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Labor Policy and Digital Technology Use

Indicative Evidence from Cross-Country Correlations

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Abstract

This paper exploits variation in country-level indicators drawn from published data to analyze the relationship between labor regulation and the use of digital technology. The analysis shows a statistically and economically significant association between digital technology use by firms and a country's statutory minimum wage and employment protection regulations. The results are robust to the inclusion of controls for level of development, economic stability, available infrastructure, and trade openness. To ensure the broadest country coverage, the paper develops new indexes of employment protection, using the World Bank's Doing Business indicators, which allow several aspects of labor market regulation—such as restrictions on hours and hiring, dismissal procedures, and severance costs—-to be analyzed separately.

This paper is a product of the Social Protection and Labor Global Practice Group. It is part of a larger effort by the World Bank to provide open access to its research and make a contribution to development policy discussions around the world. Policy Research Working Papers are also posted on the Web at http://econ.worldbank.org. The authors may be contacted at tpackard@worldbank.org.

Labor Policy and Digital Technology Use: Indicative Evidence from Cross-Country Correlations[1]

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A Technical Background Paper for the Regional Study

"Technology Adoption and Inclusive Growth: Impacts of Digital Technologies on Productivity, Jobs and Skills in Latin America"

Office of the Chief Economist, Latin America and Caribbean Region, World Bank Group

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I. Introduction, motivation and summary of findings

Productivity has become particularly pertinent to policy makers in Latin America and the Caribbean, eagerly looking for ways to sustain job-related gains against poverty and inequality since the 'tailwinds' of the commodity super-cycle abated. For countries in the region, advancing productivity through innovation has, therefore, become a critical objective. Productivity growth is sustained by the process of innovation and creative destruction. Innovating firms take risks. The adoption or use-at-scale of digital technology is a case in point. Policy can help or hinder firms' decisions to innovate. In this paper, we scrutinize the role of labor policy.

Do a country's labor policies support or constrain firms' ability to adopt and use digital technology? Are firms' decisions to use digital technology affected by different regulatory instruments in the same ways? Labor market regulations and accompanying social insurance programs in most of Latin America and the Caribbean region were designed in industrializing countries for an industrial economy, to correct market failures and help working people mitigate losses from adverse shocks. However, unlike in Europe where many of these policy models were conceived, the reach and relevance of labor market interventions remains limited to employment in the public sector, state-owned enterprises and larger firms. As countries shift further away from manufacturing and into services, and a greater number of firms move confidently into the digital economy -or adopt digital technologies as part of their production processes- the business models and employment norms on which prevailing labor institutions are based are becoming strained. Labor policies often fail to keep pace with the demands of changing economies, or the needs of firms and workers. The concern that motivates our analysis is that prevailing labor market policies may not be suited to facilitate productivity gains through innovations, like firms' adoption of digital technologies.

We conduct analysis on country-level aggregate data, to exploit variation in labor regulations and social insurance provisions across national jurisdictions. Given our research questions, a cross-country analytical approach is empirically critical. First, with some notable exceptions, labor regulations typically do not vary substantially across municipalities and regions of the same country.[2] And while labor regulation and social insurance arrangements can sometimes vary in the same jurisdiction by firm size, industry and between the private and public sectors (including state owned enterprises), in most countries the share of firms that are subject to legally differential treatment is relatively small.

Second, analysis of country level data also allows us to exploit variation in how intensively countries use different regulatory instruments, such as statutory minimum wages or different forms of employment protection. Within a given jurisdiction, the labor code will typically mandate these measures as a single, indivisible package. Regulators typically do not exercise discretion over which or how intensively to apply each instrument. Nor are firms normally allowed the freedom to pick and choose between instruments, although variation in enforcement capacity across sub-national administrative units can yield useful insights (per Almeida and Carneiro, 2008; and Almeida, Corseuil and Poole, 2017).

[2] Notable exceptions to this assertion include, differences in the level and adjustment protocols for statutory minimum wages in countries such as Indonesia and the Philippines (Del Carpio and Pabon, 2014 and 2017); and differences in employment protection regulation across the states of India (Ahsan and Pagés, 2008).

