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Competition Makes IT Better

Evidence on When Firms Use IT More Effectively

Leonardo Iacovone
Mariana Pereira-Lopez
Marc Schiffbauer

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Abstract

This paper uses a unique firm-level data set for Mexico, with information never used for research before, to assess how use of information technology (IT henceforth) influences firm performance. Further, the paper explores if, in the context of increasing competition from China, this effect is different for firms more strongly affected by competition where incentives for upgrading and innovation may be more intense. In this perspective, the paper analyzes the complementarity between IT and other changes spurred by competition, taking advantage of the exogenous shock generated by Chinese competition. The results indicate that IT use has higher effects over productivity in the case of firms facing higher competition from China, in the domestic market and in the U.S. market. Furthermore, the paper shows how these changes appear to be driven by complementary investments in innovation and organizational changes.

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Competition Makes IT Better: Evidence on When Firms Use IT More Effectively *

Leonardo Iacovone† Mariana Pereira-López‡ Marc Schiffbauer§

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†World Bank, email: liacovone@worldbank.org (Corresponding Author)

‡World Bank and University Iberoamericana, email: mpereiralopez@worldbank.org

§World Bank, email: mschiffbauer@worldbank.org

1 Introduction

The relation between information technology (IT) and productivity has been at the center of the attention of researchers since the early 2000s (Caroli and Reenen, 2001; Bresnahan and Hitt, 2002; Brynjolfsson and Hitt, 2003). According to Syverson (2011) IT is one of the "levers" that can be potentially used to increase firms' productivity. However, there is still not much evidence regarding the channels through which this observed relation operates as well as complementary changes in other factors that could enhance its impact. The knowledge of these complementarities is crucial for policy design as it could lead to more efficient mechanisms and programs to enhance firm-level productivity.

On the other hand, recent studies have stressed that external competition shocks induce faster technical change and innovation by speeding up creative destruction and, therefore have effects on firms' productivity (Iacovone et al., 2013; Bloom et al., 2015). A large part of this discussion has focused on rich countries competing with developing countries specialized in low-skilled intensive goods. An aspect of that kind of competitive shock, on which the literature has focused, is the impressive increase in Chinese manufacturing exports. Bloom et al. (2015) have found that competition from China has indeed induced both innovation and the adoption of new technologies and IT in OECD countries, contributing thus to their productivity growth. However, there is little evidence in the case of developing countries.

The purpose of this paper is to analyze, in the context of a developing country, the effect that IT use has on firm performance, and even further to evaluate if this effect is heterogeneous depending on the level of competition faced by the firms. The main hypothesis behind this analysis is that firms that face higher competition have more incentives to make an effective use of IT in order to be able to cope with the challenges posed by the entry of new competitors. More specifically, existing literature has shown that an effective adoption of IT requires important changes within the firms and is costly in terms of organizational changes, therefore only firms that face enough competitive pressures decide to do so. In this sense, this paper contributes to the existing knowledge on the relation between IT use and trade-induced technical change, which has been previously studied separately. Additionally, we test whether previous empirical results regarding IT use and productivity such as Stiroh (2002); Bresnahan et al. (2002) and Bloom et al. (2012b) hold for a developing country such as Mexico, which has a very different structure in terms of management practices than the U.S. or Europe.

Most of the studies regarding the effects of Chinese competition for Mexico have focused on aggregate effects on trade and output rather than firm-level effects (Freund and Ozden, 2006; Olarreaga et al., 2007; Jenkins et al., 2008, among others). However, according to recent empirical evidence, there is much more going on at the intra-firm level as competition can lead to organizational changes, innovation and investment in technology as a response to the competition threat. In this sense, this paper aims at expanding this literature by shedding more light on the relation between these two variables.

The rest of this paper is organized as follows: Section 2 provides a literature review of empirical studies on IT use as well as creative destruction induced by competition. In section 3, the methodology is presented. Section 4 explains the data used in the analysis as well as some descriptive statistics. Results are discussed in section 5 and conclusions in section 6.

2 Literature Review

This study is closely related with two different strands of economic literature. The first strand analyzes the effects of IT adoption on productivity while the second is related to trade competition and the adjustments needed at the firm level in order to be able to face the pressure generated by external competition.

There is a great deal of studies regarding the impact of IT on productivity both at the macro and country level as well as the micro and firm-level. The first analyses regarding this topic were conducted during the 1980s and did not find evidence of any effect of IT on productivity. This lack of evidence was defined as "the Solow paradox" (Brynjolfsson and Hitt, 1996). However, improvements in the measurement of IT as well as more detailed data allowed to find evidence that proved that previous results were not entirely correct and suggested that IT has a strong relation with productivity (Stiroh, 2002). As Draca et al. (2007) argue, causality has not yet been convincingly demonstrated, for example through a natural experiment. Therefore, most of the recent studies analyzing the effects of IT use focus on explaining the increase in U.S. aggregate productivity during the period of 1995-2005 and also try to understand the differences in terms of growth between U.S. and another OECD countries, mostly Europe (Basu et al., 2004). Among these studies are Haltiwanger et al. (2003) who find that part of the differences in productivity arise because U.S. firms engage in experimentation activities at a rate not matched by their German counterparts. In order to explain these same differences, Bloom et al. (2012b) argue that there is complementarity between IT use and management practices. That is, IT solely is not sufficient to enhance productivity, and better management practices are crucially associated to higher productivity impacts of IT.[1] From the financial point of view, previous work by Brynjolfsson et al. (2002) also supports this view, arguing that there are intangible assets associated and complementary to IT, such as the reorganization required to become an IT-intensive firm.

Another set of studies, related to our paper, focuses on the role of skills and the changes in the labor market as a result of skill-biased technological change following Autor et al. (2003).[2] The idea behind these

[1] See Draca et al. (2007) for an extensive review of articles regarding IT use and productivity.

[2] See for example Acemoglu and Autor (2011) who provide a task-based framework in order to explain the recent trends that cannot be correctly explained within the canonical model that assumes two skill groups that produce two imperfectly

studies is that technological change and IT act as substitutes for low-skilled workers but as complements for high-skilled workers. Therefore, the wage polarization observed in the U.S. could be explained by IT adoption. Michaels et al. (2014) and Akerman et al. (2015) provided evidence to support this idea.

Empirically, one of the main problems that arise in the analysis of IT use and productivity is, as pointed out by Draca et al. (2007) that IT investment is a firm's decision and it is not plausible to assume that it is independent of performance. Therefore, IT use is most likely endogenous and it is important to find an instrument that only affects productivity through IT use.

Another strand of literature related to our work are the studies analyzing the effect China's competition. However, most of these studies have focused on aggregate effects of Chinese competition and on whether Mexican products have been displaced by Chinese competition both in the domestic market and in the U.S. market. For example Freund and Ozden (2006) estimate a gravity model and find that China's exports growth had moderate effects on Latin America's growth as a region, but had negative impact on Mexico only in some sectors. Jenkins et al. (2008) find that as a result of Chinese competition some countries such as Argentina, Chile and Brazil won while Mexico and Central America experienced losses. Finally, Olarreaga et al. (2007) find no evidence of lost opportunities for Latin America. Furthermore, they find that there may be complementarities between these countries and China in external markets.

However, more recent studies make use of firm-level data in order to assess whether trade competition generates pressure on firms for speeding up IT use and technical change. In this framework, Bloom et al. (2015) find that Chinese competition led to higher R&D, patenting, IT and productivity in a sample of European countries. Furthermore, these pressures contributed to the reallocation of labor towards more technologically intensive sectors. On the other hand, Iacovone et al. (2013) analyze whether Chinese competition operates as a selection mechanism in the Mexican market, taking advantage of this exogenous shock from competition. They find heterogeneous effects on both the extensive (firm's exit) and the intensive margins. Additionally, product reallocation within plants is observed as a result of competition.

3 Empirical strategy

3.1 Modeling strategy

In order to assess if IT use affects performance, in this paper we estimate the following equation:

substitutable goods.

$$log(sales/worker)_{i,t} = \beta_0 + \beta_1 IT_{i,t} + \gamma x_{i,t} + \alpha_i + u_{i,t} \quad (1)$$

Where:
$log(sales/worker)_{i,t}$=Logarithm of sales-per-worker for firm i at time t
$IT_{i,t}$=IT use of firm i at time t
$x_{i,t}$=Vector of control variables such as age, firm's size and share of skills
α_i=firm fixed effects

In our estimation, because of data limitation[3] we use as performance indicator sales-per-worker, which has been widely used in the literature as a proxy for productivity , though an imperfect one (Haltiwanger et al., 1999; Bloom et al., 2012a).

Our equation is similar to what Stiroh (2002) and Bloom et al. (2012b) estimate. As it will be explained later, the main difference between our paper and these studies is the IT-use variables, which in their case is IT-stock-capital, while we use computers-per-worker.

Building on this equation, we then use different specifications in order to test whether the predictions of empirical models previously applied to developed countries hold for the case of Mexico, as well as to analyze the interaction between Chinese competition and IT use with firm-level data.

