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Has the Internet Fostered Inclusive Innovation in the Developing World?

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Abstract

Based on 50,013 firm observations covering 117 developing and emerging countries, this paper shows knowledge spillover effects from industries' use of the Internet boosted the average firm's productivity and innovation performance. We document that industries' "digitization" had heterogeneous impacts: results from quantile regressions indicate that the most productive firms benefited much more than others. Wider Internet adoption rates were also of larger benefit to single-plant establishments, non-exporters and firms in remote locations, particularly to the most productive among these firms. Overall, we document that the Internet can play an important role to support inclusive innovation, *conditional* on firms' "absorptive" capacities.

Keywords: Information and communication technologies (ICTs), Internet, innovation, productivity, firm heterogeneities, informal businesses, developing countries

JEL Codes: O33, O14, O12, D22, L6, L8

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1. Introduction

The uptake of the Internet and mobile technologies has been ubiquitous (ITU, 2014) changing not merely the cost but the way knowledge is exchanged. Increasingly large sets of knowledge, “big data”, can be more easily transmitted, if desired, to a large global audience and within seconds. This is not a trivial matter: the fundamental change in knowledge transmission opportunities may raise opportunities for firms and other economic agents to benefit from knowledge generated by others. This is critical for innovation, which builds on new combinations of existing ideas. Consequently, wider exposure to different ideas can raise economies’ innovation performance (Arthur, 2007). What is more, these knowledge spillovers are critical for economic growth by generating increasing returns (Romer, 1986; Krugman, 1991; Grossman and Helpman, 1991). In addition, Internet-enabled knowledge spillovers can make even more of a difference to firms with weaker connections to good “offline” knowledge networks. For instance, businesses in isolated locations operate in a weaker regional business ecosystem and may have more to gain from knowledge made available via the Internet. The regional knowledge network will provide fewer knowledge inputs than that of firms in less isolated regions. The Internet may in this way help promote more inclusive democratic innovation, i.e. the widening of the group of innovators beyond the often very small group of innovating firms in developing countries (Paunov, 2013). However, taking advantage of knowledge is not straightforward and requires firms to have absorptive capacities (Cohen and Levinthal, 1989). If firms are not able to use newly available knowledge, then better access to knowledge via the Internet will be meaningless to their overall performance. To the extent that weak innovators lack those capacities, the Internet’s impact on making innovation more inclusive may be more limited.

The paper provides evidence on the question whether industries’ use of the Internet results in spillover effects on firms’ productivity and innovation performance. It focuses explicitly on heterogeneous impacts across firms’ of different characteristics and productivity levels. Our evidence is based on 50,013 firm observations across 117 developing and emerging countries for 2006-2011. The analysis exploits information on industries’ adoption of the Internet as a tool for communicating with suppliers and clients. Our empirical specification relies on a comprehensive set of firm controls as well as industry and country-year fixed effects. This approach ensures our coefficient of interest – industries’ use of the Internet - does not pick up industry-specific effects or differences across countries and years. That is, 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, therefore, the risk of reverse causality is low. We use quantile regressions to test whether productivity differences - as proxy for differences in “absorptive capacities” - affect the beneficial impact of the Internet.

We find that industries’ adoption of the Internet has positive impacts on firms’ labor productivity and their investments in equipment. We also identify modest impacts on the likelihood of firms to seek quality certificates and patents. The evidence is robust to various tests such as including context control variables and using alternative definitions to measure Internet adoption rates that are most relevant to the firm. Moreover, we show that, on average, the "digitization" of their industries provided larger gains to firms that did not export, that were not part of multi-plant establishments and that were operating in remote locations. By contrast, we do not find that smaller firms benefited more than larger firms. Quantile regression results also show that the more productive firms gain much more from the "digitization" of their industries, while firms with productivity levels below the 50^{th} percentile had few benefits. Our evidence of larger benefits for average non-exporting firms and single-plant establishments holds only for the most productive among them. Similarly, we find larger payoffs for the most productive smaller-sized firms relative to larger businesses.

Several policy implications arise from our analysis. First, our evidence points to the existence of spillover effects from industries' adoption of the Internet. These gains, which did not depend on firms' own investments, provide support for public policies aimed at fostering industries' use of the Internet. Second, the fact that the Internet benefited more firms that commonly engage less in innovation points to the Internet's potential for facilitating more inclusive innovation. This is critical for many emerging and developing countries, where often only a very small number of firms innovate. Internet-based business intelligence platforms and exchange forums can increase benefits further. Such business intelligence services allow for a targeted analysis of firms' scientific and technological environment based on exploiting information available on the Internet. Third, the fact that "catching up" opportunities arise only for the better performing firms indicates the importance of policies aimed at building firms' absorptive capacities. If such shortcomings are not addressed, then the wider knowledge access opportunities from the Internet will continue to leave out the weakest performers. In spite of widespread adoption, this could create a new divide related to the effective use of knowledge transmitted via the Internet.

Our paper makes several contributions to the debate about the impacts of ICT in developing and emerging economies. First, to the best of our knowledge, this is the first study to provide cross-country evidence of spillover effects of the Internet adoption by industries in developing and emerging economies on firms' productivity and innovation performance. Using data for 2006-2011 is critical as the effective adoption of the Internet has only gained maturity in those years and, therefore, data covering prior years would underestimate impacts. Second, our study expands on the previous analyses by explicitly focusing on whether the Internet facilitated more inclusive innovation. It explores two dimensions: *i)* whether firms with more limited access to "offline" knowledge networks benefit more from their industries' Internet adoption and *ii)* whether impacts differ across firms' productivity distribution. We adopt quantile regressions to understand if "average" effects as captured by conventional estimation techniques hide differences in impacts across firms of different productivity levels.

The paper contributes to several strands of the literature. First, it relates to the work on the impact of ICT investments on firms' productivity. Extensive research, conducted at industry and firm levels, finds positive impacts of ICTs (e.g. Bartel et al., 2007; Jorgenson, 2001; Jorgenson and Vu, 2005, Oliner and Sichel, 2000 and Stiroh, 2002). However, complementary investments, including in improving management capacities, are often critical to maximise benefits from the Internet (Black and Lynch, 2001, 2004; Bloom et al., 2012; Bresnahan et al., 1996, 2002; Brynjolffson and Hitt, 2000). Studies on the impacts on innovation have also identified positive effects (see, for example, Spezia, 2011, for an analysis of eight OECD countries). As for developing and emerging countries, a World Bank report identifies positive correlations between a simple measure of ICT use and various firm performance indicators, such as employment and innovation for the early 2001-2003 period (World Bank, 2006). Several country studies focus on how firms' ICT use relates to their productivity and, in some cases, their innovation performance (e.g. Commander et al., 2011, for Brazil and India, Motohashi, 2005, for China; UNCTAD, 2008, for Thailand; ECLAC, 2011, for Argentina, Chile, Colombia, Peru, and Uruguay). Our paper also relates to papers that discuss opportunities for ICTs to stimulate the "democratization of innovation". Many of these case studies have identified opportunities for very small firms and entrepreneurs and the informal economy at large (e.g. Donner and Escobari, 2010; Kaushik and Singh, 2004 and Aker and Mbiti, 2010 among others). Few papers focus explicitly on the question whether the Internet might stimulate more inclusive innovation processes. An exception is the study by Ding et al. (2010) who find the Internet facilitated the inclusion of women scientists and those working at non-elite institutions in collaborative research.[1]

Second, our paper contributes to the literature that has documented that knowledge spillovers, i.e. gross social returns to knowledge investments, by far exceed private returns (Bloom et al., 2013; see Audretsch and Feldman, 2004, and Keller, 2004 for overviews of the literature on international and geographic dimensions of knowledge spillovers). Foreign multinationals in particular may be a valuable source of knowledge spillovers for domestic firms. However, while some studies identified positive spillover effects (e.g. Haskel et al., 2007), much of the evidence points to limited direct effects (see Görg and Greenaway, 2004 for an overview). One of the explanations is firms' lack of "absorptive" capacity to make use of newly available knowledge (Kokko, 1994; Kokko et al., 1997; Girma, 2005). To the extent that firms' capacities can be an obstacle, Internet-enabled knowledge access benefits may also be lower and, in particular, restrain the extent to which it promotes inclusive innovation processes. Another relevant finding from this literature relates to the "boundaries" of knowledge spillovers. While research finds geographic boundaries continue to matter, there is an ongoing debate about whether the Internet will lead to the "death of distance" (Cairncross, 1997, see discussion in Section 2). If such "boundaries" can be overcome, then opportunities for increased Internet-enabled knowledge spillovers rise.

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 describes the results of the analysis while the final section concludes.

[1] A related study by Agrawal and Goldfarb (2008) finds that the adoption of Bitnet, an early version of the Internet, disproportionately benefited middle-tier universities' collaboration with leading universities.

2. Conceptual Framework

2.1. Firms' Uptake of the Internet

Many firms in developing and emerging countries have adopted the Internet to support their operations. Evidence from our dataset, which is described in Section 3, shows that by 2006-2011 a large share of firms used the Internet to communicate with clients and suppliers. Even among firms in low-income economies 47.3% had adopted this communication tool. Moreover, while small firms were less active users than larger businesses, their uptake was of 44.5% (Figure 1). Informal businesses were also active users of mobile telephony. Table 1 shows that particularly for the African businesses in our sample 76.2% used mobile telephony in 2009-2010.[2] This is remarkable as more than two third of these firms had experienced power outages and more than one in four firms did not have electricity.

