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EMPIRICAL ARTICLE

Open innovation and growth in IT sector

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Abstract IT services are overrepresented among high-growth innovative enterprises. The nature of innovation in IT requires knowledge search and collaboration, which together constitute the inbound open innovation (IOI) strategy. This study analyses whether the IOI strategies in IT service firms lead to different performance effects in comparison to other service and manufacturing firms. A quantile regression on multi-country data from the Community Innovation Survey indicates that innovative IT service companies share the same benefits from increased cooperation as other innovators, while displaying a strong growth dynamic compared to others. Therefore, IT service firms' growth differential may not be related to external cooperation and knowledge sourcing.

Keywords Inbound open innovation · Cooperation · Knowledge sourcing · IT services · High-growth enterprises

1 Introduction

It is widely acknowledged that not all economic activities innovate at the same rate. Among the most innovative activities are IT services. Moreover, this sector stands out in sector comparisons of the share of high-growth enterprises by economic

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activity. However, where there are leaders, there are also laggards. Learning about the innovation strategies of IT leaders may not only provide lessons for the IT laggards, but also support developments in the rest of the economy due to the sector's embedded role in production in practically every activity. Due to its organic role in other sector's value chains, innovation in IT services requires skills, capabilities and practices in collaboration and internalization of externally created knowledge and technologies, which are typical activities in open innovation (OI) strategies. Software- and technology-based industries provided the first-case studies for research on OI, with the open source software movement representing the most prominent cases in the OI literature (von Hippel 2001). While case studies and descriptive analysis of the innovation processes in IT services suggest a wide implementation of OI strategies, empirical research on the topic remains scarce. The objective of this study is to investigate empirically whether high-growth innovative IT service enterprises differ from those in other sectors in terms of growth derived from OI practices.[1]

Following Chesbrough et al. (2006, 1), OI is understood as "the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively. This paradigm assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to markets, as they look to advance their technology." The original definition of Chesbrough highlights both exploitation of internalized and externalized knowledge and technologies. In this research, the focus is on the impact of inflows and internalization of external knowledge on firm-level growth along the growth distribution.

High-growth enterprises are high on the political and research agenda in many countries and also at the EU-level. The underlying reason for the interest may be attributable to the job creation potential of high-growth firms. Several studies have concluded that young high-growth SMEs drive employment growth (Birch 1981; Schreyer 2000; Henrekson and Johansson 2009). Besides job creation, high-growth firms generate knowledge spillovers, hence benefitting other enterprises either through geographical proximity (Mason et al. 2009) or due to belonging to the same industry cluster (Brown 2011).

High-growth firms are to be found in all economic activities (Acs and Mueller 2008; Anyadike-Danes et al. 2009; Mason et al. 2009). Contrary to some common beliefs, their share is no higher in the high-tech manufacturing sector than in other sectors (Henrekson and Johansson 2010; Acs and Mueller 2008; Hölzl and Friesenbichler 2010). However, Davidsson and Delmar (2003), (2006) state that high-growth firms are overrepresented in knowledge-intensive business services (KIBS), as well as in young emerging industries, with many firms entering the market simultaneously. Among services, Ejermo et al. (2011) identify IT services and marketing; advertising, design and management consulting; and R&D laboratories and security services as fast-growing.

[1] In the empirical analysis, the definition for IT services is based on the NACE Rev. 2 classification. The included activities are listed in Table 4 in Appendix. In the text, the terms IT services, IT service firms and IT service companies are used interchangeably to indicate the same set of activities.

Firm growth as a phenomenon has been often studied from the perspective of accepting or rejecting ‘Gibrat’s Law’ (see Santarelli et al. 2006). According to this law, firm growth rate is independent of its size, i.e. it is random, and hence growth in this period does not predict the growth of tomorrow. This maxim has been empirically verified by Geroski (1999). It seems that the law does not hold for very high-growth enterprises. For such firms, there is a high positive autocorrelation between past and current fast growth (Lopez-Garcia and Puente 2011). New firms are not more likely to experience high growth, but surviving new firms have higher growth rates than established firms, although they are not more likely to experience extreme growth rates (Lopez-Garcia and Puente 2011). Overall, fast growth does not depend on firm size, but how growth varies in small and large firms. Organic growth is more likely in small high-growth firms, whereas in large firms, growth largely occurs via mergers and acquisitions (Schreyer 2000).

From the strategic management viewpoint, the rationale for extreme performance lies in the firm’s ability to select strategies that perfectly match the given context. There are several factors which differentiate high-growth firms from others. High-growth is more likely to be observed in an enterprise which has highly qualified human resources (Lopez-Garcia and Puente 2011). High-growth firms also invest more in training its workforces. According to the EIM (2006), high-growth firms have almost 70 % higher expenditure on training and the educational level of the workforce is higher. The importance of the quality of human capital is also acknowledged in human resource management (Lopez-Garcia and Puente 2011), where the emphasis is on compensation schemes and training (Barringer et al. 2005). In addition, the share of employees who hold a permanent contract increases the likelihood of reaching high growth (Lopez-Garcia and Puente 2011). All in all, commitment to employees differentiates high-growth firms from the rest. Parker et al. (2010) identify other internal functions that are highly important in high-growth firms, such as sales and marketing. High-growth firms do not suffer from a lack of external finance or financial debt (Lopez-Garcia and Puente 2011). They have high export-orientation levels (Parsley and Halabisky 2008) and are generally more internationally oriented (Mason and Brown 2010).

