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ICT-enabled Innovation

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Introduction

Business innovation is regarded as a key determinant of both individual business success and national economic growth. At the micro level, business innovation has the potential to increase consumer demand through improved product or service quality and simultaneously decrease production costs. More importantly, strong business innovation at a macro level increases multifactor productivity thus lifting international competitiveness, economic growth and real per capital incomes. Therefore, it is of great interest to businesses and policy makers alike, to identify those factors which stimulate innovation and to understand how these factors interact.

ICTs have the potential to increase innovation by speeding up the diffusion of information, favouring networking among firms, enabling closer links between businesses and customers, reducing geographic limitations, and increasing efficiency in communication.

Previous analysis confirms that ICTs play an important role in enabling business innovation, e.g. Brynjolfsson and Hitt, 2000; Gago and Rubalcaba, 2007; Crespi et al., 2007; Eurostat, 2008; Van Leeuwen, 2008; Polder et al., 2009; OECD, 2010. These studies, however, differ as regards their methodology and country coverage or they do not focus on the link between ICT use and innovation.

ICT as enabler of firm innovation

ICTs are a valuable source of business innovation because they provide substantial efficiency gains. As Koellinger (2005) puts it "ICT makes it possible to reduce transaction costs, improve business processes, facilitate coordination with suppliers, fragment processes along the value chain (both horizontally and vertically) and across different geographical locations, and increase diversification."

Each of these efficiency gains provides an opportunity for innovation. For example, IT automated system links lead to more streamlined businesses processes and allow staff to be more responsive to emerging customer needs. Similarly, technologies which allow staff to effectively communicate and collaborate across wider geographic areas will encourage strategies for less centralized management, and more flexible external relations, all of which involve different types of innovative activity.

Gretton, Gali and Parham (2004) suggested two reasons why business use of ICT encourages innovative activity. Firstly, ICT is a 'general purpose technology' which provides an 'indispensable platform' upon which further productivity-enhancing changes, such as product and process innovations, can be based. For example, a business which establishes a web presence sets the groundwork from which process innovations, such as electronic ordering and delivery, can be

easily developed. In this way, adopting general purpose ICT makes it relatively easier and cheaper for businesses to develop innovations.

Secondly, the spillover effects from ICT usage, such as network economies, can be sources of productivity gains. For example, staff in businesses which have adopted broadband Internet are able to collaborate with wider networks of academics and international researchers more closely on the development of innovations and keep abreast of current consumer trends. These are spillover benefits because the R&D efforts of other researchers in the collaborative group can be appropriated by all.

Econometric analysis confirms that ICTs play an important role in enabling business innovation. Gago and Rubalcaba (2007) find that businesses which invest in ICT, particularly those which regard their investment as very important, or strategically important, are significantly more likely to engage in services innovation.

A number of studies have demonstrated that valuable insight into the relationships among innovation and ICT variables can be generated by linking firm level datasets.

Abello and Prichard (2008) link the Innovation Survey and the Business Use of Information Technology Survey in Australia and find that different ICT technologies are associated to different types of innovations. For example, connection to the internet via cable modem is significantly associated with innovation in products, while for organisational/managerial operations, wireless connection is more significant.

The Eurostat ICT impacts project (Eurostat, 2008) reveals that – on average – ICT usage is positively related to firm performance. The strength of these results varies over countries, however, and it also appears that the benefits of different types of ICT usage are industry specific. Van Leeuwen (2008) by linking Eurostat firm-level data on ICT use with estimates of ICT and other capital stocks derived from firm-level investment time series and accounting data on firm performance, shows that e-sales and broadband use affect productivity significantly through their effect on innovation output. Broadband use, however, only has a direct effect on productivity if R&D is not considered as an input to innovation.

This approach is further developed by Polder *et al*. (2009). Their study finds that ICT investment is important for all types of innovation in services, while it plays a limited role in manufacturing, being only marginally significant for organisational innovation.

The findings by OECD (2010) support the hypothesis that ICTs act an enabler of innovation, in particular for product and marketing innovation. However, these effects are large both in manufacturing and services. No evidence is found, that ICT use increases the capability of a firm to cooperate with other firms/institutions, nor that ICT intensive firms have higher capacity to develop innovation in-house or to introduce more "innovative" (new-to-the-market) products. These results suggest that ICTs enable firms to adopt innovation but they do not increase their "inventive" capabilities, i.e. the capability to develop new products and processes.

Another line of literature motivates the importance of ICT for organisational innovation (see Brynjolfsson and Hitt, 2000 for a survey). Case studies reveal that the introduction of information technology is combined with a transformation of the firm, investment in intangible

assets, and of the relation with suppliers and customers. Electronic procurement, for instance, increases the control of inventories and decreases the costs of coordinating with suppliers, and ICT offers the possibility for flexible production: just-in-time inventory management, integration of sales with production planning, et cetera. A lack of proper control for intangible assets is seen as a possible candidate for explaining the differences in productivity growth that are observed between Europe and the US.

The available econometric evidence at firm level shows that a combination of investment in ICTs and changes in organisations and work practices facilitated by these technologies contributes to firm productivity growth. Crespi, Criscuolo and Haskel (2007) use CIS data for the UK and find a positive effect on firm performance of the interaction between ICT and organizational innovation.