3.2 Instrumental variables

Considering that IT is endogenous to firm performance, we use an instrumental variable approach where the first stage is defined as follows:

$$IT_{i,j,s,t} = \beta_0 + \phi IT_{int,j} * ITHHuse_{s,t} + \beta_1 x_{i,t} + \alpha_i + v_{i,t} \quad (2)$$

Where: $IT_{i,j,s,t}$= IT use of firm i from sector j in state s at time t
$IT_{int,j}$=IT intensity of sector j in the US
$ITHHuse_s, t$=Share of households with computers in state s at time t

[3]We have no data available to estimate TFP because we lack detailed information on capital and intermediate inputs. The data we use are obtained from a firm survey which is focused on IT use and does not provide information physical non-IT related capital stocks

In order to construct our instrument $IT_{int,j} * ITHHuse_{s,t}$, we take the IT-intensity classification used in Bloom et al. (2012b) and O'Mahony and Van Ark (2003), which is based on Stiroh (2002) and interact this sectoral variable with the change in household IT-use at the state level.[4] The use of this second measure is broadly based on Akerman et al. (2015), who take advantage of broadband availability roll-out for Norway as a measure for IT adoption in order to overcome the endogeneity problem. To construct this variable we use two alternative sources. The first one is the 2000 and 2010 Population and Housing Censuses, while the second one is the Module on Information Technology Availability and Use in Households (MODUTIH 2010 and 2013).[5] An advantage of our instrument is that the sectoral IT intensity is based on U.S. data, which is by definition exogenous to the decision of Mexican firms and a better measure of "technological characteristics" at the industry level. Additionally, in our robustness tests, we consider an alternative measure of sectoral IT intensity based on the 1999 Mexico's Economic Census in which we calculate both the share of investment in computer equipment over total investment in fixed assets, as well as the share of computer equipment assets on total fixed assets.

4 Data and Descriptive Statistics

4.1 Firm-level IT use

Data regarding IT use were obtained from Mexico's National Survey on Information Technologies 2009 and 2013. This survey was designed by the National Science and Technology Council (CONACYT) and conducted by the National Institute of Statistics and Geography (INEGI). It includes detailed information on IT use at the firm-level that, to the best of our knowledge, has not been previously used for research purposes.

We constructed a panel including firms that appeared in both surveys. Due to the sample design of this survey we were able to build a panel of 719 firms.[6] Additionally, firms from the trade, minining and

[4] Considering that these classifications are based on ISIC rev.3.1 we used the correspondences tables between ISIC rev 3.1 and ISIC 4 and then we used the NAICS-ISIC 4 correspondence table. As there are different levels of aggregation in this process, we also tested an IT intensity variable based on the sectoral descriptions rather than the classification codes, which proved to be more highly correlated with our endogenous variable (IT use).

[5] Considering that for some states there are great differences between the urban and rural sectors, different versions of these indicators were analyzed restricting the sample to localities with more than 15,000 inhabitants (urban).

[6] The ENTIC surveys were designed to gather information for firms with more than ten employees from the manufacturing, construction, services, electricity, mining, transportation and communications sectors according to the NAICS 2007 classification. The sample design is probabilistic and stratified by employment level. The sample is statistically representative at the national level by economic sector. Due to this probabilistic design it is easier to find that big firms are surveyed in both waves (2009 and 2013).

services sectors are excluded from the sample, as we focus mostly on manufacturing goods for which we have available international trade data. Thus, we end up with a balanced panel of 701 firms.

As our main measure of IT use, we selected computers-per-worker, a measure which has been used in previous studies such as Bloom et al. (2015). As these authors argue, the main two advantages of this indicator is that it is a physical quantity measure that is recorded consistently across firms and sectors and it avoids the use of price deflators.

Additionally, to evaluate the robustness of our results we also use two additional proxies of IT use. The first one is the share of labor that uses Internet in the firm, and the second one is the share of labor with computer, which should be almost equal to computers-per-worker and is used mainly in our robustness tests. In fact, Bloom et al. (2012b) use the share of labor with computer as a robustness test as there could be measurement in their IT stock capital variable that could be biasing their results.

4.2 Trade data

Trade data were obtained from the World Integrated Trade Statistics (WITS) using the HS 1996 classification at the 6-digits level. Considering that some HS6 codes appear in more than one NAICS 4-digits code, we reclassified the ones that had more than one match using the Mexican Tariff Classification (8 digits), by including them into the NAICS sector that had the highest share of the 6-digits HS code for total Mexican imports in 2013.[7]

Competition is measured for the period of 2000-2008. This period was selected considering that the first year of our panel is 2008 (ENTIC 2009 gets information for the previous year). We use imports data for Mexico and the U.S. in order to analyze Chinese competition. Specifically, we calculate the share of China on imports for each NAICS-4-digits code included in the base.

$$Compet_{j,t} = \frac{Mj, China, t}{\sum_{k=1}^{n} M_{j,k,t}} \tag{3}$$

Where

$Mj, China$=Imports of country j from China

$M_{j,k}$=Imports of country j from country k

j=Mexico and the U.S.

[7]The correspondence tables fore HS 1996 and NAICS generated through this exercise are available upon request.

4.3 State household IT-use

As mentioned before, in order to construct our instrumental variable, we combine IT sectoral intensity for the US obtained from Bloom et al. (2012b) with household IT use.

Information regarding household IT use at the state level is from the National Population and Housing Censuses 2000 and 2010. We also obtained information from the Module on Information Technology Availability and Use in Households (MODUTIH 2010 and 2013) in order to compare it to the census data.

Considering the great differences between the rural and urban sectors in some states, alternative household IT use variables were constructed restricting the sample to localities with more than 15,000 inhabitants (urban IT use).

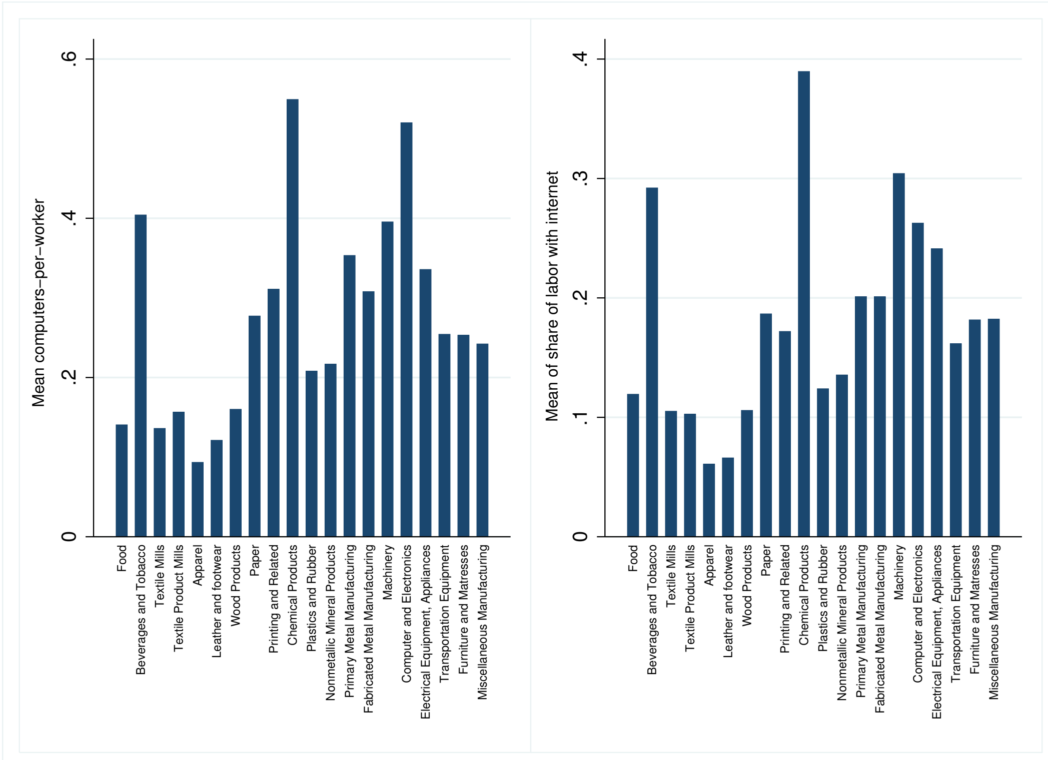
4.4 Descriptive Statistics

As mentioned before, the random sample design of the ENTIC surveys, made it possible to match only 701 firms and around 88% of them are big firms, as they are the ones that must be in both samples in order to achieve statistical representativeness. This fact has important implications regarding the interpretation of our results given that previous studies suggest that small firms are the ones more likely to exit and be negatively affected by the increasing competition (Iacovone et al., 2013). In this case, due to these data limitations we are only able to analyze the extensive margin.

Consistent with the size of the firms in our sample, approximately 50% of the firms have a share of FDI higher than 80%. Accordingly, the mean of exports/total sales is much higher than the one observed for the whole ENTIC. Table 1 shows descriptive statistics for the main variables used in this analysis for our sample and the whole ENTIC sample.

Analyzing IT use at the sectoral level, as Figure 1 shows the sectors that make more intensive use of IT measured as computers-per-worker are chemical products followed by computer equipment and electronics and beverages and tobacco. The second sector is not only an IT-use sector but an IT-producing sector. It is important to note that once we use the share of labor with Internet, the same sectors remain as the ones with most intensive IT use, but machinery also appears as an intensive user in terms of the share of labor with Internet.