High-growth firms are more likely to be innovative (Coad 2009; Mason et al. 2009) and have a higher than average productivity growth rate (Mason et al. 2009). Moreover, Coad and Rao (2008) find that innovation is of much greater importance to high-growth firms than to low-growth firms. According to Hölzl (2009), the country’s proximity to technological frontiers matters for SME performance, with R&D having higher importance for high-growth SMEs in countries closer to these frontiers. In those countries, high-growth SMEs differ from other firms only by the fact that they are more innovative. In a study focusing on manufacturing enterprises in EU15, Hölzl and Friesenbichler (2010) find that high-growth firms are mainly an economic rather than a technological phenomenon.

Growth in IT services is dependent on the growth experienced in other economic activities. Furthermore, economic development in the sector is highly cyclical, partly due to technological cycles and the emergence of new technologies. The European IT service market is populated by micro firms with 94 % of firms employing an average of 1.6 people (FWC 2009). As a general purpose technology, IT acts as enabler of the novelty creation process; a catalyst for complementary co-inventions, and a facilitator of new modes of operation in other businesses (Jalava and Pohjola 2005). As an integral part of KIBS activities, IT services share the KIBS features of acting as a "facilitator, carrier or source of innovation" (den Hertog 2000). Hence, innovations in IT services have an extensive impact, since the novel goods and services developed in the sector contribute to finding solutions for the environmental, technological and societal challenges of our time. IT services produce applications and services that support global cooperation, networking, knowledge transfer, labour mobility, strategic agenda development and policy coordination in all fields of society (Vickery and Wunsch-Vincent 2009). Furthermore, innovations in the field of intelligent infrastructures, green technologies, nano- and biotechnologies are, to a great extent, based on the smart use of IT. Moreover, many advances in both the private and public sectors are built on innovations in software development. The existence of high quality local IT services supports the productivity and competitiveness of the whole economy by being the first stop for advice and support in the adoption and use of new applications in other sectors. (Hanna 2010).

Due to the need to integrate customer views into the outputs, collaboration is also a key success factor in business. According to FWC (2009), the best performing IT service SMEs collaborate and network with suppliers, customers and competitors more often than large firms and they also seek knowledge in external sources. Internal knowledge and resource bases can be broadened through R&D alliances and cooperative relations (Ahuja 2000). Furthermore, cooperation partners and networks support the detection of emerging value chains and play a role in gaining a position as first, second or third tier suppliers (FWC 2009). Hence, collaboration and knowledge search skills and practices are central to the analysis of the performance of IT service firms.

This paper contributes to the empirical literature on high-growth innovative IT service enterprises and OI in several important ways. Using a large firm-level dataset from the Community Innovation Survey (CIS) for six European countries, it analyses to what extent the success of high-growth innovative IT service enterprises is linked to their use of inbound open innovation (IOI) practices. Moreover, it evaluates whether IT service firms differ from high-growth innovative enterprises in other sectors in terms of profiting from IOI. The differential impact of IOI practices on IT services growth is evaluated analysing companies both in other services and in manufacturing. Through this exhaustive sector coverage, the study provides a significant contribution to a body of empirical literature focused almost exclusively on manufacturing. Methodologically, the analysis applies quantile regression, correcting for the selectivity bias that arises when focusing only on innovative companies. Notably, this approach allows the evaluation of the effect of IOI practices and other relevant variables at different points of the growth distribution, instead of focusing just on the impact on the mean. First, the results show that the gap in growth performance between IT services and other economic activities increases with the growth quantile, indicating that the higher the growth, the wider the gap to growth in IT services. Second, the implementation of cooperative IOI strategies increases growth at all levels. However, decreasing returns are observed, as in other studies that consider the impact of openness on measures of innovation performance rather than directly on enterprise growth (Love and Roper 2001; Katila and Ahuja 2002; Laursen and Salter 2006; Leiponen and Helfat 2010). Third, it seems that IOI does not have a stronger impact on growth in high-growth innovative IT service enterprises than on other high-growth innovative enterprises.

This paper is structured as follows: Section 2 presents OI as the general theoretical framework, while Sect. 3 provides a more detailed discussion of OI in IT services. Section 4 describes the regression model and the data used, followed by a presentation and discussion of the empirical results in Sect. 5. The final section contains conclusions and lines of further research.

2 Open innovation

The goal of an inbound open innovation (IOI) strategy is to support internal innovation processes by integrating knowledge available from external partners. An IOI strategy comprises the following activities, performed either simultaneously or separately: R&D cooperation, R&D partnerships or alliances, joint ventures, knowledge or information sourcing, or other kinds of inter-organizational interactions. Typical for inbound activities are actions such as collaboration with external parties and search for knowledge or information from external sources, such as customers, clients, suppliers, competitors, consultants, research organizations, universities, conferences, professional fairs, trade events, journals, and professional or industry associations. (Faems et al. 2005; Love and Roper 1999; Tether and Tajar 2008). Open innovation (OI) strategies have been shown to lead to higher profits than internally oriented strategies (Chesbrough 2006). Some studies conclude that OI is a substitute for internal R&D (Laursen and Salter 2006; Faems et al. 2010), whereas others conclude that it is a complement (van de Vrande et al. 2009). The adoption of OI strategies seems to vary according to technological domain and framework conditions (Gassmann and Enkel 2004; Perkmann and Walsh 2007). OI practices are most prevalent in industries characterized by fast technological development and high research intensity, such as high-tech manufacturing (Eisenhardt and Brown 1998; Fine 1998; van de Vrande et al. 2006; Schroll and Mild 2011). Results regarding firm size and the likelihood of implementing OI are mixed. On the one hand, there are results indicating that larger enterprises are more likely to rely on OI to create a competitive edge (Schroll and Mild 2011). On the other hand, some results state that smaller firms tend to favour OI practices (Henkel 2006; van der Meer 2007). For any type of OI strategies to be successfully implemented, the firms need to possess capabilities in internal learning and innovation (Huang 2011).

