The complementarity between ICT use and competition in Mexico

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Abstract

and more investment in technology in order to be able to avoid exit in terms of the extensive margin and to avoid losses (intensive margin). In this sense, this study intends to shed light on the relation between these two variables.

The rest of this article is organized as follows: Section 2 provides a literature review of empirical studies on ICT 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 di erent strands of economic literature. The rst one is the one that analyzes the e ects of ICT adoption on productivity while the second is the one related to trade competition and the adjustments needed at the rm level in order to be able to face the pressure generated generated by external competition.

There is a great deal of studies regarding the impact of ICT on productivity both at the macro and country level as well as the micro and rm-level. The rst analyses regarding this topic were conducted during the 80s and did not nd evidence of any e ect of ICT on productivity. This lack of evidence was

explained by ICT 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 ICT use and productivity is, as pointed out by Draca et al. (2006) that ICT investment is a rm's decision and it is not plausible to assume that it is independent of performance. Therefore, ICT use is most likely endogenous and it is important to nd an instrument that only a ects productivity through ICT use.

Another strand of literature related to our work are the studies analyzing the e ect China's competition on Mexico. However, most of these studies have focused on aggregate e ects of Chinese competition and on whether Mexican products have been displaced by Chinese competition both in the domestic market and in the US market. For example Freund and Ozden (2006) estimate a gravity model and nd that China's exports growth had moderate e ects on Latin America's growth as a region, but had negative impact on

Where

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

$ICT_{i;t}$ = ICT use of rm i at time

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

$_i$ = rm xed e ects

Taking this equation as a basis, we use di erent speci cations 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 ICT use with rm-level data.

3.2 Instrumental variables

Considering that ICT is endogenous to rm performance, we use an instrumental variable approach. The instrument used is de ned as follows:

$$IV1_{j;s} = ICT_{int;j} \quad ICTHHuse_s \tag{2}$$

Where

$ICT_{int;j}$ = ICT intensity of sector j in the US

$ICTHHuse_s$ = Change in the share of households with computers in state s

In order to construct $IV1$ we take the ICT-intensity classi cation used in Bloom et al. (2012) and O'Mahony and Van Ark (2003), which is based on Stiroh (2002) and interact this sectoral variable with the change in household ICT-use at the state level. [3] The use of this second measure is based on

4 Data and descriptive statistics

4.1 Firm-level ICT use

Data regarding ICT use was 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 ICT use at the rm-level that to, the best of our knowledge, has not been previously used for research purposes.

We constructed a panel including rms that appeared in both surveys. Due to the sample design of this survey we were only able to match 719 rms out of approximately 6,210 included in the ENTIC 2013.[4] Additionally, rms of the trade and services sectors are excluded from the sample, as we focus on manufacturing goods for which we have available trade data.

As our main measure of ICT 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 rms and sectors and that it avoids the use of price de ators.

Additionally, we selected three other proxies of ICT use in order to test the robustness of our results. The rst one is the share of labor that uses Internet in the rm, the second one is E-commerce Purchases/Total Purchases, which measures a totally di erent aspect of ICT use and the last one is the share of labor with computer, which should be almost equal to computers-per-worker and is used mainly to test the robustness of our results obtained with that variable. In fact, Bloom et al. (2012) use the share of labor with computer as a robustness test as there could be mismeasurement in their IT stock capital variable that could be biasing their results.

4.2 Trade data

Trade data was obtained from the World Integrated Trade Statistics (WITS) using the HS 1996 classi cation

reclassi ed the ones that had more than one match using the Mexican Tari Classi cation (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.[5]

