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ICT AND THE CHANGING NATURE OF COMPETITION: EVIDENCE FROM INFORMATION INTENSIVE INDUSTRIES IN ITALY

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Research Paper

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Abstract

Despite the increasing interest over the transformations induced by ICT on industry structure and competition, there is still not a unified view on the effects of ICT on industrial change. On the one hand, ICT is expected to bring more competition, to reduce entry barriers and to leave more opportunities for small entrepreneurial firms. On the other hand, there is evidence of the increased market concentration favoured by ICT. The changing nature of competition has been so far studied more at firm level and more of the empirical evidence is for highly information intensive economies like the US. This paper tries to bridge this gap analysing 209 industries in Italy between 2002 and 2011.

Our results show a significant effect of ICT on industry dynamics. Firstly, we find that information intensive industries showed a higher productivity, a higher market concentration and a greater profit dispersion compared to their counterparts, thus extending related studies that identify mechanisms for ICT-enabled value creation in US. Secondly, we do not find phenomena of hi-growth of SMEs in information intensive industries as a consequence of the limited capability of Italian SMEs to use ICT to start hi-growth entrepreneurial ventures, differently from what happens in other countries.

Keywords: Industrial Change, ICT, Dynamism, Hypercompetition, Information Intensive Industries.

1 Introduction

In the last decade, the paradigm of use of information and communication technology (ICT) has been evolving from an asset supporting information processing and communication to a technology that by being ubiquitous and "embeddable" in products and services can alter traditional ways of doing business, competitive dynamics (McAfee & Brynjolfsson 2008) and industry structures (Lucas et al 2013). As a result of this trend, in many firms ICT deployment follows strategies that are moving from a functional planning of a staff area to an integration of the whole business strategy process (Bharadwaj et al. 2013). Also, ICT potentially allows firms to improve their strategic agility, enabling them to enter new businesses at a low cost (Sambamurthy et al. 2003) and to respond quickly to environmental changes. In the same way, by increasingly supporting business processes through ICT systems, firms can codify, standardize, replicate and adapt such processes on a global scale. This is another form of agility that ICT potentially gives to firms as it may allow them a rapid business growth without the need to build the bureaucratic structures that were typical of traditional corporations (Brynjolfsson et al. 2008).

At the industry level, the increasing importance of ICT is reflected in new waves of reconfigurations in the structure of industries and in new mechanisms of value creation that come with a process of cross-boundary industry disruption involving previously unrelated businesses (Lucas et al. 2013) and the blurring of traditional industry boundaries (Porter 2014). For instance, most of the largest newspaper firms and museums have recently made alliances with web platforms such as Google or Facebook to distribute of their digital contents. Amazon has progressively expanded its business model of a retailer entering a

multitude of sectors, including the online access to books and TV series and the provision of IT services. Moreover, in some sectors ICT is enabling a process of relocation of firms and jobs on a global scale (Karmarkar & Apte 2007; Mithas & Whitaker 2007) and is generating new patterns of consumption for goods and services, i.e., a sharing economy(Cusumano 2014). These examples underlie a broader trend: ICT is exposing firms to new forms of competition and to disruptive innovations that may favour new entrants.

Despite the broad consensus on the transformational effects and the strategic relevance that ICT can have, the evidence of the effects that ICT may have on industrial change and competition dynamics is not broad and conclusive yet (Schryen 2013; Fink 2011). This can be attributed to three main reasons. First, so far the majority of studies on ICT value have been at the firm level (Chau et al. 2007; Wan et al. 2007; Paré et al. 2008). Second, as we illustrated above, ICT has an evolving nature and a broader field of application in firms' functional domains. Third, it is difficult to build large datasets of industries with a time series dimension that can capture the economic impact of ICT in a comprehensive manner (Brynjolfsson & Yang 1996). Our work tries to bridge this gap by analysing how industry structure and competitive dynamics have been evolving between 2002 and 2011 depending on the industry's information intensity. Based on Resource-Based-View (RBV) and the framework of dynamic capabilities, we would expect that information intensive sectors might exhibit different competitive dynamics than other industries, given the prominence that ICT and information have in their core business processes and the role that ICT may have in increasing firms' strategic agility (Lu & Ramamurthy 2011; Sambamurthy et al. 2003; Overby et al. 2006). Specifically, this paper presents some theoretical formulations and empirical evidence that information intensive industries should exhibit more evident patterns of industry growth, market concentration, divides in performance, competitive turbulence, and the presence of a tier of new entrants having high growth. These trends may be motivated by multiple reasons: first, the effect of ICT on enriching the repertoire of competitive actions available to firms able to govern ICT-related investments (Sambamurthy et al. 2003); second, the heterogeneity existing in firms' level of competence when investing in ICT (Neirotti & Paolucci 2014); third, the shortening sustainability of competitive advantages based on ICT due to the commoditization of some technologies (Masli et al. 2011) and the impact that the Internet has on appropriability regimes (Porter 2001); finally, the winner-take-all dynamics of scale and network economies existing in many information goods (Brynjolfsson et al. 2008; McAfee & Brynjolfsson 2008; Bartelsman 2013).

Our study is an extension of a former study on the US data (Brynjolfsson et al. 2008), in a country context – Italy – that is not as fast and nimble as the US in leveraging the transformational role of ICT. As such, this study may give an important contribution to our ability to test, generalize, and enrich our current theoretical knowledge on the impact of ICT at the industry level (Santhanam & Hartono 2003). Specifically, we analyse 209 industries (at three-digits of NACE code) in Italy over a period of 10 years (2002-2011). Italy provides a unique setting for this type of research given its economic specialization in medium-tech and non-information intensive industries dominated by small and medium enterprises and the more limited availability of human capital compared to other developed nations. These traits in factor and demand conditions may pose constraints in applying ICT (Melville et al. 2004) and thus raise interest in assessing the transformational impact of ICT in countries that are less economically developed and information intensive than the US.

The paper is organized as follows. In the next section we present the theoretical background and we define the ways through which we investigate industry dynamics. Section 3 reports the hypothesis formulation. Section 4 and 5 describe the research methodology and the related findings. We then present the theoretical and managerial implications and limitations of our findings, and, finally, suggest directions for future research.

