significant coefficient of *ProductInnovationDC* in Model 14 provide support to H2 but do not support H1 for manufacturing ventures. Conversely, the non-significant coefficient of *InternationalizationDC* and the positive and significant coefficient of *ProductInnovationDC* in Model 16 support H1 but do not support H2 for service ventures.

The results of Models 15 and 17 are in line with those presented earlier. The negative coefficient of *InternationalizationDC*×*LnSales08* in Model 15 and the F-tests reported at the bottom of Table 9 reveal that venture size negatively moderates the positive association between *InternationalizationDC* and the growth performance of manufacturing firms, thus providing support to H5. Instead, the non-significant coefficient of the interactive term between *ProductInnovationDC* and *LnSales08* in Model 17 indicates that venture size does *not* moderate the positive association between *ProductInnovationDC* and the sales growth of service ventures. Hence, H4 is not supported.

## **5 Discussion and conclusion**

This paper examines the relationship between high-tech entrepreneurial ventures' use of two key DCs — the new product development and internationalization DCs — and their performance in the aftermath of an environmental jolt. Relying on data on 340 Italian high-tech entrepreneurial ventures that confronted the 2008 global crisis, we find that the ventures that used the two DCs more, exhibit superior sales growth. These effects are apparent in the period 2008-2010 and become fully evident in the longer term, suggesting that the use of these two DCs was an important source of competitive advantage for high-tech entrepreneurial ventures in the aftermath of the crisis. Using the internationalization DC has stronger positive effect on ventures' performance compared to the new product development DC, and its positive effect is greater for smaller ventures. Conversely, no negative moderating effect of size emerges for use of the new product development DC. A possible explanation is that internationalization-related resources are sticky, and their reconfiguration is difficult and takes time. Larger ventures likely have a larger base of internationalization-related resources (e.g., an international sales force, distribution channels in foreign markets, and commercial relationships with foreign firms) than their smaller counterparts. As these resources are limitedly fungible, the jolt may transform them from valuable assets

into liabilities, reducing the benefits of using the internationalization DC. Conversely, innovation-related resources are likely more fungible so that their reconfiguration in response to the crisis is easier and more effective than that of internationalization-related resources. Consequently, larger ventures do not have constraints in using their new product development DC and can use them as effectively as smaller ventures do. We also detect interesting differences across industries in the performance effects of using the two DCs under consideration. Using the internationalization DC positively affects the growth of manufacturing ventures, but not that of ventures in service industries, which likely face greater difficulties in exporting to foreign markets. Conversely, and more surprisingly, using the new product development DC benefits ventures in services but not manufacturing ventures. A possible explanation is that the development of new products entails greater costs than the development of new services (e.g., Carman and Langeard 1980). For manufacturing ventures the use of the new product development DCs in the aftermath of the crisis may have crowded out investments in other areas (e.g., in commercial activities, Stam and Wennberg 2009) that were necessary to restore growth. The difficulties that (small) manufacturing firms encounter in appropriating the benefits of their product innovations (e.g., Lanjouw and Schankerman 2004) may reinforce this effect. Lastly, and contrary to expectations, we did not find any evidence that the use of the new product development and internationalization DCs in combination generated greater benefits for high-tech entrepreneurial ventures in the aftermath of the crisis in comparison to their use in isolation.

Our work advances scholarly conversations on DCs in several respects. First, it adds to the debate on the role of the environment in the DCs–performance relationship by heeding the call to examine environmental contingencies other than dynamism (Fainshmidt et al. 2016). Our analysis of the use of DCs in the aftermath of an environmental jolt is a relevant contribution to this debate. Jolts occur rather frequently, and many firms must cope with them during their lifecycles (Meyer et al. 1990). Economic crises, technological breakthroughs, social and political upheavals, and changes in government regulations punctuate the histories of many industries (Meyer et al. 2005). Extant literature has analyzed how firms change their strategies and organizations in reaction to such jolts (e.g., Haveman 1992; Virany et al. 1992). Here, we focus on high-tech entrepreneurial ventures – a category of firms

that a jolt affects severely (Bradley 2015) – and we show that the use of the internationalization and new product development DCs is a valuable strategic response for these firms. Furthermore, we believe that Danneels’ remark (2016, p. 22) on the importance of distinguishing between the possession of DCs and their actual use is highly salient in the aftermath of a jolt, when possessing DCs may not automatically translate into their appropriate use. Consequently, we have developed measures that reflect the *use* of the internationalization and new product development DCs by high-tech entrepreneurial ventures. In doing so, we heed Grant and Verona’s (2015) call for better measurement of DCs as a fundamental step toward providing solid empirical support for theoretical discussions.