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

$$Compet_j = \frac{M_{j;China}}{\sum_{k=1}^{n} M_{j;k}} \tag{3}$$

Where

$M_{j;China}$ = Imports of country j from China

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

4.3 State household ICT-use

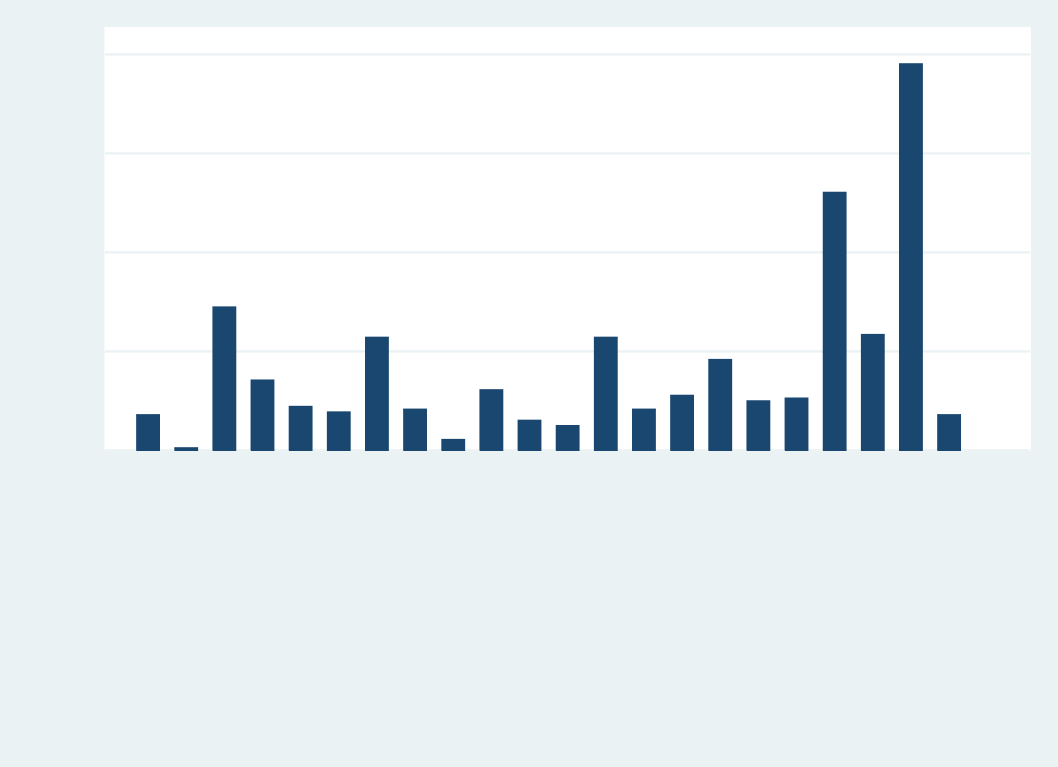
As mentioned before, in order to construct our instrumental variable, we combine ICT sectoral intensity for the US obtained from Bloom et al. (2012) with household ICT use.

Information regarding household ICT 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

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.

At the sectoral level, transportation equipment, computers and electronic and food manufacturing comprise almost 40% of the rms in the sample. Figure 1 shows how the rms are distributed by sector in the sample.