2 Theoretical Background

2.1 The attributes of ICT-based innovation

The resource-based view (RBV) has dominated the strategic Information System literature in recent years (Clemons & Row 1991; Mata et al. 1995; Bharadwaj 2000; Santhanam & Hartono 2003; Caldeira

& Ward 2003; Melville et al. 2004; Wade & Hulland 2004; Fink 2011) and from this view new theoretical frameworks have been developed for explaining firms' strategic agility (Lu & Ramamurthy 2011; Sambamurthy et al. 2003; Overby et al. 2006) and the sustainability of competitive advantages rooted in ICT (Piccoli & Ives 2005). Drawing on these theoretical streams, we expect that ICT may have a dual nature, which is manifested in the existence of two types of technology resources. On the one hand, some ICT-based systems may require limited implementation costs due to their standardized features and basic familiarity with these technologies at the industry levels in firms, workers, IT vendors and consultants. As such, their diffusion may involve a large number of firms. This is the case of ICT systems whose use is aimed at cost reduction in internally oriented operations, such as production planning and administrative activities. In contrast, other ICT-based systems require an extensive and on-going learning, the precursory adoption of interrelated technologies, and complementary investments in skills and business process innovation. This is especially the case of ICT systems supporting externally oriented processes like new product development, supply chain collaboration, Customer Relationship Management (CRM), and e-commerce initiatives. Most of these technologies can support firms in new initiatives aimed at revenue generation, responding to market changes and broadening the repertoire of competitive actions (Sambamurthy et al. 2003), connecting internal and external stakeholders (Overby et al. 2006) and increasing boundary-spanning activities (Karsten et al. 2001; Merali 2002). Their implementation involves a high level of social complexity (Mata et al. 1995, p.497) – due to the integration of information systems with those of supply chain partners – and path dependency (Dierickx & Cool 1989), due to the fact that ICT for externally oriented processes usually requires the previous successful adoption of ICT supporting internal operations. As such, the effective use of these technologies does not contribute to firm performance in isolation (Piccoli & Lui 2013), but contributes as part of a system that is not easily imitable (Piccoli & Ives 2005). The systemic nature of ICT deployment initiatives can thus generate, at an industry level, a widening performance divide between firms that are leaders in ICT use and firms that lag behind.

2.2 ICT-based innovation and industry dynamics

The dual strategic nature of ICT implies that there might a range of possible outcomes in the impact that ICT diffusion and its evolution have on industry dynamics and that several variables must be taken into account when analysing its impact. One of the most important issues in the economic appraisal of ICT investments is the question of what to measure. In this vein, productivity is probably the most intensively discussed process performance measure in literature on Information System (IS), but to understand the influence of ICT on industry dynamics the focus of analysis should be enlarged to include other variables, as well. On the one hand, the fact that some ICT systems are the object of rapid commoditization implies that they can have a broad diffusion at the industry level (Neirotti & Paolucci 2014) and this can lead to positive effects on the industry's labour productivity (Brynjolfsson & Hitt 1996; Stiroh 2001; Devaraj & Kohli 2003; Dedrick et al. 2003; Santhanam & Hartono 2003; Neirotti & Paolucci 2007; Mithas et al. 2012). By contrast, the adoption and assimilation of other technologies require firms to develop competencies in managing ICT projects and complementary organizational capabilities that are complex, rare, non-imitable and non-substitutable. The fact that firms with these input conditions can build and sustain competitive advantages based on ICT implies the existence of profitability divides between these firms and their rivals at the industry level. In addition, ICT resources, ability to manage ICT projects, and skill sets that are complementary to ICT are subject to asset stock accumulation (Piccoli & Ives 2005); this may imply that these divides persist and increase over times. On the other hand, competencies in ICT management can lead firms to improve their strategic agility, yielding more options for competitive actions (Sambamurthy et al. 2003). This raises interest in analysing the munificence of an industry, i.e., the availability of opportunities and resources for growth. In this vein, as in the majority of studies at the firm level, munificence is considered as an exogenous variable; when the focus shifts to the role of ICT in affecting industry dynamics, the rate of munificence in an industry can be considered as an endogenous variable that depends on how well firms are able to seize the opportunities for new competitive actions raised by ICT. Moreover, ICT makes it possible for better managerial practices and processes to become rapidly known and adopted throughout an organization. For firms that are leaders in ICT, this means that by codifying, standardizing and replicating their best practices and processes (Brynjolfsson et al. 2008) and by adapting them to the local conditions of a firm's operation units

(Winter & Szulanski 2001), they can rapidly extend their operational effectiveness in various geographical areas and can thus gain market share. This raises interest in analysing whether sectors where ICT is a core asset exhibit a more concentrated market structure in sales and are thus dominated by a restricted tier of large enterprises. At the same time, the evolving nature of ICT and its ongoing development may destroy the dominant market position of ICT leaders in favour of rivals or new entrants, thereby putting an industry in conditions of hypercompetition (D'Aveni 1994) and high-growth opportunities for entrepreneurial firms. Another driver of hypercompetition can lie in the effect that ICT and the Internet have in increasing market transparency and contestability and in reducing barriers to entry (Porter 2001). Hypercompetition may go along with a process of growth for small enterprises that can reflect their ability to use the Internet as a distribution channel.

2.3 Industry effects

Although ICT may have far-reaching effects on different industries, based on the way in which evolutionary economics illustrates the diffusion process of an innovation (Metcalfe 2005), there are intersectoral differences in the diffusion of ICT and in the capabilities that firms can develop from its use (Neirotti & Paolucci 2014). These differences may reflect the fact that the opportunities for technical, organizational, and business change that may arise from a new technological paradigm are endogenous to the industry. Such opportunities depend on both the nature of the sectoral production activities and the technological distance that the industry has from the "revolutionary core" in which the new technological paradigm originated (Dosi 1988, p.1139). For ICT, the "revolutionary core" can be represented by industries that are more information intensive in their products/services and their operations. Information intensity reflects the extent to which products and processes incorporate information and can be an important predictor of the extent to which industries are subject to the transformational role of ICT.