Industries uptake of the Internet was not homogeneous and varied substantially across different countries' sectors. In the textiles industry, for instance, the share of firms using the Internet for communication ranged from 21% in Nigeria, 25% in Indonesia and 33% in Pakistan to 100% in Argentina, Costa Rica and Peru. In the retail and whole sector, the same shares range from 20% for Uzbekistan or 30% for Angola to near-to full adoption in Hungary (96%) and Estonia (99%). Figure 2 shows substantial dispersion existed. The food, garment and service industries – i.e. retail and wholesale trade as well as hotels and restaurants – show evidence of a sizable number of weak adopters and of large dispersion. The chemicals and pharmaceuticals industry was very much a "frontrunner" with high adoption rates across different countries in the world. In conclusion, the statistics reported show wide but varied uptake of the Internet as a means of communication in the developing world.[3] The question on corresponding returns of adoption we address in this study is, therefore, pertinent.

2.2. Knowledge Spillovers and Firms' Innovation Performance

Industries' adoption of the Internet as a means of communication can stimulate firms' innovation performance by improving the diffusion of knowledge. More than other economic activities, innovation and technical change depend on access to new knowledge. This is because unlike physical property, knowledge grows over time based on the existing stock of knowledge. There exists, that is, much benefit from "standing on the shoulders of giants". To the extent that innovation depends on connecting to diverse sources of knowledge, the increased availability itself can provide new opportunities for innovations (Arthur, 2007). This is well illustrated by an analogy of firms drawing balls from an urn that holds knowledge relevant to their activities. The Internet supports wider access to a larger number of balls from that urn. Improved communication among members of an industry supports learning about new technologies, influencing the rate of technology adoption (e.g. Conley

[2] The average is obtained for the available informal firm surveys of Angola, Botswana, Burkina Faso, Cameroon, Cape Verde, the Democratic Republic of Congo, Ivory Coast, Mali and Mauritius.

[3] As described in the notes of Figure 2 the number of country observations differs across industries.

and Udry, 2010 and references therein).[4]

As for the types of knowledge relevant to firms' activities, information from clients, suppliers and competing firms can strengthen firms' innovation performance in different ways. First, clients' preferences and needs may offer better information about market opportunities for new products and services. The associated reduction in market risks might lead to more innovation efforts as uncertainty is a major obstacle to firms' investment decisions (see Collard-Wexler et al., 2011). Users might also be more involved, and by providing feedback - a widely used system to identify bugs in software - allow for new product and service developments.[5] Second, learning from suppliers about downstream developments of technologies, which determine the technical feasibility of introducing innovations, can also spur innovation. Third, knowledge about competitors' practices is directly relevant as a source for learning about alternative production techniques and product innovations.[6]

Finally, there are other sources of benefit from the adoption of the Internet on firms' productivity and innovation performance. This includes the use of ICTs to improve the evidence-base in firms' decision-making (e.g. Brynjolffson et al., 2011), which can also support firms' innovation performance. These factors, however, are more closely related to the firms' own adoption of the Internet and related ICT investments rather than to their industries' adoption rates. We leave these questions aside in this study and deal with the question of Internet-enabled knowledge diffusion only.

2.3. Knowledge Spillovers and the Internet

The empirical evidence points to positive impacts of knowledge spillovers on firm performance (cf. Audretsch and Feldman, 2004, and Keller, 2004). Knowledge lends itself to such spillovers since, once created, it can be replicated and disseminated at virtually no cost, and consequently benefit more firms (Arrow, 1962). The Internet has contributed to reducing those dissemination costs even more; the challenges such replication has posed to the entertainment industry illustrate its capacity. At the same time, there are possible limitations to how the Internet can contribute to stimulating spillovers: only codified knowledge can be transmitted while other types of knowledge - often referred to as "tacit" knowledge - cannot. The challenge of establishing "trust" when it comes to exchanging critical knowledge will also require face-to-face interactions (Leamer and Storper, 2001). The importance of "tacit" knowledge is one of the reasons why geographic proximity may continue to matter (Krugman, 1991, Audretsch and Feldman, 1996). However, ICTs have also reduced barriers for transmitting such knowledge. This includes the possibility to transfer large amounts of information in ways that increasingly match "proximity", including, for instance, videoconference opportunities.

Potential benefits from Internet-facilitated knowledge spillovers, if they exist, do not specifically depend on individual firms' use of the Internet. Instead wider knowledge diffusion results

[4] This could notably affect productivity and equipment investment and to some extent the adoption of quality certificates, but will not be as relevant for patents.
[5] User involvement might in some cases stimulate innovation, notably if it leads to co-innovation with users (von Hippel, 2005; Bresnahan and Greenstein, 1996).
[6] However, knowledge from competitors might be less easily obtained as these have an interest in keeping information secret from their direct competitors (see e.g. Javorcik, 2004).

from a critical mass of industries' firms relying on the Internet. For the same reason, it is also not the firm's own use of the Internet that matters most. Firms that do not use the Internet could benefit from better knowledge diffusion within their industry by other means (such as gatherings of business associations, recruitment of new staff or face-to-face contacts with other firms). The question whether the Internet facilitates knowledge spillovers is, therefore, distinct from the questions how firms' own investment and uptake of information and communication technologies has benefited their performance (cf. references of relevant studies provided in the introduction).

2.4. The Internet as a Potential Facilitator of Inclusive Innovation

The benefits from the "digitization" of their industries may be heterogeneous across firms. One reason is that the "value-added" from Internet-enabled knowledge spillovers may be larger for some firms than for others. That is because, coming back to the analogy of the urn introduced above, the increase in access to additional balls will be bounded by the full number of balls available. That is, as firms' access to knowledge networks improves, the knowledge the firm can access will eventually be equivalent to the relevant existing knowledge. This is because the adoption of the Internet as a means of communication facilitates wider access to knowledge but only contributes in the long run to expanding the stock of knowledge itself. To the extent that the characterization describes well the contributions of the Internet, it will be the case that, all else equal, firms connected to already rich *offline* knowledge networks have fewer gains from the Internet. By contrast, those with limited access to knowledge networks will have more to gain.

Several firm characteristics relate to their access to knowledge networks and may consequently determine heterogeneous impacts. One condition is about firms' connections abroad. Exporters or foreign-owned firms might have less to gain from Internet-enabled knowledge spillovers. The reason is that they already access foreign expertise, a critical source for advanced technologies, particularly for firms in developing and emerging economies (Coe and Helpman, 1995; Fagerberg, 1994; Freeman and Soete, 1997). For these firms, the wider opportunities of knowledge access provided by the Internet might not offer as much value as to firms with no such connections. Another condition is firms' geographic location. Those firms based in more remote locations have less dense local networks, and, therefore, the quality of the knowledge available to them could be lower. With the Internet's ability to cross distances more effectively, these firms may stand to benefit more than firms in larger agglomerations (and with richer knowledge sources). The question has been subject to analysis for more than a decade (e.g. Cairncross, 1997, Friedman, 2005, Forman and Van Zeebroeck, 2012). Forman et al. (2014) conclude from their analysis of Internet investment and patenting indicators across counties in the United States, that "the Internet has the potential to weaken the longstanding importance of the geographic localization of innovative activity" (p. 5).

In addition, plants size may also make a difference. Smaller-sized firms have by definition smaller internal knowledge networks and often have more modest R&D investments. This is partly because of fixed cost-spreading advantages and agglomeration benefits larger firms can benefit from with regards to R&D (Cohen, 2010). Advantages to size are likely reinforced over time as returns to R&D will disproportionately reward larger firms (Klepper and Simons, 2005). They might consequently benefit less from digitization. There is evidence confirming that smaller firms reap larger spillover benefits (cf. Acs et al., 1994). The same reasoning holds potentially for plants that are part of multi-plant establishment as they have more important internal knowledge networks and undertake more knowledge investments within the firm.

Finally, informal businesses may also be among those with larger knowledge gains. These businesses face more constraints for accessing a variety of business services, have fewer resources to engage in knowledge networks and are often disconnected from formal businesses. “Dual economy” structures reduce “direct” contacts and participation in networks. The Internet may, therefore, be particularly relevant. There is some evidence to show ICTs provide benefits to informal businesses: case studies have shown ICTs helped break information barriers (e.g. Jensen, 2007; Muto and Yamano, 2009). Muto and Yamano (2009) find mobile networks benefited farmers’ position on markets of perishable goods in rural Uganda. Farmers in regions further away from urban centers benefited more. Country case studies have also shown that micro enterprises, including those operating in the informal sector, tended to benefit in their business activities (e.g. Duncombe and Heeks, 2002, on Botswana, Donner, 2004 and 2006, on Rwanda, Esselaar et al., 2004, for a survey of 13 African countries).

2.5. Knowledge Spillovers and “Absorptive” Capacities

While better access to pieces of knowledge can support firms’ productivity and innovation efforts, firms need to have the capacity to deal with the knowledge they gain access to. Weaknesses in firms’ capacities have been identified as major factors limiting knowledge spillovers (cf. Görg and Greenaway, 2004). The reason why indigenous capacities are critical is that technology has a “tacit” component that cannot be transferred easily. Knowledge as is might be inappropriate in specific firm contexts unless adjustments are done via “localized learning by doing” (Atkinson and Stiglitz, 1969). Several empirical studies confirm how in-house capacities complement access to knowledge (Hu et al., 2005, Kokko, 1994, Kokko et al., 1997). This factor points to another possible source for heterogeneous effects: positive impacts for the average firm may hide substantial heterogeneities as the most productive firms can likely benefit more from knowledge spillovers.

2.6. Testable Hypotheses

In conclusion, the discussion regarding characteristics of knowledge spillovers and opportunities provided by industries’ adoption of the Internet suggests the following hypotheses for the empirical analysis:

- First, we analyze whether the use of the Internet as a tool for communication by industries has positive impacts on firms' productivity and innovation performance. That is, we test for Internet-enabled knowledge spillover effects.