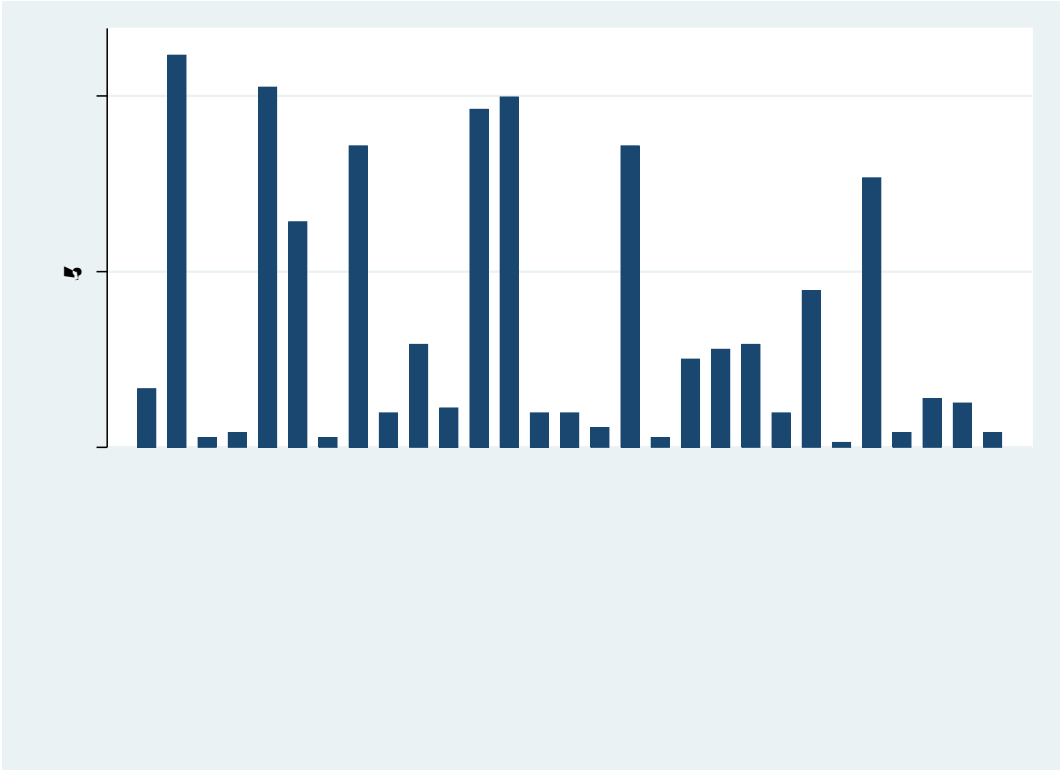
Figure 1: Distribution of rms by sector in the sample



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

As Figure 2 shows, around 60% of the rms in the sample are located in six states: Baja California,

Figure 2: Distribution of rms by State in the sample



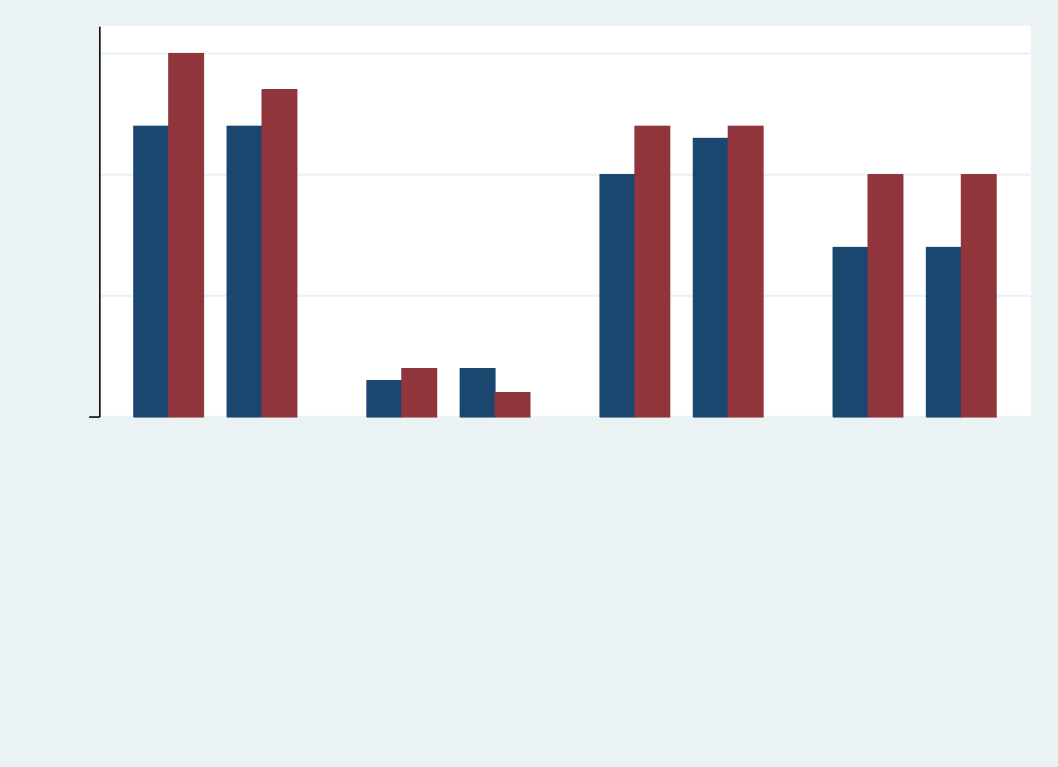
Source: Author's calculations with data from ENTIC 2009 and 2013, INEGI