Integration of the different external partners into the innovation process has been found to improve innovation performance through the emergence of synergies, diversification of risk and creation of critical mass (Hoffman and Schlosser 2001;

Miotti and Sachwald 2003; Belderbos et al. 2004; Becker and Dietz 2004; Nieto and Santamaria 2007). Moreover, the external network acts as market radar in case of the emergence of disruptive technologies that might threaten the incumbent enterprises (Chesbrough and Crowther 2006). Furthermore, implementation of IOI strategy enables cost reduction and provides opportunities for risk sharing in R&D, and access to missing knowledge, as well as improving innovation processes, enabling entry to new markets. (Hoffman and Schlosser 2001; van de Vrande et al. 2009).

Cooperation with clients and suppliers is the most frequently performed OI activity (Schroll and Mild 2011). The least explored IOI activity is knowledge and information sourcing. According to Ahuja (2000), the benefits of cooperation consist of absorbing technology, gaining access to complementary resources, learning new skills, improving economic performance and the likelihood of survival, having control over relations with other companies, keeping abreast with competitors, enduring environmental shocks and improving efficiency. Additional benefits accrued due to opening up the innovation process in terms of cooperation entail stimulation of R&D investments (OECD 2009), improvement of innovation success (Miotti and Sachwald (2003); van de Vrande et al. 2009) and economic outcomes (Criscuolo and Haskel 2003; Belderbos et al. 2004). Frequency of cooperation is reported to vary by industry, but studies on the impact on innovation focusing on services are scarce. An exception to this is van de Vrande et al. (2009), who include in their sample both manufacturing and services but do not find any differences between the two in terms of innovation performance. In a study for manufacturing, Vega-Jurado et al. (2009) find that the more technology-intensive the industry, the more often the firms cooperate with external partners, especially with science-based actors. Moreover, internal R&D remains a strategic asset for product innovations which cannot be replaced by external sourcing. Overall, the authors conclude that the role of external knowledge acquisition for innovation performance is overstated. However, according to Tao and Magnotta (2006), technology sourcing brings a number of benefits. In their view, technology sourcing reduces costs related to internal R&D, adds flexibility to internal R&D and innovation development processes, accelerates the development process, and improves performance by providing an opportunity to integrate tested technologies to the firm’s own goods and services. Table 1 provides a summary of the IOI activities, partners and benefits.

Laursen and Salter (2006) and Oerlemans and Knoben (2010) add two important dimensions to describe the degree of openness: breadth and depth. The first refers to the number of partners, whereas the latter captures their importance as cooperation partners and sources of knowledge. Depth of search is linked to major product innovations, whereas breadth of search is connected to minor product innovations. Hence, it might be that the major product innovations are not based solely on external sourcing but require internal resources and innovation processes (Lee et al. 2010). Some results indicate that the higher the number or variety of different kinds of external partners (cooperation or sourcing), the better the innovation performance (Faems et al. 2005; Roper et al. 2008; Tether and Tajar 2008; Amara and Landry 2005; Chiang and Hung 2010). Similarly, the

Table 1 IOI activities, partners and benefits

Activities		R&D cooperation; R&D partnerships or alliances; joint ventures; knowledge or information sourcing; other kinds of inter-organizational interactions
Partners		Customers; clients; suppliers; competitors; consultants; research organizations; universities; conferences; professional fairs; trade events; journals; professional or industry associations
Benefits	Economic and financial	Higher profits
		Diversification of risk
		Improved economic performance
		Higher likelihood of survival
		Cost reductions
	Resources	Complements or replaces internal resources
		New skills and knowledge
		Creation of critical mass and synergies
	Market	Control over relations with other companies
		Keep abreast with competitors
		Endure environmental shocks
		Entry to new markets
		Market watch
	RD & Technology	Higher R&D investments
		Lower costs of internal R&D
		Risk sharing in R&D
		Technology absorption
	Production process	Increased flexibility and speed of internal R&D and innovation process
		Integration of tested technologies to own processes
		Improvement in efficiency
	Innovation	Improvement of innovation success

This table is based on Chesbrough (2006); Laursen and Salter (2006); Faems et al. (2010); Faems et al. (2005); Love and Roper (1999); Tether and Tajar (2008); Hoffman and Schlosser (2001); Miotti and Sachwald (2003); Belderbos et al. (2004); Becker and Dietz (2004); Nieto and Santamaria (2007); Chesbrough and Crowther (2006); Hoffman and Schlosser (2001); van de Vrande et al. (2009); Ahuja (2000); OECD (2009); (Miotti and Sachwald 2003); van de Vrande et al. (2009); Criscuolo and Haskel (2003); Belderbos et al. (2004); Tao and Magnotta (2006)

success of the search process depends on the number of nodes, i.e. partners, in the network (Schilling and Phelps 2007). Empirically, studies focusing on manufacturing have found that external knowledge sourcing improves innovation performance, although the relationship is characterized by diminishing returns to openness. Typically, this is expressed by an inverted U-shaped relationship between openness and performance, implying negative returns after a threshold point (Katila and Ahuja 2002; Laursen and Salter 2006; Leiponen and Helfat 2010; Love and Roper 2001; Rothaermel and Deeds 2006).

3 Open innovation in IT services

There are several specificities related to the market, technology and innovation processes in IT services that may support the adoption of inbound open innovation (IOI) strategies. Typical for IT services are technology-induced heightened global competition, fast pace in technological development, changing value chains and business models. Changing customer demand, new software development methods, broadband technologies, and more collaborative strategies affect the processes in IT services. Moreover, IT services produce applications and services that support global cooperation, networking, knowledge transfer and labour mobility in all fields of the economy.