Figure 1: Mean IT use by sector

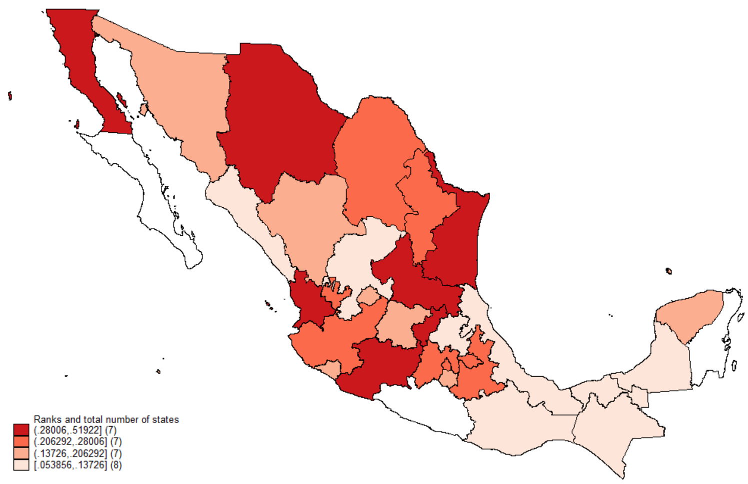


Source: Authors' calculations with data from ENTIC 2009 and 2013, INEGI

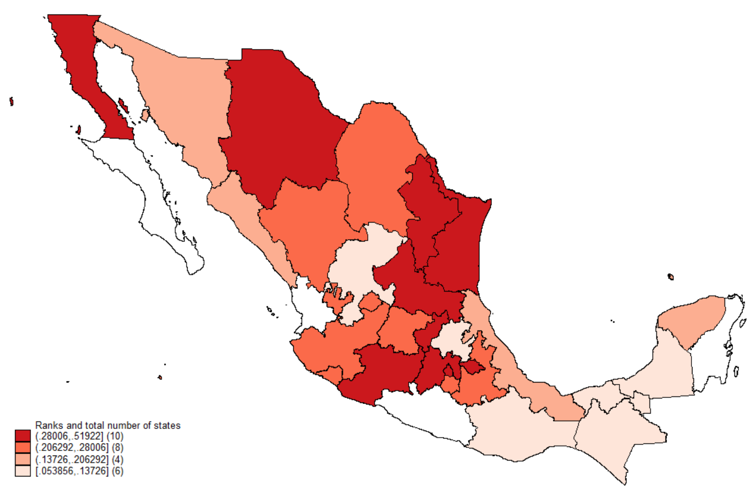
As Figure 2 shows, intensive IT-use is located in the Northern and Central region of the country. This is consistent with what we observe regarding welfare measures in Mexico. As the South-Eastern region is the region with highest level of deprivation, it is also where the lowest IT-use is observed.

Figure 2: Mean computers-per-worker by state

(a) *Mean computers-per-worker, 2008*



(b) *Mean computers-per-worker, 2012*



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

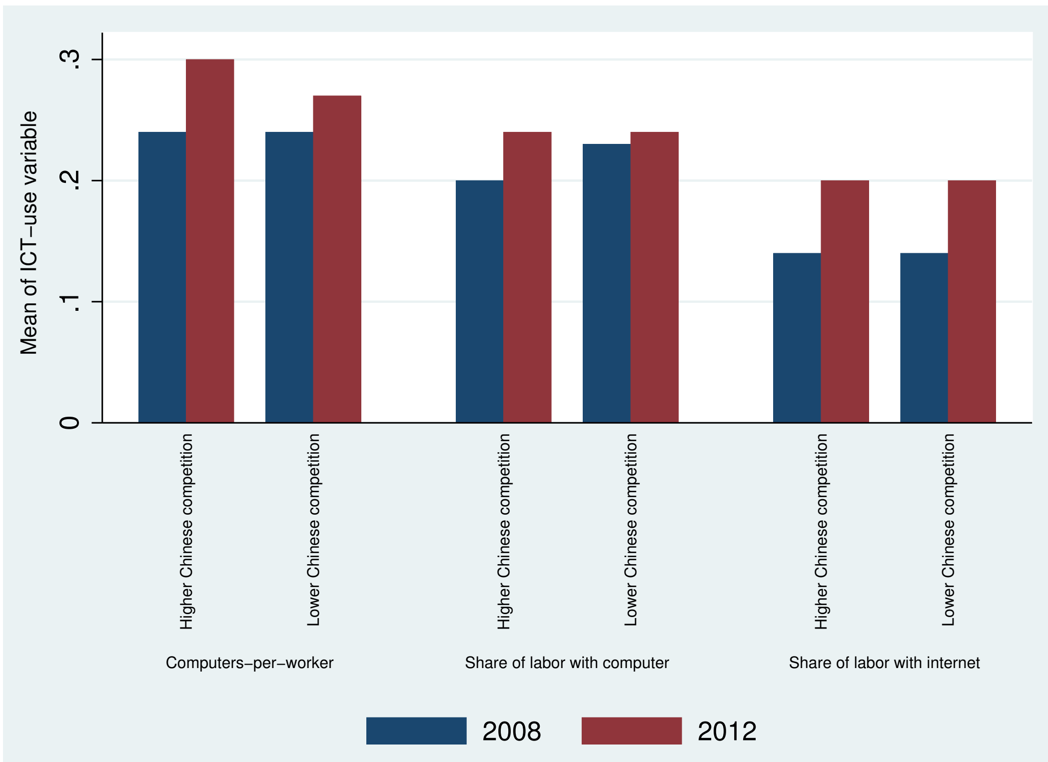
Table 1: Descriptive Statistics IT use variables

	Sample						Whole					
Variable	Mean	p50	sd	p10	p90	N	Mean	p50	sd	p10	p90	N
2008												
Computers-per-worker	0.24	0.19	0.22	0.06	0.50	701	0.34	0.23	0.34	0.05	0.80	4612
Share of labor with Internet	0.14	0.11	0.15	0.03	0.28	701	0.23	0.14	0.25	0.02	0.62	4658
Share of labor with computer	0.21	0.17	0.19	0.05	0.43	701	0.30	0.20	0.28	0.04	0.81	4658
Sales-per-worker	1,011.66	440.079	1,656.63	125.06	2,219.48	701	954.20	483.87	1,385.23	100.30	2,293.84	4566
Share of white-collar workers	0.22	0.19	0.18	0.05	0.44	701	0.32	0.22	0.29	0.06	0.90	4658
Exports/total sales	0.41	0.16	0.44	0.00	1.00	701	0.19	0.00	0.35	0.00	1.00	4637
Share of FDI	46.18	1.00	48.59	0.00	100.00	701	20.14	0.00	39.15	0.00	100.00	4658
2012												
Computers-per-worker	0.29	0.23	0.23	0.07	0.57	701	0.39	0.28	0.36	0.06	0.95	6148
Share of labor with Internet	0.20	0.15	0.19	0.04	0.41	701	0.30	0.19	0.29	0.03	0.83	6210
Share of labor with computer	0.25	0.18	0.22	0.06	0.50	701	0.34	0.23	0.30	0.04	0.93	6210
Sales-per-worker	1,011.33	476.7	1,409.18	141.42	2,486.06	701	1,018.02	446.88	1,608.47	66.00	2,471.17	6148
Share of white-collar workers	0.26	0.19	0.23	0.06	0.59	701	0.37	0.24	0.33	0.06	1.00	6210
Exports/total sales	0.39	0.15	0.43	0.00	1.00	701	0.16	0.00	0.33	0.00	0.93	6132
Share of FDI	44.17	0.00	48.90	0.00	100.00	701	17.16	0.00	36.74	0.00	100.00	6210

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

Considering the relation between IT use and a higher level of Chinese competition, we calculated an indicator variable based on the change in the share of China over Mexican imports. Comparing IT use between these two groups, as Figure 3 shows in the period 2008-2012, firms that faced more competition from China experienced a higher increase in IT use. Therefore, the data are consistent with the hypothesis of higher competition generating incentives for increases in IT use.

Figure 3: IT use by Chinese competition level 2008-2012



[1] Higher competition is defined as a sector that has a change in the share of Chinese imports over Mexico's total imports above the median.

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

5 Results

5.1 IT use and Chinese competition

Following what we observed in section 4.4 and in order to further analyze the correlation between IT use and Chinese competition, we estimated a regression of IT use over Chinese competition:

$$IT_{i,j,t} = \beta_0 + \beta_1 Compet_{j,t} + \gamma x_{i,t} + \alpha_i + u_i t \quad (4)$$

Where

$IT_{i,j,t}$=IT use of firm i, from sector j, at time t

$x_{i,t}$=Vector of control variables such as age, firm's size and share of skills

α_i=firm fixed effects

As Table 2 shows, there is indeed a strong correlation between IT use and Chinese competition as the coefficients for our main two IT-use variables (computers-per-worker and share of labor with Internet) are positive and statistically significant at the 1% level in most of the specifications. In the case of the share of labor with computers, the results are slightly lower than the ones for computers-per-worker.

5.2 IT use and productivity

First of all we estimate the relation between IT use and productivity using OLS in order to analyze if there is indeed a relation between these two variables without any further consideration regarding endogeneity or the relation with China's competition. As Table 3 shows, for all IT use variables we observe that there appears to be a positive and significant correlation between IT use and productivity measured by sales-per-worker. These results are indeed consistent with what previous studies have found for developed countries.

As mentioned before, IT use is probably endogenous because there are likely to be unobservable characteristics that are both positively correlated with IT and with productivity. Therefore, we adopt an IV strategy to estimate the same equations, where we instrument our IT use variable with the instruments described in section 3.2. Results are shown in Table 4. Overidentification tests as well as the F-test, evaluating the strength of our IV, do not indicate invalidation of our instruments (See Table 5 for the first-stage results). As the table shows, results are in line with the OLS coefficients, but slightly higher which may be the consequence of treatment effect heterogeneity (Imbens and Angrist, 1994).