Table 1: Descriptive Statistics ICT use variables

	Sample						Whole					
Variable	Mean	p50	sd	p10	p90	N	Mean	p50	sd	p10	p90	N
2008												
Computers-per-worker	0.27	0.19	0.25	0.06	0.59	715	0.34	0.23	0.34	0.05	0.80	4612

Considering the relation between ICT 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 ICT use between these two groups, as Figure 3 shows in the period 2008-2012, rms that face more competition from China experienced a higher increase in ICT use. Therefore, the data is consistent with the hypothesis of higher competition generating incentives for increases on ICT use.

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



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

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

5 Results

5.1 ICT use and productivity

First of all we estimate the relation between ICT 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 2 shows, for all ICT use variables except for e-commerce

purchases as a share of total purchases, we observe that there appears to be a positive and signi cant correlation between ICT 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, ICT use is most likely endogenous because there are likely to be unobservable characteristics that are both positively correlated. Therefore, we adopt an IV strategy to estimate the same equations, where we instrument our ICT use variable with the instruments described in section 3.2. Results are shown in Table 3. The overidenti cation tests as well as F test, evaluating the strength of our IVs, do not indicate invalidation of our instrument in the case of computers-per-worker and the share of labor with Internet. However, for e-commerce purchases/Total Purchases and share of labor with computer it is not possible to reject the hypothesis that instruments are weak so these coe cients must be interpreted with caution. As the table shows, for computers-per-worker and the share of labor with internet, results are in line with the OLS coe cients, but slightly higher which may be the consequence of treatment e ect heterogeneity (Imbens and Angrist, 1994). Additionally, when we include the share of exports and the FDI share as controls, the variables related to ICT use are no longer statistically signi cant.

In order to analyze what previous literature has found regarding the complementarity between ICT use and skills, we estimated the equation interacting ICT use with the share of white-collar workers in the rm. In all speci cations the interaction was not signi cant.[6] Thus, we don't nd much evidence that rms with a higher share of white-collar workers experience greater e ects of ICT on productivity as a result of the complementarity between skills and ICT.However, our results may be driven by the fact that the proxy we use is not an appropriate measure of skills within the rm.

5.2 ICT use, Chinese competition and productivity

Previously, we presented some descriptive evidence that rms in sector that experienced stronger competitive pressures because of increasing Chinese experts tend to be more likely to adopt ICT. Further, in this Section, in order to assess whether Chinese competition also enhances the role of ICT 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 ICT use variables.[7] As tables 4 and 5 show, for rms that face low competition from China, the e ects of ICT use on productivity are not statistically signi cant. Furthermore, in the case of e-commerce purchases over total purchases the coe cients are negative and signi cant at the 10% level. On the other hand, when we analyze rms from sectors that face high competition from China,

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

[7] A sector is classi ed 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.