Second, this paper advances our understanding of the complementarities among DCs. Scholars concur that this research stream requires further work (Peteraf et al. 2013, p. 1407). The few existing studies (e.g., Song et al. 2005) suggest that complementarities among DCs are stronger in dynamic environments. We consider a different environmental contingency, the occurrence of a jolt, and, contrary to our expectations, we do not detect any complementarity between the use of new product development and internationalization DCs by high-tech entrepreneurial ventures. These findings suggest that synergies from the combined use of DCs do not arise automatically. This result opens interesting research directions. Future works may indeed investigate under which conditions such synergies emerge. For example, it is reasonable to expect that the realization of these synergies in the aftermath of a jolt requires both financial resources and managerial skills that exceed those typically available to most high-tech entrepreneurial ventures. Therefore, we welcome future studies that test whether the ventures that likely have better access to these resources and skills, such as VC-backed firms or spin-offs of large companies, benefit more from the combined use of DCs.

Third, our work advances the conversations on DCs in the entrepreneurship field. Entrepreneurial ventures are fundamentally different from established firms: they have smaller resource bases and do not possess slack resources; moreover, due to their young age, they lack experience. Consequently, these ventures and incumbent firms develop and use DCs in different ways (Zahra et al. 2006); indeed, entrepreneurial ventures rely more on improvisation and are more unlikely to resort to experimentation. These differences hinder the generalization to entrepreneurial ventures of the results

on the use of DCs by incumbent firms and ask for research on DCs that explicitly targets entrepreneurial ventures. Previous studies focused on these latter firms show that DCs affect these ventures' growth performance (Arend 2014), innovation (Deeds et al. 2000), ability to attract early-stage capital (Townsend and Busenitz 2015), and diversification (Døving and Gooderham 2008). We contribute to this research stream by focusing attention on high-tech entrepreneurial ventures and investigating the effects of the use of DCs on their growth performance in the aftermath of a jolt. Our findings show a positive association between the use of the new product development and internationalization DCs and ventures' growth performance and a negative moderating effect of firm size (yet confined to the internationalization DC). They are in line with the view that using DCs is an effective strategy for entrepreneurial ventures to regain environmental fit in the aftermath of a jolt. This holds especially true if entrepreneurial ventures can leverage their flexibility to reconfigure their resource base rapidly and effectively, a move that more established firms may find more difficult to make.

Despite its strengths, this study has limitations that open avenues for future research. First, our work studies the DCs–performance relationship in the aftermath of a jolt. Our data do not allow us to compare the pre- and post-jolt periods. Hence, we cannot exclude that results such as those we obtain here hold also in normal times. Thus, exploring the relationship between the use of DCs and firm performance over a longer time horizon that includes both booming and bursting periods would be an interesting addition to our study. Second, this paper focuses on high-tech entrepreneurial ventures. Jolts can influence the performance of *any* firm (Meyer et al. 1990). Thus, we welcome studies that replicate our research on established firms. These firms suffer more from inertia and matching problems than their smaller and younger counterparts, and their larger resource base may be a double edged sword, making them less flexible. Hence, we claim that our findings do not necessarily apply to large established firms. Third, we test our hypotheses in the context of the environmental jolt of the 2008 global crisis; however, there are many other types of jolts (Meyer et al. 2005). In general, such jolts share some common characteristics (e.g., a sudden drop in demand); however, they also have specificities that may cause different consequences on high-tech entrepreneurial ventures. Are our findings generalizable to other jolts? For instance, economic shocks typically have detrimental effects

on high-tech entrepreneurial ventures as they reduce both their demand and capital supply (Chakrabarti 2015), even if sometimes they generate new and unanticipated business opportunities that these firms can capture. Conversely, these new business opportunities likely create a more favorable environment for high-tech entrepreneurial ventures to the detriment of established firms when jolts consist in technological breakthroughs or regulatory changes (e.g., Sine and David 2003; Liu et al. 2007). Along this line of reasoning, one may wonder which high-tech entrepreneurial ventures are better positioned to capture the opportunities for value creation offered by a jolt. For instance, previous studies show that high-tech entrepreneurial ventures that have a well-structured organization are better able to enact opportunities (see Burton et al., 2019 for a recent discussion on this topic), while Wilden et al. (2013) have documented that the DC-performance relation depends on firms' internal organization. Therefore, one may investigate whether the positive effects of the use of DCs in the aftermath of a jolt are contingent on ventures' organization.

Fourth, in line with the call for a better understanding of the moderators of the DCs–performance relationship (Barreto 2010; Di Stefano et al. 2014; Pezeshkan et al. 2016), we investigate here how this relationship is influenced by ventures' size. It would be interesting to extend our analysis to other moderators. For instance, Vanacker and Forbes (2016) show that the high-tech entrepreneurial ventures that manage to send appropriate signals are better able to attract financial resources and talented personnel. In our context, such firms may enjoy an advantage in appropriately using their DCs and ultimately achieving superior performance. Fifth, we focus on the new product development and internationalization DCs moving from the idea that these DCs are especially important for high-tech entrepreneurial ventures during a jolt. However, other DCs are worth of further investigation in this context. Prominent examples of these DCs are, for instance, the *alliance capability* (e.g., Moghaddam et al. 2016), the *transnational product development capability* (Subramaniam and Venkatraman 2001), and the *marketing capability* (e.g., Danneels 2008, 2012, 2016; Song et al. 2005). The alliance capability provides firms with access to novel resources and complementary assets; which favors entry into new product-markets; the transnational product development capability allows firms to leverage knowledge from sources in different countries and develop new products simultaneously for multiple markets. The

marketing capability reflects the firm's ability to add new customers, thus boosting the positive effects of other DCs. Accordingly, we encourage researchers to examine whether and how these other DCs help high-tech entrepreneurial ventures to achieve superior performance in the aftermath of an environmental jolt.