Porat and Rubin (1977) have provided a seminal contribution in applying the concept of information intensity to sectors in their attempt to measure the information component of the total value generated in the economy. Information intensive industries are "involved in transforming information from one pattern to another" whereas the non-information – or material domain – are "involved in the transformation of matter and energy from one pattern to another". The operational definition of information used by Porat and Rubin (1977) includes "all workers, machinery, goods and services that are employed in processing, manipulating and transmitting information" (Porat 1977). In simpler terms, we could generalize that information intensive industries handle "bits", whereas non-information intensive sectors handle "atoms". This dichotomy between atoms and bits has been used in a few studies (Karmarkar & Apte 2007; Brynjolfsson 2011; Neirotti & Paolucci 2014) that have investigated intersectoral differences in ICT use and in its economic impact. These studies have typically considered as information intensive sectors such as banking, insurance, software, consulting, retail, R&D, professional services, telecommunications, postal services, energy utilities, logistics, healthcare, education and publishing, electronics and computer manufacturing.

Based on the characterising traits described above, in information intensive industries firms have superior abilities in using ICT to support core activities, in identifying strategic opportunities by employing ICT in core processes (Bergeron et al. 1991) and in developing new mechanisms of value creation at the industry level (Cheng & Nault 2007). Such abilities result in higher spending on ICT assets and in the fact that in information intensive industries, ICT is more likely to be used for new sources of revenue generation rather than being simply a means of cost reduction and automation (Mithas et al. 2012). Also, firms in information intensive sectors may be more likely to have developed higher ICT management competencies given their higher need for ICT in their business activities and because they have started to invest in ICT initiatives earlier than firms in other sectors and have thus developed a greater knowledge base in this domain. Finally, these sectors usually count on a larger availability of production factors for innovation and entrepreneurship, such as relationships with universities, public research organizations, accelerators of entrepreneurial firms and venture capital funds (Malerba 2006). As a consequence of these characteristics, previous studies highlighted that the weight of information intensive industries in a country is strongly related to the level of an economy's development (Van Ark et al. 2008) and the fact that ICT-intensive industries experienced a productivity growth that was greater than other industries (Stiroh 2001).

3 Hypotheses

The improvements in labour productivity due to ICT can mainly be attributed to the rise of modern information systems that allowed information integration across a firm's functions and business divisions and in interfirm relationships. Integration and the break of information silos allowed business process reengineering (Davenport & Short 1990), the automation of routine administrative tasks and the delayering of organizations, thereby resulting in a reduction of labour into processes and activities generating a limited value added. This trend can be conceptualized as the role of ICT in allowing firms to "do the same things with less". Such processes started in more information intensive sectors in the 1990s and now include a larger number of enterprises in these settings due to the progressive commoditization of information systems into standardized "off-the shelves" packages. A second driver of productivity growth can lie in the possibility of "doing new things". In this vein, for firms in information intensive sectors, it is easier than their non information intensive counterparts to rely on multiple ways of creating economic value through ICT, given the inherent characteristics of their sectors. For instance, in these settings firms can move a greater part of their distribution over the Internet and by digitalizing their information products and services they have been able to move the richness/reach trade-off frontier in information further out (Evans & Wurster 1998). In the same way, in information intensive contexts, firms can offer a wider variety of customized products/services to the customer with a limited marginal cost of production and distribution. Customization increases economic value by increasing the customer's willingness to pay. In sum, firms in information intensive industries are more likely to have started earlier to deploy mechanisms of ICT use that are aimed at revenue generation, along the "traditional" mechanisms of value generation through cost reduction and automation of routine back-office activities. As such, we may expect what follows.

H1. Information Intensive industries exhibit a higher labour productivity.

Since the process of adoption and use of ICT is more recent and slower in non-information intensive contexts, we may also expect that in these contexts a large majority of firms have deployed simple and "commoditized" ICT systems aimed at reducing costs and automating routine administrative activities. In these settings, firms may not yet have exhausted the efficiency gains due to the use of ICT aimed at efficiency improvement and this may have led to a high productivity growth in recent years. On the other hand, in information intensive industrial contexts, the use of ICT for new revenue generation mechanisms may involve a lower number of firms and its business benefits may still not be visible at the industry level in the form of higher productivity (Brynjolfsson 2011; Brynjolfsson & McAfee 2014). As such, despite their higher expected labour productivity, information intensive sectors may experience a weak effect at the industry level stemming from the use of ICT to support new revenue generation mechanisms. Therefore, in recent years their labour productivity may have stagneted since the diffusion process of ICT usage patterns allowing firms to "do new things" has been limited. Thus:

H2. The labour productivity growth rate is higher in non-information intensive industries than in information intensive industries.

The fact that in information intensive industries firms have a higher strategic dependence on ICT implies that in these settings firms may more likely use ICT-based applications for broadening their repertoire of either competitive actions or strategic changes (Sambamurthy et al. 2003). Specifically, the digitalization of some goods and services gives firms the possibility to rapidly scale up operations and revenue – due to the low marginal costs in replicating information – (Brynjolfsson et al. 2008), to expand their operations (Malhotra & Temponi 2010) and to support product innovation and collaboration with partners (David et al. 2003). These mechanisms imply that information intensive sectors are more likely to be munificent environments that present opportunities for business expansion in existing and new markets and in markets that are rich in slack resources through which firms – even the less efficient ones – can pursue growth (Keats & Hitt 1988). The munificence of information intensive sectors can also stem from the increasing demand for ICT goods and related services (e.g., consulting on business process innovation) expressed by firms in more traditional and less information intensive industries. Therefore, information intensity can be associated with higher levels of munificence in the industry. Thus, we posit what follows.

H3. Information intensive industries show a higher munificence (growth in industry revenue).