- Second, we examine whether the Internet has heterogeneous impacts depending on characteristics that affect the quality of firms' knowledge networks. In other words, we test for differences in effects across *i)* exporting and non-exporting firms, *ii)* firms located in larger and smaller agglomerations, *iii)* single- and multi-product firms and *iv)* differently sized firms. We also test *v)* whether informal businesses benefited from their industries' adoption of the Internet.

- Third, we investigate whether different capabilities influence the impact of industries' adoption of the Internet on firms' productivity and innovation performance. We do so by testing for differential impacts change for firms at different productivity levels.

3. Data

We use the second improved wave of the World Bank Enterprise Surveys (WBES) for our empirical analysis. The WBES is uniquely suitable to providing robust quantitative evidence on aggregate and heterogeneous impacts of ICTs on firms in developing and emerging countries. Our analysis uses information for 50,013 firm observations across 117 countries for 2006-2011. This sample is a selection from the full 65,285 firm observations available, excluding observations without information on firms' labor productivity and industries' use of the Internet for communication purposes.[7] Table 2 summarizes data coverage across world regions, manufacturing and service industries, firm size categories, years, and country income levels. The WBES have been widely used, including in Almeida and Fernandes (2008), Beck et al. (2005), Fisman and Svensson (2007) and Paunov (2014) among many others. The WBES collect information in each country on a representative sample of formal firms in the non-agricultural sector. The selection of firms in each country is done by stratified random sampling. Dethier et al. (2011) give a comprehensive review of the dataset and a comprehensive list of studies that have used these data.

Interestingly for our purposes, the WBES include information on firms' actual use of the Internet rather than simply investment information which says little about actual use. In particular, the dataset has information on whether firms used email to communicate with suppliers and customers. The indicator is suitable for our purpose since it directly relates to whether the Internet is used for communication purposes. That is, it relates to the exchange of knowledge with clients and suppliers, which, as discussed above, is critical for firms' acquisition of relevant knowledge for their business activities. The dataset also has information about whether firms owned websites, which we use as a proxy variable of firms' investments in Internet technologies.[8] We add this variable systematically to

[7] The routines used by the authors to clean the original dataset are available upon request.
[8] Other information (including for what purposes the Internet is used) is also available but only for a small selection of firms.

our regressions in order to capture knowledge spillover effects rather than returns to private investments in ICTs.

The surveys also cover basic information on firms (sales, employment, ownership type, and export performance). The information allows computing labor productivity and we also have information on firms' investments in equipment, a critical factor for firms' innovation activities, as well as firms' patent and quality certificate ownership. With regards to patent information, unfortunately only a small set of observations is available as the variable is not collected across all surveys we combine in our analysis.

Finally, in order to see to what extent the Internet supports the "democratization of innovation", we also assess impacts on firms in the informal economy. This is critical the more so since its size is substantial, particularly in developing and emerging economies (Schneider et al., 2011). We use the informal firm dataset, provided by the WBES, which covers 1,557 firms for 7 countries[9] in 2010, to explore the uptake of mobile phones. As the nature of the data is different from the main WBES dataset, we use the data separately from the analysis of the main dataset, applying, however, the same methodology applied to the main WBES dataset.

4. Analytical Framework

To study the impact of industries' adoption of the Internet on firms' innovation and productivity performance, we adopt the following baseline estimation:

$$Y_{ict} = \alpha + \beta_1 * ICT_{jct} + \gamma * X_{ict} + \lambda_j + \lambda_{ct} + \varepsilon_{ict} \quad (1)$$

where Y_{ict} is a measure of firm i's labor productivity or its innovation efforts, i.e. whether the firm owns a quality certificate or patent and its equipment investment. ICT_{jct} is an indicator of industry j's uptake of using email to communicate with clients and suppliers (excluding firm i's uptake) [10] in country c in year t. X_{ict} is a full set of firm-level control variables which are discussed in Section 5. Coefficient β_1 is our variable of interest as it identifies spillover effects. We test for spillovers by obtaining a measure of country-year industry adoption, identified across 15 different industries.[11] The set-up is similar to that used in Acs et al. (1994) or Haskel et al. (2007) to study impacts of industries' R&D or FDI intensities, to provide an example for each. Seker (2012) and Dollar et al. (2006) apply a similar approach to identify impacts of business conditions on firm performance. We also add λ_j and λ_{ct}, respectively a set of industry and country-year dummies. In other words, our identification strategy exploits differences in industry's adoption of the Internet across countries while controlling for characteristics specific to industries or countries in any year.

[9] The countries for which we use data are Angola, Argentina, Botswana, the Democratic Republic of Congo, Guatemala, Mali and Peru.

[10] The ICT measure is built for industries (by country-year) with at least 10 observations, excluding the firm i's own response.

[11] We test whether our results hold for more narrowly defined industry knowledge-spillovers, such as including only industries that are geographically close to the firm, as part of our robustness.

Two challenges affect the analysis of the impacts of firms' ICT use on firm performance: *i)* endogeneity - while IT might support innovation performance, it could also be the case that more innovative firms rely more on IT; in fact it is very likely that most productive firms self-select into such activities, and *ii)* omitted variable biases (i.e. the fact that there might be other unaccounted factors that effectively drive the relationship picked up in the regressions). Both factors point to a positive bias on coefficients of ICT uptake leading to an overestimate of the contribution of ICTs towards firm performance as we expect more productive firms to be more likely to adopt ICTs. This, however, is less of a challenge for our analysis, which focuses instead on the adoption of the Internet at the industry level. It is unlikely that firms' innovation and productivity performance has a direct impact on their industry's adoption of the Internet. To avoid potential endogeneity concerns, firm *i*'s own use of the Internet is excluded from the industry average we compute. Also, as our variable of interest is aggregated, measurement error is less of a concern. In addition, we address omitted variable biases by introducing industry and country-year fixed effects in addition to firm-level controls. Country-year fixed effects allow isolating potential differences across countries in specific years. This includes government policies with possible impacts on firms' productivity and innovation performance. Controlling for industries is also important because certain industries are more technology-intensive than others, so that allowing for the variation across industries may bias results. We also include an extensive set of controls in our regressions. Appendix Table 2 describes each of the variables in detail.

In order to test for possible heterogeneous effects across firms we estimate the following modified model:

$$Y_{ict} = \alpha + \beta_{Type1} * [ICT_{jct} * Type_{ict}] + \beta_1 * ICT_{jct} + \gamma * X_{ict} + \lambda_j + \lambda_{ct} + \varepsilon_{ict} \qquad (2)$$

$$Y_{ict} = \alpha + \beta_{ADV1} * [ICT_{jct} * TypeADV_{ict}] + \beta_{DIS1} * [ICT_{jct} * TypeDIS_{ict}] + \gamma * X_{ict} + \lambda_j + \lambda_{ct} + \varepsilon_{ict} \qquad (3)$$

where $Type_{ict}$ indicates certain firm characteristic (as notably firm *i*'s size) and $TypeADV_{ict}$ and $TypeDIS_{ict}$ are dichotomous variables of firm characteristics (for instance, whether the firm is an exporter, $TypeADV_{ict}$, or not, $TypeDIS_{ict}$).

Moreover, we apply quantile regressions in order to assess whether impacts differ based on firms' labor productivity. Quantile regressions can be expressed in the general form (Koenker and Basett, 1978) $Prod_{ict} = x_{ict}'\beta + \varepsilon_{ict}$ with $Q_\theta (Prod_{ict} / z_{ijct}) = z_{ijct}'\beta_\theta$, where z_{ijct} includes all explanatory variables as in (1), (2) and (3). Estimating θ from 0 to 1 gives the entire conditional distribution of $Prod_{ict}$, conditional on z_{ijct} (Buchnisky, 1998). In other words, using quantile regressions shows the effect of industries' Internet adoption at different levels of the conditional productivity distribution, rather than at the conditional mean of our dependent variable. Other empirical applications of quantile regression techniques include, for example, Yasar and Morrison Paul (2007), Fattouh et al. (2005) and

Coad and Rao (2008). We analyze differential impacts on other innovation variables, interacting our variable of interest, industries' adoption of the Internet, with above or below median firm productivity at *t-3* or, respectively, the quartile of the distribution of productivity at *t-3* the firm was part of.

Finally, to estimate equations for the average firm we apply ordinary least squares regressions for the analysis of labor productivity and equipment investment and logistic estimation models to assess the impacts of industry Internet adoption on quality certificates and patents. Robust standard errors clustered by country, industry and year level are applied systematically following the procedure to account for our aggregate variable of interest (Moulton, 1990).

5. Results

5.1. Baseline Results: ICT-enabled Spillovers on Firm Productivity and Innovation Performance

First, we test whether the wider diffusion of ICTs leads to knowledge spillovers and results in higher firm productivity and improves innovation performance. Panel A of Table 3 shows regression results of Equation (1) for labor productivity: column (1) reports results for industries' use of the Internet with industry and country-year fixed effects. We find a positive significant effect. We progressively add controls at the firm level. These include firms' employment and age (column 2), indicators of public ownership and whether the establishments are part of multi-plant establishments (column 3) and controls for whether the firm has connections abroad (i.e. foreign-ownership and exporter status) (column 4). We also add proxies for managerial quality and access to finance (column 5). Consistently with the prior literature, we find that these factors are positively correlated with firms' productivity except for public ownership which is negatively correlated with firms' productivity. We also find firms' own investment in ICTs, proxied by a variable indicating whether firms owned a website (column 6), affects labor productivity positively. The latter finding is consistent with previous findings of the literature on the private returns to investments in ICTs. Our variable of interest, industry-wide adoption of the Internet as a means of communication, is positive significant and changes only modestly as additional factors, including the proxy for firms' own investment in ICTs, are added.