To conclude, notwithstanding these limitations, the paper offers a key message to practitioners. When an environmental jolt occurs, entrepreneurs may think that it is better to wait for the storm to pass and, because of the great uncertainty in the business environment, abstain from changing their resource base. Our findings show that this approach is fated to fail. A jolt dramatically alters the business environment. To regain environmental fit, high-tech entrepreneurial ventures can use their DCs to find new ways of earning a living. In this regard, the flexibility that is typical of smaller ventures is clearly an advantage if such ventures are able to acquire the novel resources they need. Accordingly, high-tech entrepreneurial ventures should wisely accumulate slack resources during normal times. When a jolt occurs, these slack resources can allow them to use their DCs to rapidly and wisely change their resource base and regain environmental fit.

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## Tables

**Table 1: Descriptive statistics on the sample of high-tech entrepreneurial ventures**

	No.	%
<b>Industry</b>		
ICT manufacturing	80	23.5
Biotechnology, pharmaceuticals and advanced materials	32	9.4
Other high-tech manufacturing	41	12.1
Internet and telecommunication services	73	21.5
Software	86	25.3
Other high-tech services	28	8.2
<i>Total</i>	<i>340</i>	<i>100.0</i>
<b>Geographic area</b>		
Northwest	145	42.6
Northeast	74	21.8
Center	65	19.1
South and islands	56	16.5
<i>Total</i>	<i>340</i>	<i>100.0</i>
<b>Age on December 31, 2007</b>		
≤5 years	136	40.0
6-10 years	126	37.1
>10 years	78	22.9
<i>Total</i>	<i>340</i>	<i>100.0</i>
<b>Employees on December 31, 2007</b>		
<10	268	78.8
10 – 49	61	17.9
≥50	4	1.2
Unknown number of employees	7	2.0
<i>Total</i>	<i>340</i>	<i>100.0</i>
<b>Sales in 2007</b>		
≤2,000 k€	316	92.9
2,001 – 10,000 k€	22	6.5
>10,000 k€	2	0.6
<i>Total</i>	<i>340</i>	<i>100.0</i>

*Legend:* ICT manufacturing includes computers; electronic components; telecommunication equipment; and optical, medical, and electronic instruments. Other high-tech manufacturing includes aerospace; and robotics and process automation equipment. Other high-tech services include environmental services and R&D and engineering services.

**Table 2: Use of the internationalization and new product development capabilities in response to the 2008 global crisis**

	Internationalization capability <sup>a</sup>						New product development capability <sup>b</sup>				
	No.	Mean	Std. dev.	Min	Max	t stat.	Mean	Std. dev.	Min	Max	t stat.
Whole sample	340	1.632	0.892	1.000	5.000		2.497	0.941	1.000	5.000	
<b>Industry</b>											
Manufacturing	153	1.506	0.893	1.000	5.000		2.485	0.987	1.000	4.500	
Services	187	1.786	0.873	1.000	5.000	2.91***	2.507	0.886	1.000	5.000	0.21
<b>Geographic area</b>											
North	219	1.623	0.866	1.000	5.000		2.469	0.929	1.000	4.500	
Center, South and islands	121	1.648	0.940	1.000	5.000	0.25	2.548	0.965	1.000	5.000	0.73
<b>Employees on December 31, 2007</b>											
<10	268	1.530	0.824	1.000	5.000		2.424	0.941	1.000	5.000	
≥10	65	2.083	1.040	1.000	4.200	4.59***	2.815	0.914	1.000	4.500	3.03***
<b>Sales in 2007</b>											
≤2,000 k€	316	1.605	0.875	1.000	5.000		2.475	0.945	1.000	5.000	
>2,000 k€	24	1.983	1.050	1.000	4.200	2.01**	2.792	0.856	1.000	4.500	1.59
<b>Age on December 31, 2007</b>											
≤5 years	136	1.679	0.830	1.000	4.200		2.489	0.894	1.000	4.750	
>5 years	204	1.600	0.932	1.000	5.000	0.80	2.502	0.974	1.000	5.000	0.12

*Legend:* <sup>a</sup> Number of items for which we compute the average score: 5. <sup>b</sup> Number of items for which we compute the average score: 4.