We adopt the analytical approach followed by Alesina, Battisti and Zeira (2015) to analyze the relationship between labor regulation and firms' technology adoption in member countries of the Organisation for Economic Co-operation and Development (OECD). However, we substantially increase the number and diversity of countries in our analysis. To ensure the broadest country coverage, we develop new indices of employment protection using the World Bank's Doing Business labor market regulation indicators, which allow differences in restrictions on hours and hiring, dismissal procedures and severance costs to be considered separately in our analysis. We find a statistically and economically significant association between digital technology use by businesses and a country's statutory minimum wage and its employment protection regulations. Our results are robust to the inclusion of controls for countries' levels of development, economic stability, available infrastructure and trade openness.

The remainder of this paper is structured as follows. Section II provides a brief overview of the relevant literature. Section III sets out our empirical strategy and describes our data, including the new employment protection variables we constructed from the Doing Business data. Section IV presents results from our cross country multivariate correlations. Section V concludes with a discussion of the implications of our findings for policy making and avenues for further research.

II. Review of the literature

Labor market regulations and interventions such as social insurance are formulated according to each country's policy making institutions in an attempt to address market imperfections, such as uneven power between those who seek and those who sell labor and human capital, information failures on all sides, and limited or weak insurance markets to mitigate the costs to households from loss of work income (Boeri and van Ours, 2008). The textbook predictions of how regulations, like a statutory minimum wage and restrictions on dismissals, create a wedge between the cost of labor and what people take home, are well known and actively debated. Furthermore, a large literature has been produced applying the textbook models in countries where most people work beyond the reach of regulation, in the informal economy (Perry *et al.* 2007; Packard, Koettl, and Montenegro, 2012).

Where the option to 'informalize' the production process is available to firms, segmentation of the labor market can happen when a floor is imposed on the cost of labor from a legislated minimum wage that forces a wedge between the earnings of workers not covered by these arrangements and those that are. The textbook models predict that a minimum wage increases labor costs for firms and prevents them from offering formal employment to workers whose marginal productivity does not exceed the minimum. The effect will be stronger for workers with the lowest marginal productivity, especially younger, less experienced workers. Priced out of formal employment, they can join those genuinely unemployed, take informal employment, or seek formal work while working informally. Workers who remain formally employed—those with higher marginal labor productivity—benefit from higher earnings.

Employment protection (employment protection legislation, or EPL) is expected to reduce flows into, but also out of unemployment. Theory shows that EPL reduces turnover and increases average tenure. But it can also slow new employment. If restrictions on dismissing workers make separations costly, it can make employers wary of taking on someone new, or of making innovations to their business processes that involve changes to their workforce, even if doing so would raise productivity and output (Boeri and van Ours, 2008, Koeniger, 2005, Bartelsman and Hinloopen 2005). Restrictions that raise the costs of hiring and dismissing workers, can prejudice the job opportunities firms offer to young people and women (Montenegro and Pages, 2004), as well as increase the incentives firms have to hire informally (Packard, Koettl and Montenegro, 2012).

While EPL can encourage employers to invest in training to make their workers more productive and even encourage employee commitment, it can also slow productivity growth if it forces firms to keep unproductive workers (Almeida and Aterido, 2008) or forgo innovating altogether. This constraint can be offset if restrictive EPL causes firms to become more selective with the new hires and if they are encouraged to invest more in worker training. Acharya, Baghai and Subramanian (2013) argue that stricter labor regulation functions as a commitment device, by preventing firms from dismissing workers after short-run failures and thus encouraging employees to engage in risky, innovative activities that can eventually lead to higher production and profits. Furthermore, by creating a 'tax on dismissals,' EPL can increase the incentives that firms have to train workers to use new technology and make them more productive (Boeri and van Ours, 2008).

The impact of social insurance arrangements is also theoretically ambiguous on employment outcomes. On the one hand, unemployment benefits can improve the quality of matches between employers and workers. Workers who are covered by benefits and lose employment, are able to search for a new job with greater care, facilitating a more efficient job-matching process. If the quality of matching between firms and workers improves, structural unemployment can fall. On the other hand, insurance benefits may give unemployed workers a reason to search with less effort and intent than they otherwise would have and to turn down available work. If the level of unemployment benefits is high or the maximum duration of benefits is long, the urgency of finding new work is diminished. This moral hazard can lower the intensity of job search and lengthen spells of unemployment (Mortensen 1977). Even though the existence of severance and unemployment insurance can help mitigate losses from employment adjustments in the wake of new technology, the non-wage labor costs of such arrangements can also dissuade firms from expanding formal employment.