Panel B of Table 3 shows similarly positive significant effects on average firms' investment in equipment (columns 1 and 2). We also identify positive effects on firms' ownership of quality certificates (columns 3 and 4) and patents (columns 5 and 6). These effects hold also if the same comprehensive set of firm controls applied for Panel A of Table 3 is included. Overall, our results provide evidence that industries' adoption of the Internet facilitates positive spillover effects on firms' productivity and innovation performance, confirming the first empirical hypothesis.

As for the magnitude of estimated effects, all else equal, our findings indicate that a one standard deviation rise in the intensity of a firm's industries' use of the Internet would improve its labor productivity by an amount equivalent to productivity increasing from the 50^{th} to the 54^{th} percentile of the distribution and from the 50^{th} to the 55^{th} percentile of equipment investment. Impacts on firms' ownership of quality certificates and patents are modest. An increase by one standard deviation would, all else equal, lead to an increase in formal intellectual property rights' ownership of 3% and 5% respectively.

5.2. Robustness Tests

This section presents robustness tests of our results. Findings for labor productivity are reported in Table 4. First, we test whether our results are robust to including additional controls. Results reported in column (1) add other industry characteristics as these might be correlated with industries' Internet adoption. In order to ensure our variable of interest does not pick up the effects of other industry characteristics, we obtain for each of the firm-level variables the corresponding contextual equivalent. That is, we include measures for country industries' average employment, their age, foreign ownership status, the volume of exporter activities, an indicator of public ownership, the share of multi-plant establishments, the average of years of managers' experience and an indicator of credit access for each specific year. Results, reported in column (1) of Table 4, confirm our evidence is robust to the inclusion of such measures. Unreported tests show our results also hold if we include firms' past productivity performance as a control to account for a variety of possible omitted factors.[12] We also check whether controlling for firms' location in different agglomerations (column 2) modifies our findings by adding location fixed effects to our specification. We do not find this to be the case. Our results are not driven by differences regarding where firms are located.

Second, we check if our evidence is consistent with the findings of the literature that has documented positive effects of firms' own investments in ICTs on their performance. In order to avoid endogeneity, we adopt the strategy used in Fisman and Svensson (2007) and instrument firms' use of the Internet by the industry average. Our results, reported in column (3) of Table 4, document positive significant effects and correspond to positive findings identified by the previous literature on firm returns to private investments in ICTs.

Third, we check whether our results are different for firms in the manufacturing and services sectors. As shown in column (4), we find positive significant effects for both types of firms but larger returns for services firms. This may be related to the fact that for the services firms the transfer of intangible knowledge is even more critical than for manufacturing firms (where tangible assets continue to matter). Thus, they may gain more from wider access to knowledge.

Fourth, our main results focus on spillover effects within the firm's industry, as product markets provide most of the relevant knowledge for firms' innovation and productivity performance. As part of our robustness, we test whether we find similar results for differently defined sources of knowledge spillovers for firms. We obtain three alternative more restrictive measures of the relevant industry's adoption of the Internet by country-year. The first measure obtains separate measures of industries' adoption of the Internet for smaller and large firms. Smaller firms may have more to gain from other

[12] All unreported results are available from the authors upon request.

firms of similar size as processes adopted by large firms may be out of reach for them. By contrast, for large firms the practices adopted by smaller entities may be irrelevant. The second measure, which was also used in Fisman and Svensson (2007), obtains separate measures of industries' adoption of the Internet for different types of locations. That is, it associates to firm *i* the adoption of the Internet by those of industry *j* located in a similarly sized location. The measure does not indicate whether firms are geographically close. The rationale for computing this type of measure is that firms in rural areas with very few inhabitants may have more to gain from the practices of other firms located in similar types of locations.[13] The third measure focuses on explicitly geographic proximity by obtaining industry adoption rates separately for firms co-located in the capital city or elsewhere. This indicator reflects the hypothesis that the Internet may only benefit in a complementary way with co-location. Unfortunately, the only geographic information we have is about whether firms are located in the capital city. It is, therefore, a rather crude measure of geographic proximity. Results reported in columns (5), (6) and (7) of Table 4 are positive significant and larger compared to our baseline results of Table 3. Unreported results, using a measure of Internet adoption for country-location-year level (as in Arnold et al., 2008, and Dollar et al., 2006), are also positive significant.

Finally, we test whether access to higher exposure to technology will lead to even larger returns. We do so by interacting our variable of interest with whether these industries use imported technologies intensively or not. This follows the above-mentioned literature on the large knowledge benefits from foreign knowledge sources. We find effectively that spillover returns from the Internet are larger where the exposure to technology is larger. The difference in returns is positive significant.

Robustness tests for our measures of innovation performance are shown in Appendix Table 3. As shown in Panel A, we find robustness tests largely confirm findings regarding firms' investments in equipment. With regards to effects across manufacturing and services firms we do not find significant differences (Column 4). We also do not find impacts to be different with regards to the exposure to technology. With regards to quality certificates and patents, Panels B and C of Appendix Table 3 show our overall evidence to be less robust than that on productivity and equipment investments. We find higher quality knowledge leads to larger spillover effects (columns 8 and 7 of Panel B and C, respectively). With regards to quality certificates, manufacturing firms benefit more. We cannot report similar tests for patents, for which we have mainly information on patenting firms.

5.3. Testing for Heterogeneous Impacts of the Internet across Firms

We test our second hypothesis regarding whether gains from industry Internet adoption are heterogeneous. We explore in particular differences in impacts across *a)* exporters versus non-exporters, *b)* firms located in larger and smaller agglomerations, *c)* single- and multi-product firms, and *d)* smaller and larger firms. We also test whether *e)* informal businesses benefited from their industries' adoption of the Internet.

[13] Unreported results for a measure of Internet adoption by location-type, firm size, sector, country and year are also positive significant. Aterido et al. (2007) apply this approach in their analysis.

Panel A of Table 5 reports results for impacts on labor productivity. We find that there is more to be gained for non-exporters (Column 1 of Panel A of Table 5). Unreported results indicate that national firms also benefited more than foreign-owned firms. Column (2) of Panel A of Table 5 shows results of equation (3) by agglomeration type. We split into those located in countries' capitals or in cities of more than 1 million inhabitants and those located in smaller agglomerations. Controlling for possible effects of location, we find statistically significant stronger impacts on labor productivity for firms in small agglomerations. Column (3) of Panel A of Table 5 shows that single-plant firms benefit more compared to multi-plant firms. Finally, with regards to differently sized firms, as reported in Column (4) of Panel A of Table 5, we do not find evidence of heterogeneous effects when it comes to labor productivity.

The evidence for innovation indicators also points to differential effects, but is more mixed. We identify weaker effects on exporters, as shown in columns (1), (5) and (9) of Panel B of Table 5. As for location, while we find that firms in remote locations to have larger returns for all innovation indicators, the coefficient is only statistically significant for firms' ownership of quality certificates. Results are shown in columns (2), (6) and (10) of Panel B of Table 5. As reported in columns (3), (7) and (11) of Panel B of Table 5 we also find larger benefits for multi-plant firms when it comes to quality certificate and patent ownership but not for equipment investment levels. With regards to firm size differences, we find as reported in columns (4), (8) and (12) no significant effects, except for results on quality certificates.

Finally, column (1) of Table 6 shows that informal businesses also benefited from knowledge spillovers in terms of their sales gains. In the case of informal business we use the industry's use of cellphones as a proxy for the "digitization" of informal business sectors. The evidence is maintained if control variables - firm employment size, their age, their ownership of bank accounts and whether they had a loan – are added.[14] What is more, columns (3) - (4) show industry cell phone use also had positive impacts on informal firms' machinery investments.

In conclusion, our evidence suggests that the Internet provides larger opportunities for firms facing fewer opportunities for tapping into alternative knowledge sources, particularly when it comes to their labor productivity and also to some extent for certain innovation efforts. This, however, does not hold for differently sized firms. We also identify effects for informal businesses, confirming previous case study evidence of wider benefits.

5.4. Testing for the Effects of "Absorptive Capacities"

We test our third hypothesis on the importance of firms' "absorptive" capacities for benefits from Internet-enabled knowledge spillovers. In order to test whether average firm effects identified so far hide highly differential benefits, we conduct quantile regressions of impacts on labor productivity. Results for equation (1), which are shown in Figure 3, indicate differences in the benefits from

[14] We select a different set of control variables due to the different nature of firms analysed and the different variables contained in the informal firm survey.

industries' adoption of the Internet exist. Returns are quite low for firms with productivity below the 35th percentile and increase steadily afterwards, leveling off for firms reaching the 70th percentile. The finding lends support to the "absorptive" capacities hypothesis for firms to effectively benefit from the knowledge spillovers facilitated by the Internet. The least productive firms hardly reap positive returns from their industries' Internet adoption.

In addition, we test how impacts identified across firm characteristics change across the productivity distribution. With regards to exporter status, Figure 4 (a) shows highest differential returns for non-exporting firms arise at productivity levels above the median. While the gains for exporters rise only marginally across the productivity distribution, we find benefits for non-exporters remain fairly low, even for the most productive firms. In other words, the larger average impacts identified in our previous analysis are driven by much larger gains for the most productive non-exporters. There is hardly any difference in (low) benefits for the least productive firms.