In order to analyze what previous literature has found regarding the complementarity between IT use and skills, we estimated the equation interacting IT use with the share of white-collar workers in the firm. In all specifications the interaction was not significant.[8] Thus, we don't find much evidence that firms with a higher share of white-collar workers experience greater effects of IT on productivity as a result of the complementarity between skills and IT. However, our results may be driven by the fact that the proxy we

[8]Results are not shown here but are available upon request.

use is not an appropriate measure of skills within the firm.[9]

5.3 IT use, Chinese competition and productivity

Previously, we presented some descriptive evidence that firms in sector that experienced stronger competitive pressures because of increasing Chinese exports tend to be more likely to adopt IT. Further, in this Section, in order to assess whether Chinese competition also enhances the role of IT use as a productivity lever, we use the indicator variable for the sectors that face higher competition from China and estimate a split OLS regression of sales-per-worker on IT use variables.[10] As tables 6 and 7 show, for firms that face low competition from China, the effects of IT use on productivity are not statistically significant. On the other hand, when we analyze firms from sectors that face higher competition from China, the effects of IT on productivity are positive and statistically significant at the 1% level in all of the specifications. That is, these results suggest that the effects of IT use on productivity appear to be entirely driven by those sectors that experienced a stronger increase in Chinese competition.

Taking into consideration the endogeneity of IT use for the same specifications, as Table 8 shows, once again we find no evidence of the effects of IT on productivity for firms exposed to lower competition from China. However for firms that face higher competition from China, results indicate that the effects of IT are not only statistically significant but higher than the ones observed in the OLS specification (see Table 9).

Finally, we estimate a specification that uses the competition variable (share of Chinese imports over total Mexican imports) interacted with the IT use variables appropriately instrumented as before. The results of these estimates are shown in Table 10. It is important to note here that in the case of the share of labor with computers it is not possible to reject the hypothesis of weak instruments so the results for this variable should be interpreted with caution. As the table shows, once we include this interaction the IT use variables (computers-per-worker and the share of labor with Internet) are no longer statistically significant except for the case of the interaction. Thus, the effect of IT on sales-per-worker depends on the level of Chinese competition -and where competition is low there is no effect of IT adoption on productivity. Evaluating for example computers-per-working on the mean of the share of China in Mexican imports, we get that a change of 0.1 in computers-per-worker generates an increase of around 8 percent on sales-per-worker under specification (2). However, if we evaluate these results on the maximum of Chinese competition, the same change in IT use yields an increase in productivity of around 35 percent. Additionally, it is important

[9] We use the share of administrative workers over total workers as information regarding the educational level of employees is only available for the IT area.

[10] A sector is classified as facing high competition with China if the change in the share of China on Mexico's total imports between 2008 and 2013 is above the median.

to note that the coefficient associated to China's competition has a negative sign in some specifications for all of our IT use proxies, indicating that in order to observe positive effects of Chinese competition over productivity, firms need to surpass a certain level of IT use. If it is not the case, competition will have adverse effects on the firm's productivity.

Table 2: OLS estimates of IT use vs. Chinese competition

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable:Computers-per-worker						
Chinese competition	0.315***	0.260**	0.278**	0.268**	0.263***	0.217*
	(0.114)	(0.129)	(0.111)	(0.104)	(0.099)	(0.114)
R^2	0.77	0.77	0.81	0.81	0.82	0.82
Dependent variable: Share of labor with Internet						
Chinese competition	0.340***	0.274**	0.303***	0.274***	0.267***	0.148
	(0.101)	(0.113)	(0.104)	(0.091)	(0.088)	(0.108)
R^2	0.71	0.71	0.75	0.76	0.76	0.77
Dependent variable: Share of labor with computer						
Chinese competition	0.222**	0.195	0.232*	0.196*	0.193*	0.183
	(0.103)	(0.124)	(0.122)	(0.110)	(0.103)	(0.125)
R^2	0.73	0.73	0.76	0.77	0.77	0.77
Controls						
Age	No	Yes	Yes	Yes	Yes	Yes
Firm size	No	No	Yes	Yes	Yes	Yes
Share of white-collar workers	No	No	No	Yes	Yes	Yes
Capital/worker	No	No	No	Yes	Yes	Yes
Exports/sales	No	No	No	No	Yes	Yes
FDI share	No	No	No	No	Yes	Yes
Time effects	No	No	No	No	No	Yes
Observations	1402	1402	1402	1402	1402	1402

Robust standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

All specifications include firm's fixed effects.

Source: Authors' calculations using data from ENTIC, INEGI

Table 3: OLS estimates of the effect of IT use on firm-level productivity

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable log(sales/worker)						
Computers-per-worker	0.898***	0.845***	0.977***	0.911***	0.858***	0.843***
	(0.228)	(0.256)	(0.222)	(0.215)	(0.212)	(0.218)
R^2	0.848	0.849	0.852	0.856	0.858	0.858
Share of labor with Internet	0.786***	0.753***	0.814**	0.685*	0.650*	0.624*
	(0.255)	(0.275)	(0.353)	(0.354)	(0.333)	(0.338)
R^2	0.846	0.847	0.850	0.853	0.856	0.856
Share of labor with computer	0.857***	0.805***	0.883***	0.776***	0.721***	0.710***
	(0.193)	(0.195)	(0.270)	(0.276)	(0.251)	(0.249)
R^2	0.848	0.848	0.848	0.855	0.857	0.857
Controls						
Age	No	Yes	Yes	Yes	Yes	Yes
Firm size	No	No	Yes	Yes	Yes	Yes
Share of white-collar workers	No	No	No	Yes	Yes	Yes
Capital/worker	No	No	No	Yes	Yes	Yes
Exports/sales	No	No	No	No	Yes	Yes
FDI share	No	No	No	No	Yes	Yes
Time effects	No	No	No	No	No	Yes
Observations	1402	1402	1402	1402	1402	1402

Robust standard errors in parentheses

* Significant at the 1% level, **Significant at the 5% level, *** Significant at the 1% level

All specifications include firm's fixed effects.

Source: Authors' calculations using data from ENTIC, INEGI

Table 4: IV estimates of the effect of IT use on firm-level productivity

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable log(sales/worker)						
Computers-per-worker	2.017***	1.834**	2.175**	2.036**	1.968**	1.999*
	(0.656)	(0.744)	(0.889)	(0.881)	(0.895)	(1.080)
Share of labor with Internet	1.579***	1.755**	1.985**	2.047**	2.091**	2.610**
	(0.598)	(0.752)	(0.840)	(0.842)	(0.848)	(1.241)
Share of labor with computer	2.952***	2.748***	2.783***	2.444**	2.358**	2.150*
	(0.800)	(0.860)	(0.937)	(1.067)	(1.092)	(1.154)
Controls						
Age	No	Yes	Yes	Yes	Yes	Yes
Firm size	No	No	Yes	Yes	Yes	Yes
Share of white-collar workers	No	No	No	Yes	Yes	Yes
Capital/worker	No	No	No	Yes	Yes	Yes
Exports/sales	No	No	No	No	Yes	Yes
FDI share	No	No	No	No	Yes	Yes
Time effects	No	No	No	No	No	Yes
Observations	1402	1402	1402	1402	1402	1402

Robust standard errors in parentheses

* Significant at the 1% level, **Significant at the 5% level, *** Significant at the 1% level

All specifications include firm's fixed effects.

Source: Authors' calculations using data from ENTIC, INEGI

Table 5: First stage regression from Table 4

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable: computers-per-worker						
IV1	0.090***	0.111***	0.095***	0.099***	0.102***	0.102***
	(0.019)	(0.023)	(0.021)	(0.021)	(0.021)	(0.024)
IV2	8.357***	7.867***	6.433***	5.877***	5.037**	5.001**
	(2.076)	(2.118)	(1.945)	(1.956)	(1.958)	(2.106)
First stage F-value	26.3	20.5	17.2	17.1	17.1	11.4
Underid p-value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Sargan p-value	0.107	0.106	0.171	0.323	0.365	0.359
Dependent variable: share of labor with Internet						
IV3	0.413***	0.418***	0.377***	0.391***	0.380***	0.314***
	(0.059)	(0.069)	(0.065)	(0.064)	(0.064)	(0.069)
IV4	0.663***	0.640***	0.566***	0.489**	0.518***	0.369*
	(0.207)	(0.213)	(0.199)	(0.198)	(0.198)	(0.207)
First stage F-value	41.8	26.7	24.3	24.7	24.7	12.1
Underid p-value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Sargan p-value	0.84	0.92	0.94	0.87	0.77	0.68
Controls						
Age	No	Yes	Yes	Yes	Yes	Yes
Firm size	No	No	Yes	Yes	Yes	Yes
Share of white-collar workers	No	No	No	Yes	Yes	Yes
Capital/worker	No	No	No	Yes	Yes	Yes
Exports/sales	No	No	No	No	Yes	Yes
FDI share	No	No	No	No	Yes	Yes
Time effects	No	No	No	No	No	Yes
Observations	1402	1402	1402	1402	1402	1402

Robust standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

All specifications include firm's fixed effects.

1 The hypothesis of weak instruments cannot be rejected for specification (6)

Source: Authors' calculations using data from ENTIC, INEGI

Table 5 Continued: First stage regression from Table 4

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable: Share of labor with computer						
IV1	0.113***	0.120***	0.103***	0.093***	0.085***	0.090***
	(0.022)	(0.023)	(0.022)	(0.022)	(0.022)	(0.024)
IV5	0.126***	0.137***	0.136***	0.115***	0.120***	0.127***
	(0.031)	(0.036)	(0.034)	(0.034)	(0.034)	(0.037)
First stage F-value	20.3	17.2	15.8	11.7	11.7	9.7
Underid p-value	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001
Sargan p-value	0.88	0.93	0.62	0.63	0.69	0.69
Controls						
Age	No	Yes	Yes	Yes	Yes	Yes
Firm size	No	No	Yes	Yes	Yes	Yes
Share of white-collar workers	No	No	No	Yes	Yes	Yes
Capital/worker	No	No	No	Yes	Yes	Yes
Exports/sales	No	No	No	No	Yes	Yes
FDI share	No	No	No	No	Yes	Yes
Time effects	No	No	No	No	No	Yes
Observations	1402	1402	1402	1402	1402	1402

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

All specifications include firm's fixed effects.