Consistent with the fact that complexity in ICT initiatives has an external orientation, higher spending in ICT at the industry level may be associated with greater profit dispersion within the industry, since some firms cannot easily replicate the ICT-based initiatives introduced by leaders in ICT use (McAfee & Brynjolfsson 2008). There are indeed asset stock accumulation dynamics (Dierickx & Cool 1989; Eisenhardt & Martin 2000) and time compression diseconomies (Rumelt 1984; Dierickx & Cool 1989; Karmarkar & Apte 2007) that hinder followers to from bridging the gap in ICT use separating them from early leaders by simply accelerating the pace of annual expenditures on ICT. In other words, the ICT adoption process is cumulative and the opportunities for innovation enabled by ICT are path-dependent and firm-specific: the foundation of resources and capabilities already accumulated by a firm influences the marginal costs and the returns of adopting an ICT resource (Knott et al. 2003). Thus, although many technologies are readily available to firms on the open market, the need to predicate new ICT purchases on existing resources explains the response lag of competitors in replicating the IT resource portfolios of leaders in ICT use (Neirotti & Paolucci 2007). A second driver of profit dispersion due to ICT is related to the way it affects strategic agility. Although ICT is a potential enabler of a firm' strategic agility, it can also hinder agility in firms that are poor in ICT management capabilities (Lu & Ramamurthy 2011). Specifically, when ICT spending is not properly supported by ICT management competencies, ICT can ossify business processes rather than making them more agile and easy to reconfigure. Past studies have also shown that high ICT spending in the face of change and uncertainty reinforces the current underlying patterns and logic in managerial and organizational routines when firms lack the competences to manage investments in ICT. This leads to unintended firm rigidity in responding to radical environmental changes (Lu & Ramamurthy 2011). In sum, the technical and organizational complexity of ICT-initiatives with an external orientation and the ambivalent nature of ICT as a resource that enhances agility in some firms and hinders it in others, may imply that information intensive sectors have become more amenable to seeing profitability divides with the increasing importance and spending in ICT. Thus, we may expect the following.

H4. Information intensive industries show a higher profit dispersion.

Greater profit dispersion may come with a high market concentration that stems from two effects that are both related to the low ease of replication/imitability of many ICT projects (Rumelt 1984). First, some ICT-based initiatives – like the ones in digital platforms (Lucas et al. 2013) – entail high fixed development costs and low marginal costs. Also, network economies are evident in many information intensive industries. Due to the combination of these effects the distribution of performance at the industry level becomes increasingly skewed (Shapiro et al. 1999; Brynjolfsson et al. 2008). The second effect lies in the ability of larger firms to encode operational best practices in enterprise systems such as Enterprise Resource Planning (ERP) or Customer Relationship Management (CRM), and to replicate them across their operational units. This allows firms to achieve an operational predominance due to superior efficiency or organizational effectivness in many market segments at the same time, thereby leading to higher market concentration (Brynjolfsson et al. 2008). The combination of these forces has led to winner-take-all dynamics in the information intensive industries and hence greater concentration at the industry level. Thus, we expect the following:

H5. Information intensive industries show a higher industry concentration of sales revenue.

Despite an expected high level of market concentration, a high level of turbulence can characterize information intensive industries. Specifically, dominant positions cannot be maintained over the long term due to the low sustainability of competitive advantages based on ICT. This occurs for a variety of reasons. First, there is broad agreement that sectors with a high penetration of the Internet exhibit high price competition, lower barriers to entry and more competition from substitute products (Porter 2001). Second, the evolving nature of ICT implies a higher level of turbulence in technology and then in market conditions, since firms can always deploy the "next big thing". In the last decade, technology evolution in ICT has included new enabling technologies such as IoT, big data, machine and deep learning, as well as the resurgence of artificial intelligence, cloud computing and additive manufacturing. It is unlikely that all the firms that have dominated an era of ICT can still maintain their dominant position in the following one. This has been, for example, the case of Yahoo!, which has been displaced by Google in the industry of content distribution and advertising, by Apple in music distribution, and risks being displaced by other players whose value proposition lies in online streaming (e.g. Spotify). At the firm level,

these trends imply that ICT can offer firms an avenue for new competitive actions (Sambamurthy et al. 2003), which at the industry level result in a greater level of turbulence and into trends of of creative destruction (Schumpeter 1939; Schumpeter 1947). Based on these considerations, we offer the following hypothesis.

H6. Information intensive sectors show a higher of environmental turbulence (dynamism).

The higher expected level of turbulence in information intensive sectors implies that market concentration may also go hand-in-hand with a process of growth for small enterprises. High-growth phenomena for small enterprises can be the consequence of two distinct mechanisms. On the one hand, by deploying technologies based on a new paradigm and thanks to their entrepreneurial competencies, some new entrants can alter their way of doing business in the sector and the distribution of market shares in the industry and can thus bring a phase of creative destruction. On the other hand, the growth of small firms can also stem from an evolutionary approach that established firms can take in innovating their business model through e-commerce initiatives (Anderson 2006). Small and medium-sized enterprises are often specialized in niche products and can access the web platforms of retailers like Amazon, Google, eBay and Apple to target their customers on a broader geographical scale. This is more likely to occur in information intensive sectors like software, hospitality, retail and books, and can be enabled by technologies such as collaborative filtering (Piccoli & Ives 2005). In traditional manufacturing industries, this process is less likely since the growth of small enterprises has more frictions and obstacles since the product is idiosyncratic, and needs to be distributed along with a certain level of customer service and codesign. These factors often require the presence of intermediaries that cannot exploit the low marginal cost of distribution allowed by the Internet. In other words, manufacturing sectors cannot rely on the Internet and ICT mitigating the trade-off between richness and reach in information and this cannot enable the phenomena of disintermediation that can occur in information intensive contexts. In sum, based on these considerations we may expect what follows.

H7. Information intensive industries report a higher rate of high and medium growth enterprises.

4 Research Methodology

4.1 Empirical context: relevant country-level factors

Previous research on the business value of ICT has called for a broader perspective to take into account the role that contextual factors like country variables related to the political, social, educational, cultural and regulatory environments have in shaping the way ICT is used and the way it generates economic value. As this study is focused on a single country (Italy), it is not possible to assess how these contextual variables matter in shaping industry dynamics; however, it is possible to weight their influence. In this regard, it is important to point out that Italy has some unique conditions that can in part influence the generalizability of the theoretical considerations and the empirical evidence included in this study.