Figure 4 (b) plots the coefficients of our variable of interest across firms' location in different agglomerations. Both groups of firms reap fewer gains at lower levels of the productivity distribution while gains are much larger for firms with productivity levels above the median. The gap between largest and smallest locations is largest for the firms with productivity around the median productivity range. Above the median productivity threshold there is a leveling off of benefits in that more productive firms do not gain additional benefits. This might be because for the most productive firms there are relatively fewer efficiency improvements to be had from stronger knowledge spillovers.

Moreover, Figure 4 (c) reports results for multi- and single-product firms. The evidence shows that the Internet provided limited returns to the least productive single- and multi-product firms. However, for the group of single-product firms the benefits rise particularly for firms with productivity above the median. By contrast, for multi-product firms the rise is modest only. As is the case of results for exporters and non-exporters, we find that the higher average gains reported in Table 5 are driven by the large returns for the most productive non-exporters.

Last, Table 7 shows quantile regression estimates, which include an interaction term for firm size differences. While aggregate results reported in Table 5 do not show differences in effects, quantile regression results indicate that there are differences across small and large firms. Larger firms have lower benefits than smaller ones among those beyond the median distribution of firms.

Finally, with respect to innovation indicators, we find, as shown in Table 8, that when splitting impacts for firms with past above- or below-median productivity or different performance quantiles, the returns are larger for those with higher productivity with respect to their equipment investments and quality certificates. We find no evidence of differences for patenting activities.

6. Concluding Remarks

This paper provides systematic evidence of the positive impact of industries' Internet use on firm performance for 50,013 firm observations, covering 117 countries for 2006-2011. These gains, which did not depend on firms' own ICT investments, provide support for public policies aimed at fostering industries' use of the Internet. We also find that the Internet provided larger benefits to firms located in smaller agglomerations, to single-plant establishments and to non-exporters. These firms commonly engage less in innovation and consequently Internet-enabled knowledge spillovers can serve the "democratization of innovation". That is the more so the case because positive effects also arise even in contexts where firms face financial constraints, frequent power outages, skills shortages, corruption or cumbersome labor regulations (Paunov and Rollo, 2014). Having more inclusive innovation processes is particularly critical in many emerging and developing countries, as in these economies often only a very small number of firms innovate (Paunov, 2013). However, we also find that only the more productive firms among those types of firms benefited more than others. This points to the continued importance of policies aimed at building firms' innovation capacities. Otherwise, the Internet will only play a limited role in supporting inclusive innovations. Finally, questions for future research arise, including how increasingly more sophisticated uses of the Internet influence potential spillovers and returns to firm performance. Adjusting firm surveys to take novel applications into account is critical for such research.

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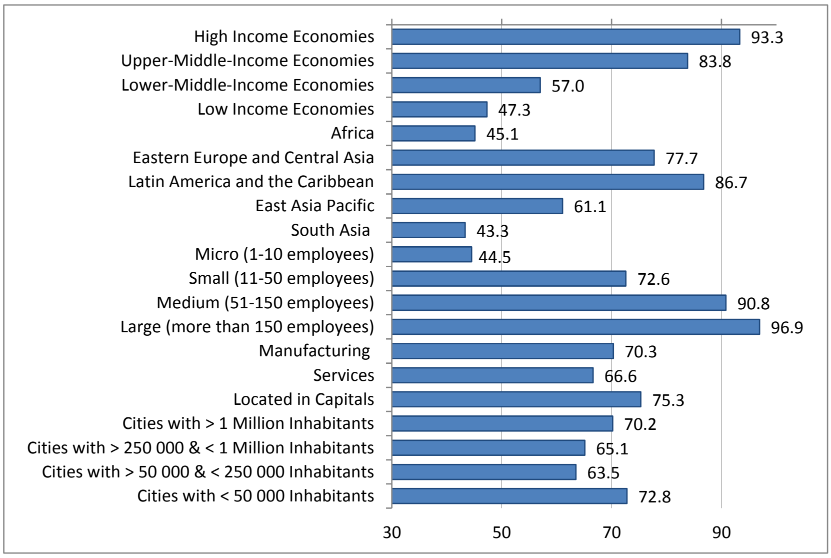
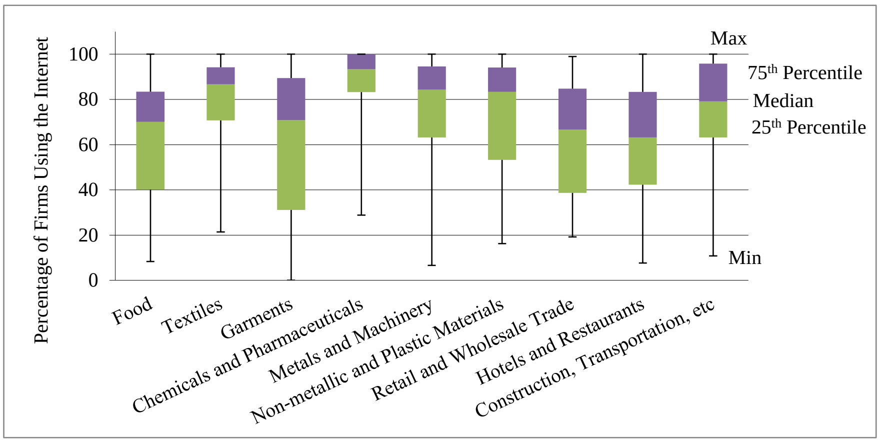
Figures and Tables

Figure 1: Share of firms communicating with clients and suppliers by e-mail in 2006-2011 (in percentages)



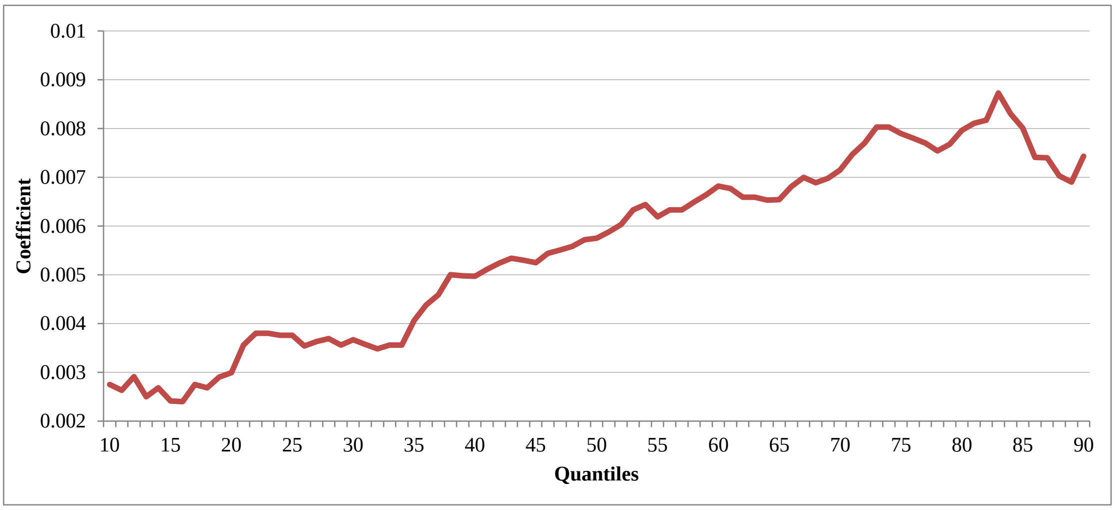
Note: Statistics provided are obtained for the 50,013 firms included in our baseline sample. See Table 2 and Appendix Table 1 for details regarding the sample.

Figure 2: Percentiles of industries' adoption of the Internet across countries



Note: The deciles for different industries are computed based on the following number of country observations on the share of firms using the Internet to communicate by email with clients and users: 110 for food, 71 for garments, 50 for textiles, 48 for chemicals and pharmaceuticals, 68 for metals and machinery, 64 for non-metallic and plastic materials, 123 for retail and wholesale trade and 74 for hotels and restaurants. Statistics provided are obtained for the 50,013 firms included in our baseline sample. See Table 2 and Appendix Table 1 for details regarding the sample.

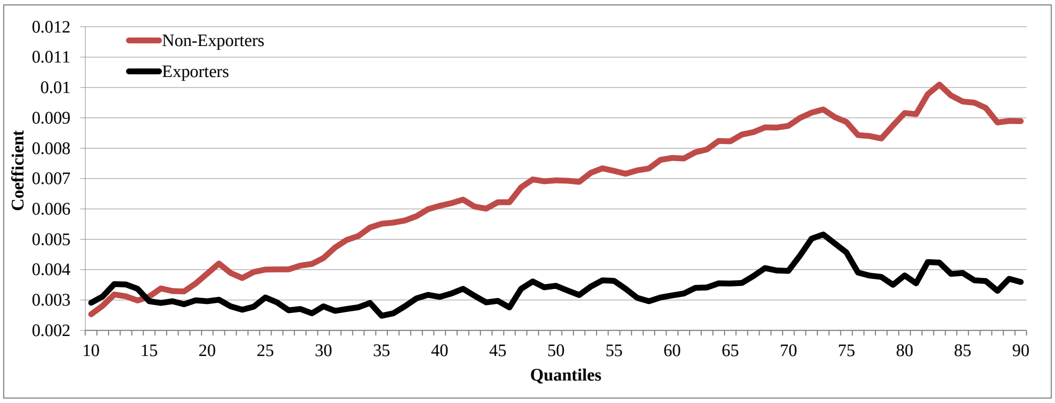
Figure 3: Estimated Coefficients of Quantile Regressions of Labor Productivity



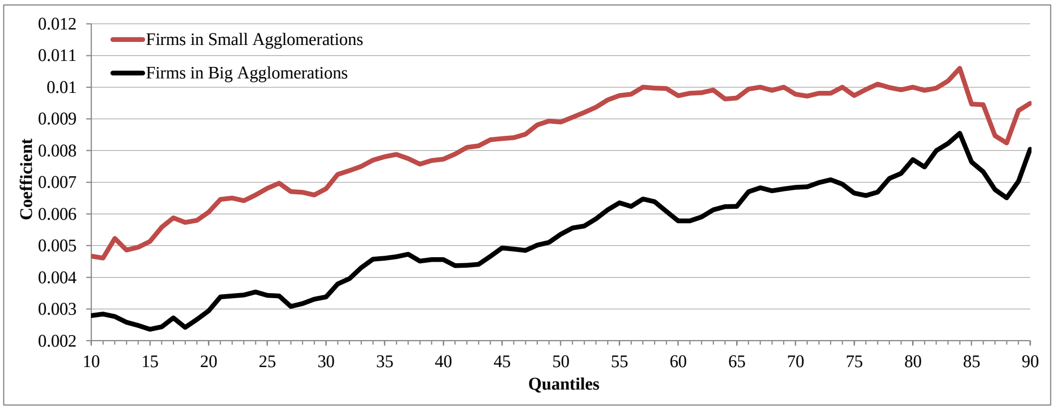
Note: The figure plots coefficients from quantile regressions of the impact of the share of firms using email on labor productivity for the 10^{th} to the 90^{th} quantile of the distribution.

