

Has the Internet Fostered Inclusive Innovation in the Developing World?

CAROLINE PAUNOV^a and VALENTINA ROLLO^{b,*}

^a *OECD, France*

^b *International Trade Centre, Switzerland*

Summary. — The adoption of the Internet has been widespread across countries, making much more information available and thus facilitating knowledge diffusion among businesses to boost their innovation performance. However, differences in firms' capabilities to use this newly available knowledge could create a new "digital divide" instead. Using 50,013 firm observations covering 117 developing and emerging countries over the 2006–11 period, this paper tests for knowledge spillover effects from industries' adoption of the Internet on firms' productivity and innovation performance. We test for heterogeneous spillover impacts on groups of firms that are commonly less engaged in innovation and on firms with different productivity levels. Our specification regresses firm productivity and innovation performance – i.e., their investment in equipment and ownership of quality certificates and patents – on industries' use of the Internet. Spillover effects are identified by controlling for firms' own investment in Internet technology, industry and country-year fixed effects as well as extensive firm-level controls. Our results show that industries' use of the Internet positively affects the average firm's productivity and its investment in equipment. We also identify modest impacts of industries' use of the Internet on the likelihood that firms obtain quality certificates and patents. On average, we find that the returns to productivity are larger for firms that commonly engage less in innovation, including single-plant establishments, non-exporters, and firms located in small agglomerations. However, results from quantile regressions show that only the most productive firms reap productivity gains from Internet-enabled knowledge access. Firms with productivity levels below the 50th percentile do not benefit much. The spillover effects from industries' adoption of the Internet identified in our work justify public policies aimed at fostering industries' use of the Internet. However, since we show that only firms with adequate absorptive capabilities benefit from the widespread Internet adoption, policy support should also focus on facilitating firms' access to networks and strengthening their capacities to use them.

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1. INTRODUCTION

The adoption of the Internet has been widespread across countries (ITU, 2014). With the Internet, increasingly large sets of knowledge and information ("big data") can be more easily diffused to large groups of people. By allowing for wider access to ideas, the Internet may boost innovation as innovation arises from new combinations of existing pieces of knowledge (Arthur, 2007). With the Internet, opportunities to benefit from knowledge created by others are possibly higher. Such knowledge spillovers are critical for economic growth as they generate increasing returns (Grossman & Helpman, 1991; Krugman, 1991; Romer, 1986). In addition, the Internet can support more inclusive innovation, i.e., the widening of the often very small group of innovating firms in emerging and developing economies (OECD, 2015; Paunov, 2013). The Internet may help groups of firms that engage less in innovation, by improving their access to knowledge. By contrast, leading innovators often have access to quality "offline" knowledge and consequently may have less to gain from Internet-enabled knowledge transfers. However, less innovative firms may lack capabilities to use newly available knowledge for their business purposes (Cohen & Levinthal, 1989).

This paper provides evidence of knowledge spillover effects from industries' adoption of the Internet on firms' productivity and innovation performance. It analyses whether the Internet as a conduit of knowledge spillovers has heterogeneous impacts on groups of firms that differ with regard to their innovation performance and productivity. This study provides comprehensive evidence on these questions for a sample of

50,013 firm observations for 117 developing and emerging countries for the 2006–11 period.

Our empirical methodology exploits information on industries' adoption of the Internet as a tool for communicating with suppliers and clients to identify Internet-enabled knowledge spillover effects. Our specification regresses firm productivity and innovation performance – i.e., their investment in equipment and ownership of quality certificates and patents – on industries' use of the Internet, a comprehensive set of firm controls as well as industry and country-year fixed effects. We control for firms' own use of the Internet in all specifications. Our identification exploits within country-year differences in the adoption of the Internet across industries.

An industry's adoption of the Internet is unlikely to be affected by an individual firm's productivity and innovation performance and, hence, the risk of reverse causality is low. Notwithstanding, we cannot exclude a small risk of endogeneity which would arise if the most productive and innovative firms' use of the Internet caused other firms in the industry

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to adopt the Internet. Consequently, higher industry adoption rates could be positively correlated with strong performance. We address these endogeneity concerns as part of our robustness tests.

We use ordinary least squares regressions to study aggregate effects on firm productivity and equipment investment rates as well as logistic and probit regressions to analyze impacts on firms' ownership of quality certificates and patents. In addition, we apply quantile regressions to test whether benefits from industries' adoption of the Internet differ across firms of different productivity levels, which proxy for their capacities to absorb new knowledge. We also use quantile regression to ensure our results are not driven by non-normal errors and outliers as might be the case for ordinary least squares regressions.

We find that industries' use of the Internet has positive impacts on firms' labor productivity and on their investments in equipment. We also identify modest impacts on the likelihood that firms obtain quality certificates and patents. The evidence is robust to various tests such as removing potential outliers and using alternative sources of Internet-enabled knowledge spillovers, including the Internet uptake by firms within geographic locations and industries as well as at the country rather than at the country-industry level.