Specifically, Italy has an economic structure based primarily on manufacturing industries and SMEs, which explains its difficulties in accessing international markets: Italy is, in fact, the fifth-largest manufacturer in the world, but it is “only” the seventh exporting economy (OECD 2013b). Italian comparative advantage is mainly in medium-tech sectors such as machinery and equipment, mechanics and automotive. Compared to other developed nations, the Italian economy has a more diversified industry structure, which implies that a wide range of industries account for a relatively small share of the economy (OECD 2013b). In terms of supply of ICT products and services, this may turn out to be a disadvantage that can hinder the diffusion of new solutions, since ICT vendors and consultants have to sustain higher costs in adapting their ICT-based solutions to each industry-specific factor. This can slow down the diffusion of new technologies at the country level and can lead to a fragmentation of the supply of ICT services in smaller firms that have a limited industry specialization. In addition, the educational and technological conditions are not favourable to rapid ICT penetration. The number of graduates and investments in education are fairly below the OECD average (OECD 2013a). Also, according to OECD, Italy has the lowest percentage of ICT investment – 11.3% of total non-residential gross fixed capital formation – as opposed to 32.14% of the US and 25% of the UK and Sweden. Investments in ICT in Italy have also had a lower and decreasing incidence on the GDP compared to the investments of the

other largest European nations, such as France and Germany (OECD 2016). In this regard, Eurostat surveys indicate that the Italian delay is especially in those uses of ICT that are externally-oriented and thus entail more radical innovations aimed at "doing new things", whereas with reference to internally-oriented uses (which require more incremental changes) there are no critical delays. Finally, Italy has a regulatory and institutional environment that offers little support to entrepreneurship. In 2011, Italy was 80th in the ranking for the "Ease of Starting a Business", performing worse than the average of the 28 EU countries.

Based on these traits, we may expect that the educational, technological and institutional framework that support ICT-related innovation limits the transformational role that ICT can assume. In terms of industry dynamics this may result in limited growth for labour productivity for SMEs and a more reduced level of turbulence and munificence compared to the ones that information intensive sectors can report in other European countries such as Germany and France. In the same way, the level of market concentration can also be limited, possibly due to the lack of any Italian web platform like Google. The fact that only a very restricted number of firms can employ ICT as a transformational resource – altering ways of doing business and competitive equilibria – can lead to more visible trends of profit dispersion and to reduced turbulence (since ICT-based advantages can more easily be sustained over the long term) in information intensive sectors.

4.2 Data Sources and Variables

The literature suggests using different levels to examine the economic impact of ICT (Schryen 2013). One widely used classification distinguishes firm level, industry level and economy level (Brynjolfsson & Yang 1996; Devaraj & Kohli 2003; Chau et al. 2007). As our study is focused on the industry level, our data combine industry-level data on national accounting statistics collected from the Italian Bureau of Statistics (ISTAT) and an aggregation of firm-level data from AIDA, a Bureau Van Dijk dataset that collects data on all the Italian enterprises. We built this dataset specifically for this study and we took into account industries at the three-digit level of NACE code[1].

Our final data set for this study consists of 209 industries and around one million firms for which complete data on key variables of interest were available from 2002 to 2011. Of the 209 industries in our panel, 96 were classified as information intensive[2]. We also validated our measure of information intensity by assessing whether these industries report high ICT spending, considered as the ratio between software expenditures and sales revenues estimated at the industry level from 2008 and 2011 by ISTAT. Software investments are considered by ISTAT as the sum of self-produced and purchased software, which arguably are correlated with the total ICT spending (Oz 2005; Mithas et al. 2012). Although complete data on software expenditures were not available for the entire panel of our data set, the differences were negligible. To assess whether the software expenditures may be influenced by the weight of the large enterprises, we checked the correlation between software investments and the weight of the industry – as a percentage of the total yearly value added – and found it to be 7% (p-value of 0.069). Nevertheless, the average ratio between ICT expenditures and sales shows a higher share in information intensive industries – classified following Porat & Rubin's taxonomy (1977) – with an average ratio of 0.25% for information intensive industries compared to 0.07% for non-information intensive ones (p-value of 0%).

With regards to the dependent variables, Table 1 illustrates their definition, operationalization and the main references.

1 Banks, Savings Banks and Financial Institutions were excluded from the analysis due to the difference in their accounting system and their nature of operations.

2 The classification of the industries – following Porat and Rubin's taxonomy (1977) – in information intensive sectors (1) and non-information intensive sectors (0), is available on the link: https://drive.google.com/open?id=0B2RLCo95JkaiLWRETENFeEd0dFU

Variable Name	Variable operationalization and main references
Labour Productivity	Value Added per employee (value deflated to 2002 in thousands of euros) between 2002 and 2011 (Brynjolfsson et al. 2002).
Labour Productivity Growth	Logarithmic growth rate for productivity between 2002 and 2011.
Revenue Growth	Logarithmic growth rate for industry sales revenue (value deflated to 2002) between 2002 and 2011 (Brynjolfsson & Hitt 1996).
Industry Competition (Market Concentration)	Herfindahl-Hirschman Index (HHI) calculated as the sum of the squares of the market shares of the 100 largest firms within the industry.
Industry Turbulence (Dynamism)	Industry total sales from 2002 to 2011 were regressed on the year variable. Dynamism was thus calculated as standard error of the regression slope coefficient divided by the average industry sales (Dess & Beard 1984; Stoel & Muhanna 2009).
Industry Growth (Munificence)	Industry total sales from 2002 to 2011 were regressed on the year variable. Munificence was thus calculated as the regression slope coefficient divided by the average industry sales. (Dess & Beard 1984; Stoel & Muhanna 2009).
Profitability Dispersion	Interquartile range in Return on Assets (ROA) between 2002 and 2011(Brynjolfsson et al. 2008).
Number of High Growth Enterprises	High-growth enterprises (or "gazelles") are enterprises with average annualized growth in turnover greater than 20% a year, over a three-year period, and with ten or more employees at the beginning of the observation period (OECD 2012a).
Number of Medium Growth Enterprises	Medium-growth enterprises are enterprises with average annualized growth in turnover greater than 10% a year, over a three-year period, and with ten or more employees at the beginning of the observation period (OECD 2012a).
Revenue share of High-Medium Growth Enterprises	The revenue share of high-medium growth enterprises on the total industry revenue (OECD 2012a).
Employment share of High-Medium Growth Enterprises	The employment share of high-medium growth enterprises on the total industry employment (OECD 2012a).