Figure 4: Estimated Coefficients of Quantile Regressions of Firms' Use of the Internet

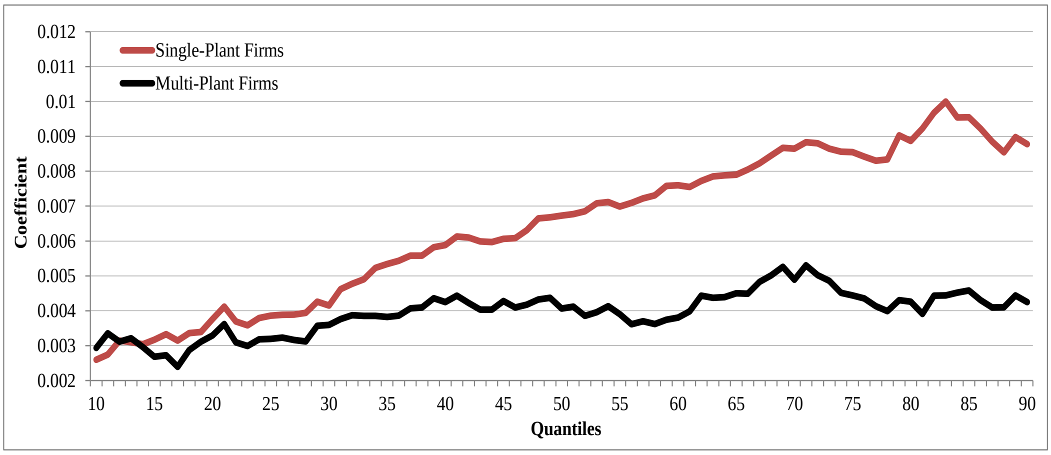
(a) By Exporter Status



(b) By Agglomeration Type



(c) By Single- and Multi-Plant Firms



Note: The figures plots coefficients from quantile regressions of the impact of industry in big and small agglomerations as in column (3) of Panel A of Table 5 on labor productivity for the 10th to the 90th quantile of the distribution.

Table 1: Statistics on Technology Use of the Informal Sector in 2009-2010

	Overall		AFR		LAC	
	Firm Nbr.	Percent	Firm Nbr.	Percent	Firm Nbr.	Percent
Use of cell-phone						
No	1026	40.7	295	23.8	674	58.0
Yes	1495	59.3	943	76.2	489	42.1
Use of electricity						
No	553	24.9	369	29.7	178	20.7
Yes	1668	75.1	873	70.3	681	79.3
Experienced power outages						
No	765	46.1	275	31.8	489	72.0
Yes	894	53.9	591	68.2	190	28.0

Note: Information is based on firm observations for 14 countries: Angola, Argentina, Botswana, Burkina Faso, Cameroon, Cape Verde, Democratic Republic of Congo, Ivory Coast, Guatemala, Madagascar, Mali, Mauritius, Nepal and Peru.

Table 2: Descriptive Statistics

	Number of Observations	Share in Total
Region		
Africa	13,741	27.5%
Eastern Europe and Central Asia	9,968	19.9%
Latin America and the Caribbean	19,772	39.5%
Middle East	1,007	2.0%
East Asia Pacific	3,677	7.4%
South Asia	1,848	3.7%
Industry		
Food	6,326	12.7%
Garments	3,987	8.0%
Textiles and Leather	2,567	5.1%
Wood and Furniture	689	1.4%
Non-metallic and Plastic Materials	2,337	4.7%
Metals, Machinery and Electronics	3,738	7.5%
Chemicals and Pharmaceuticals	2,387	4.8%
Other Manufacturing Activities	6,921	13.8%
Total Manufacturing	28,952	57.9%
Services (incl. Construction)		
Hotels and Restaurants	1,816	3.6%
Retail and Wholesale Trade	11,641	23.3%
Construction and Transportation	2,629	5.3%
Other Services	4,975	10.0%
Total Services	21,061	42.1%
Size		
Micro (1-10 employees)	16,549	33.1%
Small (11-50 employees)	20,022	40.0%
Medium (51-150 employees)	7,772	15.5%
Large (more than 150 employees)	5,670	11.3%
Year		
2006	12,280	24.6%
2007	8,261	16.5%
2008	2,382	4.8%
2009	14,057	28.1%
2010	11,182	22.4%
2011	1,851	3.7%
Income Level		
High Income	2,627	5.3%
Upper-middle Income	21,126	42.2%
Lower-middle Income	17,925	35.8%
Low Income	8,335	16.7%
Full Sample	**50,013**	

Table 3: Baseline Results

Panel A: Labor Productivity

	Dependent Variable: Labor Productivity					
	(1)	(2)	(3)	(4)	(5)	(6)
Industry Internet Use	0.010***	0.008***	0.008***	0.007***	0.007***	0.006***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Firm-Level Controls						
Employment		0.151***	0.132***	0.082***	0.058***	0.023**
		(0.010)	(0.010)	(0.010)	(0.010)	(0.010)
Age		0.083***	0.078***	0.087***	0.078***	0.075***
		(0.011)	(0.011)	(0.011)	(0.011)	(0.011)
Public Ownership			-0.133*	-0.149**	-0.121*	-0.136*
			(0.073)	(0.072)	(0.073)	(0.071)
Multi-Plant Firm			0.333***	0.280***	0.285***	0.254***
			(0.022)	(0.022)	(0.022)	(0.022)
Foreign Ownership				0.443***	0.476***	0.453***
				(0.025)	(0.026)	(0.025)
Exporter Status				0.258***	0.241***	0.191***
				(0.022)	(0.022)	(0.021)
Credit Access					0.302***	0.279***
					(0.016)	(0.016)
Managerial Expertise					0.026**	0.027**
					(0.011)	(0.011)
Website						0.386***
						(0.017)
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Country-Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	56,169	55,121	52,839	52,146	50,107	50,013
R^2	0.79	0.80	0.80	0.81	0.81	0.81

Panel B: Indicators of Innovation Performance

	Equipment Investment		Quality Certificates		Patents	
	OLS Regressions		Logistic Regressions			
	(1)	(2)	(3)	(4)	(5)	(6)
Industry Internet Use	0.016***	0.009***	0.019***	0.005**	0.018***	0.012**
			[0.003]	[0.001]	[0.004]	[0.002]
	(0.003)	(0.003)	(0.002)	(0.002)	(0.004)	(0.005)
Firm-Level Controls	No	Yes	No	Yes	No	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Country-Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	36,501	33,080	61,965	54,586	9,879	9,061
R^2	0.44	0.45				
Pseudo R^2			0.09	0.25	0.13	0.19

Note: Panel A reports results from ordinary least squares regressions. Robust standard errors clustered at country-industry-year level are shown in parentheses. For logistic regressions, marginal effects are reported in brackets. Firm-level controls are the same as those of column (5) of Panel A of Table 3. ***, ** and * indicate significance at 1%, 5% and 10% confidence levels, respectively.

Table 4: Robustness

	Dependent Variable: Labor Productivity							
	Adding Context Controls	Adding Location Fixed Effects	Instrumental Variable Results	Manufacturing and Services	Alternative Aggregation			Exposure to Technology
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Industry Internet Use	0.005***	0.007***						
	(0.001)	(0.001)						
Email Use			1.218***					
			(0.291)					
Industry Internet Use * Manufacturing				0.005***				
				(0.001)				
Industry Internet Use * Services				0.008***				
				(0.001)				
Industry Internet Use (Firm Size)					0.007***			
					(0.001)			
Industry Internet Use (Location Type)						0.009***		
						(0.001)		
Industry Internet Use (Geographic Location)							0.009***	
							(0.001)	
Industry Internet Use * High Exposure to Technology								0.006***
								(0.001)
Industry Internet Use * Low Exposure to Technology								0.005***
								(0.001)
P-Value for the Difference in Coefficients				0.01				0.00
Firm-Level Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country-Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	49,790	44,706	50,013	50,013	44,476	41,442	42,528	50,013
R^2	0.81	0.82	0.81	0.81	0.82	0.82	0.82	0.81

Note: The table reports results from ordinary least squares regressions. Firm-level controls are the same as those of column (5) of Panel A of Table 3. Robust standard errors clustered at country-industry-year level are shown in parentheses. ***, ** and * indicate significance at 1%, 5% and 10% confidence levels, respectively.

