

ICT Use, Competitive Pressures and Firm Performance in Mexico

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Abstract

This paper presents a set of stylized facts on the relation between information and communications technology (ICT) use, firm performance, and competition. Taking advantage of a novel firm-level data set on information and communications technology for Mexico, the study finds that firms facing higher competition appear to have more incentives to increase their use of information and

communications technology. Accordingly, although there is indeed a positive relation between information and communications technology use and firm performance, this effect is greater for firms that face higher competition pressures, which is consistent with the theoretical predictions of the trade-induced technical change hypothesis.

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1 Introduction

The question of whether the digital revolution has had effects on productivity has been around for a long time. Firms expect to become more efficient as a result of using more Information and Communication Technologies (ICT) and therefore, to obtain positive returns from these investments. Accordingly, ICT has been the most dynamic component of total investment in OECD countries (OECD, 2007). However, empirical studies have not found much evidence on this relationship. Moreover, this lack of evidence led to the so called Solow Paradox during the 1980s in which the computer age was everywhere but in the productivity statistics (Solow, 1987).

Recent evidence points to a reversal of this paradox as ICT is considered one of the factors that can potentially increase firm-level productivity (Syverson, 2011). According to Brynjolfsson and Hitt (1996) previous non-significant results arise from mismeasurement, lags on the effects, as well as the fact that the impact of ICT on variety, quality and other intangibles is more likely to be detected at the firm level than using more aggregated data. Using firm-level data for the U.S., these authors find that computers have significant effects over output, and that their contribution to marginal product is at least as high as the one from other capital investments. Among other studies that obtain similar results are Stiroh (2002), Oliner et al. (2008) and Jorgenson et al. (2008).

Even though some agreement has been reached regarding the positive effects of ICT on productivity, there is still little evidence on the channels or the factors that could enhance these effects. For example, as Jorgenson et al. (2008) argue, in order to successfully leverage ICT investments, firms must undergo complementary investments such as changes in business organization, human resources, workplace practices, training, etc., which Brynjolfsson et al. (2002) refer to as intangible assets. In order to explain the differences in terms of productivity growth after 1995 between the U.S. and Europe, that had previously been widely studied,¹ Bloom et al. (2012b) dig deeper in the analysis of this statement and conclude that these differences arise from the human resources practices of U.S. firms.

On the other hand, there is a different strand of the literature that analyzes the effects of increasing competition over productivity. As Aghion et al. (2001) argue, the idea behind these studies is that firms decide to innovate and adopt new technologies in order to temporarily escape competition from neck-and-neck rivals. Oliner et al. (2008) analyze those industries that were under the most intense pressure as a result of the 2001 recession and find that they experienced the strongest productivity growth but ICT does not appear to facilitate the adjustment to competitive pressures. However, recent studies that take advantage of the surge of Chinese competition as an external shock, find evidence in favor of trade-induced technical change, innovation and thus, productivity increases. For example, Bloom et al. (2015) find that this shock

¹See for example Van Ark et al. (2003), Haltiwanger et al. (2003), and Van Ark et al. (2008)

led to higher R&D, patenting, innovation and productivity in the case of European countries. Iacovone et al. (2013) evaluate the effects of Chinese competition for Mexico both on the extensive (firm exit) and intensive margins, obtaining heterogeneous results depending on the size of the firm, as small firms experience losses and in some cases are forced to exit the market, bigger firms exhibit the opposite effects leading to productivity growth.

In this paper we take advantage of a very rich and novel data set regarding ICT use in Mexico in order to shed some light on the relation between ICT use and firm productivity in the case of a developing country, which has been seldom studied. Furthermore, we build upon the ICT-productivity literature and extend it by taking into consideration the strand of literature that analyzes competition as a factor that speeds up the creative destruction process. Thus, we analyze whether facing higher competition pressures can enhance the relation between ICT use and productivity by providing the incentives for firms to either pursue the organizational changes that the adoption of these new technologies requires or simply to use them in a more efficient way.