Table 1 Description, operationalization and references for the main dependent variables

The majority of these measures have been widely used in IS research investigating the value of ICT and in some cases – such as dynamism and munificence – have their roots in strategic management research investigating industry dynamics. Instead, the construct related to high-growth SMEs has rarely taken into account in IS research, given the marginal weight of industry level data. The measure was thus taken by studies on entrepreneurship investigating the phenomenon of gazelles, i.e., small firms registering rapid and significant trends of growth in revenue and/or employment (OECD 2012a). In this regard, OECD defines gazelle enterprises with average annualized growth in turnover greater than 10% a year, over a three-year period, and with ten or more employees at the beginning of the observation period. Coherent with this definition, the incidence of high-growth SMEs in the industry structure was operationalized at three levels: i) the number of enterprises that could be defined as gazelles; ii) the weight of their revenue on the total industry revenue; iii) the weight of their workforce on the total industry employment.

Control variables. In estimating the effects of information intensive industries on industry dynamics we checked for other variables that can affect the dependent variables under analysis. First, we added two dummy variables to distinguish trade and services industries from manufacturing. Second, the year variables were used to take into account the economic cycle and in particular the economic crisis, whose effects were expected to be particularly evident in 2008 and 2011(OECD 2012b). Third, we took into account the number of firms in the industry since turbulence, munificence, market concentration and SMEs' growth can depend in large part on the number of firms. Also, the number of firms affects the diffusion process of ICT. In industries with a high number of enterprises, the diffusion of ICT solutions may take a longer time to involve the late majority since there is a higher number of enterprises that have to be "infected" by the diffusion process and many of them are smaller and thus face more obstacles to innovation adoption. Finally, we also included a distinction between high-tech and low-tech firms, which was based on including science based sectors from the Pavitt's taxonomy (Pavitt 1984) in the high-tech group defined by the United Nations in the International Standard Industrial Classification of all economic activities (ISIC Rev. 4). The inclusion of high-tech sectors was motivated by the fact that in manufacturing some sectors – despite having a material and non-information intensive nature – may follow dynamics that are similar to the one expected for information intensive sectors, given the importance of R&D projects. Since R&D projects are similar to ICT-based initiatives in terms of risk, asset stock accumulation and time compression diseconomies, we might expect high-tech manufacturing sectors to show high levels of turbulence and market concentration.

5 Findings

5.1 Descriptive Statistics

Table 2 provides the descriptive statistics on the entire variable used in regression models sorted by the information intensity of sectors (value 0 for non-information intensive industries and 1 for information intensive industries).

Variable Name	Information intensity	Obs.	Mean	Std. Dev.	Min	Max
Labour Productivity	0	977	53.4320	18.7115	5.3153	176.1574
(Value deflated to 2002 in k€)	1	793	65.1518	35.5382	7.0641	198.3048
Labour Productivity Growth	0	858	-0.0017	0.6668	-0.5597	0.3566
(LOG)	1	686	-0.0028	0.1043	-0.7401	0.8259
Revenue Growth	0	883	1.0118	0.1720	0.1575	1.7438
(LOG)	1	735	1.0236	0.1826	0.2358	1.9253
Industry Munificence	0	206	-0.1566	1.6535	-6.5476	5.6953
	1	163	0.2494	1.8898	-5.6416	4.7675
Profitability Dispersion	0	899	8.0257	2.4795	0.0000	19.2700
(IQR of ROA)	1	757	10.4647	3.2722	1.5000	19.8300
Market Concentration	0	778	0.0569	0.0676	0.0074	0.6486
	1	720	0.0896	0.1166	0.0006	0.9502
Industry Dynamism	0	197	-0.1636	1.6023	-2.6094	6.4992
	1	153	0.0335	1.6518	-2.6685	7.3938
Number of Hi-Medium	0	556	1.3813	0.6482	0.0000	3.0656
Growth Enterprises *(LOG)*	1	458	1.3984	0.5831	0.0000	2.6758
Revenue Share of High	0	565	0.1777	0.1590	0.0000	1.0000
Growth Enterprises *(%)*	1	480	0.1555	0.1259	0.0000	0.7911
Employment Share of High	0	553	0.1560	0.1464	0.0004	1.0000
Growth Enterprises *(%)*	1	458	0.1636	0.1362	0.0018	0.7685

Table 2 Descriptive Statistics

From descriptive statistics and from a further analysis on the compound average labour productivity growth rate – which is not reported in the paper but is available upon request from the authors – it is worth noting three facts. First, labour productivity growth rates have been limited in the period under observation, for both information and non-information intensive industries. Second, each of the two industry categories have had limited productivity growth even before the economic crisis occurred in 2008 (i.e., between 2002 to 2007). Third, the crisis has had a more negative impact on labour productivity in non-information intensive sectors. Since then, labour productivity has been rising at very limited annual growth rates in each of the two industry categories. Finally, a further significant fact is the limited weight of SMEs that have registered high growth in the period under observation. The percentage of SMEs falling into this category is 3.23%. It is slightly lower than the Eurostat estimate for Italy (5%) and considerably lower than the estimate for France (15%) (Eurostat 2014).

5.2 Regression Results

Table 3 presents the random effects panel estimates with robust standard errors. As a robustness check, we estimated the same models considering ICT spending and estimates were comparable to those reported in Table 3. The descriptive statistics and the random effect regression models are not reported in the paper because of page limit restrictions but are available upon request from the authors. Panel models (e.g. random and fixed effects models) assume exogeneity of the industry characteristics (e.g. information intensity). We conducted a Hausman test (Hausman 1978) to asses potential endogeneity of the information intensity variable by comparing fixed and random effects. We accounted for heteroskedastic error distribution and considered heteroskedasticity-consistent standard error for all of our models (Greene 2000). At the end, in order to take into account the exogenous and endogenous characteristics of each industry, weighted regression models were used to maximize the efficiency of parameter estimation and to assess industries' heterogeneity. Thus, incorporating a weight that measured the yearly value added of each industry as a percentage of the total yearly value added we considered the influence of each industry over the parameter estimates.