Market demand drives sector and innovation development, and the customers have a strong role in innovation, particularly in the development of high-value processes. (FWC 2009) SMEs in IT services tend to increasingly rely on service development to increase productivity and competitiveness. In software enterprises, the implementation of innovative business strategies is associated with the availability of highly skilled people with diverse specializations (Harison and Koski 2010). The ability to commercialize the knowledge embodied in the workforce and organizational practices is a decisive factor in competition between enterprises (Sampson 2007).

Innovation in IT services contains several features of IOI strategy. First, innovations in IT services are based on hitching and matching existing knowledge and technologies. The cumulative nature of these innovations calls for knowledge of preceding sequential advances in technology. The state of the technology is easily accessed via formal and informal interactions and exchanges within the value chain. Second, IT service firms provide technology and system integration to other activities. In order to ensure the interoperability requirement, exchanges with actors along the value chain are needed. The novelty creation process requires client involvement; hence, the needs and wants of the clients act as the source of innovations in software firms (Akman and Yilmaz 2008). The role of external actors in the innovation process is not limited to the clients; in the software industry, other firms in the same business are rather perceived as partners than as competitors (Akman and Yilmaz 2008). Third, IT and IT services are characterized by fast technological development and declining prices over time, both of which contribute to the fast pace of competition in the sector. When enterprises have to redefine and reposition themselves in the technology market, they will benefit from having access to broader technology bases through open innovation (Stuart 1998). Overall, short product life cycles and increasing R&D costs are associated with wider adoption of open innovation (Gassmann and Enkel 2004; Chesbrough 2006). The more competition in the industry, the more likely it is for firms to use external sources to improve innovation performance in a cost-efficient manner. A wider breadth of inbound OI activities is more likely in the presence of a short-term orientation and growing development costs (Drechsler and Natter 2008). Taking these points into account, and the typically small firm size which contributes to limited internal knowledge and resource bases, the essential innovation capabilities and practices have to include knowledge search, collaboration and network building which are embodied in the IOI strategy.

Recently, Parida et al. (2012) analyse the impact of IOI activities on innovation performance in SMEs in the software sector. Inbound OI practices comprise technology scouting (systematic internal and external search), technology sourcing (acquiring external IPR), horizontal technology collaboration (partners outside the value chain) and vertical technology collaboration (partners along the value chain). The results indicate that technology scanning has a positive impact both on incremental and radical innovations. Technology scanning and horizontal technology collaboration are more important for incremental innovation, whereas technology sourcing and vertical technology collaboration boost radical innovations. Horizontal collaboration may refer to cooperation with competitors and, due to fear of opportunistic behaviour from counterparts; the extent of exchanged knowledge might be limited and lead only to incremental innovations (Christensen et al. 2005). The opposite impact may arise if the cooperation partner is a large client enterprise with resources invested in technology foresight and trend analysis. In such cases, this cooperation may lead the (high-tech based) SMEs to radical innovations (Parida et al. 2012).

Overall, the literature provides clear hints for the successful implementation of IOI strategies in high-growth innovative IT service enterprises. However, empirical studies on the topic remain scant. Hence, it is of interest to investigate whether the IT service sector differs from other sectors along the growth distribution and if the growth performance of high-growth innovative IT service enterprises can be traced back to the implementation of IOI strategies.

4 Econometric approach

As mentioned before, the empirical analysis relies on a quantile regression (QR) approach. Rather than focusing on the mean, QR allows the evaluation of the impact of the variables at different quantiles of the growth rate distribution. Given the focus on the effect of openness on high-growth enterprises, and therefore on the upper quantiles of the growth distribution, this feature is particularly useful for the current research. The Community Innovation Survey gathers information on sourcing and cooperation activities, as well as on other relevant innovation inputs and outputs, only for innovative companies. Companies that have not introduced an innovation in the reference period are not asked to provide the same information. Therefore, the analysis has to take into account that the structure of the questionnaire induces a problem of sample selection, as often discussed in the innovation literature (e.g. Mairesse and Mohnen 2002). In other words, the problem arises because the selection between innovative and non-innovative companies cannot be interpreted as the outcome of a random process. To address the sample selection bias within the specific QR framework, this paper follows a variant of the approach proposed by Buchinsky (1998).

As Huber and Melly (2012) point out, Buchinsky (1998, 2001) was the first to extend the series estimator proposed by Newey (2009) to the QR settings to address sample selection. Essentially, this two-step method consists of augmenting the QR by powers of the inverse Mills ratio (IMR) obtained from a preliminary estimation of the selection probability. A brief and effective description of Buchinsky's method, together with some comments on the underlying hypotheses, can be found in Albrecht et al. (2009, p 384).

Buchinsky's approach has been implemented in different variants by various studies, which tend to differ both in terms of the estimator adopted for the first-stage and in terms of the number of IMR powers included in the second step. For instance, Errico (2013) applies the semiparametric estimators proposed by Klein and Spady (1993) for the first-step estimates, while other studies have followed variants based on a probit model (e.g. Bosio 2009; Manquilef-Bächler et al. 2009).

In this paper, the first-step estimator is the semi-non-parametric estimator (SNP) proposed by Gallant and Nychka (1987), as implemented by De Luca (2008). In the second step, the QRs have been estimated with four, three and two terms for the IMR power series expansions, without detecting substantial differences in the results.

4.1 Model specification and estimation

Based on the econometric approach described in the previous section, the econometric model comprises two equations. The first equation models the probability of introducing an innovation and allows for the calculation of the IMR series expansion to correct for selectivity in the second equation, which in turn evaluates the impact of openness on the growth of innovative companies. Explanatory variables have been selected based on the above reviewed theoretical and empirical literature addressing both innovation likelihood and growth. Overall, the CIS data provide data on central features generally assumed to have an impact on innovation and growth.

The dichotomous-dependent variable in the first equation indicates whether or not the firm has introduced either a product or a process innovation in the reference period. A new product may be a good or a service.