Table 5: Firm Characteristics

Panel A: Labor Productivity

	Dependent Variable: Labor Productivity			
	Exporters	Firm Location	Multi-Plant Firms	Firm Size
	(1)	(2)	(3)	(4)
Industry Internet Use * Exporters	0.003*			
	(0.002)			
Industry Internet Use * Non-Exporters	0.006***			
	(0.001)			
Industry Internet Use * Big Agglomeration		0.005***		
		(0.001)		
Industry Internet Use * Small Agglomeration		0.008***		
		(0.001)		
Industry Internet Use * Multi-Plant Firms			0.004**	
			(0.002)	
Industry Internet Use * Single-Plant Firms			0.006***	
			(0.001)	
Industry Internet Use * Bigger Firms				0.006***
				(0.001)
Industry Internet Use * Small Firms				0.006***
				(0.001)
Firm Controls	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes
Country-Year Fixed Effects	Yes	Yes	Yes	Yes
P-Value of the Difference in Coefficients	0.00	0.01	0.04	0.45
Observations	50,013	44,706	51,521	50,013
R^2	0.81	0.82	0.81	0.81

Note: The tables reports results from ordinary least squares regressions. Firm-level controls are the same as those of column (5) of Panel A of Table 3. Robust standard errors clustered at country-industry-year level are shown in parentheses. ***, ** and * indicate significance at 1%, 5% and 10% confidence levels, respectively.

Panel B: Firm Characteristics and Benefits from the Internet: Innovation Indicators

	Dependent Variables											
	Equipment Investment				Quality Certificates				Patents			
	OLS Regressions				Logistic Regressions							
	Exporters	Firm Location	Multi-Plant Firms	Firm Size	Exporters	Firm Location	Multi-Plant Firms	Firm Size	Exporters	Firm Location	Multi-Plant Firms	Firm Size
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Industry Internet Use * Exporters	0.001				0.004*				0.001			
					[0.001]				[0.000]			
	(0.005)				(0.003)				(0.006)			
Industry Internet Use * Non-Exporters	0.010***				0.008***				0.015***			
					[0.001]				[0.003]			
	(0.003)				(0.002)				(0.005)			
Industry Internet Use * Big Agglomeration		0.008**				0.002				0.010**		
						[0.000]				[0.002]		
		(0.004)				(0.002)				(0.005)		
Industry Internet Use * Small Agglomeration		0.011**				0.006**				0.014**		
						[0.001]				[0.003]		
		(0.004)				(0.003)				(0.006)		
Industry Internet Use * Multi-Plant Firms			0.009**				-0.001				0.004	
							[-0.000]				[0.001]	
			(0.004)				(0.003)				(0.006)	
Industry Internet Use * Single-Plant Firms			0.009***				0.009***				0.012**	
							[0.001]				[0.002]	
			(0.003)				(0.002)				(0.005)	
Industry Internet Use * Bigger Firms				0.009***				0.006***				0.011**
								[0.001]				[0.002]
				(0.003)				(0.002)				(0.005)
Industry Internet Use * Small Firms				0.009***				0.004**				0.013**
								[0.001]				[0.002]
				(0.003)				(0.002)				(0.005)
Firm Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country-Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
P-Value of the Difference in Coefficients	0.01	0.44	0.93	0.93	0.05	0.08	0.00	0.01	0.00	0.31	0.03	0.31
Observations	31,281	27,612	34,013	31,281	56,476	49,048	56,476	54,586	9,535	9,061	9,535	9,061
R^2	0.45	0.44	0.45	0.45								
Pseudo R^2					0.23	0.25	0.23	0.25	0.18	0.19	0.18	0.19

Note: Firm-level controls are the same as those of column (5) of Panel A of Table 3. Robust standard errors clustered at country-industry-year level are shown in parentheses. For logistic regressions, marginal effects are reported in brackets. ***, ** and * indicate significance at 1%, 5% and 10% confidence levels, respectively.

Table 6: Informal Businesses

	Dependent Variables:			
	Sales		Machinery Investment	
	(1)	(2)	(3)	(4)
Industry Cell Phone Use	0.010**	0.011**	0.017**	0.016*
	(0.003)	(0.003)	(0.009)	(0.009)
Firm Controls	No	Yes	No	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes
Country-Year Fixed Effects	Yes	Yes	Yes	Yes
Observations	1,406	1,207	1,430	1,219
R^2	0.80	0.83	0.09	0.14

Note: The table reports results from ordinary least squares regressions. Firm controls include employment size, their age, their ownership of bank accounts and whether they had a loan. Robust standard errors clustered at country-sector-year level are shown in parentheses. ***, ** and * indicate significance at 1%, 5% and 10% confidence levels, respectively.

Table 7: Differential Impacts of Size across the Productivity Distribution

	Dependent Variable: Labor Productivity Quantile Regression								
	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Industry Internet Use * Size	-0.000	-0.001**	-0.002***	-0.002***	-0.002***	-0.003***	-0.003***	-0.003***	-0.003***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)
Industry Internet Use	0.003	0.006***	0.009***	0.011***	0.012***	0.014***	0.015***	0.015***	0.016***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)
Firm-Level Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country-Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	50,013	50,013	50,013	50,013	50,013	50,013	50,013	50,013	50,013
R^2	0.78	0.80	0.81	0.81	0.81	0.81	0.81	0.80	0.79

Note: Firm-level controls are the same as those of column (5) of Panel A of Table 3. Robust standard errors clustered at country-sector-year level are shown in parentheses. ***, ** and * indicate significance at 1%, 5% and 10% confidence levels, respectively.

Table 8: Impacts of Productivity Differences on Innovation Variables

	Equipment Investment		Quality Certificates		Patents	
	OLS Regressions		Logistic Regressions			
	(1)	(2)	(3)	(4)	(5)	(6)
Industry Internet Use * Below Median	0.005		0.004*		0.009*	
			[0.000]		[0.002]	
	(0.003)		(0.002)		(0.005)	
Industry Internet Use * Above Median	0.007**		0.005**		0.010*	
			[0.001]		[0.002]	
	(0.003)		(0.002)		(0.005)	
Industry Internet Use * Q1		0.006		0.004*		0.011**
				[0.001]		[0.002]
		(0.003)		(0.002)		(0.005)
Industry Internet Use * Q2		0.004		0.004		0.008
				[0.000]		[0.001]
		(0.003)		(0.002)		(0.005)
Industry Internet Use * Q3		0.006*		0.005*		0.010*
				[0.001]		[0.002]
		(0.003)		(0.002)		(0.005)
Industry Internet Use * Q4		0.008**		0.006***		0.009*
				[0.001]		[0.002]
		(0.004)		(0.002)		(0.005)
Firm-Level Controls	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Country-Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
P-Value of Difference in Coefficients (Below and Above Median)	0.02		0.02		0.47	
P-Value of Difference in Coefficients (Between Q1 and Q4)		0.12		0.02		0.40
Observations	26,642	26,642	41,720	41,720	7,087	7,087
R^2	0.46	0.46				
Pseudo-R^2			0.26	0.26	0.18	0.18

Note: Firm-level controls are the same as those of column (5) of Panel A of Table 3. Robust standard errors clustered at country-industry-year level are shown in parentheses. For logistic regressions, marginal effects are reported in brackets. ***, ** and * indicate significance at 1%, 5% and 10% confidence levels, respectively.

Appendix Table 1: Observations by Country

Country	Observations	Percentage Share in Total	Country	Observations	Percentage Share in Total	Country	Observations	Percentage Share in Total
Albania	199	0.40	The Gambia	153	0.31	Pakistan	843	1.69
Angola	659	1.32	Georgia	243	0.49	Panama	587	1.17
Antigua and Barbuda	116	0.23	Ghana	475	0.95	Paraguay	719	1.44
Argentina	1,790	3.58	Grenada	129	0.26	Peru	1,464	2.93
Armenia	262	0.52	Guatemala	858	1.72	Philippines	944	1.89
Azerbaijan	291	0.58	Guinea	192	0.38	Poland	260	0.52
The Bahamas	114	0.23	Guinea-Bissau	133	0.27	Romania	304	0.61
Barbados	120	0.24	Guyana	136	0.27	Russian Federation	717	1.43
Belarus	193	0.39	Honduras	595	1.19	Rwanda	183	0.37
Belize	146	0.29	Hungary	248	0.50	Samoa	35	0.07
Benin	90	0.18	Indonesia	1,122	2.24	Senegal	479	0.96
Bhutan	215	0.43	Iraq	707	1.41	Serbia	327	0.65
Bolivia	681	1.36	Jamaica	225	0.45	Sierra Leone	126	0.25
Bosnia and Herzegovina	252	0.50	Kazakhstan	400	0.80	Slovak Republic	165	0.33
Botswana	502	1.00	Kenya	636	1.27	Slovenia	243	0.49
Brazil	1,077	2.15	Kosovo	200	0.40	South Africa	895	1.79
Bulgaria	1,171	2.34	Kyrgyz Republic	154	0.31	Sri Lanka	462	0.92
Burkina Faso	310	0.62	Laos	271	0.54	St. Kitts and Nevis	117	0.23
Burundi	265	0.53	Latvia	211	0.42	St. Lucia	130	0.26
Cameroon	320	0.64	Lesotho	88	0.18	St. Vincent and the Grenadines	129	0.26
Cape Verde	96	0.19	Liberia	111	0.22	Suriname	152	0.30
Central African Republic	135	0.27	Lithuania	209	0.42	Swaziland	259	0.52
Chad	120	0.24	Macedonia	292	0.58	Tajikistan	247	0.49
Chile	1,702	3.40	Madagascar	336	0.67	Tanzania	388	0.78
Colombia	1,774	3.55	Malawi	83	0.17	Timor-Leste	82	0.16
Democratic Republic of the Congo	517	1.03	Mali	654	1.31	Togo	102	0.20
Republic of the Congo	91	0.18	Mauritania	214	0.43	Tonga	107	0.21
Costa Rica	408	0.82	Mauritius	275	0.55	Trinidad and Tobago	308	0.62
Ivory Coast	462	0.92	Mexico	2,454	4.91	Turkey	835	1.67
Croatia	561	1.12	Micronesia	35	0.07	Uganda	515	1.03
Czech Republic	165	0.33	Moldova	327	0.65	Ukraine	544	1.09
Dominica	134	0.27	Mongolia	336	0.67	Uruguay	907	1.81
Dominican Republic	289	0.58	Montenegro	60	0.12	Uzbekistan	320	0.64
Ecuador	836	1.67	Mozambique	440	0.88	Vanuatu	81	0.16
El Salvador	884	1.77	Namibia	307	0.61	Venezuela	158	0.32
Eritrea	91	0.18	Nepal	328	0.66	Vietnam	953	1.91
Estonia	232	0.46	Nicaragua	633	1.27	Yemen	300	0.60
Fiji	47	0.09	Niger	85	0.17	Zambia	434	0.87
Gabon	108	0.22	Nigeria	1,865	3.73	Zimbabwe	547	1.09