Hypothesis H1 predicted that information intensive industries would be likely to show higher productivity. The results support Hypothesis H1 because the coefficient estimate for information intensive industries in Model-1 is positive and statistically significant ($p<0.001$). Furthermore, the results show that ICT produces a greater effect on productivity in services than in trade and manufacturing ones. Hypothesis H2 predicted that non-information intensive industries would be likely to show a higher productivity growth rate. The results in Model-2 do not have the expected negative signs for information intensive coefficient but show a higher – albeit limited – productivity growth rate in information intensive sectors. Therefore, consistent with the evidence from the descriptive statistics previously highlighted in Table 2, we may conclude that Hypothesis H2 is not supported. In Hypothesis H3, we posited that information intensity could be associated with higher levels of industry growth. Specifically, Model-4 on industry munificence shows a positive and significant effect due to information intensity. Therefore, Hypothesis H3 is supported. Consistent with the dual nature of ICT, Hypothesis H4 predicted that higher spending in ICT at the industry level may be associated with greater profit dispersion within the industry. Model-5 shows a positive and significant effect for profit dispersion on information intensive industries. Thus, Hypothesis H4 is supported. In Hypotheses H5 we posited that the greater profit dispersion expected for information intensive sectors may come with a higher market concentration. The regression results in Model-6 show that the coefficient estimate for information intensive industries is positive and statistically significant; thus, Hypothesis H5 is supported. In Hypotheses H6 we posited that information intensive industries may show higher dynamism compared to their counterparts, due to more evident patterns of hypercompetition enabled by ICT. Model-7 shows a positive and significant coefficient for the information intensive sectors. Interestingly, the dummy associated with high-tech sectors had no significant coefficient, thereby suggesting that dynamism can be higher in information intensive industries than in high-tech ones. A Wald test comparing the magnitude of the two coefficients confirmed this evidence. Finally, Hypothesis H7 posited that the number of high-growth SMEs could be higher in information intensive sectors. Model-8 shows a significant negative effect of information intensive industries on the number of "gazelles". However, Model-9 and Model-10 show that information intensive sectors do not exhibit a higher revenue share due to gazelles at the industry level, but exhibit a higher percentage of employment due to these firms. Based on these results, Hypothesis H7 is thus not entirely supported.

6 Discussion and Conclusions

Our results suggest a significant effect of ICT on industry dynamics, thus confirming the strategic role of ICT. At a glance, our results indicate that information intensive industries showed higher productivity, higher market concentration, higher munificence and greater profit dispersion compared to their non information intensive counterparts. Our findings also confirmed the greater concentration and hypercompetitive nature of information intensive industries, thus extending to a less information intensive country like Italy the evidence of previous studies conducted in the US (Brynjolfsson et al. 2008). On the contrary, the higher market concentration and greater profit dispersion contradicted the prediction that claimed that ICT industries are subject to a destructive zero-sum form of competition that tends to alter industry structures in ways that dampen overall profitability (Porter 2001; Bayoumi & Haacker 2002). This may be because there is not sufficient variation across companies in the use of ICT for cost reduction. On the other hand, ICT-enabled revenue growth may have learning-based advantages that lead to higher path dependence and lower replicability of such advantages, thus enabling differential advantage in profitability (Mithas et al. 2012). Coherent with the dual nature of ICT, and like the unexplored results in previous studies, we found higher levels of munificence for information intensive industries. This result is consistent with the idea that ICT provides firms with a greater number of competitive actions and digital options (Sambamurthy et al. 2003). However, our research suggests that the possibilities of pursuing growth through ICT have involved a limited percentage of enterprises. Specifically, our statistics on productivity show limited growth over the entire period under observation. This contradicts the view of ICT as a General Purpose Technology (Stiroh 2001; Carr 2003; Davenport 2005) manifesting its effects at the industry level through pervasive diffusion. One of the more significant findings to emerge from this study is that the growth of small enterprises in information intensive industries is lower than the one observed in non-information intensive industries. Overall, there is no evidence of more extended disruptive innovation phenomena produced either by new entrants or small firms able to penetrate large international markets following a "Long-Tail" marketing approach (Anderson 2006),

which is different from what has been observed in other countries. This might be the consequence of the weaknesses of related and supporting industries (i.e., venture capital, startup accelerators) in Italy, a peculiarity of this country that is extensively reported in literature (Hall et al. 2012; Colombo et al. 2007; Malerba 2006). However, a recent study from the US reports similar results, showing that the number of startups has been object of a progressive reduction in high-tech sectors during the last decade (Hathaway 2014). This is a topic that has received limited attention at the industry level so far and it would be interesting to extend this study to other medium-tech countries with a large number of SMEs. Finally, our findings on higher dynamism and market concentration in information intensive industries have some important implications for managers since they showed that ICT favours temporary advantages and that large enterprises are in a more favourable position to benefit from ICT-based innovations. An interesting and intriguing outcome is that dynamism is higher in information intensive industries than in high-and-medium tech ones. This is probably due to the fact that the lower barrier to entry and the higher competition in information intensive industries make these sectors more contestable than R&D intensive ones. The higher contestability of information intensive sectors may be also due to the weaker appropriability regimes that these sectors exhibit compared to high-tech industries such as pharmaceuticals, biotech, etc. (Malerba & Orsenigo 1990; Breschi et al. 2015). Another consideration in favour of the higher dynamism that information intensive industries present compared to the high tech ones could lie in the risk due to the uncertainty of the future and states (Mata et al. 1995) that managing an ICT project portfolio presents compared to managing a portfolio of R&D investments, as measured by their relative contributions to the overall riskiness of the firm (Dewan et al. 2007). Future research could compare the risk factor of these two different types of projects.