\*\*significance level greater than 5%; \*\*\*significance level greater than 1%.

Manufacturing includes computers; electronic components; telecommunication equipment; optical, medical, and electronic instruments; biotechnology; pharmaceuticals; advanced materials; aerospace; and robotics and process automation equipment. Services include software, Internet, and telecommunication services; environmental services; and R&D and engineering services.

**Table 3: Descriptive statistics**

<i>Variable</i>	<i>Mean</i>	<i>Std.dev.</i>	<i>Min</i>	<i>Max</i>
(1) <i>InternationalizationDC</i>	0.000	1.000	-0.707	3.788
(2) <i>ProductInnovationDC</i>	0.000	1.000	-1.594	2.618
(3) <i>LnSales<sub>08</sub></i>	5.764	1.402	1.891	9.508
(4) <i>SalesGrowth<sub>0708</sub></i>	0.682	2.272	-0.562	14.112
(5) <i>Age<sub>08</sub></i>	7.600	4.335	1.000	16.000
(6) <i>DICTManufacturing</i>	0.235	0.425	0.000	1.000
(7) <i>DBioPharma</i>	0.094	0.292	0.000	1.000
(8) <i>DOtherManufacturing</i>	0.121	0.326	0.000	1.000
(9) <i>DInternet</i>	0.215	0.411	0.000	1.000
(10) <i>DSoftware</i>	0.253	0.435	0.000	1.000

**Table 4: Correlation matrix**

<i>Variable</i>	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) <i>InternationalizationDC</i>	1.000								
(2) <i>ProductInnovationDC</i>	0.427***	1.000							
(3) <i>LnSales<sub>08</sub></i>	0.134**	0.147***	1.000						
(4) <i>SalesGrowth<sub>0708</sub></i>	-0.061	-0.091*	0.002	1.000					
(5) <i>Age<sub>08</sub></i>	-0.039	0.002	0.356***	-0.278***	1.000				
(6) <i>DICTManufacturing</i>	0.104*	0.052	0.061	-0.016	0.008	1.000			
(7) <i>DBioPharma</i>	0.075	-0.043	-0.046	0.079	-0.033	-0.179***	1.000		
(8) <i>DOtherManufacturing</i>	0.035	-0.048	0.045	0.019	-0.031	-0.205***	-0.119**	1.000	
(9) <i>DInternet</i>	-0.089	0.025	-0.058	-0.035	0.103	-0.290***	-0.169***	-0.194***	1.000
(10) <i>DSoftware</i>	-0.114*	0.034	-0.005	-0.069	0.049	-0.323***	-0.188***	-0.216***	-0.304***

*Legend.* \*significance level greater than 10%; \*\*significance level greater than 5%; \*\*\*significance level greater than 1%.

**Table 5: Use of DCs and relative sales growth of high-tech entrepreneurial ventures in the aftermath of the crisis (2008-2010)**

<i>Variables</i>	<b>Model 1</b>			<b>Model 2</b>			<b>Model 3</b>		
$\alpha_0$ <i>Constant</i>	2.230	(0.630)	***	2.325	(0.610)	***	2.314	(0.614)	***
$\alpha_1$ <i>InternationalizationDC</i>	-			0.110	(0.044)	**	0.084	(0.046)	*
$\alpha_2$ <i>ProductInnovationDC</i>	-			0.073	(0.036)	**	0.079	(0.036)	**
$\alpha_3$ <i>InternationalizationDC</i> × <i>ProductInnovationDC</i>	-			-			0.032	(0.035)	
$\alpha_4$ <i>LnSales<sub>08</sub></i>	-0.093	(0.062)		-0.131	(0.062)	**	-0.129	(0.062)	**
$\alpha_5$ <i>SalesGrowth<sub>0708</sub></i>	-0.022	(0.013)	*	-0.013	(0.014)		-0.014	(0.014)	
$\alpha_6$ <i>Age<sub>08</sub></i>	-0.005	(0.008)		0.000	(0.009)		0.000	(0.008)	
$\alpha_7$ <i>InverseMillsRatioFailure</i>	0.131	(0.260)		0.065	(0.255)		0.059	(0.256)	
$\alpha_8$ <i>InverseMillsRatioAcquisition</i>	0.446	(0.156)	***	0.472	(0.147)	***	0.484	(0.146)	***
$\alpha_9$ <i>DICTManufacturing</i>	-0.017	(0.152)		-0.055	(0.148)		-0.042	(0.147)	
$\alpha_{10}$ <i>DBioPharma</i>	0.052	(0.183)		0.014	(0.185)		0.025	(0.184)	
$\alpha_{11}$ <i>DOtherManufacturing</i>	-0.143	(0.167)		-0.155	(0.163)		-0.151	(0.162)	
$\alpha_{12}$ <i>DInternet</i>	0.048	(0.145)		0.044	(0.147)		0.054	(0.145)	
$\alpha_{13}$ <i>DSoftware</i>	0.102	(0.143)		0.109	(0.140)		0.118	(0.139)	
N. of observations	340			340			340		
F	2.11 (10, 329)**			2.42 (12, 327)***			2.33 (13, 326)***		
R <sup>2</sup>	0.086			0.144			0.145		

*Legend.* \*\*Significance level greater than 5%; \*\*\*significance level greater than 1%. Robust standard errors and degrees of freedom are in parentheses.