Table 2: OLS estimates of the effect of ICT use on productivity

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable log(sales/worker)						
Computers-per-worker	1.230***	1.230***	1.099***	1.182***	1.177***	1.255**
	(0.326)	(0.218)	(0.219)	(0.274)	(0.267)	(0.522)
N	1,423	1,423	1,423	1,398	1,398	1,076
R^2	0.869	0.869	0.873	0.878	0.878	0.913
Share of labor with Internet	1.266***	1.266***	1.140***	1.192***	1.170***	1.177**
	(0.307)	(0.188)	(0.200)	(0.292)	(0.293)	(0.534)
N	1,427	1,427	1,427	1,402	1,402	1,080
R^2	0.865	0.865	0.869	0.874	0.874	0.909
E-commerce purchases/total purchases	0.00234	0.00234	0.00220	0.00206	0.00204	0.00483
	(0.00484)	(0.00369)	(0.00303)	(0.00266)	(0.00270)	(0.00371)
N	1,427	1,427	1,427	1,402	1,402	1,080
R^2	0.856	0.856	0.862	0.867	0.867	0.906
Share of labor with computer	1.096***	1.096***	1.006***	1.022***	1.004***	1.233***
	(0.239)	(0.162)	(0.159)	(0.256)	(0.258)	(0.399)
N	1,427	1,427	1,427	1,402	1,402	1,080
R^2	0.865	0.865	0.869	0.874	0.874	0.912
Controls						
Sector	No	Yes	No	No	No	No
Age	No	No	Yes	Yes	Yes	Yes
State	No	No	Yes	Yes	Yes	Yes
Firm size	No	No	No	Yes	Yes	Yes
Share of white-collar workers	No	No	No	No	Yes	Yes
Exports/sales	No	No	No	No	No	Yes
FDI share	No	No	No	No	No	Yes

Standard errors in parentheses

All specifications include firm's fixed effects.

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

Source: Authors' calculations using data from ENTIC, INEGI

Table 3: IV estimates of the effect of ICT use on firm-level productivity

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable log(sales/worker)						
Computers-per-worker	1.920***	2.206***	3.075***	2.916***	0.668	
	(0.622)	(0.773)	(0.993)	(0.988)	(0.776)	
N	1434	1434	1409	1409	1086	
R^2	0.837	0.833	0.823	0.827	0.866	
Share of labor with Internet	1.666***	2.240***	2.943***	2.929***	0.744	
	(0.562)	(0.793)	(0.949)	(1.005)	(0.962)	
N	1438	1438	1413	1413	1090	
R^2	0.836	0.831	0.824	0.825	0.864	
E-commerce purchases/total purchases[1]	0.0707*	0.0885	0.0760*	0.0721*	-0.0825	
	(0.0413)	(0.0627)	(0.0431)	(0.0419)	(0.194)	
N	1438	1438	1413	1413	1090	
R^2	0.508	0.323	0.457	0.497	0.552	
Share of labor with computer[1]	3.859**	5.093**	9.462*	11.19	1.875	
	(1.513)	(2.335)	(5.726)	(8.301)	(2.430)	
N	1438	1438	1413	1413	1090	
R^2	0.779	0.716	0.382	0.180	0.864	
Controls						
Age	No	Yes	Yes	Yes	Yes	
State	No	Yes	Yes	Yes	Yes	
Firm size	No	No	Yes	Yes	Yes	
Share of white-collar workers	No	No	No	Yes	Yes	
Exports/sales	No	No	No	No	Yes	
FDI share	No	No	No	No	Yes	

Standard errors in parentheses

All specifications include firm's fixed effects.

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

1 The test of weak indicates that instruments for these variables are weak

Source: Authors' calculations using data from ENTIC, INEGI

Table 4: Split regression ICT use on productivity: Low competition with China

Dependent variable log(sales/worker)	(1)	(2)	(3)	(4)	(5)
Computers-per-worker	0.313	0.339	0.335	0.320	0.102
	(0.350)	(0.356)	(0.400)	(0.394)	(1.114)
N	703	703	678	678	508
R^2	0.866	0.867	0.869	0.870	0.862
Share of labor with Internet	0.156	0.193	0.265	0.271	-0.0842
	(0.515)	(0.525)	(0.551)	(0.558)	(1.350)