In raising these points, our study has some limitations that are inherent in our research design and data availability. First, the phenomena observed in the study might not hold in countries with a different penetration of ICT technologies. Second, we may have biases in our results due to the omission of other relevant variables, such as the expenditures in R&D. However, previous studies have found that ICT investments had a more significant impact on firm profitability and industry competitive dynamics than R&D investments (Mithas et al. 2012). Third, in a world in which ICT is becoming increasingly pervasive, continually improving and catalysing new disruptive innovations, the dichotomy between information intensive industries and traditional industries will probably lose its relevance. From the managerial point of view, this means that we might see the effects of market concentration and profit dispersion reported in these studies in a greater number of sectors that have traditionally been considered "mature" from a technological and market standpoint. Although our study provides two different methods of explaining information intensity explanation both procedures require longitudinal data spanning many more years and specific industry data to gauge information intensity. It would be useful to investigate the moderating effect of information intensity on the relationship between information quality and industry outcomes. Fourth, our findings on turbulence, industry munificence and profit dispersion can be in part affected by the economic recession that started in 2008, which is the most severe of the last century. Despite we already control for year dummy variables in our empirical models, some results would have been more or less prominent in a period of "business as usual". Finally, because of the web-based nature of information intensive services, ICT's impact remains difficult to capture at the industry level in many service sectors. On the one hand, this is due to problems in the output measurements at country level, which do not take into account the market presence of foreign players, since they do not require geographical proximity in the sale of ICT-based services. On the other hand, because most new information intensive services have zero price, these services are virtually invisible in the national statistics (Brynjolfsson & McAfee 2014). They add value to the economy but not to the GDP. From a methodological perspective, both the delocalization of ICT services and the boost of free digital goods pose serious problems that further work in the services sector should explore.

To conclude, this study enriches our understanding on the disruptive effects exerted by ICT in the last decade and provides a base from which to continue the investigation of industrial change and competition dynamics and how they influence the origin of competitive advantages at the firm level. As the rise of smart and information intensive sectors may enable an enlargement of the trends of market concentration, profit dispersion, munificence and dynamism to other sectors seen in this study, these dynamics may have intensified in the last few years – and may continue to the future – due to the rise of a new paradigm in ICT.

	Model-1 *H1*	*Model-2* *H2*	*Model-3*	*Model-4* *H3*	*Model-5* *H4*	*Model-6* *H5*	*Model-7* *H6*	*Model-8* *H7*	*Model-9* *H7*	*Model-10* *H7*
Regressors	***Productivity***	***Productivity growth***	***Revenue growth***	***Industry Munificence***	***Profit Dispersion (ROA)***	***Market Concentration***	***Industry Dynamism***	***Rate of hi-medium Growth Enterprises***	***Revenue Share of hi-medium Growth Enterprises***	***Employment Share of hi-medium Growth Enterprises***
Information Intensive industries	31.0451***	0.0076†	0.0098**	0.5912**	1.0394**	0.0284*	0.3490**	-0.1601*	-0.0125	0.0100*
	(2.5330)	*(0.0039)*	*(0.0111)*	*(0.2090)*	*(0.4120)*	*(0.0182)*	*(0.1945)*	*(0.0727)*	*(0.0078)*	*(0.0072)*
High Tech industries	-4.8049	0.0005	-0.0301	-1.3779**	0.7497	0.0059	0.3048	0.1358	0.0347	0.0381†
	(5.4224)	*(0.0058)*	*(0.0241)*	*(0.4175)*	*(0.7390)*	*(0.0327)*	*(0.4256)*	*(0.1492)*	*(0.0248)*	*(0.0229)*
Medium-High Tech industries	7.9919**	0.0057*	-0.0169†	-0.2520	0.7171	0.0349†	-0.3944	0.1967*	-0.0112	0.0069
	(2.4667)	*(0.0027)*	*(0.0102)*	*(0.2728)*	*(0.4551)*	*(0.0207)*	*(0.2556)*	*(0.0963)*	*(0.0105)*	*(0.0098)*
Medium-Low Tech industries	7.2077*	0.0008	0.0038	-0.4417	0.4812	0.0108	0.2102	0.1028	0.0028	-0.0006
	(2.9593)	*(0.0029)*	*(0.0129)*	*(0.2854)*	*(0.4905)*	*(0.0222)*	*(0.2640)*	*(0.1023)*	*(0.0133)*	*(0.0123)*
Number of firms *(LOG)*	-0.7030	-0.0053*	-0.0062	-0.2380*	0.3192*	-0.0083	-0.3797***	0.3849***	-0.0130**	-0.0116**
	(1.0483)	*(0.0024)*	*(0.0044)*	*(0.1123)*	*(0.1437)*	*(0.0060)*	*(0.1094)*	*(0.0323)*	*(0.0044)*	*(0.0041)*
Services Industries *(Dummy)*	2.9545**	-0.0002	0.0196*	1.0894***	3.8146***	0.0272	0.3797†	-0.2706**	-0.0164†	0.0074†
	(2.7622)	*(0.0038)*	*(0.0121)*	*(0.2879)*	*(0.4629)*	*(0.0205)*	*(0.2733)*	*(0.1015)*	*(0.0123)*	*(0.0115)*
Trade industries *(Dummy)*	-11.2141***	0.0061	0.0448**	1.4021***	0.4662	-0.0043	-0.1008†	-0.4958†	0.0359*	0.0222†
	(3.3720)	*(0.0063)*	*(0.0154)*	*(0.3579)*	*(0.5708)*	*(0.0248)*	*(0.3407)*	*(0.1253)*	*(0.0145)*	*(0.1396)*
Lagged values of the growth variables *(Productivity - Revenue)*		-0.0007***	-0.0000***							
		(0.0001)	*(-0.0000)*							
Constant	54.7886***	0.0388**	1.0098***	0.8077†	5.2093***	0.0780**	1.278**	0.0598	0.2854***	0.2462***
	(5.3014)	*(0.0144)*	*(0.0216)*	*(0.4469)*	*(0.5777)*	*(0.0257)*	*(0.4410)*	*(0.1287)*	*(0.0215)*	*(0.0201)*
N	1770	1544	1618	368	1484	1355	349	932	958	930
adj. R^2	0.1609	0.1982	0.1803	0.1336	0.2279	0.1724	0.1421	0.1263	0.1083	0.1147

Table 3 Random effect regression models (robust standard errors in parentheses)
† p < 0.10, * p < 0.05, ** p < 0.01, *** p < 0.001

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