Most reviews of empirical evidence of the impact of labor market policies reflect these ambiguities in economic theory. Trying to identify the impact of any of these measures is made more difficult by obvious differences in what a country mandates and what it can enforce job-seekers and firms to adhere to. Despite what the labor code says, these regulations are partially and poorly enforced in many low- and middle-income countries. Actual restrictions on the choices of firms and individuals are, in most cases, far less binding than what the laws intend.

With respect firms' decisions at the margin whether to invest in productivity-augmenting (possibly) labor savings technology, economic theory is also ambiguous. On one hand, high statutory wages, dismissal costs, and limits on the use of term contracts and outsourced labor constrain firms' choices and could raise the costs -and slow the pace- of adopting new technology and accompanying business processes. On the other hand, stringent labor regulations that raise the unit costs of labor relative to capital can make investments in capital more attractive at the margin, speeding the adoption of labor-saving technology, particularly in sectors that are intensive in low-skilled labor input, made costlier, per unit of value added when regulations bind. Finally, the prospect of relatively higher earnings or greater job security could attract the 'best and the brightest', and longer employment spells allow workers to develop expertise and encourage employers to invest in growing their capacity.

In their analysis of labor market regulations and the extent of technology adoption across high-income countries, Gust and Marquez (2004) find a negative correlation between investment in information and communication technology (ICT) and employment protection legislation: where the human resources decisions of firms are more constrained by regulation, investment in digital technology is lower. The authors develop a dynamic model of vintage capital and SBTC. In each period a firm decides whether to upgrade technology, which in turn requires upskilling the labor force. Thus, dismissal costs delay or prevent firm decisions to adopt technology. Employers that are unable to change their workforce to keep up with new technology or otherwise align their workers with changing needs and new processes within the firm, can soon find themselves at a disadvantage.

Bartelsman, Gautier and De Wind (2016) argue that because of the experimentation and changes required in a firm's organizational structure to put a new technology in place, the outcome of investment in that technology can be uncertain. If a firm's investment in a new technology is unsuccessful, the firm might be forced to exit the market. Incentives to innovate can thus depend on exit costs, with higher exit costs deterring innovation if gains from technology adoption are risky. Bartelsman, *et al.*, find that technology-intensive sectors are smaller in countries with stricter labor regulations, measured by the number of people they employ. They estimate that aggregate productivity in the United States would be 10 percent lower due to lower investment in ICT if severance payments in the US were similar to the average dismissal cost in Europe.

Alesina, Battisti and Zeira (2015) find that where labor regulation is more restrictive, firms' take up of technology is greatest in low-skill sectors. The authors develop a theoretical model in which labor regulation raises the cost of low-skilled labor and reduces the skill premium. More restrictive labor regulation will, the authors derive, lead firms to adopt more labor-saving technology in sectors that mainly employ lower-skilled labor. Conversely, their model predicts firms in sectors that use skilled labor more intensively, will adopt less technology. Thus, for a sample of member countries of the OECD, their model predicts relatively higher levels of technology adoption in lower-skilled manufacturing in countries like Spain and Italy where labor regulation is more restrictive on firms' decision, than in the United Kingdom and United States where firms' choices are less constrained by labor regulation. This prediction is also made by Acemoglu and Restrepo (2017). Empirically, Alesina, *et al.* (2015) show that more restrictive labor regulation lowers ratio of capital in high-skill/capital in low-skill sectors, lowers productivity (output per worker) in high-skill sectors; raises productivity in low-skill sector; and raises patents/capita in low-skilled sector.

To the best of our knowledge, the current literature covers mainly the member countries of the OECD and some other higher-middle income countries, many of which are still in the process of becoming members. The current limitation of analytical work to these countries is a critical shortcoming of the existing body of evidence. There is considerable added insight to be gained from analyzing the much broader variation in labor market institutions and key contextual factors (such as level of development, economic stability, available infrastructure and degree of openness to trade) across high-, middle- and low-income countries, that firms are likely to take into account when choosing whether to adopt technology.