Source: Authors' calculations using data from ENTIC, INEGI

IV1: IT intensity dummy based on name from (Bloom et al., 2012b) and Share of urban households with computers (2000 and 2010 Population and Housing Censuses)

IV2: IT intensity based on investment from (O'Mahony and Van Ark, 2003) and Share of households with internet (MODUTIH)

IV3: IT intensity dummy based on name from (Bloom et al., 2012b) and Share of households with internet (MODUTIH)

IV4: IT intensity based on investment from (O'Mahony and Van Ark, 2003) and Share of urban households with computers (2000 and 2010 Population and Housing Censuses)

IV5: IT intensity dummy based on name from (Bloom et al., 2012b) and Share of urban households with Internet (2000 and 2010 Population and Housing Censuses)

Table 6: Split OLS regression of the effects of IT use on firm-level productivity: Low competition with China

Dependent variable log(sales/worker)	(1)	(2)	(3)	(4)	(5)	(6)
Computers-per-worker	0.308	0.337	0.400	0.352	0.372	0.366
	(0.334)	(0.317)	(0.355)	(0.400)	(0.387)	(0.387)
R^2	0.876	0.876	0.876	0.877	0.879	0.879
Share of labor with Internet	0.209	0.260	0.315	0.225	0.297	0.268
	(0.516)	(0.527)	(0.551)	(0.575)	(0.549)	(0.605)
R^2	0.876	0.876	0.876	0.877	0.879	0.879
Share of labor with computer	0.317	0.385	0.442	0.393	0.443	0.437
	(0.346)	(0.345)	(0.331)	(0.330)	(0.316)	(0.319)
R^2	0.876	0.877	0.877	0.878	0.880	0.880
Controls						
Age	No	Yes	Yes	Yes	Yes	Yes
Firm size	No	No	Yes	Yes	Yes	Yes
Share of white-collar workers	No	No	No	Yes	Yes	Yes
Capital/worker	No	No	No	Yes	Yes	Yes
Exports/sales	No	No	No	No	Yes	Yes
FDI share	No	No	No	No	Yes	Yes
Time effects	No	No	No	No	No	Yes
Observations	672	672	672	672	672	672

Robust standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

All specifications include firm's fixed effects.

Source: Authors' calculations using data from ENTIC, INEGI

Table 7: Split OLS regression of the effects of IT use on firm-level productivity: High competition with China

Dependent variable log(sales/worker)	(1)	(2)	(3)	(4)	(5)	(6)
Computers-per-worker	1.168***	1.079***	1.353***	1.282***	1.220***	1.219***
	(0.285)	(0.319)	(0.286)	(0.201)	(0.164)	(0.170)
R^2	0.810	0.814	0.822	0.830	0.834	0.834
Share of labor with Internet	1.107***	1.110***	1.260***	1.102**	1.014***	0.999***
	(0.255)	(0.249)	(0.476)	(0.449)	(0.372)	(0.381)
R^2	0.804	0.811	0.817	0.824	0.828	0.828
Share of labor with computer	1.234***	1.155***	1.319***	1.156***	1.038***	1.023***
	(0.211)	(0.211)	(0.423)	(0.407)	(0.332)	(0.333)
R^2	0.809	0.814	0.821	0.826	0.830	0.830
Controls						
Age	No	Yes	Yes	Yes	Yes	Yes
Firm size	No	No	Yes	Yes	Yes	Yes
Share of white-collar workers	No	No	No	Yes	Yes	Yes
Capital/worker	No	No	No	Yes	Yes	Yes
Exports/sales	No	No	No	No	Yes	Yes
FDI share	No	No	No	No	Yes	Yes
Time effects	No	No	No	No	No	Yes
Observations	730	730	730	730	730	730

Robust standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

All specifications include firm's fixed effects.

Source: Authors' calculations using data from ENTIC, INEGI

Table 8: Split IV regression of the effects of IT use on firm-level productivity: Low competition with China

Dependent variable: log(sales/worker)	(1)	(2)	(3)	(4)	(5)	(6)
Computers-per-worker	0.995	1.613	1.639	1.454	1.642	1.391
	(1.356)	(1.681)	(1.731)	(1.818)	(1.844)	(1.772)
F-first stage	8.5	5.7	6.1	5.5	5.5	5.7
Sargan	0.90	0.98	0.72	0.67	0.75	0.90
Share of labor with Internet	1.075	0.954	1.019	1.046	1.327	0.806
	(1.262)	(1.245)	(1.328)	(1.377)	(1.471)	(1.781)
F-first stage	11.3	12.0	12.0	11.0	11.0	6.7
Sargan	0.92	0.83	0.66	0.47	0.39	0.29
Share of labor with computer	0.517	0.475	0.353	-0.238	-0.447	-0.391
	(1.472)	(1.422)	(1.144)	(1.277)	(1.281)	(1.267)
F-first stage	5.4	6.0	10.3	8.3	8.3	8.6
Sargan	0.71	0.76	0.98	0.93	0.98	0.78
Controls						
Age	No	Yes	Yes	Yes	Yes	Yes
Firm size	No	No	Yes	Yes	Yes	Yes
Share of white-collar workers	No	No	No	Yes	Yes	Yes
Capital/worker	No	No	No	Yes	Yes	Yes
Exports/sales	No	No	No	No	Yes	Yes
FDI share	No	No	No	No	Yes	Yes
Time effects	No	No	No	No	No	Yes
Observations	672	672	672	672	672	672

Robust standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

All specifications include firm's fixed effects.

Source: Authors' calculations using data from ENTIC, INEGI

Table 9: Split IV regression of the effects of IT use on firm-level productivity: High competition with China

Dependent variable: log(sales/worker)	(1)	(2)	(3)	(4)	(5)	(6)
Computers-per-worker	2.456***	2.289***	2.372***	2.097***	2.175***	2.692**
	(0.651)	(0.704)	(0.731)	(0.727)	(0.803)	(1.055)
F-first stage	22.5	19.2	22.7	21.6	21.6	11.03
Sargan	0.14	0.14	0.36	0.59	0.53	0.58
Share of labor with Internet	1.594***	1.784**	1.881**	1.745**	1.819**	2.045*
	(0.579)	(0.718)	(0.780)	(0.778)	(0.840)	(1.070)
F-first stage	40.1	26.0	26.7	26.9	26.9	14.7
Sargan	0.55	0.49	0.24	0.35	0.30	0.25
Share of labor with computer	3.072***	2.849***	3.331***	3.085***	3.338**	3.493**
	(0.885)	(0.911)	(1.063)	(1.131)	(1.378)	(1.538)
F-first stage	14.9	13.6	12.1	10.6	10.6	6.4
Sargan	0.29	0.28	0.78	0.96	0.84	0.87
Controls						
Age	No	Yes	Yes	Yes	Yes	Yes
Firm size	No	No	Yes	Yes	Yes	Yes
Share of white-collar workers	No	No	No	Yes	Yes	Yes
Capital/worker	No	No	No	Yes	Yes	Yes
Exports/sales	No	No	No	No	Yes	Yes
FDI share	No	No	No	No	Yes	Yes
Time effects	No	No	No	No	No	Yes
Observations	730	730	730	730	730	730

Robust standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

All specifications include firm's fixed effects.

Source: Authors' calculations using data from ENTIC, INEGI

Table 10: IV regression IT use on firm-level productivity considering China's competition

Dependent variable: log(sales/worker)	(1)	(2)	(3)	(4)	(5)	(6)
Computers-per-worker	0.736	0.672	0.460	0.449	-0.091	-0.423
	(0.926)	(0.991)	(1.043)	(1.039)	(1.106)	(1.384)
Chinese competition*IT	8.722**	8.448**	8.186**	7.974*	8.095**	9.492*
	(4.030)	(4.104)	(4.086)	(4.075)	(4.057)	(5.397)
Chinese competition	-2.605*	-2.591	-2.451	-2.463	-2.334	-3.027
	(1.578)	(1.681)	(1.648)	(1.635)	(1.620)	(2.316)
F-first stage IT	9.0	9.7	11.8	11.7	10.1	9.8
F-first stage IT*competition	10.6	12.9	15.2	15.1	14.7	9.8
Sargan	0.62	0.60	0.84	0.93	0.93	0.91
Share of labor with internet	-1.657*	-1.814	-1.302	-0.902	-0.922	-1.453
	(0.967)	(1.121)	(1.232)	(1.158)	(1.146)	(1.914)
Chinese competition*IT	18.483***	18.647***	17.006***	15.374**	14.151**	15.598*
	(6.543)	(6.520)	(6.428)	(6.286)	(6.179)	(9.011)
Chinese competition	-2.966*	-3.153**	-2.915*	-2.658*	-2.292	-2.793
	(1.529)	(1.566)	(1.538)	(1.486)	(1.465)	(2.277)
F-first stage IT	15.2	13.5	12.5	14.0	13.1	10.2
F-first stage IT*competition	8.7	10.6	11.3	11.6	11.0	11.3
Sargan	0.62	0.60	0.84	0.93	0.93	0.91
Controls						
Age	No	Yes	Yes	Yes	Yes	Yes
Firm size	No	No	Yes	Yes	Yes	Yes
Share of white-collar workers	No	No	No	Yes	Yes	Yes
Capital/worker	No	No	No	Yes	Yes	Yes
Exports/sales	No	No	No	No	Yes	Yes
FDI share	No	No	No	No	Yes	Yes
Time effects	No	No	No	No	No	Yes
Observations	1402	1402	1402	1402	1402	1402

Robust standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

All specifications include firm's fixed effects.