**Table 6: The moderating effect of high-tech entrepreneurial venture size on the relationship between the use of DCs and relative sales growth in the aftermath of the crisis (2008-2010)**

<i>Variables</i>	<b>Model 4</b>			<b>Model 5</b>			<b>Model 6</b>		
$\alpha_0$ <i>Constant</i>	2.117	(0.587)	***	2.308	(0.602)	***	2.095	(0.594)	***
$\alpha_1$ <i>InternationalizationDC</i>	0.499	(0.241)	**	0.107	(0.042)	**	0.580	(0.240)	**
$\alpha_2$ <i>ProductInnovationDC</i>	0.061	(0.037)	*	0.207	(0.220)		-0.101	(0.199)	
$\alpha_3$ <i>InternationalizationDC</i> × <i>LnSales<sub>08</sub></i>	-0.066	(0.038)	*	-			-0.079	(0.037)	**
$\alpha_4$ <i>ProductInnovationDC</i> × <i>LnSales<sub>08</sub></i>	-			0.023	(0.036)		0.027	(0.031)	
$\alpha_5$ <i>LnSales<sub>08</sub></i>	-0.118	(0.060)	**	0.125	(0.061)	**	-0.123	(0.061)	**
$\alpha_6$ <i>SalesGrowth<sub>0708</sub></i>	-0.014	(0.015)		0.014	(0.014)		-0.013	(0.015)	
$\alpha_7$ <i>Age<sub>08</sub></i>	0.001	(0.008)		0.001	(0.008)		0.001	(0.008)	
$\alpha_8$ <i>InverseMillsRatioFailure</i>	0.030	(0.253)		0.076	(0.260)		0.010	(0.258)	
$\alpha_9$ <i>InverseMillsRatioAcquisition</i>	0.442	(0.143)	***	0.464	(0.147)	***	0.446	(0.142)	***
$\alpha_{10}$ <i>DICTManufacturing</i>	-0.058	(0.156)		0.064	(0.149)		-0.049	(0.156)	
$\alpha_{11}$ <i>DBioPharma</i>	-0.022	(0.194)		0.000	(0.189)		-0.013	(0.194)	
$\alpha_{12}$ <i>DOtherManufacturing</i>	-0.168	(0.167)		0.163	(0.163)		-0.162	(0.166)	
$\alpha_{13}$ <i>DInternet</i>	-0.006	(0.152)		0.039	(0.148)		-0.010	(0.152)	
$\alpha_{14}$ <i>DSoftware</i>	0.082	(0.143)		0.101	(0.139)		0.086	(0.142)	
N. of observations	340			340			340		
F-test: $\alpha_1 = \alpha_3 = 0$	3.83 (2, 326)**			-			4.08 (2, 325)**		
F-test: $\alpha_2 = \alpha_4 = 0$	-			2.03 (2, 326)			2.50 (2, 325)*		
F	2.57 (13, 326)***			2.63 (13, 326)***			2.66 (14, 325)***		
R <sup>2</sup>	0.168			0.146			0.171		

*Legend.* \*Significance level greater than 10%; \*\*significance level greater than 5%; \*\*\*significance level greater than 1%. Robust standard errors and degrees of freedom are in parentheses.