The probability of innovation is expressed as a function of several independent variables which typically affect the innovation outcome. These variables include the size of the firm expressed as the logarithm of employment, whether the company is part of a group, whether the firm is active on the international market, and dummy variables for both sector- and country-specific effects.

Enterprise growth is the dependent variable in the second equation. Growth is expressed in terms of turnover and calculated as the logarithmic difference between the 2008 and 2006 values. The Eurostat-OECD definition for high-growth enterprises states: "All enterprises with average annualised growth greater than 20 % per annum, over a three-year period should be considered as high-growth enterprises. Growth can be measured by the number of employees or by turnover." (Eurostat and OECD 2007). This definition is developed for the purpose of data collection, statistics and indicator building. In empirical research, however, there is more freedom in this respect. The definition for high-growth enterprises may vary and actually be dependent on the context and/or the data. Therefore, instead of adopting absolute measures or setting thresholds, relative growth measures are applied.

In line with the theoretical premises, the independent variables include the breadth of both cooperation and knowledge sourcing activities. Following the literature (e.g. Laursen and Salter 2006; Love et al. 2014), a squared term for each of these variables is included to test the hypothesis of diminishing returns to openness. By using breadth measures, the adoption of open innovation practices is not treated as a binary decision, but rather as a matter of extent.

The breadth of knowledge sourcing is calculated by counting how many of the ten information sources listed in the survey are used by each enterprise in its innovation activities. These ten sources are classified into four main sub-categories: internal sources, market sources, institutional sources and other sources. Details for each sub-category are provided in Table 5 in Appendix. The breadth of knowledge sourcing varies therefore between zero and ten, ranging from zero for companies that do not report any source of information and ten for firms that use all the listed sources.

The breadth of cooperation is calculated by considering both the number of cooperation partners and their geographical location. For each of the seven potential cooperation partners listed in the CIS 2008 questionnaire (see Table 6 in Appendix), respondents are asked to indicate whether they engage in cooperation activities in five different geographical locations (own country, other Europe, United States, China or India, all other countries). The breadth of cooperation varies therefore from a minimum of zero for an innovative company without any cooperation to a maximum of 35 for a company cooperating with all seven partners in each of the five locations.

Given the focus on IT services, sector controls play an important role in the specification. In addition to intercept dummies for all sectors, an interaction dummy for IT services is applied to cooperation breadth and its square to assess differences in the impact of cooperation for IT service companies' growth. This study adopts a definition of IT services that rely on the NACE Rev. 2 classification. Based on this classification, it includes activities related to game and other software publishing, computer programming, consultancy, facility management and other IT services, data processing and hosting, web portals and repair of computers and communication equipment. The detailed classification is reported in Table 4 in Appendix.

The effect of firms' innovation activities on turnover growth is evaluated through a measure of innovation intensity, which is defined as the ratio of internal R&D per employee in 2008. A squared term of the same variable allows for possible non-linearities in the impact of R&D inputs. Firm size is accounted for by total employment, expressed in logarithm. A set of country dummies completes the econometric specification for the second equation.

4.2 Data description

The data used in the estimation come from the Community Innovation Survey (CIS) 2008 for selected western European countries.[2] These include France, Germany, Italy, the Netherlands, Portugal and Spain. The choice of countries provides a sufficiently heterogeneous representation of European countries within the constraints posed by data availability. The final sample includes around 64,000 observations for the innovation probability equation and almost 29,000 for the sales growth equation, clearing the ground of any concerns related to sample size.

The CIS is implemented through a harmonized questionnaire whose concepts are developed according to the Oslo Manual guidelines and definitions (OECD and Eurostat 2005). Use of CIS data, therefore, has the advantage of providing harmonized definitions for the relevant variables. This also facilitates comparability of results across studies. The information gathered by the survey refers to highly relevant features of enterprise innovation activities, covering different innovation types as well as important aspects of their development. The survey targets firms with 10 or more employees in core economic sectors, encompassing both services and manufacturing. The CIS 2008 data cover innovation activities over the three-year period from 2006 to 2008, although some of the variables are recorded only for 2008.

5 Econometric results

The econometric results for the first-step semi-non-parametric estimation of the innovation probability are reported in Table 2. Notably, the likelihood ratio test of the probit model against the semi-non-parametric estimator favours the choice of the former (p value $= 0.00003$).

While the quantification of the impacts based on marginal effects would be more informative, the main purpose of this equation is to correct for selectivity in the QR rather than providing a detailed picture of the determinants of innovation. However, based on the estimated coefficients, results indicate that larger companies are significantly more likely to introduce an innovation. The same applies to firms exposed to the international market and to those belonging to a group. Compared to manufacturing, which has been chosen as the reference category, firms in IT services and in other business services are significantly more likely to innovate. The opposite applies to all other sectors apart from finance, for which no significant difference is detected.

The QRs in the second step are estimated at the 25th, 50th, 75th and 90th percentile. Henceforth, the quantiles will be referred to as Q25, Q50 and so on. Results are presented in Table 3 for the IMR series expansion with four terms. The results obtained with fewer terms are only marginally different for some variables.

[2] The firm-level microdata coming from the Community Innovation Survey 2008 and used in this work were accessed with the permission of DG Eurostat, European Commission, at the Microdata Safe Center in Luxembourg. The authors bear sole responsibility for the results, their interpretation and conclusions.

