

“Internet, Jobs and Task Content of Occupations in Chilean firms: Learning from 2007-2013
Internet Roll out”

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Extended Abstract

1. Introduction

Information and communications technologies (ICT) or digital technologies have expanded dramatically during the last decade around the world. Internet adoption in particular has increased across businesses and households in countries at all income levels (World Bank, 2016). Latin America has not been an exception. The access to the internet has been perceived in the region as a way to improve worker and firm productivity, one of the major challenges/bottlenecks for the region (Aedo and Walker, 2012). ICT can complement the firm’s human capital, by allowing workers to focus their efforts on activities with higher value and making them more productive. It can also improve access to information or create new market opportunities for firms, potentially enhancing firm productivity and growth. However, in a region where more than 40% of the work force is low skilled (SEDLAC, 2016), there are also concerns with the extent to which the majority of the workers can actually benefit. This paper will address this fundamental question on what are the impacts of a growing access to the internet on the labor market, including on the skills composition of jobs, labor earnings and firm productivity. We explore unique administrative data on firms in Chile over the period 2007-2013 to inquire on the impacts of internet use on firm-level employment composition, wages, task content of occupations, and labor productivity.

There is substantial agreement, and some concern, that digital technologies are changing the labor market in emerging countries and potentially making some jobs, skills and firms more productive. Digital technologies are affecting the content of tasks and changing the skills that are useful for employers. While this digital transformation can increase the productivity and earnings of workers with certain types of skills, it can also make other skills obsolete and eligible to be replaced by automation (Autor and Dorn, 2013; Frey and Osborne, 2013; Autor, 2014). In developed countries, the growing use of digital technologies is leading markets to become more polarized, meaning that employment and earnings are shifting from middle-skilled jobs to both high-skilled and low-skilled jobs.

This non-monotonic relationship between employment changes and skills as a result of digital technologies has been related with the task composition of jobs changing with the expansion of ICT (see Autor et al., 2003). First, computers substitute for workers carrying out activities that follow explicit rules (routine tasks). Second, computers complement workers in carrying out complex communication and problem-solving activities (non-routine tasks). Thus, the rapid expansion of ICT should increase the demand for abstract and cognitive tasks, while decreasing the demand for routine tasks, both cognitive and manual. .

We explore survey and administrative data for Chile for the period 2007-2013 to assess the impacts of having access to digital technology on firm-level employment composition, wages, task content

of occupations, and labor productivity. The data is unique as it allows us to differentiate impacts across workers of different categories (including managers, administrative workers, skilled and unskilled production workers). This allow us to identify *who* may disproportionately appropriate the benefits from the adoption of digital technologies, and who will bear the cost. In this work, we proxy access to ICT by the access to the internet. The reason for this choice is that the internet represents an objective and measurable indicator of broader types of digital and computerized technology adoption which are more difficult to measure.

Our paper explores four novel sources of data. First, the main firm-level dataset is the Chilean Encuesta Longitudinal de Empresas (ELE survey) carried out in three waves: 2007, 2009 and 2013. ELE is a large representative survey of formal firms, operating in all sectors and in all regions of Chile. It collects information on general characteristics of the firms, employment and wages for different worker categories, use of digital technologies, and production and financial variables. Second, we use data on the task content of each occupation for Chile from the Survey of Adult Skills developed by the OECD as part of the Programme for the International Assessment of Adult Competencies (PIAAC) as well as for the U.S. as a benchmark country and for Latin America as an average.¹ Third, we use data from Chile's Subsecretary of Telecommunications on regional internet infrastructure in Chile covering the number of fast internet connections and users. Finally, we use information on internet access from the Chilean national household survey (CASEN) and on ICT intensity across sectors from the Chile's input-output table and from the United States (U.S.) information in the World KLEMS database.

