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ABSTRACT. For developed countries it has been well-documented that people that use a computer at work earn higher wages than people who don't. Whether this effect is causal remains an unresolved issue. This paper examines whether the same association holds in a developing country. To that end we analyze longitudinal data from urban Ecuador. OLS estimates show that workers who use a computer earn up to 67% higher wages than people that don't. First difference estimates suggest that this impact is to a large extent causal. People who started using a computer experience an average wage increase of around 10%, while we find no wage increase for people who started to use desk materials.

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1. Introduction

Wages inequality has increased significantly during the 1980s in developed countries. Three main approaches are found in the literature to explain it, especially in the U.S. a) Skill Bias technological change. The main argument of this approach is that technical change favors more skilled workers, replaces task previously performed by the unskilled, and exacerbates inequality. According to Acemoglu (2002), there are two ways of understand technological change. First, technological change can be view as exogenous, stemming from advances in science. In this regard, the demand for skills increased faster during the past years because of a technological revolution led by personal computers. (e.g., Krueger (1993), Berman, Bound and Griliches (1994), Berman, Bound and Machin, (1998), Machin and Van Reenen, (1998), Autor, Katz and Krueger (1998), Autor, Levy and Murnane (2002a and 2002b)). Second, technological change can be view as endogenous and respond to incentives. The main argument in this case is that was the large increase in the supply of skilled workers that induced the acceleration in the demand for skills. According to this approach, when skill-biased technologies are more profitable, firms have greater incentives to develop and adopt such techniques. (e.g., Acemoglu, 2002)[1]. 2) Changes in labor market institutions. In this regard, the reduction of the power of unions has caused a reduction on wages of many facturing workers (e.g., Richard Freeman 1991; Di Nardo, Fortin and Lemieeux 1995). However, the behavior of labor market is different in the U.S. and Western Europe. Labor institutions are more rigid in Europe and more flexible in the U.S. As an example, Card, Kramarz, and Lemieux (1997) find that wages of less-skilled workers feel the most in the U.S., fell somewhat less in Canada, and did not fall at all in France.

3) International trade between skill-scarce less-developed countries and skill-abundant rich countries, which may have put downward pressure on the wages of low skill workers in developed countries, because of a reduction in manufacturing employment in large part associated with the increase in the trade deficit. (e.g., Wood, 1995).

In the case of Latin American countries, several hypotheses have been suggested to understand the increase in wage inequality during the 1980s and 1990s. Skill-biased

[1] For a critique to the skill biased technological approach see Card and Di Nardo (2002).

technological change has created the conditions to firms to increase the demand for educated workers across the region, especially workers with university education. The rising demand for educated workers has bid up the relative wages of these workers. (Berman and Machin, (2000), Sánchez Páramo and Schady, 2003). The main mechanism for the adoption of skill biased technological change could be trade. According to Sánchez Páramo and Schady, increases in the demand for the most skilled workers took place at a time when countries in Latin America considerably increased the penetration of imports, including imports of capital goods. Changes in the volume and research and development intensity of imports are significantly related to changes in the demand for more skilled workers in the region.

Another approach points that structural adjustment policies applied during the 1980s and 1990s in the region have led to an increase in inequality. Especially, domestic financial marker reform, capital account liberalization and tax reform have contributed to increase wage differentials in the region. On the other hand, privatization contributed to narrowing wage differentials and trade openness had no significant effect on wage differentials. (Behrman, Birdsall and Szekelly, 2001).

Another interpretation gives trade liberalization an important role on increasing wage inequality in Latin America. In this regard, one consequence of trade liberalization could be an increase in the demand for highly skilled workers across the region accompanied by an increase in wage inequality. (e.g., Ganuza et al (2004), Vos and León (2003)).

This paper contributes to the current debate by analyzing the impact of computer use on wages in urban Ecuador by using a unique panel date set. In this regard, our study intent the test the skill bias technological change hypothesis.