2 Data

Our data are from Mexico's National Survey on Information Technologies 2009 and 2013, which is a survey designed by the National Science and Technology Council (CONACYT) and conducted by the National Institute of Statistics and Geography (INEGI). This survey includes detailed firm-level data regarding ICT and some other firm characteristics and it is under constant revision in order to improve the quality of the information obtained.²

Using ENTIC 2009 and 2013, we were able to match 1,017 firms that appeared in both waves of the survey and using the correspondences between North American Industry Classification System (NAICS) codes, which is the sectoral classification used in ENTIC, and the Harmonized System (HS1996) codes, we merged this information with trade data from the World Integrated Trade Statistics (WITS), World Bank. Therefore, we ended up considering only the manufacturing sector and our final sample consists of a balanced panel of 715 firms. Due to the representative random sampling design of the survey, as it is not meant to follow the same firms over time, big firms are more likely to appear in both waves of the survey. Thus, 87% of the firms in our sample are big firms and 40% are older than 27 years in 2012.

In order to measure ICT use, we rely on physical measures that were previously used by other

²Even though the first wave of ENTIC was conducted in 2004, it was included as a short module of the Innovation Survey and most of the relevant information for this analysis is not compatible with what we observe in later waves. Additionally, due to the random sampling design of this survey, only 297 of the firms that were surveyed in 2004 can be found in the 2013 wave.

authors such as Beaudry et al. (2006) Bloom et al. (2015) and Bloom et al. (2012b). As these authors argue, these kinds of measures have the advantage of being recorded consistently in all firms and they do not depend on price indexes. Furthermore, as Bloom et al. (2012b) argue, they are highly correlated with other measures such as IT capital stock per worker. In this sense, we analyze computers-per-worker, the share of labor with Internet, and the share of labor with computer which should behave similarly to computers-per-worker and allows us to test the robustness of our main measure.

As our performance indicator considering the information available in ENTIC, we use sales-per-worker, which, although it is an imperfect measure of productivity, has been widely used in previous studies.³ For example Haltiwanger et al. (1999) and more recently Bloom et al. (2012a) use this indicator as their productivity measure. Table 1 shows descriptive statistics for firms in our sample in terms of performance, ICT use and other characteristics.

Finally, in order to analyze whether firms face competition, following Iacovone et al. (2013) we use the natural shock generated by the increasing competition from China in the Mexican market. In this sense, we measure competition as the change in the share of China in total Mexican imports for each HS1996 subheading between 2000 and 2008.⁴

Table 1: Descriptive Statistics

Variable	2008				2012			
	Mean	sd	p10	p90	Mean	sd	p10	p90
Computers-per-worker	0.24	0.22	0.06	0.50	0.28	0.23	0.07	0.57
Share of labor with Internet	0.20	0.19	0.03	0.40	0.20	0.19	0.03	0.40
Share of labor with computer	0.21	0.19	0.05	0.43	0.24	0.22	0.06	0.50
Sales-per-worker (thousand pesos)	997.36	1,638.24	123.01	2,192.49	1,005.39	1,407.87	131.20	2,494.11
Share of white-collar workers	0.22	0.17	0.05	0.42	0.25	0.23	0.06	0.59
Investment fixed assets/worker (thousand pesos)	46.10	111.03	0.00	130.11	41.34	91.19	0.05	113.05

*The sample includes 715 firms.

Source: Authors' calculations with data from ENTIC 2009 and 2013, INEGI

³We are unable to construct TFP measures because the survey does not include information on physical non-ICT related capital stocks

⁴Considering that according to data from Mexico's Ministry of Economy, the U.S. market accounts for 80% of Mexican exports, we also analyzed the share of China in U.S. imports. Results are similar. This analysis is shown in Iacovone et al. (2015).