Moreover, we show that, on average, the Internet adoption of their industries benefits more groups of firms that commonly engage less in innovation: firms that do not export, firms that are not part of multi-plant establishments and firms that operate in small agglomerations.

Quantile regression results show that the more productive firms gain more from their industries' intensive use of the Internet. Firms with productivity levels below the 50th percentile do not benefit much. Moreover, only the most productive non-exporting firms and single-plant establishments benefit from knowledge spillovers. Interestingly, while we do not find that firm size affects productivity gains of the average firm, quantile regression results reveal larger payoffs for the most productive small firms compared to larger firms.

Several policy implications arise from our analysis. First, the existence of spillover effects from industries' adoption of the Internet, which do not depend on firms' own investments, justify public policies aimed at fostering industries' use of the Internet. The potential returns from policy support of industries' Internet adoption are high because, differently from other private sector development policies, benefits arise even for firms that commonly engage less in innovation and for firms that face cumbersome business environment conditions (Paunov & Rollo, 2015).

However, differences in capabilities to use the knowledge made available on the Internet could create a new "digital divide". Only firms with absorptive capabilities can benefit from business intelligence platforms, which give access to knowledge relevant to their scientific and technological needs. Therefore, facilitating firms' access to such networks and strengthening their capacities to use them deserve policy support. Human capital investments are core complementary policies (Indjikian & Siegel, 2005).

This paper relates to the research on the contributions of ICT to development. An ongoing debate focuses on adequate infrastructure conditions in developing and emerging economies such as bandwidth capacity and affordable access prices. Forbiddingly high prices to access the Internet, which may be caused by technical or market imperfections, can reduce uptake (Hilbert, 2010; Howard & Mazaheri, 2009). These are pre-conditions for firms to use ICT for their business operations to support their productivity (Ref. Section 2(a)).

Moreover, our work relates to studies on the opportunities for ICT to support very small firms and entrepreneurs from disadvantaged socio-economic backgrounds. ICT have helped smallholder farmers and fisheries obtain market information (including on price trends) as well as knowledge about production techniques (Jensen, 2007; Muto & Yamano, 2009; Ogotu, Okello, & Otieno, 2014). Several studies have identified gains from ICT-based services for disadvantaged producers (e.g., Aker & Mbiti, 2010; Donner, 2004, 2006; Donner & Escobari, 2010; Duncombe & Heeks, 2002; Esselaar, Stork, Ndiwalana, & Deen-Swarra, 2007; Kaushik & Singh, 2004). However, improved access to knowledge has not always benefitted these groups as they often lack capabilities to exploit new knowledge (e.g., Tadesse & Bahiigwa, 2015).¹

In addition, our paper relates to the literature on knowledge spillovers. Several studies have shown that gross social returns to knowledge investments exceed private returns (Bloom, Schankerman, & Van Reenen, 2013). Audretsch and Feldman (2004) and Keller (2004) discuss research findings on the international and geographic dimensions of knowledge spillovers. There is also evidence on barriers to knowledge spillovers, including from foreign direct investment (see Görg & Greenaway, 2004). Firms' lack of "absorptive" capacity to make use of newly available knowledge explains some of the limitations (Girma, 2005; Kokko, 1994; Kokko, Tansini, & Zejan, 1996). Geographical proximity also matters for spillovers (Ref. Section 2(c)).

Our paper makes several contributions to the literature. To the best of our knowledge, this is the first study to provide comprehensive cross-country evidence of knowledge spillovers of industries' Internet adoption on firm productivity and innovation performance. Using data for the 2006–11 period allows estimating global impacts at a point in time when the Internet adoption gained some maturity. Data for earlier years may underestimate impacts. Moreover, our study expands on the previous analyses by testing whether groups of firms that commonly innovate less benefit more from their industries' Internet adoption. In addition, we apply quantile regression techniques to explore whether average effects – obtained from conventional estimation techniques – hide differences in impacts across firms of different productivity levels.

The remainder of the paper is organized as follows. Section 2 discusses the conceptual framework while Section 3 presents the data we use for our analysis. Section 4 introduces the empirical framework. Section 5 provides descriptive statistics while Section 6 describes the results of the analysis. Section 7 concludes.

2. CONCEPTUAL FRAMEWORK

(a) *ICT investments as driver of efficiency improvements*

Firms, industries, and countries that invested in ICT have improved the efficiency in which they transform inputs into outputs. Research, conducted at industry and firm levels, has consistently found that ICT investments positively relate to higher productivity (e.g., Bartel, Ichniowski, & Shaw, 2007; Bloom, Sadun, & Van Reenen, 2012; Jorgenson, 2001; Jorgenson & Vu, 2005; Oliner & Sichel, 2000; Stiroh, 2002).² There is also some evidence for firms in developing and emerging economies (e.g., Commander, Harrison, & Menezes-Filho, 2011; ECLAC, 2011; Motohashi, 2008; Pohjola, 2001; UNCTAD, 2008; World Bank, 2006). In addition, firms' ICT investments also relate positively to their innovation performance (see, for example, Spezia, 2011, for an analysis of eight OECD countries).

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