The impact of computer use on wages has been widely analyzed in developed countries. Studies can be found for both, at firm level and at individual level. At firm level most studies conclude that firms that use more advanced technologies tend to pay higher wages. (e.g., Berman, Bound and Griliches (1994), Berman, Bound and Machin (1998), Machin and Van Reenen (1998), Gera, Gu and Lin (2001)). At individual level there are two main approaches regarding the impact of computer use on wages. First, those who argue that increases in salaries received by computer users can be attributed to real increases in productivity led by skill biased technological change. In this regard, the classic paper by Krueger (1993) found a positive effect of computer use on wages of 10 to 15 per cent in the U.S. Although the paper intent to correct for un-observables, finally the author can't get strong conclusions in this regard. In the same vein, Miller and Mulvey (1997) found that computer use is associated with a wage premium of 13 per cent for males and 16 per cent for females in Australia. Chiswick and Miller (2007) found that using a computer at home is associated whit about 7 and 13 per cent higher earnings for native-born and foreign-born men, respectively in Australia. Reilly (1995) found a 13.5% advantage for Canada. Arabsheibani, Emami and Marin (2004) found a 23% in 1985 and 20% advantage in 1990 for the United Kingdom. Second, those who argue that increase on wages of computer users could be attributed to unobserved heterogeneity among workers. In this approach the following studies can be found. Di Nardo and Pischke (1997), in German, found that using pencils or pens at work also has a positive effect on wages because they are used by workers who would be highly paid anyway. If this argument is true for pencils then the same could be said about computers. Given that 65 per cent of their sample uses pencils, this claim is not as strong as it seems at first sight since it would be stating that 65 per cent of the workers are likely to be highly paid. Using a very similar approach for Canada, Morissette and Drolet (1998) show that using fax machines positively and significantly affects earnings and that it yields a higher return compared to computer. In the same vein, Oosterbeek (1997) found an 11% advantage for the Netherlands. He found that returns to computer use do not vary with the intensity of computer use, which can be seen as evidence against the productivity interpretation. Entorf, Gollac and Kramarz (1999) for France, found that computer users are better paid than nonusers in around 15 to 20 per cent more. This paper has the advantage of using a longitudinal data. As an argument against the productivity approach the authors found that these workers were already better compensated before the introduction of personal computers. However, one limitation of this paper is that they do not have information of computer use in the baseline, and they have to impute this value using retrospective questions in the follow up survey. In addition, the income variable is captured in discrete terms. Finally, they find a significant and positive effect of computer experience that never exceed of 2% far from the cross-section estimates (15%-20%), which can be used in favor of the productivity argument.

In developing countries empirical evidence on the impact of computers on wages is scarce. Choi (1993) shows that workers are paid more in industries where technology changes rapidly than in industries where technologies change slowly in Korea. In Mexico, Taiwan, Colombia, and Malaysia Tan and Batra (1995 and 1997) find that workers are more likely to get training the higher is the rate of technological change in the workplace, and be paid a wage premium. Investments in technology at the firm level leads to large wage premiums for skilled workers, but not for unskilled workers. Sakellariou (2002) finds that sustained high returns to education over time are posited to be the result of a growing "knowledge economy" and increasing demand for highly skilled graduates in Singapore. Finally, Sakellariou and Patrinos (2000), find that earning increase if the required job required language and computer skills by 10 to 14 percent in Vietnam. In addition, the same authors find that their results support the unobserved heterogeneity explanation for computer wage premium, and they suggest that computers may make the productive workers even more productive. Sakellariou and Patrinos (2003).

The remainder of the paper is organized as follows. The next section describes some country characteristics with emphasis on employment. Section 3 describes the empirical approach adopted in this paper, the data used, and some descriptive statistics. Section 4 presents and discusses the empirical results. Section 5 summarizes and concludes.

2. Country background and labor conditions

Ecuador is a lower-middle income country[2], characterized by high poverty levels[3] as well as high inequality. Inequality has increased permanently during the last few decades. The Gini coefficient in the urban areas increased from 0.43 to 0.55 during the 1990s and 2000s.

Labor conditions worsened during the 1990s and 2000s. Labor market reforms, which started at the beginning of the 1990s, increased labor market instability and insecurity. As an example, the percentage of people employed in the formal sector reduced from around 50% in 1990 to 38% in 2006. As a consequence, informality increased by around 10%

[2] In 2004, its per capita GDP was 1,435 in constant 2000 US dollars.
[3] Around 61% using the criteria of unmet basic needs according to the 2001 population census.

during the same period. In addition, the percentage of employees with social security reduced from 37% to 27% during the same period.

As part of the same economic reforms, trade openness policies, which also started at the beginning of the 1990s, increased the demand for highly skilled workers expanding wage differentials and leading to an increase in income inequality. (Vos and León, 2003).

In general terms, real wages behaved in a pro-cyclical way. They decreased sharply during economic crises and increased during the booms. After the economic crisis of 1999 the country adopted the dollar as the national currency. Inflation rates were controlled and exchange rate appreciation generated an important increase in real wages. From 2000 to 2006 the real wage index increased considerably.

3. Data, empirical approach and descriptive statistics

Data

Data were collected by the Latin America Faculty of Social Sciences (FLACSO) in Ecuador. The baseline survey was collected in March 2006, and the follow up in May 2007. The questionnaire has the conventional structure of a survey of urban wage labor force and includes, in addition to individual earnings, labor conditions, years of education, and years of experience, specific questions regarding to the use of computers at work and at home.

The sample is representative for the three main cities of Ecuador: Quito (the capital), Guayaquil and Cuenca. A stratified sample design was used and the total number of individuals covered in the panel, and for whom we had income information is around 2,700.