Table 5: Split regression ICT use on productivity: High competition with China

Dependent variable log(sales/worker)	(1)	(2)	(3)	(4)	(5)
Computers-per-worker	1.168***	1.079***	1.353***	1.361***	1.295**
	(0.270)	(0.284)	(0.437)	(0.425)	(0.610)
N	731	731	731	731	578
R^2	0.810	0.814	0.822	0.823	0.881
Share of labor with Internet	1.147***	1.154***	1.313***	1.295***	1.234**
	(0.254)	(0.249)	(0.474)	(0.487)	(0.615)
N	732	732	732	732	579
R^2	0.803	0.811	0.816	0.817	0.874
E-commerce purchases/Total purchases	0.00794	0.00744	0.00694*	0.00694*	0.0135**
	(0.00622)	(0.00490)	(0.00385)	(0.00387)	(0.00531)
N	732	732	732	732	579
R^2	0.797	0.804	0.809	0.809	0.875
Share of labor with computer	1.241***	1.163***	1.328***	1.314***	1.419***
	(0.211)	(0.212)	(0.425)	(0.437)	(0.485)
N	732	732	732	732	579
R^2	0.808	0.813	0.820	0.820	0.879
Controls					
Age	No	Yes	Yes	Yes	Yes
State	No	Yes	Yes	Yes	Yes
Firm size	No	No	Yes	Yes	Yes
Share of white-collar workers	No	No	No	Yes	Yes
Exports/sales	No	No	No	No	Yes
FDI share	No	No	No	No	Yes

Table 7: Split IV regression ICT use on productivity: High competition with China

	(1)	(2)	(3)	(4)	(5)
Computers-per-worker	2.394***	2.008**	2.895***	2.706***	0.690
	(0.662)	(0.788)	(0.912)	(0.880)	(0.866)
N	731	731	731	731	578
R^2	0.791	0.804	0.802	0.807	0.878
Share of labor with Internet	1.750***	1.588**	2.145***	2.149***	0.527
	(0.491)	(0.633)	(0.673)	(0.709)	(0.804)
N	732	732	732	732	579
R^2	0.800	0.809	0.812	0.812	0.872
E-commerce purchases/total purchases	0.0570**	0.0435**	0.0438**	0.0414**	0.0271
	(0.0227)	(0.0218)	(0.0173)	(0.0168)	(0.0419)
N	732	732	732	732	579
R^2	0.598	0.699	0.702	0.716	0.867
Share of labor with computer	3.244***	2.712**	3.993***	4.223***	1.161
	(0.986)	(1.136)	(1.413)	(1.603)	(1.722)
N	732	732	732	732	579
R^2	0.766	0.789	0.761	0.751	0.879
Controls					
Age	No	Yes	Yes	Yes	Yes
State	No	Yes	Yes	Yes	Yes
Firm size	No	No	Yes	Yes	Yes
Share of white-collar workers	No	No	No	Yes	Yes
Exports/sales	No	No	No	No	Yes
FDI share	No	No	No	No	Yes

Standard errors in parentheses

Source: Authors' calculations using data from ENTIC, INEGI

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

Table 8: IV regression ICT use on productivity considering China's competition

	(1)	(2)	(3)	(4)
Computers-per-worker	-2.080	-1.526	-0.496	-0.541
	(1.831)	(1.417)	(2.974)	(2.959)
China's competition*computers-per-worker	8.988	9.319*	13.40**	13.41**
	(5.503)	(5.464)	(5.695)	(5.689)
China's competition	-1.831	-2.307	-4.392	-4.396
	(2.552)	(2.368)	(2.696)	(2.694)
N	1428	1428	1403	1403
R^2	0.796	0.809	0.799	0.799
Share of labor with internet	-3.259**	-3.547	-4.456	-4.349
	(1.463)	(2.398)	(4.858)	(4.896)
China's competition*share of labor with Internet	18.15**	19.41*	24.91*	24.69*
	(8.763)	(11.15)	(13.77)	(13.59)
China's competition_	-2.368	-2.787	-4.002	-3.955
	(2.121)	(2.490)	(2.604)	(2.541)
N	1432	1432	1407	1407
R^2	0.793	0.786	0.754	0.757
E-commerce purchases/Total purchases	-1.199	-0.251	-0.166	-0.193
	(14.14)	(1.415)	(0.504)	(0.627)
China's competition*E-commerce purchases/Total purchases	4.238	0.964	0.740	0.835
	(48.33)	(4.739)	(1.798)	(2.236)
China's competition_	-14.15	-2.126	-1.854	-2.273
	(167.5)	(14.03)	(6.160)	(7.821)
N	1418	1418	1393	1393
R^2	-53.64	-1.478	-0.133	-0.488
Share of labor with computer	17.27	10.27	1.395	1.324
	(25.10)	(13.70)	(2.586)	(2.544)
China's competition*share of labor with computer	-31.39	-17.85	9.440	9.647
	(67.47)	(37.32)	(9.768)	(9.787)
China's competition_	7.205	5.050	-2.157	-2.187
	(15.98)	(9.543)	(2.783)	(2.789)
N	1432	1432	1407	1407
R^2	-0.513	0.398	0.816	0.816