Table 2 SNP Estimation of binary-choice model

	Coef.	Robust Std. Err.	z	$p > \|z\|$
Employees (log)	0.2793	0.0677	4.120	0.000
International market	0.5959	0.1410	4.230	0.000
Group status	0.1027	0.0305	3.370	0.001
Mining	−0.5094	0.1425	−3.570	0.000
EGW	−0.2535	0.0737	−3.440	0.001
Sales	−0.4078	0.1019	−4.000	0.000
Transport	−0.7333	0.1816	−4.040	0.000
IT Services	0.5713	0.1227	4.650	0.000
Media	−0.2012	0.0709	−2.840	0.005
Finance	0.0294	0.0338	0.870	0.384
Business services	0.0859	0.0425	2.020	0.044

Likelihood ratio test of Probit model against SNP model

Chi2(2) statistic = 20.8445 (p value = 0.00003)

Number of obs = 64376

Wald chi2 (16) = 27.16

Prob > chi2 = 0.0398

Source Authors' calculations on CIS 2008 data for France, Germany, Italy, the Netherland, Portugal and Spain

Country dummies and model constant are not reported

The coefficients for the breadth of cooperation and its square are statistically significant in all quantiles. Their signs show the presence of decreasing returns with respect to this dimension of openness. The lack of statistical significance at conventional levels for the IT interaction dummies in all quantiles suggests no differences for IT service companies in terms of benefits deriving from an increase in cooperation breadth.

Although the sign of the coefficients on the breadth of sourcing and its square from Q25 to Q75 would be compatible with the hypothesis of diminishing returns, their lack of statistical significance does not provide support for it. Only the squared term gains statistical significance at a 10 % level in Q90, but the signs of the effects are not aligned with the hypothesis. Overall, while additional analysis might reveal some role for sourcing breadth in promoting sales growth, the current statistical evidence does not support the presence of diminishing returns with the selected functional form. Finally, it is worth mentioning that alternative specifications which also included interaction terms for IT services did not reveal differences with regard to the impact of the sourcing variable.

The IT services dummy is positive and statistically significant in all quantiles. Its magnitude increases steadily from Q25 to Q90, indicating a growing differential impact on sales growth compared to the manufacturing sector reference. Based on the sector dummy coefficients, Fig. 1 shows the differential impact of IT services relative to other sectors when taking manufacturing as the base category. The

Table 3 Quantile regression results

	Q25				Q50			
	Coef.	Bootstrap Std. Err.	t	$P > \|t\|$	Coef.	Bootstrap Std. Err.	t	$P > \|t\|$
Employees (log)	0.00833	0.00242	3.45	0.001	−0.00180	0.00208	−0.87	0.386
R&D intensity	1.32E−06	4.28E−07	3.07	0.002	2.79E−06	4.32E−07	6.45	0.000
(R&D intensity)^2	−1.08E−11	3.96E−12	−2.74	0.006	−2.80E−11	4.65E−12	−6.02	0.000
Coop. Breadth	0.00405	0.00110	3.68	0.000	0.00284	0.00110	2.57	0.010
Coop. Breadth * IT	−0.00611	0.00600	−1.02	0.309	−0.00224	0.00805	−0.28	0.780
(Coop. breadth)^2	−0.00029	0.00008	−3.85	0.000	−0.00021	0.00008	−2.66	0.008
(Coop. breadth)^2 * IT	0.00098	0.00061	1.61	0.108	0.00044	0.00058	0.75	0.452
Sourcing breadth	0.00225	0.00233	0.97	0.334	0.00242	0.00236	1.03	0.305
(Sourcing breadth)^2	−0.00006	0.00019	−0.34	0.736	−0.00009	0.00020	−0.43	0.666
IT Services	0.06056	0.00975	6.21	0.000	0.11365	0.01185	9.59	0.000
Mining	−0.05714	0.02175	−2.63	0.009	−0.04103	0.01465	−2.80	0.005
EGW	0.05637	0.00774	7.28	0.000	0.07304	0.00951	7.68	0.000
Sales	0.01445	0.00689	2.10	0.036	0.00812	0.00505	1.61	0.108
Transport	0.04479	0.01099	4.07	0.000	0.03595	0.00662	5.43	0.000
Media	0.00063	0.00989	0.06	0.949	−0.02875	0.00961	−2.99	0.003
Finance	0.03696	0.00622	5.95	0.000	0.10411	0.01029	10.11	0.000
Business services	0.08879	0.01041	8.53	0.000	0.11204	0.01095	10.23	0.000
Number of observations: 28997								
	Q75				Q90			
	Coef.	Bootstrap Std. Err.	t	$P > \|t\|$	Coef.	Bootstrap Std. Err.	t	$P > \|t\|$
Employees (log)	−0.01609	0.00308	−5.22	0.000	−0.02190	0.00693	−3.16	0.002
R&D intensity	6.01E−06	6.30E−07	9.55	0.000	1.10E−05	1.43E−06	7.72	0.000

Table 3 continued

	Q75				Q90			
	Coef.	Bootstrap Std. Err.	t	$P > \|t\|$	Coef.	Bootstrap Std. Err.	t	$P > \|t\|$
(R&D intensity)^2	−5.35E−11	5.76E−12	−9.29	0.000	−9.06E−11	1.18E−11	−7.70	0.000
Coop. Breadth	0.00351	0.00133	2.63	0.009	0.00523	0.00296	1.77	0.077
Coop. Breadth * IT	−0.00439	0.00922	−0.48	0.634	0.01850	0.02035	0.91	0.363
(Coop. breadth)^2	−0.00022	0.00007	−3.10	0.002	−0.00040	0.00017	−2.34	0.019
(Coop. breadth)^2 * IT	0.00013	0.00066	0.19	0.846	−0.00160	0.00121	−1.33	0.185
Sourcing breadth	0.00459	0.00357	1.28	0.200	−0.00654	0.00710	−0.92	0.356
(Sourcing breadth)^2	−0.00019	0.00031	−0.60	0.547	0.00098	0.00058	1.67	0.095
IT Services	0.19461	0.01917	10.15	0.000	0.32859	0.02907	11.30	0.000
Mining	−0.03509	0.02980	−1.18	0.239	−0.12401	0.02826	−4.39	0.000
EGW	0.09104	0.01790	5.09	0.000	0.16987	0.04671	3.64	0.000
Sales	−0.00428	0.00917	−0.47	0.640	−0.02696	0.01645	−1.64	0.101
Transport	0.03124	0.01306	2.39	0.017	0.04299	0.02864	1.50	0.133
Media	0.01141	0.01824	0.63	0.532	0.02178	0.08370	0.26	0.795
Finance	0.19141	0.01192	16.06	0.000	0.20523	0.02198	9.34	0.000
Business services	0.18472	0.02172	8.50	0.000	0.30918	0.05693	5.43	0.000
Number of observations: 28997								