The survey has a complete module of computer skills and use. In addition to the question of whether the person uses a computer at work or not, the questionnaire includes questions about the knowledge about computers (whether the person knows how to use a computer, and whether the person is a computer programmer or not); access to computers (both at work and at home), the use of computer at home, the number of hours that the person uses computers both at work and at home. In addition the questionnaire includes questions related to the type of job, especially whether the person works at a desk, and uses other desk materials (than a computer).

Empirical approach

We use a difference in difference approach in order to identify the impact of the use of computers on wages. The following equation was used.

$$\Delta Y_i = X_{it-1}\beta + \alpha \Delta D_i + \varepsilon_i \qquad (1)$$

Where, ΔY_i is the change in the logarithm of the hourly wages (the difference between the log of hourly wages at the follow up minus the log of the hourly wages at the baseline), X_i is a vector of individual characteristics at baseline, and ΔD_i is the change in the dummy for computer use. ΔD_i can take on three values: 0 for those whose status related to computer use did not change (either users at baseline and follow-up, or non-users at both occasions); 1 for those who change from not using computers at baseline to using computers in the follow up; and -1 for those who change from using computers at baseline to not using computers in the follow up. The parameter of interest is α. ε_i is an error term with mean zero.

Descriptive statistics

In Ecuador, around 19% of workers use a computer at work. Table 1 introduces the changes in computer use between 2006 and 2007 among the workers of our sample. From a total of 2,700 workers for whom we have income information in 2006 and 2007, 150 were nonusers in 2006 and became users in 2007. In the opposite direction, 119 workers were users in 2006 and became nonusers in 2007. Finally, 423 workers were always users, and 2041 were never users.

Table 2 introduces descriptive statistics at baseline. As expected, there are important differences among computer users and non-users. Users have more schooling years and are younger that non-users. The percentage of women among users is 45%, while the percentage of women among non-users is 36%. Around 86% of the user works on the modern sector, 57% has social security filiation, and 22% received training during the last three years. The correspondent percentages for non-users are 35%, 20% and 3%. In addition computer users are employees (80%), has permanent contract (48%), and works on big enterprises (composed of around 52 workers). Finally, among computer users, 14% has a diploma on computer programming, 73% works with other desk materials, and 61% uses computer at home. The percentages for non-users are, 1%, 3% and 8% respectively.

In summary, computer users have more schooling years, are younger, have better labor conditions, work on bigger enterprises from the modern sector, use more desk materials at work, and computer at home, than non-users. Based on these differences in observables it seems reasonable to think that there are also un-observables that could influence computer use. As already mentioned, our identification strategy exploits the panel data to control for un-observables individual characteristics that are time-invariant.

4. Results

We start reporting level results at baseline. In this case the dependent variable is the log of hourly wages, and we use the following specifications. Specification 1includes as independent variable only the dummy for computer use. Specification 2 includes, in addition, the conventional variables used by a Mincerian model: the number of years of schooling, and age (squared), and a dummy variable for sex (1=female). Specification 3 includes, in addition, some variables directed to control for working conditions, such as dummies for the branch of economic activity of the enterprise (fifteen dummies), whether the worker works on the modern sector, has social security affiliation, received training during the last three years, is self-employed, has a permanent contract, and the size of the enterprise. Finally, specification 4 includes, in addition, some worker characteristics related to computer use, such as a dummy for computer programmer, for the use of other desk materials at work, and for the use of computers at home. Table 3 shows that the dummy for computer use has a significant and positive coefficient in all specifications. However, the inclusion of additional controls reduces the magnitude of the coefficient, from 0.67 in the simplest specification (specification 1) to 0.21 in the most complete specification (specification 4). The previous gives us some clue about the possibility of the existence of unobsevables that could bias the results. To deal with this, as already mentioned, we carried out first difference estimates. In this case, according to equation 1, the dependent variable is the difference in the log of hourly wages between the follow up and the baseline, and the treatment variable, delta D_i, is the change in the dummy for computers use as previously defined. We used the same four specifications as in the level case. Results are reported in table 4 and look very robust. The coefficient is around 0.10, and it is the same through the four, as well as the standard errors. The previous means that workers who use a computer at work earn 10 percent higher wages.

5. Summary and discussion

The important increase in wages disparities during the 1980s and 1990s has generated an important theoretical debate about its causes. Among the different explanations, the skill bias technological hypothesis plays a central role in the debate. Related to this topic, since the classical paper by Krueger (1993) there has been a lot of interest in analyzing the effect of the use of computers at work on wages. A question that still remains is the role of un-observables. The paper by DiNardo and Pischke (1997) found also large differences for on the job use of calculators, telephones, pens or pencils, or for those who work while sitting down. The previous increased the doubt about the role of un-observables. The empirical evidence to evaluate the effect of computers use in developing countries is scarce. Researches that correct for the role un-observables in developing countries do not exist. In this regard this paper attempt to contribute to the debate on the effect of computers use on wages in developing countries by using a panel data to correct for un-observables, as well as a rich data set that allow us to correct for those variables used by DiNardo and Pischke. One interesting result is that, as mentioned in the previous part, the effect of computers use on wages remains the same under the most complete specification (specification 4), which includes the use of calculators, telephones, pens or pencils.