Standard errors in parentheses

Source: Authors' calculations using data from ENTIC, INEGI

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

Controls: (1) Only rm-level xed e ects (2) age and region (3) age, region and size (4) Adding share of white-collar

Table 9: IV regression ICT use on productivity considering China's competition

	(1)	(2)	(3)	(4)
Computers-per-worker	-0.711	-0.219	0.0426	0.0738
	(0.917)	(0.883)	(0.999)	(0.994)
Competition in US*computers-per-worker	5.385*	4.107*	5.026**	4.745**
	(2.862)	(2.416)	(2.399)	(2.388)
Competition in US	-1.064	-0.584	-0.932	-0.878
	(1.068)	(0.886)	(0.882)	(0.877)
N	1428	1428	1403	1403
R^2	0.835	0.842	0.841	0.842
Share of labor with Internet	-1.501	-0.702	-0.484	-0.467
	(1.057)	(1.231)	(1.354)	(1.331)
Competition in US*Share of labor with Internet	5.479**	4.316*	4.905**	4.832*
	(2.793)	(2.623)	(2.455)	(2.511)
Competition in US	-0.0977	0.0705	-0.105	-0.103
	(0.571)	(0.526)	(0.509)	(0.511)
N	1428	1428	1403	1403
R^2	0.839	0.845	0.847	0.847
shshop_ecom	0.205	0.0799	0.0912	0.0855
	(0.452)	(0.179)	(0.207)	(0.213)
intUSshshopecom	-0.630	-0.143	-0.175	-0.161
	(1.616)	(0.606)	(0.687)	(0.697)
Competition in US	3.057	1.216	1.301	1.224
	(6.409)	(2.297)	(2.585)	(2.675)
N	1428	1428	1403	1403
R^2	-0.635	0.564	0.488	0.528
Share of labor with computer	47.98	73.32	0.342	0.303
	(324.9)	(2421.1)	(7.644)	(8.539)
intUSshslabcomp	-60.07	-90.73	4.633	4.632
	(435.4)	(3121.4)	(7.306)	(7.279)
Competition in US	10.26	18.44	-0.367	-0.370
	(72.19)	(612.7)	(1.418)	(1.475)
N	1428	1428	1403	1403
R^2	-8.401	-20.87	0.845	0.845

Standard errors in parentheses

Source: Authors' calculations using data from ENTIC, INEGI

* $p < 0:10$, ** $p < 0:05$, *** $p < 0:01$

Controls: (1) Only rm-level xed e ects (2) age and region (3) age, region and size (4) Adding share of white-collar

6 Conclusion

ICT use and technology adoption have been identi ed as key factors capable of increasing rm-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 ICT and competition from China for the case of Mexico between 2008 and 2012 using a rm-level data panel constructed from ICT surveys that, to the best of our knowledge, were never used for research purposes before. Results indicate that on average ICT use positively a ect productivity, and these are results to our instrumental variable approach. However, when we dig deeper we nd that only rms that face higher competition pressure exhibit a positive e ects of ICT use on productivity. We interpret this results as either they make more e ective use of ICT in order to cope with the pressures of Chinese competition or they are willing to make also organization changes that improve the returns to the ICT use. Results are robust to the di erent speci cations in the case of the two

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