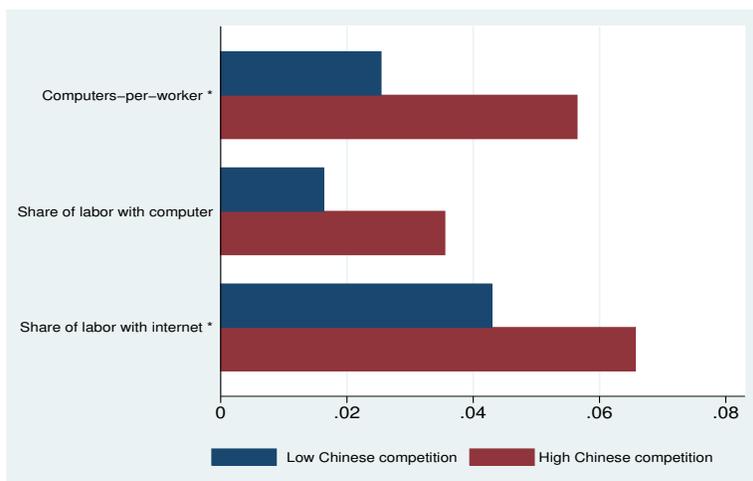
3 Results

Fact 1. Firms facing higher competition have increased more their use of ICT.

First of all, we analyzed whether firms that faced more competition, measured as a value above the median in our competition variable, experienced higher increases in terms of ICT use. Figure 1 shows that for the period 2008-2012 this is indeed the case. Firms producing goods that experienced higher import competition from China invested more in ICT; the difference is statistically significant at the 10% level for computers-per-worker and the share of labor with Internet.⁵

A possible mechanism behind the relation between ICT use and competition is trade-induced technical change. Under this hypothesis, competition generates incentives for innovation and the adoption of new technologies, speeding up the creative destruction process (Bloom et al., 2015). In this sense, considering all the side investments in terms of changes in processes and organization that entail increasing ICT use, firms that face higher competition pressures have more incentives to pursue these investments.

Figure 1: Mean change in ICT use 2008-2012



Source: Authors' calculations with data from ENTIC 2009 and 2013, INEGI. Differences in means significant at the: * 10% level, ** 5% level, *** 1% level
Note: High Chinese competition is defined as a value above the median in the change of the share of China in total Mexican imports between 2000 and 2008.

Fact 2. Firms that become more intensive in their use of ICT exhibit higher increases in productivity.

In order to test whether the predictions from previous studies regarding the relation between ICT and firm performance hold for developing countries, we analyze if firms that showed higher increases in their

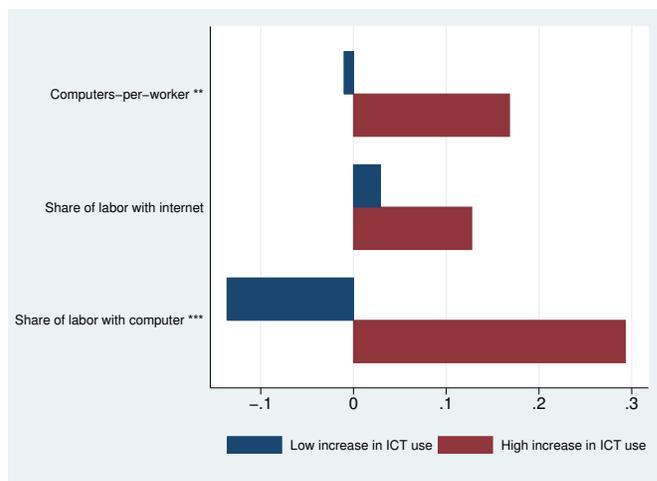
⁵In Iacovone et al. (2015) this is tested using regression analysis and the results indicate that this relation is significant for the three ICT use variables considered, even after controlling for firm characteristics.

use of ICT also increased their productivity.

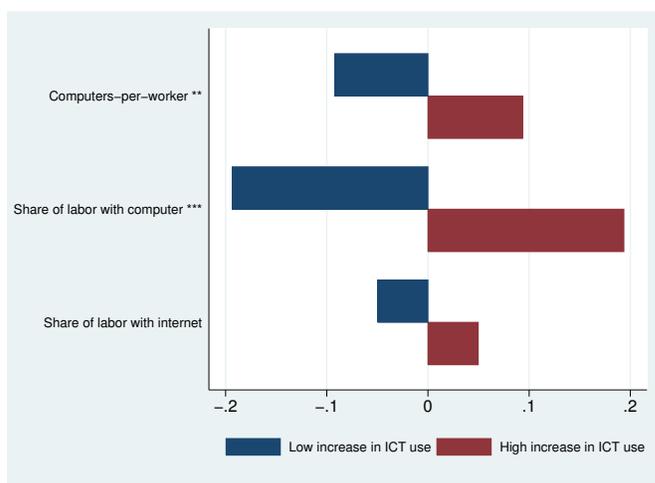
As Figure 2 shows, firms that exhibited changes in their ICT use above the median showed much higher increases in sales-per-worker. Furthermore, as shown in the second panel of the figure, this is the case even when we analyze the residuals of a regression of the change in sales over firm size, age, investment in fixed assets per worker and the share of white-collar workers. That is, even controlling for firm characteristics, firms that increased their use of ICT became more productive.