**Table 7 – Check of robustness: inclusion of additional controls.**

<i>Variables</i>	<b>Model 7</b>			<b>Model 8</b>			<b>Model 9</b>			<b>Model 10</b>			<b>Model 11</b>		
$\alpha_0$ <i>Constant</i>	2.495	(0.747)	***	2.497	(0.748)	***	2.188	(0.743)	***	2.437	(0.730)	***	2.189	(0.748)	***
$\alpha_1$ <i>InternationalizationDC</i>	0.137	(0.061)	**	0.132	(0.055)	**	0.817	(0.339)	**	0.135	(0.057)	**	0.810	(0.361)	**
$\alpha_2$ <i>ProductInnovationDC</i>	0.092	(0.038)	**	0.093	(0.036)	**	0.085	(0.038)	**	0.503	(0.304)		0.100	(0.259)	
$\alpha_3$ <i>InternationalizationDC</i> × <i>ProductInnovationDC</i>	-			0.007	(0.032)		-			-			-		
$\alpha_4$ <i>InternationalizationDC</i> × <i>LnSales</i> <sub>08</sub>	-			-			-0.110	(0.049)	**	-			-	(0.052)	**
$\alpha_5$ <i>ProductInnovationDC</i> × <i>LnSales</i> <sub>08</sub>	-			-			-			-	(0.047)		-	(0.038)	
$\alpha_6$ <i>LnSales</i> <sub>08</sub>	-0.172	(0.106)		-	(0.105)		-0.140	(0.079)	*	-	(0.097)	*	-	(0.079)	*
$\alpha_7$ <i>SalesGrowth</i> <sub>0708</sub>	-0.024	(0.015)		0.171	(0.015)		-0.019	(0.015)		0.161	(0.015)		0.140	(0.015)	
$\alpha_8$ <i>Age</i> <sub>08</sub>	-0.007	(0.012)		0.024	(0.012)		-0.005	(0.011)		0.022	(0.011)		0.019	(0.011)	
$\alpha_9$ <i>CostCut</i> <sub>0810</sub>	-0.236	(0.090)	**	0.007	(0.090)	**	-0.005	(0.011)	**	0.007	(0.091)	**	0.005	(0.090)	**
$\alpha_{10}$ <i>Liquidity</i> <sub>08</sub>	0.376	(0.228)		0.235	(0.231)		0.378	(0.219)	*	0.224	(0.226)		0.190	(0.220)	*
$\alpha_{11}$ <i>InverseMillsRatioFailure</i>	-0.164	(0.340)		0.164	(0.341)		-0.161	(0.320)		0.142	(0.333)		0.161	(0.323)	
$\alpha_{12}$ <i>InverseMillsRatioAcquisition</i>	0.716	(0.179)	***	0.721	(0.178)	***	0.676	(0.171)	***	0.696	(0.177)	***	0.675	(0.170)	***
$\alpha_{13}$ <i>DICTManufacturing</i>	0.079	(0.140)		0.081	(0.142)		0.111	(0.157)		0.083	(0.147)		0.111	(0.158)	
$\alpha_{14}$ <i>DBioPharma</i>	0.199	(0.150)		0.201	(0.151)		0.180	(0.176)		0.197	(0.160)		0.180	(0.176)	
$\alpha_{15}$ <i>DOtherManufacturing</i>	-0.044	(0.158)		-	(0.158)		-0.030	(0.168)		-	(0.164)		-	(0.169)	
$\alpha_{16}$ <i>DInternet</i>	0.303	(0.143)	**	0.045	(0.146)	**	0.295	(0.164)	*	0.045	(0.153)	**	0.030	(0.165)	*
$\alpha_{17}$ <i>DSoftware</i>	0.429	(0.128)	***	0.431	(0.129)	***	0.439	(0.145)	***	0.418	(0.134)	***	0.439	(0.145)	***
N. of observations	217			217			217			217			217		
F-test: $\alpha_1 = \alpha_4 = 0$	-			-			4.09 (2, 201)**			-			3.96 (2, 200)**		
F-test: $\alpha_2 = \alpha_5 = 0$	-			-			-			3.17 (2, 201)**			3.66 (2, 200)**		
F	2.98 (14, 202)***			2.76 (15, 201)***			3.21 (15, 201)***			3.42 (15, 201)***			3.42 (16, 200)***		

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$R^2$	0.246	0.246	0.311	0.263	0.311
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**Table 8: Use of DCs and relative sales growth of high-tech entrepreneurial ventures in the aftermath of the crisis: effects in the long term (2008-2012)**

<i>Variables</i>	<b>Model 12</b>			<b>Model 13</b>		
$\alpha_0$ <i>Constant</i>	5.168	(2.063)	**	2.344	(1.956)	
$\alpha_1$ <i>InternationalizationDC</i>	0.630	(0.279)	**	0.197	(0.147)	
$\alpha_2$ <i>ProductInnovationDC</i>	0.258	(0.142)	**	4.317	(1.578)	***
$\alpha_3$ <i>InternationalizationDC</i> × <i>LnSales</i> <sub>08</sub>	-			-0.612	(0.237)	**
$\alpha_4$ <i>LnSales</i> <sub>08</sub>	-1.505	(0.496)	***	-1.365	(0.439)	***
$\alpha_5$ <i>SalesGrowth</i> <sub>0708</sub>	0.220	(0.164)		0.233	(0.161)	
$\alpha_6$ <i>Age</i> <sub>08</sub>	-0.012	(0.042)		-0.007	(0.039)	
$\alpha_7$ <i>InverseMillsRatioFailure</i>	-2.601	(1.310)	**	-3.228	(1.311)	**
$\alpha_8$ <i>InverseMillsRatioAcquisition</i>	0.967	(0.509)	*	0.684	(0.511)	
$\alpha_9$ <i>DICTManufacturing</i>	0.411	(0.499)		0.331	(0.575)	
$\alpha_{10}$ <i>DBioPharma</i>	2.491	(1.124)	**	2.114	(1.138)	*
$\alpha_{11}$ <i>DOtherManufacturing</i>	0.937	(0.673)		0.756	(0.724)	
$\alpha_{12}$ <i>DInternet</i>	0.240	(0.505)		-0.316	(0.570)	
$\alpha_{13}$ <i>DSoftware</i>	0.857	(0.568)		0.452	(0.554)	
N. of observations	254			254		
F	1.83 (12, 241)**			2.04 (12, 240)**		
F-test: $\alpha_1 = \alpha_3 = 0$	-			4.27 (2, 240)**		
R <sup>2</sup>	0.290			0.371		

*Legend.* \*Significance level greater than 10%; \*\*significance level greater than 5%; \*\*\*significance level greater than 1%. Robust standard errors and degrees of freedom are in parentheses.