Source: Authors' calculations using data from ENTIC, INEGI

Table 10 Continued: IV regression IT use on firm-level productivity considering China's competition

Dependent variable: log(sales/worker)	(1)	(2)	(3)	(4)	(5)	(6)
Share of labor with computer	-0.713	-0.557	-0.197	-0.417	-0.784	-1.186
	(1.351)	(1.237)	(1.458)	(1.503)	(1.568)	(1.819)
Chinese competition*IT	14.489**	13.979***	12.014**	11.947**	10.963**	12.013**
	(5.719)	(5.248)	(5.282)	(5.210)	(5.036)	(6.001)
Chinese competition	-3.216*	-3.179**	-2.697*	-2.711*	-2.275	-2.700
	(1.642)	(1.589)	(1.572)	(1.544)	(1.485)	(1.895)
F-first stage IT	6.5	7.9	6.6	6.3	5.2	5.3
F-first stage IT*competition	10.3	12.5	13.4	14.0	13.6	13.3
Sargan	0.62	0.60	0.84	0.93	0.93	0.91
Controls						
Age	No	Yes	Yes	Yes	Yes	Yes
Firm size	No	No	Yes	Yes	Yes	Yes
Share of white-collar workers	No	No	No	Yes	Yes	Yes
Capital/worker	No	No	No	Yes	Yes	Yes
Exports/sales	No	No	No	No	Yes	Yes
FDI share	No	No	No	No	Yes	Yes
Time effects	No	No	No	No	No	Yes
Observations	1402	1402	1402	1402	1402	1402

Robust standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

All specifications include firm's fixed effects.

Source: Authors' calculations using data from ENTIC, INEGI

5.4 Robustness tests

In order to analyze the robustness of these results, all the equations were estimated using pooled regressions instead of fixed effects to test the sensitivity of our results to unobserved heterogeneity. Even though coefficients from the pooled regressions are slightly higher in all cases, the conclusions and statistical significance do not change.[11]

With the purpose of analyzing what previous studies, such as Bloom et al. (2012b) have found regarding the relation between management and IT use and how these two factors combined enhance productivity, we included an interaction of IT use and a proxy for management in the productivity equation.

[11] Results are not shown here but are available upon request.

In this case management is measured as a dummy variable that takes the value of one if IT use has led to better communication within the firm, increased logistics efficiency, better activities management or to the implementation of automatized systems. These factors were selected as a proxy because ENTIC does not include specific information regarding management practices. The results of these regressions indicate that the interaction term is not statistically significant. However, these results could be driven by the limitations of our proxy.

Additionally, considering that business environment variables such as the ones included in the World Bank's Doing Business reports could be factors explaining higher returns to IT use over productivity, we included an interaction of IT use with business environment variables such as the state Doing Business rankings from 2007[12] and its components (ease of starting a business, ease of registering property, ease of enforcing a contract, ease of obtaining credit) as well as distance to the U.S. border and financial inclusion (measured as the number of ATMs for each 10,000 adults in 2009).[13] The results indicate that only the interaction with the ease of enforcing contracts yields statistically significant results and only for the computers-per-worker and share of labor with computer variables. This is a research line that should be analyzed further using different data sources.

As a robustness test of the interaction between IT use and Chinese competition, we considered competition in the U.S. market instead of the domestic measure of competition. The rationale behind this robustness test is that firms may not be facing pressure from Chinese competition in their domestic market but in the U.S. market and that should lead to the same kind of heterogeneity. As Table 11 shows, the effects are smaller but in the same direction as the ones observed in Table 10. Additionally the coefficients associated to Chinese competition solely are no longer significant, indicating that Chinese competition in the U.S. market only has effects over productivity when it is interacted with higher IT use.

Additionally, we tested other alternative instrumental variables, constructed as explained in equation 2, but using different measures of household IT use. The results do not change much, although in some cases it is not possible to reject the hypothesis of weak identification, which makes it impossible to compare those magnitudes to the results shown in previous tables.

[12] World Bank.

[13] Comisión Nacional Bancaria y de Valores.

Table 11: IV regression IT use on firm-level productivity considering China's competition in the U.S.

Dependent variable: log(sales/worker)	(1)	(2)	(3)	(4)	(5)	(6)
Computers-per-worker	0.079	0.389	0.384	0.345	-0.134	-0.447
	(1.129)	(1.124)	(1.045)	(1.035)	(1.076)	(1.359)
Competition in U.S.*computers-per-worker	7.097*	5.742*	5.731*	5.772*	6.083*	6.864*
	(3.738)	(3.307)	(3.268)	(3.213)	(3.144)	(3.772)
Competition in U.S.	-1.863	-1.393	-1.326	-1.412	-1.438	-1.843
	(1.222)	(1.161)	(1.157)	(1.134)	(1.111)	(1.575)
F-first stage IT	11.1	11.3	12.0	11.9	10.3	9.1
F-first stage IT*competition	9.5	12.9	12.3	12.6	12.3	12.0
Sargan	0.90	0.72	0.58	0.68	0.60	0.64
Share of labor with Internet	-2.391*	-2.043*	-1.858	-1.678	-1.779	-3.191
	(1.296)	(1.197)	(1.270)	(1.261)	(1.237)	(2.266)
Competition in U.S.*Share of labor with Internet	11.271**	10.056**	9.693**	9.422**	8.748*	12.062*
	(5.648)	(4.625)	(4.582)	(4.577)	(4.514)	(6.614)
Competition in U.S.	-1.180	-1.075	-1.018	-1.021	-0.826	-1.902
	(1.045)	(0.920)	(0.903)	(0.871)	(0.870)	(1.604)
F-first stage IT	18.1	16.1	15.7	17.7	15.9	10.1
F-first stage IT*competition	9.6	11.3	12.7	14.3	12.8	12.7
Sargan	0.91	0.86	0.90	0.98	0.88	0.99
Controls						
Age	No	Yes	Yes	Yes	Yes	Yes
Firm size	No	No	Yes	Yes	Yes	Yes
Share of white-collar workers	No	No	No	Yes	Yes	Yes
Capital/worker	No	No	No	Yes	Yes	Yes
Exports/sales	No	No	No	No	Yes	Yes
FDI share	No	No	No	No	Yes	Yes
Time effects	No	No	No	No	No	Yes
Observations	1402	1402	1402	1402	1402	1402

Standard errors in parentheses

Source: Authors' calculations using data from ENTIC, INEGI

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 11 Continued: IV regression IT use on firm-level productivity considering China's competition in the U.S.

Dependent variable: log(sales/worker)	(1)	(2)	(3)	(4)	(5)	(6)
Share of labor with computer	-2.481	-1.998	-1.952	-2.311	-2.625	-3.286
	(2.057)	(1.761)	(1.782)	(1.830)	(1.880)	(2.463)
Share of labor with computer*Competition in U.S.	10.177**	8.824**	8.523**	8.702**	8.327*	9.796*
	(4.947)	(4.007)	(4.333)	(4.360)	(4.340)	(5.545)
Competition in U.S.	-1.646	-1.398	-1.322	-1.432	-1.269	-1.929
	(1.124)	(1.000)	(1.083)	(1.098)	(1.091)	(1.653)
F-first stage IT	6.9	7.0	10.9	10.0	8.5	8.1
F-first stage IT*competition	14.9	17.2	23.2	22.1	20.2	20.1
Sargan	0.91	0.98	0.99	0.98	0.95	0.90
Controls						
Age	No	Yes	Yes	Yes	Yes	Yes
Firm size	No	No	Yes	Yes	Yes	Yes
Share of white-collar workers	No	No	No	Yes	Yes	Yes
Capital/worker	No	No	No	Yes	Yes	Yes
Exports/sales	No	No	No	No	Yes	Yes
FDI share	No	No	No	No	Yes	Yes
Time effects	No	No	No	No	No	Yes
Observations	1402	1402	1402	1402	1402	1402

Standard errors in parentheses

Source: Authors' calculations using data from ENTIC, INEGI

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

5.4.1 The role of initial endowment IT increases and returns to IT use

So far our results indicate that IT use is only related to a better firm performance when firms face higher competition from China. However, it is important to analyze whether these results are driven by an increase in IT use from firms that face these pressures or if this firms already had a higher IT level than firms that do not compete directly with China. In order to test this, first of all we estimated the following model:

$$\begin{aligned} log(sales/worker)_{i,t} = \beta_0 + \beta_1 IT_{i,t} + \beta_2 Competition_{i,t} + \beta_3 Competition * IT_{i,t} \\ + \beta_4 InitialIT_i * Competition_{i,t} + \gamma x_{i,t} + \alpha_i + u_{i,t} \end{aligned} \tag{5}$$

Where

$log(sales/worker)_{i,t}$=Logarithm of sales-per-worker for firm i at time t

$IT_{i,t}$=IT use of firm i at time t

$Competition_{i,t}$= Share of China in Mexico's imports in 2000 (for 2008) and 2008 (for 2012)

$InitialIT_i$= IT use of firm i in 2008

$x_{i,t}$=Vector of control variables such as age, firm's size and share of skills

α_i=firm fixed effects

Initial IT is included as an interaction with competition because otherwise it would be a time invariant variable. The results from this equation are shown in Table 12 and indicate that the coefficients of the interaction between competition and IT use are positive as in previous specifications and are much higher, but can be partially offset by a higher level of initial IT combined with higher competition, as this interaction has negative effects over performance. That is, according to these results the positive effects of IT use for firms that face higher competition are due to the change in IT use during the period of analysis rather than to initial endowments.