Figure 2: Mean change in sales/worker 2008-2012

(a) Mean change in sales/worker



(b) Mean change in sales/worker controlling for firm characteristics



Source: Authors' calculations with data from ENTIC 2009 and 2013, INEGI.

Differences in means significant at the: * 10% level, ** 5% level, *** 1% level

Note: In panel (a) the means of the differences in $\ln(\text{sales/worker})$ are shown for each ICT-use group. In panel (b) we take the residuals of a regression of the difference of $\ln(\text{sales/worker})$ over size dummies, age dummies, $\ln(\text{investment in fixed assets/worker})$ and the share of white-collar workers.

It is important to note that one of the empirical problems associated with the analysis of this relation is that the decision of investment in ICT cannot be taken as independent from performance (Draca et al., 2007) . Relying on the same data, Iacovone et al. (2015) adopt an instrumental variable (IV) approach and find that the positive relationship between ICT use and productivity still holds.

Fact 3. Firms that face higher competition and make more intensive use of ICT have a better performance.

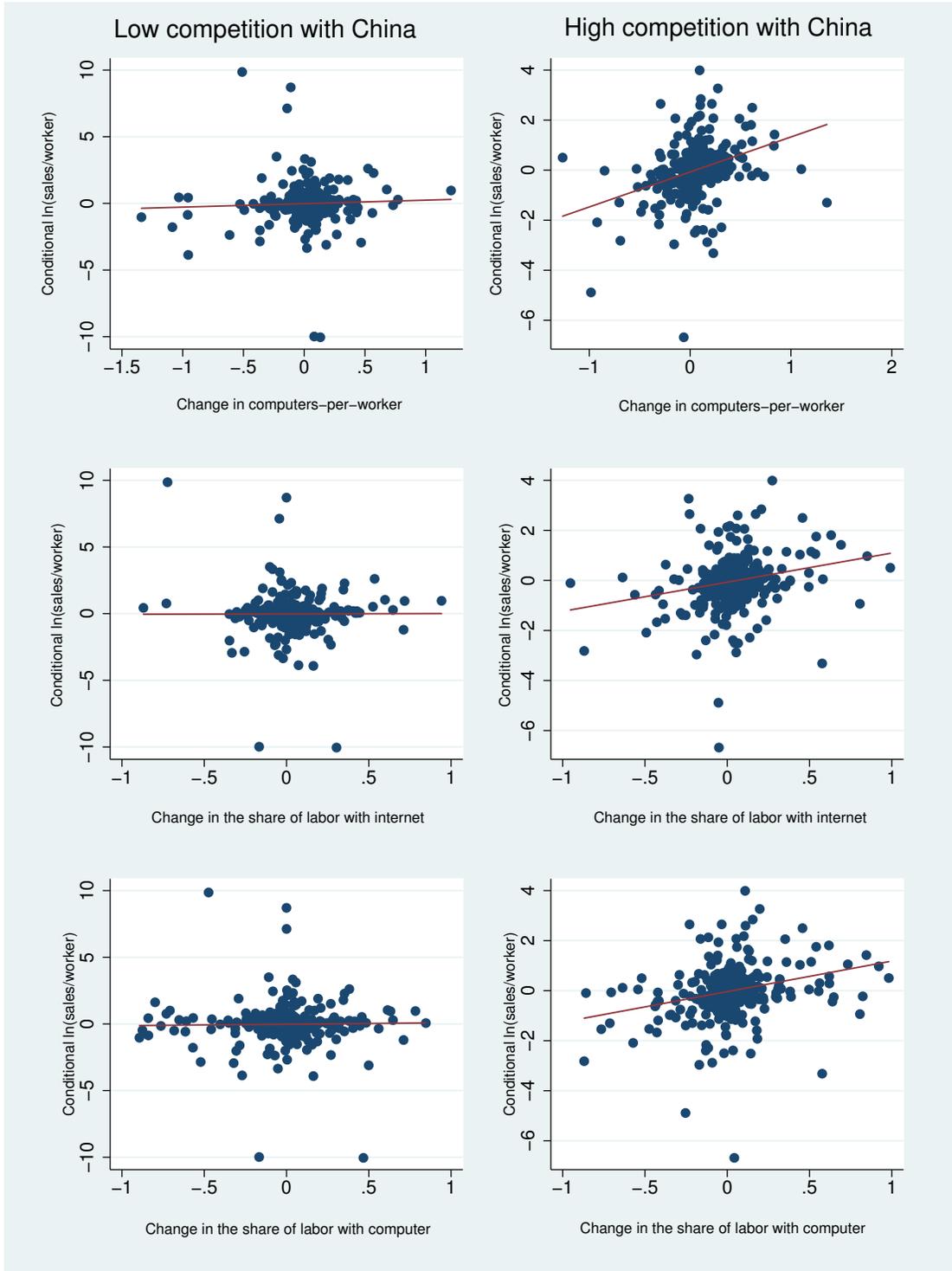
Testing the mechanism of the trade-induced technical change hypothesis, we analyzed the differences in terms of productivity according to the level of Chinese competition. We used the dummy variable that takes a value of one if our competition variable (change in the share of China in Mexico's imports) is above the median. As depicted in Figure 3, conditional on firm characteristics, only firms that face competitive pressures from China exhibit improvements in their performance as a result of a more intensive use of ICT (column 2 in the figure). For firms that face low competition there does not appear to be a relation at all.