We relate to two important literatures. First, we relate to the literature studying the changing patterns in the demand for skills and employment. To date, the evidence on how ICT impacts on labor markets has focused heavily on developed countries: the U.S. (Acemoglu, 1999; Autor et al., 2008; Acemoglu and Autor, 2011; Autor and Dorn, 2013; Frey and Osborne, 2013; Autor, 2014), the United Kingdom (Goos and Manning, 2007) and European countries more broadly (Goos et al., 2011). These studies show, based on sectoral data, a pattern of polarization in the labor market, where occupations difficult to automate (i.e., those with a high content of cognitive tasks) gained share and occupations easily replaced by technology (i.e., those with a high content of routine tasks) lost share in total employment. A rare study using firm-level data to analyze job polarization and ICT is Akerman et al. (2015) who show that the increase in broadband availability in a municipality in Norway raises significantly the wages of skilled workers while lowering those of low-skilled workers for firms located in the municipality. In general the conclusion from the studies is that the digital transformation has been skill-biased and labor-saving. The evidence for emerging economies is scarcer. Santos et al. (2015) show for 30 developing countries that occupations using ICT more intensively have a high demand for cognitive skills and a low demand for routine and non-routine manual skills. For Brazil, Chile and Costa Rica, Aedo et al. (2013) find a strong increase in the use of non-routine cognitive analytical skills and a moderate increase in the use of non-routine interpersonal skills. In contrast, they show a decline in the use of non-routine manual skills. The patterns of use of routine cognitive and routine manual skills are mixed, increasing in some countries and falling in others.² For Brazil, Dutz et al. (2012) show that ICT-intensive firms exhibit higher wage growth across skill groups, but not faster employment growth.

¹ For the Latin America average we rely on the Skills Towards Employment and Productivity Survey (STEP) collected by the World Bank to obtain information on the task content of each occupation in Colombia, El Salvador, and Bolivia.

² The sample periods used are 1981-2009 for Brazil, 1992-2008 for Chile, and 2000-2008 for Costa Rica.

Wage growth is especially high for workers changing firms but not so high for workers remaining within the same firm. Their evidence suggests that during a time of technological change firms in Brazil were able to absorb jobs and generate wage increases across the skills and occupational distribution. Regarding the polarization of labor markets, the general trend in Latin America is weak due to the strong commodity boom experienced by most economies during the 2000s which benefited primarily low-skilled workers (Cruces et al., 2016). However, the evidence shows some signs of polarization in Chile as the employment share of occupations with a high content of routine skills and a low content of abstract skills fell, while the share of employment in occupations with a moderately high content of abstract and routine skills increased (Messina et al., 2016). The indirect evidence for Mexico, Brazil and Peru suggests an increase in the share of high-wage occupations in total employment.³

Second, this paper contributes to the literature on the impact of ICT adoption on firm productivity. Such impact is difficult to identify given the endogeneity problems arising from the fact that more productive firms are also more likely to adopt ICT. This literature can be divided into studies analyzing the correlation and studies establishing a causal relationship between ICT adoption and firm productivity. In the first set, there is clear-cut evidence of a positive correlation between productivity growth and ICT capital accumulation in high-income countries (Cardona et al., 2013) and some developing countries such as Brazil, Colombia, India, Uruguay and Vietnam (Commander et al., 2011; Gutierrez, 2011; Charlo, 2011; Nguyen and Schiffbauer, 2016). Studies that analyze firm-level data across a large number of developing countries show that firm productivity is higher when internet access is greater and firms use the internet more intensively (Clarke et al., 2015; Paunov and Rollo, 2015). In the second set, the evidence is mixed. Bloom et al. (2012) take advantage of the presence of U.S. multinationals in the U.K. and show that establishments owned by U.S. multinationals use ICT capital stocks more productively than others and these productivity differentials are higher in sectors with significant ICT and productivity growth in the U.S.. Grimes et al. (2012) and Akerman et al. (2015) find that firm productivity increased as a result of broadband internet expansion in New Zealand and Norway. Akerman et al. (2015) exploit the fact that Norway's sequential roll-out of broadband internet access across municipalities was done in the context of a public program with limited funding and was thus exogenous to local productivity growth. Their study considers labor demand outcomes, namely they show that broadband internet increases the demand for skilled workers (by increasing its productivity) but is a substitute for workers without a high-school diploma. They interpret their evidence in light of the tasks approach, suggesting that broadband internet complements skilled workers in executing non-routine abstract tasks and substitutes for unskilled workers in performing routine tasks. Colombo et al. (2013), Bertschek et al. (2013) and Haller and Lyons (2015) use firm-level data and information on broadband infrastructure rollout at the sub-national level but do not find any significant impact of the internet rollout on firm productivity in Italy, Germany and Ireland. The absence of productivity improvements in Bertschek et al. (2013) study occurs simultaneously with a significant increase in process and product innovation.

One of the novelties of our study is the assessment of the impact of the adoption of digital technologies on the task content of occupations, which is the mirror image of changes in employment and wages for different worker categories. In order to assess that impact, we construct different task indexes, weighting the task content of each worker category by its participation in the firm's total employment. We divide jobs' task demand into four broad categories, abstract,

³ The sample periods used are 2002-2012 for Brazil and Peru, 2000-2008 for Chile, and 2002-2008 for Mexico.

routine-cognitive, routine-manual and manual skills following the tasks literature, mainly Autor and Handel (2013) for the U.S. and Messina et al. (2016) for Latin America.