Deepening on this result, an equation including all the interactions between initial IT, competition and IT use was estimated:

$$\begin{aligned} log(sales/worker)_{i,t} = \beta_0 + \beta_1 IT_{i,t} + \beta_2 Competition_{i,t} + \beta_3 * Competition_{i,t} * IT_{i,t} \\ + \beta_4 * InitialIT_i * Competition_{i,t} + \beta_5 IT_{i,t} * InitialIT_i + \beta_6 * IT_{i,t} * InitialIT_i \gamma_7 x_{i,t} + \alpha_i + u_{i,t} \end{aligned} \tag{6}$$

Results are shown only for computers-per-worker in Table 13. The estimators indicate that the positive effects over performance are driven by the interaction between IT and Chinese competition, meaning that increases in IT lead to productivity improvements. As the triple interaction has a negative sign, firms that already had a higher level of IT exhibit much lower effects. Evaluating the change in productivity due to a 0.1 change in IT use in the mean of Chinese competition and on mean initial IT, we find that it leads to around a 7% change in sales-per-worker. Using the mean initial IT but the maximum of Chinese competition, it yields a 44% change in productivity. Therefore, once again what leads to increasing productivity is the change and not the initial level of IT use.

Finally, we perform a Oaxaca-Blinder decomposition over the same equation in differences in order to test whether the magnitude of the change in IT use is the main cause of the differences observed between firms that face higher competition pressure from China and firms that do not, or if differing returns (coefficients) are the main drivers of our results. As table 14 shows, difference in endowments (changes in IT) are statistically significant both with and without control variables. This result is in line with the results discussed above.

Table 12: IV regression IT use on firm-level productivity considering China's competition and initial IT

Dependent variable: log(sales/worker)	(1)	(2)	(3)	(4)	(5)	(6)
Computers-per-worker	-0.963	-0.603	-0.180	0.256	0.077	-0.368
	(1.584)	(1.460)	(1.567)	(1.514)	(1.508)	(1.980)
Competition*computers-per-worker	14.468***	12.841**	11.535**	10.810**	10.615**	12.318*
	(5.545)	(5.473)	(5.316)	(5.224)	(5.175)	(7.102)
Competition	-0.946	-0.943	-0.581	-0.818	-0.615	-0.880
	(1.204)	(1.168)	(1.061)	(1.030)	(1.012)	(1.272)
Initial IT*Competition	-10.888**	-9.408**	-9.278**	-8.312*	-8.412*	-9.777*
	(4.923)	(4.627)	(4.536)	(4.430)	(4.395)	(5.884)
F-first stage IT	7.0	9.7	9.1	9.9	10.0	9.9
F-first stage IT*competition	12.5	14.9	16.8	17.8	17.8	16.2
Sargan	0.90	0.72	0.58	0.68	0.60	0.64
Share of labor with Internet	-2.135*	-2.296*	-1.494	-1.132	-1.051	-2.470
	(1.174)	(1.378)	(1.420)	(1.321)	(1.316)	(3.044)
Competition*Share of labor with Internet	22.785***	22.959***	19.460***	17.441***	15.514***	20.178*
	(6.056)	(6.542)	(6.169)	(5.925)	(5.780)	(11.821)
Competition	-1.742	-1.862	-1.521	-1.359	-1.008	-1.471
	(1.115)	(1.134)	(1.029)	(0.989)	(0.964)	(1.352)
Initial IT*Competition	-13.430***	-13.859**	-12.133**	-10.802**	-9.779*	-14.529
	(4.971)	(5.663)	(5.408)	(5.118)	(5.054)	(10.937)
F-first stage IT	14.5	12.9	11.9	12.7	12.2	9.4
F-first stage IT*competition	13.1	14.0	15.4	15.3	15.3	15.1
Sargan	0.28	0.32	0.40	0.44	0.45	0.30
Controls						
Age	No	Yes	Yes	Yes	Yes	Yes
Firm size	No	No	Yes	Yes	Yes	Yes
Share of white-collar workers	No	No	No	Yes	Yes	Yes
Capital/worker	No	No	No	Yes	Yes	Yes
Exports/sales	No	No	No	No	Yes	Yes
FDI share	No	No	No	No	Yes	Yes
Time effects	No	No	No	No	No	Yes
Observations	1402	1402	1402	1402	1402	1402

Standard errors in parentheses

Source: Authors' calculations using data from ENTIC, INEGI

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 12 Continued: IV regression IT use on firm-level productivity considering China's competition and initial IT

Dependent variable: log(sales/worker)	(1)	(2)	(3)	(4)	(5)	(6)
Share of labor with computer	-2.306	-1.565	-1.024	-1.743	-1.544	-1.769
	(2.678)	(2.579)	(2.794)	(3.031)	(3.035)	(2.455)
Share of labor with computer*Competition	20.832*	19.805*	18.794*	20.457*	18.549*	20.300**
	(10.788)	(10.157)	(10.294)	(10.886)	(10.559)	(9.063)
Competition	-1.017	-1.436	-1.445	-1.411	-1.146	-1.647
	(1.182)	(1.219)	(1.223)	(1.200)	(1.193)	(1.408)
Initial IT*Competition	-15.397*	-13.215	-12.697	-14.633	-13.256	-14.190*
	(9.325)	(8.860)	(8.929)	(9.591)	(9.441)	(7.679)
F-first stage IT	7.5	7.1	5.9	5.9	5.0	5.1
F-first stage IT*competition	12.1	12.1	11.1	11.8	10.6	9.7
Sargan	0.17	0.13	0.15	0.15	0.15	0.17
Controls						
Age	No	Yes	Yes	Yes	Yes	Yes
Firm size	No	No	Yes	Yes	Yes	Yes
Share of white-collar workers	No	No	No	Yes	Yes	Yes
Capital/worker	No	No	No	Yes	Yes	Yes
Exports/sales	No	No	No	No	Yes	Yes
FDI share	No	No	No	No	Yes	Yes
Time effects	No	No	No	No	No	Yes
Observations	1402	1402	1402	1402	1402	1402

Standard errors in parentheses

Source: Authors' calculations using data from ENTIC, INEGI

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 13: IV regression IT use on firm-level productivity considering China's competition and initial IT interactions

Dependent variable: log(sales/worker)	(1)	(2)	(3)	(4)	(5)	(6)
IT (Computers-per-worker)	-1.095	-0.932	-1.248	-1.315	-1.962	-2.075
	(1.236)	(1.381)	(1.357)	(1.352)	(1.413)	(1.762)
Competition*IT	16.144***	15.181***	14.396***	14.337***	14.147***	14.050**
	(5.752)	(5.280)	(4.968)	(4.922)	(4.906)	(5.750)
Competition	-3.216*	-3.137*	-2.188	-2.343	-1.794	-3.164
	(1.950)	(1.898)	(1.657)	(1.625)	(1.628)	(2.287)
Initial IT*Competition	3.181	3.193	-0.296	-0.124	-2.141	4.212
	(7.073)	(6.828)	(6.529)	(6.521)	(6.653)	(6.689)
IT*initial IT	1.984	1.869	1.780	1.975	2.176	3.594
	(1.491)	(1.725)	(1.650)	(1.677)	(1.670)	(2.295)
IT*initial IT*Competition	-17.030*	-16.074*	-12.698	-12.553	-10.196	-15.739*
	(8.983)	(8.806)	(8.026)	(7.943)	(8.025)	(9.096)
F-first stage IT	13.4	14.4	14.2	14.8	13.6	14.7
F-first stage IT*competition	11.0	12.3	13.6	14.2	13.9	13.3
F-first stage IT*initial IT	14.8	13.7	13.8	13.5	13.3	13.1
F-first stage triple interaction	26.0	27.1	26.1	26.2	26.1	26.2
Sargan	0.59	0.47	0.45	0.44	0.61	0.35
Controls						
Age	No	Yes	Yes	Yes	Yes	Yes
Firm size	No	No	Yes	Yes	Yes	Yes
Share of white-collar workers	No	No	No	Yes	Yes	Yes
Capital/worker	No	No	No	Yes	Yes	Yes
Exports/sales	No	No	No	No	Yes	Yes
FDI share	No	No	No	No	Yes	Yes
Time effects	No	No	No	No	No	Yes
Observations	1402	1402	1402	1402	1402	1402

Standard errors in parentheses

Source: Authors' calculations using data from ENTIC, INEGI

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 14: Oaxaca Blinder Decomposition of effects

	(1)	(2)
Prediction sales/worker change		
Low competition	0.02	0.02
High competition	0.12	0.12
Difference	-0.09	-0.09
Endowments		
IT	-0.03*	-0.03*
Other factors		0.11*
Coefficients		
IT	-0.05*	-0.03
Other factors constant	-0.04	-0.05
Interactions		
IT	0.02	0.02
Other factors constant		-0.11
Observations	701	701

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Source: Authors' calculations using data from ENTIC, INEGI

5.5 Mechanisms behind the relation between IT, competition and performance

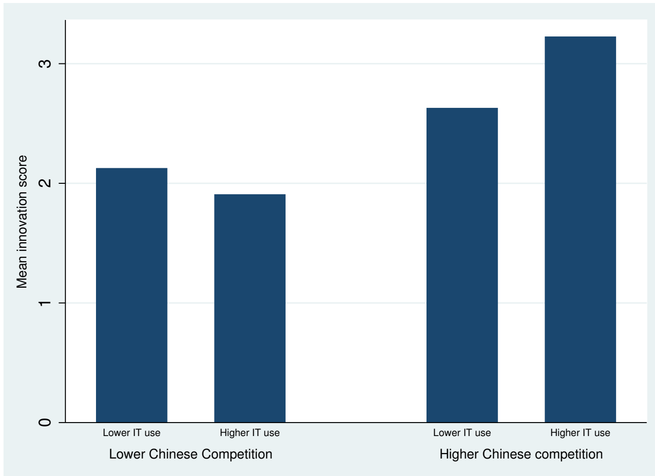
As previously mentioned, IT solely cannot increase productivity as it is necessary to incorporate the use of these technologies into the firm's processes. These requires reorganization and changes in processes which represent complementary investments. Our results support the view of competition providing the right incentives to pursue all of these organizational and processes investments but it is important to deepen into the channels through which this occurs.