In addition, in order to test for the effect of desk variables on wages, table 5 and 6 present OLS estimates of the effect of the use of desk materials on wages in level and differences respectively. The same four specifications as above are used, except that in this case the treatment variable is the use of desk materials (and the change in the use of desk materials), and specification 4 does not include desk materials as regressors. Results are quite consistent and show no significant effect of desk materials on wages neither in levels nor in differences.

In the same vein, as mentioned previously, the paper by Oosterbeek show that an easy test of the productivity hypothesis and skill bias technological change is to include a variable of intensity in the use of computers. In our data we have information about the number of hours that the worker used computer at work during the last week. In table 7 we report the results for the baseline. In this case the treatment variable is the number of hours that the worker used a computer at work during the last week (taking the value of zero for those that do not use computers). Results are significant and positive showing that the increase in the intensity of the use is associated with higher wages.

All the results reported in this paper support the hypothesis of the productivity and skill bias technological change hypothesis for urban Ecuador.

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Tables

Table 1

Changes in computer use between 2006 and 2007 among workers in the sample

		2007		
		Nonusers	Users	Total
2006	Nonusers	2,041	150	2,191
	Users	119	423	542
	Total	2,160	573	2,733

Table 2: Descriptive statistics by computer use at baseline

Variable	Users	Non users	Difference	
Years of schooling	18.3460	10.2245	8.1215	*
			(0.2527)	
Age	36.6819	40.3361	-3.6542	*
			(0.6711)	
Sex (female=1)	0.4558	0.3619	0.0939	*
			(0.0234)	
Sector (Modern=1)	0.8621	0.3529	0.5092	*
			(0.0218)	
Sector (informal)	0.1378	0.6326	-0.4948	*
			(0 .0220)	
Social security (1=yes)	0.5716	0.2067	0.3649	*
			(0.0205)	
Training (1=yes)	0.2205	0.0267	0.1938	*
			(0.0115)	
Dummy for employer	0.0753	0.0495	0.0258	**
			(0.0110)	
Dummy for self-employed	0.0919	0.4139	-0.322	*
			(0.0220)	
Dummy for employee	0.8069	0.4531	0.3538	*
			(0.0230)	
Dummy for permanent contract	0.4834	0.2667	0.2167	*
			(0.0219)	
Number of workers	52.3051	19.1090	33.1961	*
			(1.8057)	
Dummy for computer programmer	0.1452	0.0089	0.1363	*
			(0.0088)	
Dummy for workers that use desk materials	0.7334	0.0257	0.7077	*
			(0.0119)	
Dummy for workers that use computer at home	0.6102	0.0842	0.526	*

			(0.0161)	

* Significant at 99%; ** significant at 95%.

Table 3

OLS estimates of the impact of computer use. Level results at baseline.

Variable	Esp_1	Esp_2	Esp_3	Esp_4
Computer use	0.674	0.425	0.315	0.211
	0.038	0.041	0.043	0.058
N	2045	2045	2045	2045
r2	0.141	0.265	0.336	0.377

legend: b/se

Table 4

OLS estimates of the impact of computer use. First difference results

Variable	Esp_1	Esp_2	Esp_3	Esp_4
Delta computer	0.092	0.095	0.101	0.103
	0.042	0.043	0.044	0.046
N	1751	1751	1751	1751
r2	0.003	0.006	0.021	0.026

legend: b/se

Table 5

OLS estimates of the impact of the use of desk materials at work. Level results.

Variable	Esp_1	Esp_2	Esp_3	Esp_4
Pencils	-0.018	-0.015	-0.02	-0.027
	0.032	0.04	0.044	0.046
N	1762	1751	1751	1751
r2	0	0.003	0.018	0.023

legend: b/se

Table 6

OLS estimates of the impact of the use of desk materials at work. First difference results

Variable	Esp_1	Esp_2	Esp_3	Esp_4
Delta pencils	0.063	0.063	0.066	0.064
	0.041	0.041	0.041	0.04
N	1762	1751	1751	1751
r2	0.001	0.004	0.019	0.024

legend: b/se

Table 7

OLS estimates of the intensity in the use of computers at work. Level estimates at baseline.

Variable	Esp_1	Esp_2	Esp_3	Esp_4
Hours of use	0.018	0.011	0.007	0.006
	0.001	0.001	0.001	0.001
N	2055	2042	2042	2042
r2	0.09	0.249	0.327	0.37

legend: b/se