Once again, the results support the idea that competition from China generates the incentives for firms not only to increase ICT but to use it more efficiently and pursue the complementary investments that these technologies require, meaning training and organizational changes.

Due to the construction of our sample, by definition we are analyzing the effects of competition only in terms of the intensive margin, as the exit of firms (extensive margin) cannot be tested due to data limitations. Considering the results of Iacovone et al. (2013) this should be less of a problem for our purpose as smaller firms are the ones that tend to exit the market under competitive pressures and most of the firms included in our analysis are big firms.

Further evidence on this relation is provided by Iacovone et al. (2015). In that study we also conduct robustness tests and deal with the endogeneity problem of ICT that we already mentioned.

Figure 3: Change in sales/worker vs. ICT use



Source: Authors' calculations with data from ENTIC 2009 and 2013, INEGI

Note: For conditional ln(sales/worker) we use the residuals of a regression of ln(sales/worker) over size dummies, age dummies, ln(investment in fixed assets/worker) and the share of white-collar workers.

4 Conclusions and Policy Implications

Empirical studies have experienced difficulties in finding evidence about the positive effects of ICT on productivity. Furthermore, the wide variation in terms of the elasticities for developed countries, mainly the U.S. and Europe, creates an expectation of heterogeneity in the effects by country, industry and type of firm (Draca et al., 2007).

Therefore, it is important to extend this analysis to the case of a developing country such as Mexico which has the additional characteristic of being one of the countries directly affected by the sudden increase in Chinese competition in recent years. This fact led us not only to analyze whether previous results hold, but also to test the relation between ICT and competition.

Our results indicate that ICT alone is not going to improve firm performance unless appropriate incentives are provided through higher competition to use ICT more effectively by making complementary investments in reorganization and skills. That is, in order to cope with the pressure of Chinese competition, firms appear to either make more effective use of ICT or to be willing to make the organizational changes necessary to improve the returns of ICT use.

Thus, the implications for policy are straightforward and suggest going back to the basics and removing existing barriers to private sector competition. This does not mean just enforcing antitrust laws but designing policies aimed at opening markets, building the infrastructure to make them more connected, as well as eliminating red tape, among other strategies.

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