2. Preliminary Summary Statistics

Preliminary work based on the ELE firm-level survey shows that across firms in Chile production workers are the main worker category, with the share of the firms' total labor force being accounted for by skilled production workers growing over the sample period from 35% in 2007 to 48% in 2013.⁴ The evolution in within-firm wage inequality across worker categories measured by the ratio of average wages of managers per firm to average wages of unskilled workers per firm show a decline from 13.7 in 2007 to 5.0 in 2013. A decline is also verified for the ratio of average wages of skilled production workers per firm to average wages of unskilled workers per firm. The use of digital technologies by firms in Chile appears to experience a growing trend as the proportion of firms in the sample that use the internet to sell or buy products grows importantly from less than 10% in 2007 to, respectively, 22% (sell) and 39% (buy) by 2013.

Combining the information in Chile's PIAAC on the task content of occupations into a standardized scale of abstract, routine cognitive, routine manual, and manual tasks the evidence shows that for managers the most important task is abstract, followed by manual and routine manual tasks, while routine cognitive is last.⁵ This ranking is very intuitive as managers are expected to perform the abstract problem-solving tasks included in the definition of abstract tasks. The high value for manual tasks for managers can be justified by the finding of Messina et al. (2016) that occupations with a high content of manual tasks in Latin America include (besides the expected occupations such as machine operators, drivers, etc.) some high-level occupations like database and network professionals, managing directors and chief executives. The low value of routine cognitive tasks is also in line with expectations, as managers have the freedom to decide the way they work. For administrative workers, the most important tasks are routine cognitive and abstract. Again, this finding is very in line with the expectations. For skilled production workers, the most important tasks are manual and routine-cognitive, while for unskilled production workers their main tasks are routine-manual and manual.

The internet infrastructure improved rapidly in Chile in the last decade: between 2007 and 2013 the number of fixed connections per 100 people increased from 7.90 to 13.1, though with great variability across regions. All regions experienced an increase in the number of fixed connections between 2007 and 2013 with improvements ranging between a 177% increase in the number of connections per capita in Aysen and a 33% increase in Tarapaca. We find a positive correlation between the number of fixed per capita internet connections per region and variables capturing the level of development of the region. Data from the CASEN shows that the percentage of workers in Chile having access to a computer improved notably over time, increasing from 30.1% in 2006

⁴ The ELE sample that we use covers firms present in at least two rounds of the survey (for which a panel of data is available). The sectoral distribution is such that the largest proportions of firms operate in the wholesale and retail trade sector (35.5% on average) and in real estate and business activities (14.4% on average), and less than a fifth in manufacturing (11.1% on average) and primary activities (10.4% on average). The size distribution is such that the majority of firms are micro or small.

⁵ The standardized scale is constructed using the first component of a principal component analysis as in Messina et al. (2016).

to 63.9% in 2013. The percentage having a cell phone was already high in 2006 (70.0%) and it grew further to 95.9% in 2013. The percentage of workers with access to internet (conditional on having a computer) grew from 47.2% in 2006 to 82.3% in 2013, while the share using internet for educational purposes increased from 2.9% to 22.5% over the same period.

Preliminary evidence combining the firm-level data with the region information on internet access shows a significant positive correlation between changes in the number of fixed internet connections per capita and changes in the share of unskilled production workers in firms' total employment but a significant negative correlation between changes in the number of fixed internet connections per capita and changes in the share of skilled production workers in firms' total employment. Focusing on tasks, the only significant correlation is positive and is between changes in the number of fixed internet connections per capita and changes in the index of routine cognitive tasks. We expect to obtain much finer summary statistics and much finer correlations after we obtain information on each firm's comuna location instead of just using its region location.

3. Econometric Strategy

As discussed above, the access and use of internet can complement or substitute labor depending on the tasks involved by each occupational category. Following the tasks-based literature, we expect the use of the internet to substitute for workers performing routine tasks which are easier to codify, and to complement workers performing non-routine abstract tasks, such as information-intensive tasks, problem-solving, complex communication. We expect an increase in the employment of managers who engage mostly in abstract tasks and less in routine tasks (cognitive and manual). For administrative workers, the expected change in their employment is not clear as both routine-cognitive and abstract tasks are important for them. For production workers (both skilled and unskilled), we expect a reduction in their employment as routine tasks are an important part of their jobs. The impacts on labor earnings depend also on the change in employment. An increase in firm-level labor productivity is expected. The access and use of internet can improve the access to knowledge and facilitate the coordination of firms' production and delivery chains (Paunov and Rollo, 2015).