Source Authors' calculations on CIS 2008 data for France, Germany, Italy, the Netherland, Portugal and Spain

Country dummies, model constant and IMR terms are not reported

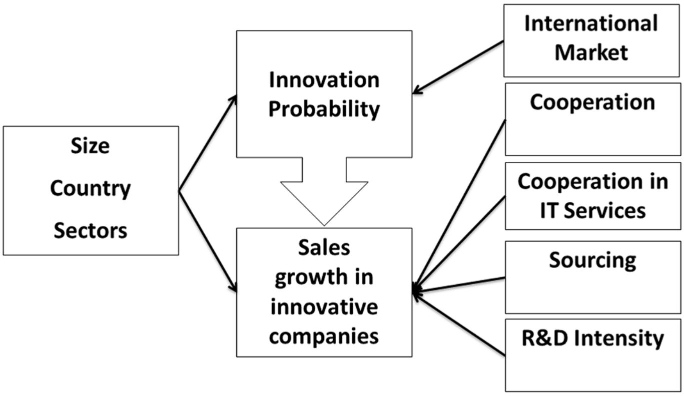

Fig. 1 Estimated model

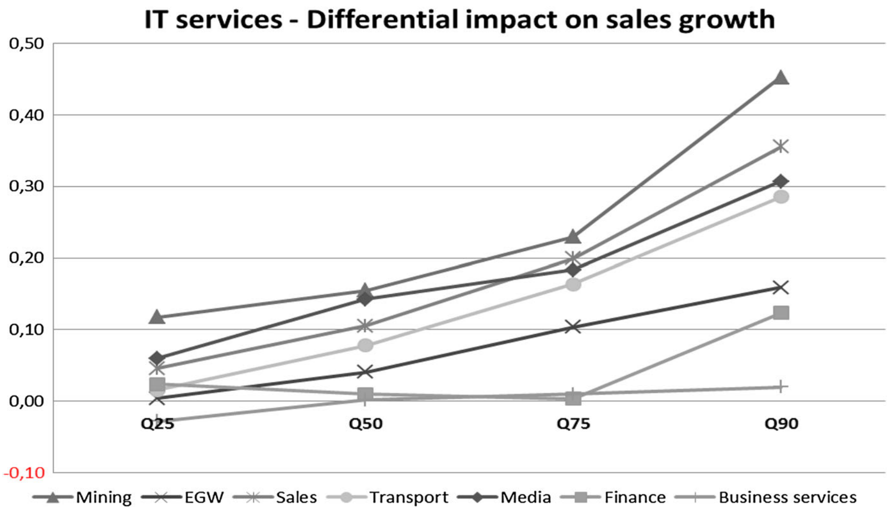

Fig. 2 Differential impact on sales growth of IT services by quantile. *Source* Authors' calculations on CIS 2008 data for France, Germany, Italy, the Netherlands, Portugal and Spain

chart shows that the differential impact is positive with respect to all sectors starting from Q50. Moreover, with the exception of financial services, the differential impacts uniformly increase from Q25 onwards. Although precise conclusions would require evaluating the statistical significance of the differential impacts, the overall results suggest that the firms in IT services tend to grow the quickest among the fastest growing firms (Fig. 2).

The impact of company size decreases monotonically along the growth distribution, and also presents an inversion in the sign of the effect. In particular, size exerts a positive and statistically significant impact on sales growth in Q25 before losing significance in Q50 and then turning negative and significant in the upper quantiles of the sales growth distribution. It appears therefore that larger firms grow faster among slower growing firms and grow slower among the fastest growing ones.

Finally, the coefficients for R&D intensity and its square are significant in all quantiles. Their sign indicates a less than proportional increase in the impact on sales growth.

5.1 Discussion of the results

The obtained results are aligned with some stylized facts on innovation likelihood in different firm types. The bigger the firm, the more likely it is to innovate. Similarly, the innovation likelihood increases if the firm is engaged in selling its goods or services in international markets. However, the main interest in this study lies in the growth impacts of various innovation activities and enterprise characteristics.

Some interesting findings are observed on the growth performance of IT services vis-à-vis other economic activities. In all economic activities, R&D intensity seems to have positive yet decreasing impact on growth at firm-level. Moreover, the results suggest that the firms in IT services grow fastest among the high-growth enterprises. In other words, there exists a growth gap between IT services and other economic activities, which tends to increase along the growth distribution. The growth gap remains the smallest with respect to business services and finance. In terms of firm size, larger firms grow faster among the low-growth firms but slower among the high-growth firms. This result highlights the relative importance of small firms among the high-growth enterprises. Unfortunately, the data did not allow for controlling for firm age, which would have contributed to the discussion on young innovative high-growth enterprises.

Results on the impact of inbound open innovation (IOI) confirm and extend previous empirical results. Indeed, implementation of IOI strategy improves growth performance. However, among the IOI activities, only cooperation turns out to have a significant and positive impact. Echoing earlier studies, cooperation breadth has a positive, yet decreasing impact on firm growth described by an inverted U-shaped relationship. As mentioned earlier, many studies concluding on the decreasing returns in terms of cooperation have so far focused solely on the manufacturing sector and on measures of innovation success. The current research extends, therefore, these results to enterprise growth and, as far as this dimension is concerned, to services.