**Table 9: Use of DCs and relative sales growth of manufacturing and service high-tech entrepreneurial ventures in the aftermath of the crisis (2008-2010)**

Variables	Manufacturing ventures						Service ventures					
	Model 14		Model 15		Model 16		Model 17					
$\alpha_0$ Constant	2.869	(0.931) ***	2.173	(0.858) **	2.046	(0.740) ***	2.050	(0.749) ***				
$\alpha_1$ InternationalizationDC	0.180	(0.068) ***	0.023	(0.051)	0.075	(0.055)	0.074	(0.055)				
$\alpha_2$ ProductInnovationDC	0.029	(0.052)	0.892	(0.376) **	0.081	(0.048) *	0.115	(0.291)				
$\alpha_3$ InternationalizationDC $\times$ LnSales <sub>08</sub>	-		-0.119	(0.058) **	-		-					
$\alpha_4$ ProductInnovationDC $\times$ LnSales <sub>08</sub>	-		-		-		-0.006	(0.046)				
$\alpha_5$ LnSales <sub>08</sub>	-0.131	(0.104)	-0.116	(0.101)	-0.120	(0.067) *	-0.119	(0.065)				
$\alpha_6$ SalesGrowth <sub>0708</sub>	-0.020	(0.021)	-0.020	(0.022)	-0.003	(0.017)	-0.003	(0.017)				
$\alpha_7$ Age <sub>08</sub>	0.019	(0.013)	0.018	(0.012)	-0.013	(0.011)	-0.013	(0.011)				
$\alpha_8$ InverseMillsRatioFailure	0.473	(0.429)	0.311	(0.413)	-0.108	(0.297)	-0.102	(0.309)				
$\alpha_9$ InverseMillsRatioAcquisition	0.357	(0.212) *	0.275	(0.200)	0.524	(0.183) ***	0.522	(0.183) ***				
$\alpha_{10}$ DICTManufacturing	-0.045	(0.148)	0.011	(0.161)	-		-					
$\alpha_{11}$ DOtherManufacturing	-0.130	(0.161)	-0.085	(0.169)	-		-					
$\alpha_{12}$ DInternet	-		-		0.090	(0.146)	0.089	(0.146)				
$\alpha_{13}$ DSoftware	-		-		0.145	(0.139)	0.143	(0.135)				
N. of observations	153		153		187		187					
F-test: $\alpha_1 = \alpha_3 = 0$	-		5.89 (2, 142)**		-		-					
F-test: $\alpha_2 = \alpha_4 = 0$	-		-		-		1.48 (2, 176)					
F	1.89 (9, 143)*		2.43 (10, 142)**		2.37 (9,177)**		2.37 (10, 176)**					
R <sup>2</sup>	0.199		0.249		0.143		0.143					

*Legend.* \*Significance level greater than 10%; \*\*significance level greater than 5%; \*\*\*significance level greater than 1%. Robust standard errors and degrees of freedom are in parentheses.

## Appendix

To test the *convergent* and *discriminant* validity of our DCs measures, we conducted a single exploratory factor analysis on all the survey items. We identified two factors with eigenvalues greater than 1 corresponding to our two DCs. The items exhibited high loadings only for their appropriate capabilities. These results offer preliminary support for our scale's discriminant and convergent validity. Then, we subjected our measures to confirmatory factor analysis (CFA). A CFA, in which all items were forced to load on a single factor, confirmed discriminant validity. The model shows poor fit, with a root mean squared error of approximation (RMSEA) equal to 0.204, a comparative fit index (CFI) equal to 0.773 and a Tucker-Lewis index (TLI) equal to 0.698, supporting convergent validity. A two-factor CFA showed better fit (RMSEA=0.093, CFI=.955, TLI=0.937).

To assess the nomological validity of the DCs measures, we checked whether the uses of our two DCs are associated with greater investments in the corresponding areas. To reconfigure resources and competences in the internationalization and product innovation fields (i.e., our two DC measures), high-tech entrepreneurial ventures must have made investments to either expand in international markets or develop new products and services. Thus, we developed two measures of the investments made in those two areas based on the survey items reported in Table A2. We then performed PCAs on these two groups of items. The two measures of the investments made in internationalization and new product development were highly reliable, as shown by high Cronbach's alpha values (0.928 and 0.746, respectively). Moreover, these two measures were positively and significantly correlated with the corresponding DC measures (0.900 for the scale related to internationalization and 0.672 for the scale related to new product development). These high correlations support the nomological validity of our DC measures. Finally, we regressed the two measures of the investments made against *InternationalizationDC* and *ProductInnovationDC* and a series of controls for firm age, size, and industry of operation. The results (available from the authors upon request) are as expected. *InternationalizationDC* is a stronger predictor of the investments made in internationalization than *ProductInnovationDC*, whereas the opposite holds for the investments made in new product (service) development.