This section presents a summary of our proposed reduced regression relating the access to digital technology – the use of the internet - on Chilean firms' employment and wages of different worker categories, on the task content of occupations, and on labor productivity. Specifically we will consider an equation given by:

$$Y_{jsr} = \beta_0 + \beta_1 internet_{jsr} + \delta X_{jsr} + I_r + I_s + \varepsilon_{jsr} \quad (1)$$

where j is a firm, r is a location, and s is a sector and Y_j is, alternatively, (the log of) employment or wage variables of different worker categories, the task content of each occupational/worker category (i.e., indexes of the abstract, routine cognitive, routine manual, and manual task content of occupations at the firm level), or labor productivity. The variable $internet_{jsr}$ is a dummy variable indicating that the firm located in r and from the sector s uses the internet for contacts with buyers and suppliers. The vector X_{jsr} includes firm observable characteristics, while I_r and I_s are location and sector fixed effects respectively.

As a starting point, we estimate equation (1) by Ordinary Least Squares (OLS) for each of the years 2007, 2009, and 2013. These cross-sectional specifications are based on each separate round of the ELE survey. The main coefficient of interest in equation (1) is β_1 which shows the effect of access to the internet on a given firm-level outcome. The OLS estimates of β_1 can show whether within sectors and locations, digital technology adoption by firms correlates with those firms employing more or less of (or pay more or less to) certain types of occupations. However, we cannot infer any causality of the internet on those firm-level outcomes from such specifications. Equation (1) suffers from potential endogeneity as firms may make their internet adoption choices and their employment decisions jointly and based on unobserved characteristics such as manager quality.

To minimize potential endogeneity concerns we will apply an instrumental variables strategy to the cross-sectional models proposed in Equation (1). In order to this, we will first use infrastructure variables related to the provision of internet services at the subnational level to construct alternative instruments. Additionally, we will use the panel structure of the ELE survey to control for time-invariant unobserved firm characteristics.

First, we estimate the cross-sectional specifications in Equation (1) based on each separate round of the ELE survey by instrumental variables (IV) instrumenting firm-level use of the internet by measures of the availability of/accessibility to the internet in the firm's location. These measures will be (i) the (lagged) numbers of fixed internet connections in the firm's location, and depending on availability (ii) the distance between the firm's location and points of presence (POPs), points with DSL available, or fiber optic points of presence,⁶ or (iii) the number of years since broadband was deployed in the firm's location (when main distribution frames were equipped with broadband DSL for example). The idea of these specifications is that regional availability of internet must be highly correlated with actual internet use by the firm and from a single firm's perspective, the decision of a telecom provider to invest in internet provision in a location is exogenous (even though internet availability is likely to be related to regional economic performance as providers may prefer to invest first in well-performing regions).

Second, these IV specifications will be refined by using as instrument for firm-level use of the internet the measures of the availability of/accessibility to the internet in the firm's location (i), (ii), or (iii) above interacted with a proxy for the intensity/importance of internet use for the firm's sector. The proxies that we will consider are the share of ICT inputs in total costs by sector based on the 2003 Chilean input-output matrix (which is previous to our period of analysis) and the share of ICT capital services in total capital (the sum of ICT and non-ICT capital) services by U.S. sector in 2007 (first year of our period of analysis) based on the World KLEMS database. Such specifications can be more rigorous in terms of identification since they allow the control for location and sector fixed effects.

Third, we will estimate specifications based on the panel version of the ELE survey, again instrumenting firm-level use of the internet using measures (i), (ii), or (iii) above but including firm fixed effects which thus allows us to control for time-invariant unobserved firm heterogeneity.

⁶ As an alternative to the measure of distance we will consider if available the actual speeds of internet connections by Chilean location.

We will also estimate the refined version of these specifications where we use as instrument for firm-level use of the internet the measures (i), (ii), or (iii) above interacted with a proxy for the intensity/importance of internet use for the firm's sector. In these panel specifications given the variation over time we are exploiting the impact of the subnational rollout of the internet in Chile on firms' internet use (in the first stage) and subsequently on its employment decisions (in the second stage).

In all specifications, we will pay particular attention to account for potential omitted variable bias, so, depending on the feasibility, we will control for a rich set of firm characteristics such as size, age, international orientation as well as a rich set of location characteristics. Also we will check the robustness of our results along multiple dimensions, in particular across urban and rural areas and using alternative measures of the internet.

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