Overall, growth in IT service enterprises benefits from IOI practices. However, these results do not allow us to conclude that the impact of IOI on high-growth IT service enterprises would differ from IOI impact in other enterprises. It seems that the driver of the growth gap between IT services and other economic activities should be looked for in other factors that this analysis does not or is not able to control for. One of these factors could be the applied set-up for comparison. A more detailed split of economic activities allowing for the contrast of IT services with KIBS and other sectors separately might provide results to support the hypotheses. Another factor could be the quality of the workforce. Previous studies have suggested that high-growth firms not only have highly educated workforces, but also spend more than other firms in training (EIM2006; Lopez-Garcia and Puente 2011). Sampson (2007) presents conclusions along similar lines stating that the knowledge embodied in employees and organizational practices enhance the competitiveness of and improve commercialisation in IT service firms.

It is worth mentioning that there are also some studies that present less optimistic conclusions on the impact of external networks for innovation, and hence on growth. For example, Oerlemans et al. (1998) and Freel (2003) state that the impact of external networks is relatively restricted and that internal resource is what ultimately drives innovation performance. Nelson (2000) reminds us of the possibility of overestimating the impact of external partners and networks, and Coombs (1996) concludes that outsourcing R&D may actually have a negative impact on the firm's core competences.

6 Conclusions

In recent years, high-growth innovative enterprises have received a lot of attention among scholars and policymakers alike. Unanimously, it can be said that IT services as part of knowledge-intensive business services are overrepresented among the high growers. So far, the identification of which innovation strategies boost the exceptional growth in IT services has remained underexplored. In qualitative studies, it has been found that IT services have actively implemented open innovation strategies, composed of cooperation and knowledge sourcing practices. Hence, the current study integrates these three aspects in order to shed some light on the innovation strategy that might drive the growth gap between IT services and other economic activities.

Using data from the Community Innovation Survey for six EU countries, a quantile regression is estimated to address the effects of IOI strategies and firm characteristics along the entire growth distribution, not just at the mean. Due to the structure of the data, the need to control for selection bias in the quantile regression arises. Hence, a two-step approach is applied. The first phase yields the selection control from the innovation-likelihood regression, whereas the second phase estimates the growth regression.

Given the lack of empirical studies focusing on the topic in the service sector, the paper provides some new insights into the discussion on the composition of high-growth firms and the role played by open innovation in this context. Clear differences between sectors and firm size among high-growth enterprises are observed. The IT service firms stand out with their fastest growth performance among the high-growth enterprises. The growth gap is the smallest with respect to business services and finance. Larger firms grow faster among the low-growth firms but slower among the high-growth firms.

Cooperation appears as the effective IOI strategy to improve growth performance independently from the sector of economic activity. Moreover, cooperation breadth has a positive but decreasing impact on firm growth. Hence, it appears that the reasons for the high-growth in IT service firms should be looked for in factors other than the firms' cooperation practices. In terms of managerial implications, the results show that cooperation is important for growth and companies should regard it as a strategic practice. At the same time, the findings suggest that cooperation activities do not seem to be responsible for faster growth in IT services compared to all other economic sectors. As IT services show the highest growth among the sectors, it might well be that the governance of this growth calls for extensive resources and hence other activities, such as cooperation partner management, suffer effects of the strain on resources. Unfortunately, the study gives little guidance with respect to additional contributing factors since these have not been considered in the analysis.

These results open some avenues for future studies. While the data used in the study are adequate in terms of information on innovation practices, expenditures and output, it does not provide sufficient information in terms of intangible inputs such as human resources. Moreover, qualitative research should not be underestimated in terms of its contribution to understanding innovation and growth strategies of high-growth innovative IT service enterprises. Other factors to be looked into when analysing in the future the differences in the impact of IOI between economic activities include the proper level of aggregation of various innovation practices. It might be that aggregating all the cooperation and knowledge sourcing partners is not the best strategy. The positive growth impact arising from cooperation with or sourcing from certain partners may need varying time lags. It has been found that suppliers and customers are the most valuable partners, but it might also be that their impact on growth becomes more apparent sooner, whereas the impact of science-based partners materializes over a longer time scale. Hence, analysing the impact of different partners in isolation might provide further interesting insights into the topic.

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Appendix

See Tables 4, 5, and 6.

Table 4 Definition for the IT services

NACE Rev. 2 Class	Definition
58.21	Publishing of computer games
58.22	Other software publishing
62.01	Computer programming activities
62.02	Computer consultancy activities
62.03	Computer facilities management activities
62.09	Other information technology and computer service activities
63.11	Data processing hosting and related activities
63.12	Web portals
95.1	Repair of computers and communication equipment

Table 5 Information sources in CIS 2008

Information source	
Internal	Within your enterprise or enterprise group
Market sources	Suppliers of equipment, materials, components, or software
	Clients or customers
	Competitors or other enterprises in your sector
	Consultants, commercial labs, or private R&D institutes
Institutional sources	Universities or other higher education institutions
	Government or public research institutes
Other sources	Conferences, trade fairs, exhibitions
	Scientific journals and trade/technical publications
	Professional and industry associations

Source CIS 2008 Harmonized Survey Questionnaire

Table 6 Type of cooperation partners in CIS 2008

Type of cooperation partner
A. Other enterprises within your enterprise group
B. Suppliers of equipment, materials, components, or software
C. Clients or customers
D. Competitors or other enterprises in your sector
E. Consultants, commercial labs, or private R&D institutes
F. Universities or other higher education institutions
G. Government or public research institutes

Source CIS 2008 Harmonized Survey Questionnaire

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