**Table A1: Measures of DCs**

Construct	Items	Loading	Uniqueness
Internationalization capability* Eigenvalue = 3.715 Variance explained = 74.3% Cronbach's alpha = 0.913	Has developed new competences/resources useful to operate in international markets that it did not possess in 2008	0.874	0.236
	Has developed stronger brand reputation and/or better firm image in international markets that it did not possess in 2008	0.874	0.236
	Has developed new distribution channels in international markets that it did not possess in 2008	0.888	0.211
	Has modified its network of commercial relationships in international markets	0.832	0.308
	Has changed the roles and/or tasks of employees in commercial functions operating in international markets	0.839	0.295
New product development capability* Eigenvalue = 2.500 Variance explained = 62.5% Cronbach's alpha = 0.795	Has developed new technological competences/resources that it did not possess in 2008	0.848	0.281
	Has developed new technological collaborations that it did not possess in 2008	0.809	0.346
	Has developed new organization of new product (service) development activities that it did not possess in 2008	0.841	0.292
	Has changed the roles and/or tasks of engineers/technicians in new product (service) development functions	0.648	0.580

\* These items were preceded by the statement: "To what extent, during the period 2009-2010, in response to the crisis, your firm has developed new resources and/or competences that it did not have in 2008 or has changed the resources and/or competences in the following areas: ..." All items were measured on five-point scales, where 1 = the firm did not develop any new resources/competences or made any changes in this area and 5 = the firm developed many new resources/competences or made many changes in this area. Respondents were asked to indicate for each item the extent to which it described her firm. Please note that we carried out two separate factor analyses for the five items of the construct "Internationalization capability" and for the four items of the construct "New product development capability."

**Table A2: Measures of the investments made in internationalization and new product development**

Construct	Items	Loading	Uniqueness
Investments in internationalization* Eigenvalue = 4.927 Variance explained = 70.38% Cronbach's alpha = 0.928	Has invested in assessing the potential of new international markets	0.772	0.404
	Has invested in setting up new distribution channels in international markets	0.877	0.231
	Has recruited new employees in commercial functions to operate in international markets	0.710	0.497
	Has invested to leverage its brand reputation and/or its image in international markets	0.866	0.250
	Has invested to research new customers in international markets	0.909	0.174
	Has invested to develop new advertising or promotion strategies in international markets	0.886	0.215
	Has invested to develop new pricing strategies in international markets	0.836	0.301
Investments in new product development* Eigenvalue = 2.287 Variance explained = 57.18% Cronbach's alpha = 0.746	Has invested in assessing the feasibility of new products (services)	0.682	0.535
	Has invested in implementing new methods to develop new products (services)	0.836	0.301
	Has launched new product (service) development projects	0.813	0.339
	Has recruited engineers/technicians in new product (service) development functions	0.680	0.538

*Legend:* \*These items were preceded by the statement: "In response to the crisis, in the period 2009-2010, your firm ...". All items were measured on five-point scales, where 1 = not at all and 5 = yes, a lot. Respondents were asked to indicate for each item the extent to which it described her firm. Please note that we carried out two separate factor analyses for the seven items of the construct "Investments in internationalization" and for the four items of the construct "Investments in new product development".

**Table A3: Determinants of failure and acquisition in the 2009-2011 period among the high-tech entrepreneurial ventures included in the RITA Directory at the outset of the crisis: bivariate probit model**

Variables	Failure	Acquisition
$\mu_0$ Constant	-0.766 (1.145)	-0.446 (1.170)
$\mu_1$ Age <sub>08</sub>	0.001 (0.020)	-0.013 (0.020)
$\mu_2$ LnSales <sub>08</sub>	-0.204 (0.065) ***	0.064 (0.094)
$\mu_3$ DManufacturing	0.121 (0.173)	0.340 (0.234)
$\mu_4$ DNorth	-0.321 (0.222)	-0.460 (0.297)
$\mu_5$ DSouth	-0.066 (0.236)	-0.292 (0.414)
$\mu_6$ FirmFailureRate	0.238 (14.657)	-30.311 (14.751) **
N. of observations	1,046	
$\chi^2$	28.09 (12)***	
Wald test of independence of the equations	33.625 (1)***	

*Legend.* \*Significance level greater than 10%; \*\*significance level greater than 5%; \*\*\*significance level greater than 1%. Robust standard errors and degrees of freedom are in parentheses.