Appendix Table 2: Description of Variables Used

Name	Description	Mean	Std. Dev.
Dependent Variables			
Labor Productivity	Logarithm of the ratio of total annual sales over full time employment windsorized at the top and bottom 1% for any country-year, reported in thousand USD.	18	2.17
Equipment Investment	Logarithm of sum of 1 and the ratio of total annual expenditure for purchases of equipment over full time employment, reported in thousand USD.	2.1	1.08
Certificates	A dummy equal to one if the establishment has an internationally-recognized quality certification, such as ISO 9000 or 14000 certifications.	0.21	
Patents	A dummy equal to one if the establishment has a registered patent and zero otherwise.	0.39	
Internet Use Variable			
Industry Internet Use	Percentage share of firms using email to communicate with clients and suppliers in industry *j* of country *c* in year *t* . Robustness tests include alternative measures for Internet i) by industry, country-year and firm size, ii) by industry, country-year and location type and iii) by industry, country-year and	68.7	27.1
Firm-Level Controls			
Employment	Logarithm of the establishment's full-time employment.	3.2 [25]	1.4
Age	Logarithm of the difference between the year the survey was conducted and the year the firm was created.	2.7 [15]	0.7
Public Ownership	A dummy equal to one if the government or state own a share of 10% or more of the establishment and zero otherwise.	0.01	
Multi-Plant Firm	A dummy equal to one if the firm the establishment belonged to had at least one other business and zero otherwise.	0.15	
Foreign Ownership	A dummy equal to one if the share of foreign ownership is bigger or equal to 10 percent and zero otherwise.	0.12	
Exporter Status	An indicator that is equal to one if the firm has exporter activities (direct or indirect).	0.23	
Credit Access	Dummy variable is equal to one if the firm has a line of credit or loan from a financial institution and zero otherwise.	0.42	
Managerial Expertise	Logarithm of years of the managers' experience	2.70 [15]	0.68
Website	Dummy variable where the firm owns a website and zero otherwise.	0.41	
Industry	A variable indicating in which sector the firm is operating: i) food, ii) wood and furniture, iii) textiles, iv) garments, v) leather, vi) non-metallic and plastic materials, vii) chemicals and pharmaceuticals, viii) electronics, ix) metals and machinery, x) auto and auto components, xi) other manufacturing, xii) retail and wholsesale trade, xiii) hotels and restuarants, xiv) construction and transportation, xv) other services.		
Variables Used for Robustness Tests			
Email Use	Indicator of whether firm *i* used email to communicate with suppliers and clients.	0.69	
Location Variables	A variable indicating if the firm is located in the capital (1), in a city of more than 1 million of inhabitants (2), in a town of less than 1 million but more than 250,000 inhabitants (3), of less than 250,000 but more than 50,000 inhabitants (4) or less than 50,000 inhabitants (5).		
High (Low) Exposure to Technology	Indicator of whether the number of firms that use foreign technology in the industry is above (below) the average number of firms that use foreign technology, across industries.		
Interaction Variables			
Size	Establishment's full time employment.		
Big (Small) Agglomeration	Indicator of whether the firm is (not) located in the capital or a city of more (less) than 1 million inhabitants.		
Bigger (Small) Firms	Indicator of whether the firm full-time employment was above or below the median distribution.		
Above (Below) Median of Past Productivity	Indicator of whether the firm's productivity at *t-3* (windsorized at the top and bottom 1% for any country-year) was above or below the median productivity distribution.		
Q1, Q2, Q3 and Q4 of Past Productivity	Dummy variable indicating if the firm's productivity at *t-3* (windsorized at the top and bottom 1%) was in the first (Q1), second (Q2), third (Q3) or fourth (Q4) quartile of the productivity distribution.		
Variables Used for the Analysis of Informal Businesses (Separate Dataset from Above)			
Sales	Logarithm of total sales of the establishment, windsorized at the top and bottom 1% for any country-year, reported in thousand USD, value in parenthesis.	0.5	1.41
Machinery Investments	A dummy equal to one if the establishment invested in machinery and zero otherwise.	0.23	
Industry Cell Phone Use	Share of firms in a country sector who used cell phones for their operations.	51.18	21.52
Employment	Logarithm of total employment of the business.	0.46 [1.6]	0.68
Age	Logarithm of the difference between the year the survey was conducted and the year the firm was created.	1.98 [7.2]	0.90
Bank Account	A dummy equal to one if the firm owned a bank account.	0.15	
Loan	Indicator of whether the firm had a bank loan or not.	0.12	
Sectors	A variable indicating in which sector the firm is operating in i) food, ii) furniture, iii) handicrafts, iv) clothes and shoes, v) other manufacturing, vi) construction, vii) sales, viii) other services		

Appendix Table 3: Robustness for Innovation Variables

Panel A: Equipment Investment

	Dependent Variable: Equipment Investment							
	Adding Context Controls	Adding Location Fixed Effects	Instrumental Variable Results	Manufacturing and Services	Alternative Aggregation			Exposure to Technology
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Industry Internet Use	0.012*** (0.004)	0.010*** (0.004)						
Email Use			1.800*** (0.636)					
Industry Internet Use * Manufacturing				0.009*** (0.003)				
Industry Internet Use * Services				0.009** (0.004)				
Industry Internet Use (Firm Size)					0.015*** (0.002)			
Industry Internet Use (Location Type)						0.006* (0.003)		
Industry Internet Use (Geographic Location)							0.007** (0.003)	
Industry Internet Use * High Exposure to Technology								0.009*** (0.003)
Industry Internet Use * Low Exposure to Technology								0.009*** (0.003)
P-Value for the Difference in Coefficients				0.96				0.89
Firm Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country-Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	32,954	29,220	33,080	33,080	29,408	27,236	27,923	33,080
R^2	0.45	0.45	0.45	0.45	0.45	0.44	0.45	0.45

Panel B: Quality Certificates

	Dependent Variable: Quality Certificates							
	Adding Context Controls	Adding Location Fixed Effects	Instrumental Variable Results	Manufacturing and Services	Alternative Aggregation			Exposure to Technology
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Industry Internet Use	0.003 [0.000] (0.002)	0.004 [0.000] (0.002)						
Email Use			0.038 (0.053)					
Industry Internet Use * Manufacturing				0.004*** [0.001] (0.001)				
Industry Internet Use * Services				-0.001 [0.000] (0.002)				
Industry Internet Use (Firm Size)					0.007*** [0.001] (0.001)			
Industry Internet Use (Location Type)						0.003 [0.000] (0.002)		
Industry Internet Use (Geographic Location)							0.004** [0.0005] (0.002)	
Industry Internet Use * High Exposure to Technology								0.005** [0.001] (0.002)
Industry Internet Use * Low Exposure to Technology								0.003 [0.000] (0.002)
P-Value for the Difference in Coefficients				0.01				0.04
Firm Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country-Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	54,344	49,048	54,625	54,625	48,527	45,417	46,648	54,586
R^2			0.25					
Pseudo R^2	0.25	0.25		0.22	0.26	0.25	0.25	0.25

Panel C: Patents

	Dependent Variable: Patents						
	Adding Context Controls	Adding Location Fixed Effects	Instrumental Variable Results	Alternative Aggregation			Exposure to Technology
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Industry Internet Use	0.009*	0.012**					
	[0.002]	[0.002]					
	(0.006)	(0.005)					
Email Use			0.438*				
			(0.230)				
Industry Internet Use (Firm Size)				0.013***			
				[0.003]			
				(0.003)			
Industry Internet Use (Location Type)					0.006		
					[0.001]		
					(0.004)		
Industry Internet Use (Geographic Location)						0.003	
						[0.001]	
						(0.004)	
Industry Internet Use * High Exposure to Technology							0.010**
							[0.002]
							(0.005)
Industry Internet Use * Low Exposure to Technology							0.008
							[0.002]
							(0.005)
P-Value for the Difference in Coefficients							0.11
Firm Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Country-Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	9,019	9,061	9,061	6,423	8,335	8,502	9,061
R^2			0.17				
Pseudo R^2	0.19	0.19		0.19	0.19	0.19	0.19

Note: Panel A reports results from ordinary least squares regressions while Panels B and C report results from logistic regressions. Firm-level controls are the same as those of column (5) of Panel A of Table 3. Robust standard errors clustered at country-industry-year level. For logistic regressions, marginal effects are reported in brackets. ***, ** and * indicate significance at 1%, 5% and 10% confidence levels, respectively.

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