ICT, Knowledge Flows and Innovation Networks

Information and communication technologies can also be seen as a source of innovation because they enable closer links between businesses, their suppliers, customers and competitors and collaborative partners. These agents are all understood to be important sources of ideas for innovation. By enabling closer communication and collaboration, ICT assists businesses to be more responsive to innovation opportunities and provides significant efficiency gains. For example, having ICTs such as broadband Internet, web presence and automated system linkages, assists businesses to keep up with customer trends, monitor competitor's actions and get rapid user feedback, thereby assisting them to exploit opportunities for all types of innovations.

Besides enabling networks among businesses, suppliers, customers, competitors and collaborative partners, in recent years, the idea has emerged that the diffusion of ICT, particularly Internet, has significantly reduced the geographic barriers to knowledge flows and innovation networks (Friedman, 2005). In the words of Friedman's bestseller, "the word is flat": information travels around the globe at rapid speed so that ideas generated in California spread to Calcutta or Coventry through the Internet, conferences, telephone and other communication devices at an unprecedented rate, and geography plays little role. The diffusion and adoption of ICT, therefore, would have increased the opportunities to innovate for all countries, regions and firms.

There are, however, several counter-arguments that suggest that "the world is spiky" (Florida, 2005) and geographical proximity continues to exert a strong influence over knowledge flows and innovation networks.

First, some recent studies have showed that the propensity to cite prior art and scientific knowledge is correlated significantly with spatial proximity of inventors (Guellec and Thoma, 2008; Usai 2008; Criscuolo and Verspagen, 2008).

Second, there is little evidence that distance has become any less important for trade flows (Disdier and Head, 2008; Leamer, 2007), and some evidence that its importance may have actually increased (Evans and Harrigan, 2005). The deployment of these ICT networks can go with a reinforced need to face to face contact, there seem to be a certain form of complementarity between new means of communication and face to face contact (Gaspar and Gleaser, 1998) Distance still matters if face-to-face interactions are important even in high tech sectors, because knowledge is tacit and hard to codify.

The discussion of the channels of knowledge flows cannot be dissociated from the analysis of the conditions underlying the ability of firms to benefits from these flows. Absorption capacities based on internal resources, human capital, diversity of competencies and extent of the technological gap between transmitters and receivers of knowledge may all play a role in describing observed differences in knowledge diffusion efficiency (Autant-Bernard and Massard, 2009).

Understanding the role of ICT in knowledge diffusion and innovation networks is key to understanding a number of innovation policies, namely the intellectual property rights regimes, the system of R&D subsidies, and the broader regulatory framework. There are three main line of research trying to disentangle the role of ICT in knowledge diffusion and innovation networks.

A first line tries to identify the transfer of technology indirectly by examining changing rates of total factor productivity (TFP) growth across countries and assuming that the faster productivity growth rates of (some) countries or industries that lie further behind the frontier is due to the transfer of ideas. A recent development of this approach explores the role of knowledge flows and TFP growth by using direct survey data on knowledge flows linked to firm-level TFP growth data (Crespi *et al*., 2007).

A second approach takes a production function and includes the R&D of other countries as an additional variable. These papers tend to find that the R&D of other countries is valuable, but usually not as valuable as R&D in domestic economy. This approach has the advantage of using a direct measure of technology (Bernstein and Mohnen, 1998; Griffith, Harrison and Van Reenen, 2006).

Finally, the third line of research uses patent citation as a direct measure of the transfer of knowledge. The citation of one patent by another strongly suggests that the first patent contained useful knowledge which helped the second innovation. This approach appears promising to investigate the role of ICT. On the one hand, it permits to examine whether knowledge spread more quickly in technological fields that are ICT intensive, eg: computer, communication, biotechnology, etc (Spiezia, 2008). On the other, one can test if the observed differences in the speed of knowledge diffusion through time and across can be ascribed to the diffusion of ICT (Griffith, Lee and van Reenen, 2007). The direct or indirect economic impact of online social networks would also be considered whenever suitable data are available

Issues for discussion

The correlation between IT intensive firms and innovation does not answer the critical question about causality: does IT enable innovation or are innovative firms simply willing to spend more on IT? The answer to this question has crucial implication for policy. If ICT is an enabler of innovation, then policies have a sound rationale for supporting their adoption and diffusion among firms. On the contrary, if innovative firms simply adopt ICT more frequently, then policy should not target ICT *per se* but the broader set of assets (skills, intangibles, R&D, etc.) which the innovative capability of firms rely upon.

Country-specific studies exploit the richness of national micro level datasets to measure innovation and ICT use. As a result, their findings can hardly be compared internationally and this limits significantly the scope of what policy can learn from the experience of other countries.

Previous experiences, eg: the OECD Micro Data Projects and the Eurostat ICT impacts project, show that a network of researchers in the field of ICT and innovation would be in a position to coordinate the ongoing research based on the same methodologies and, comparable data sets.

Understanding the role of ICT in favouring knowledge sharing and creating innovation networks is important for the formulation of policies related to R&D subsidies and intellectual property rights. However, the difficulty in evaluating the implications of the creation of these networks of knowledge is given by the lack of suitable data and the recent nature of the introduction of ICT which allow for evaluation only over a short period.

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