Therefore, we analyze variables included in the ENTIC 2013, which are directly related to organizational, product and processes innovation. We use two innovation score variables, one for products and processes innovation, and another one for marketing and organization. The first one includes cost reductions, reduction of training costs, time-saving, labor productivity increases, access to knowledge sources, exchange of ideas, plant and production scaling, improvements in industrial design of products and processes. The organization and marketing innovation score includes access to new markets, better communication within the firm, increasing logistics efficiency, implementation of automatized systems, improving communication with clients, a higher diversity in products delivery and more personalized products or services orders.

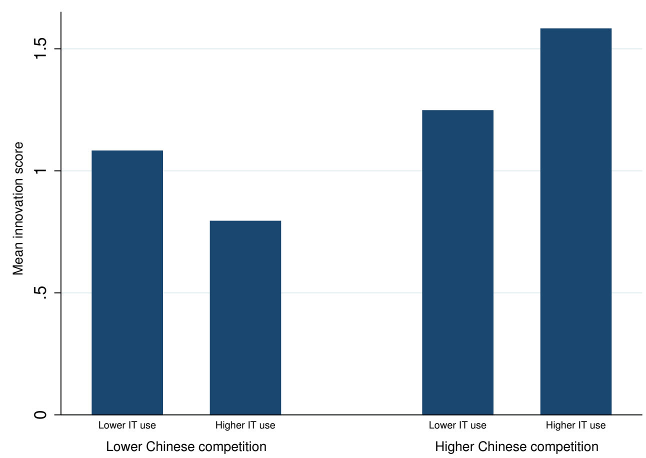
As Figure 4 shows, even though the average innovation score is low for firms included in our sample (the score has a range of 0-10), in general firms that face higher competition pressures from China have a higher innovation score, both in terms of product and processes innovation and in marketing and organization. Furthermore, firms that invest in IT in order to cope with competition, hold the highest mean innovation scores.

Figure 4: Innovation score by IT use and Chinese competition levels

(a) *Mean Products and Processes Innovation Score*



(b) *Mean Marketing and Organization Innovation Score*



Source: Authors' calculations with data from ENTIC 2009 and 2013, INEGI. The innovation scores range from 0-10. Note: Results are only shown for our main IT use variable (computers-per-worker) but for our other proxies are available upon request.

In order to test statistically this relation, we estimated the probability of innovating as a function of the change in IT use, competition and the interaction of both. We use the change in these variables between 2008 and 2012 because the Innovation Module of ENTIC was included for the first time in the 2013 wave. The equation estimated is as follows:

$$
\begin{aligned}
Pr(Innovation|x_i, \Delta IT_i, \Delta Competition_i) = \beta_0 + \beta_1 \Delta IT_i + \beta_2 \Delta Competition_i \\
+\beta_3 * \Delta Competition_i * \Delta IT_i + \gamma x_i + u_i
\end{aligned}
\tag{7}
$$

As Table 15 shows, positive effects over the probability of implementing innovation in the firm are only observed when the interaction term between change in IT and competition is higher. These results indicate that firms that compete more with China and make more intensive use of IT have also a higher probability of innovating which means that they are pursuing the complementary investments necessary to make the most of investments in IT. Similar results are obtained when we estimate a split regression of innovation scores on IT use appropriately instrumented as before for firms that show lower competition with China and firms that face higher competition pressures. Once again for firms that do not compete with China, IT use is not associated with a higher innovation score as coefficients are not significant. The contrary is observed for firms that face higher competition pressures as a 0.1 change in computers-per-worker is associated to an increase in the products and processes innovation score of almost 1 point and to an improvement of 0.6 points in the marketing and organization scores.

Finally, in order to analyze clearly how IT use is related to this improvements in processes, we used variables regarding the use of software for processes such as logistics and distribution and control of processes. A split panel regression of the probability of using this kind of software on IT use, indicates that there is a direct relation between IT use and the probability of using software for this kind of activities when firms face higher competition. For firms that do not compete with China there is not a significant association. [14]

[14] Results are not shown here but are available upon request.

Table 15: Linear probability model Innovation on IT use and competition changes

Dependent variable: =1 if had innovation	(1)	(2)	(3)	(4)	(5)
Innovation in product and processes					
Δ Computers-per-worker	-0.236**	-0.238**	-0.159	-0.164	-0.167
	(0.102)	(0.101)	(0.108)	(0.106)	(0.107)
ΔChinese competition	-0.002	0.023	0.053	0.064	0.054
	(0.175)	(0.176)	(0.174)	(0.174)	(0.174)
ΔComputers-per-worker*ΔChinese competition	1.185**	1.197**	1.098**	1.107**	1.114**
	(0.477)	(0.470)	(0.482)	(0.478)	(0.477)
Innovation in marketing and organization					
Δ Computers-per-worker	-0.191*	-0.195*	-0.106	-0.109	-0.112
	(0.103)	(0.102)	(0.109)	(0.107)	(0.108)
ΔChinese competition	-0.116	-0.099	-0.067	-0.052	-0.062
	(0.175)	(0.176)	(0.174)	(0.174)	(0.174)
ΔComputers-per-worker*ΔChinese competition	1.121**	1.144**	1.034**	1.039**	1.046**
	(0.475)	(0.472)	(0.484)	(0.480)	(0.480)
Controls					
Age	No	Yes	Yes	Yes	Yes
Firm size	No	No	Yes	Yes	Yes
Share of white-collar workers	No	No	No	Yes	Yes
Capital/worker	No	No	No	Yes	Yes
Exports/sales	No	No	No	No	Yes
FDI share	No	No	No	No	Yes
Observations	701	701	701	701	701

Robust standard errors in parentheses

Source: Authors' calculations using data from ENTIC, INEGI

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 16: IV split regression innovation score over IT use

Dependent variable: Innovation score	(1)	(2)	(3)	(4)	(5)
Low competition with China					
Products and processes					
Δ Computers-per-worker	-6.954*	-6.372*	-6.715	-5.958	-6.228
	(4.012)	(3.854)	(4.534)	(4.518)	(4.631)
F-first stage	9.7	10.2	7.1	6.5	6.6
Sargan	0.92	0.72	0.75	0.96	0.95
Marketing and Organization					
Δ Computers-per-worker	-4.461	-3.678	-2.779	-2.353	-2.328
	(3.069)	(2.925)	(3.375)	(3.404)	(3.474)
F-first stage	9.7	10.3	7.0	6.5	6.6
Sargan	0.56	0.73	0.85	0.72	0.71
Observations	336	336	336	336	336
High competition with China					
Products and processes					
Δ Computers-per-worker	9.295**	9.020**	7.823**	7.846**	8.599**
	(3.870)	(3.841)	(3.445)	(3.524)	(3.779)
F-first stage	13.1	13.1	13.5	13.0	12.0
Sargan	0.64	0.64	0.48	0.48	0.54
Marketing and Organization					
Δ Computers-per-worker	5.971**	5.882**	5.254**	5.404**	5.824**
	(2.773)	(2.772)	(2.559)	(2.629)	(2.817)
F-first stage	13.1	13.1	13.5	12.9	9.2
Sargan	0.31	0.31	0.23	0.24	0.27
Observations	365	365	365	365	365
Controls					
Age	No	Yes	Yes	Yes	Yes
Firm size	No	No	Yes	Yes	Yes
Share of white-collar workers	No	No	No	Yes	Yes
Capital/worker	No	No	No	Yes	Yes
Exports/sales	No	No	No	No	Yes
FDI share	No	No	No	No	Yes
Time effects	No	No	No	No	No

Standard errors in parentheses

Source: Authors' calculations using data from ENTIC, INEGI

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

6 Conclusion

IT use and technology adoption have been identified as key factors capable of increasing firm-level productivity (Syverson, 2011). Even though there is a great deal of evidence for developed countries regarding this relation, it is not clear whether these predictions hold for a developing country such as Mexico or how these mechanisms operate in a context of external competition shocks.

In this paper we analyzed the relation between IT and competition from China for the case of Mexico between 2008 and 2012 using a firm-level data panel constructed from IT surveys that, to the best of our knowledge, were never used for research purposes before. The results indicate that on average IT use positively affects productivity, and these are results to our instrumental variable approach. However, when we dig deeper we find that only firms that face higher competition pressure exhibit a positive effect of IT use on productivity. Combining these results with the relationship found between IT use and products, processes and organizational innovation when firms face higher competition, we interpret these results as either they make more effective use of IT in order to cope with the pressures of Chinese competition or they are willing to make also organizational changes that improve the returns to IT use. The results are robust to the different specifications.

Our results have straightforward policy implications as they indicate that subsidizing IT use is not enough if firms are not provided with the appropriate incentives in terms of competition and business environments that lead to the required complementary changes (i.e. organizational changes, innovation).

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