III. Empirical strategy and data

Following Alesina, *et al.*, (2015) we conduct analysis on country level data. The contribution of this paper is to exploit the greater economic and regulatory variation across a much larger, and more diverse sample of countries, including middle and low-income countries. In addition, we 'unpack' the composite measures of labor regulation used widely in the current literature into separate components that we argue are likely to shape firms' decisions differently. Although Alesina, *et al*, (2015) analyze regulatory instruments such as statutory minimum wages, employment protection and the power of unions separately, as in previous papers by others, they use the OECD's composite indicator of employment protection legislation (EPL).

Rather than a single, composite measure of employment protection, we construct four measures that separately capture: (i) rigidity of working hours; (ii) restrictions on the use of temporary, fixed-term contracts and outsourced labor; (iii) procedural difficulty of dismissing workers; and (iv) mandated payments to workers upon dismissal (severance). We also add variables to capture other statutorily mandated non-labor cost, specifically contributions required of employers and employees for social insurance (old age pensions, disability, survivor, unemployment benefits and health coverage).

3.a. Data

The data are drawn from published data sets of country-level indicators, per Table 1 (full citations of sources are listed in the references section).

Table 1. Data sources

Measures of digital technology use	International Telecommunications Union (ITU) Quality of Government (QoG) Basic Data, University of Gothemburg World Economic Forum (WEF)
Level of development and other key economic parameters	World Development Indicators (WDI): World Bank Group
Labor market policy indicators	EPLex: International Labor Organization Inter-American Development Bank and Organization of Economic Cooperation and Development Doing Business Labor Market Regulation (LMR): World Bank Group, observation years 2010-2014 Jobs Database: World Development Indicators Social Security Programs Around the World: US Social Security Administration

Given the wealth of options for measuring the use of digital technology provided by the ITU, QoG and WEF data sets, we elected to construct two new, composite measures to separately capture the extent of non-business (i.e. general household) and business usage. Rather than assign weights to component variables, we apply principal components analysis, or PCA.

PCA is a way to identify patterns in data with high dimension, which is otherwise hard to simplify. It is a mathematical procedure that uses an orthogonal transformation to convert a set of observations of possibly correlated variables into a set of values of uncorrelated variables—called principal components (Johnson and Wichern, 2008). The main advantage of PCA is that it can compress the data by reducing the number of dimensions, without much loss of information. For it to work properly, the main criterion is to subtract the mean from each data dimension. The methodology captures the highest variation between correlated variables, and reduces it to a set of orthogonal variables. In every case where we use the PCA methodology, we employ the first principal component (i.e. the one that explains the greatest proportion of the joint variation). The weighting of indicators maximizes the variance of the components across countries.

Our choice to construct new composite variables for the analysis in this paper might be criticized echoing Ravallion's (2016) arguments against 'mashup' indices. However, the core of this argument is the prior (sometimes poorly explained) assumptions that researchers use to weight components of their indices. PCA sidesteps this problem and avoids the loss of information or bias that could arise from having to impose assumptions of how each indicator in the composite measure should be weighted (Johnson, 2003). Furthermore, our application of PCA is purely to enable analysis. We do not advocate using any of the composite measures created for this paper in policy debate, and would agree with Ravallion (2016) that policy makers should monitor a wide range of variables.

Table 2 provides a detailed list of the variables we use in the analysis as well as the names and definitions of their components as they originally appear in the source data sets. For ease of interpreting results, in the analysis we use the logs of all our variables.

Table 2. Variable names, definitions and components

lint_usage			**Log digital whole economy index (PCA)**
		I99H	Percentage of individuals using the Internet
		XHH4_IDI	Percentage of households with computer
		XHH6_IDI	Percentage of households with Internet
ldig_bus_pca			**Log digital business index (PCA)**
		fix_broad_sus	Fixed broadband subscriptions (per 100 people)
		sec_int_servers	Secure Internet servers (per 1 million people)
lgdppcppp			**Log of GDP PC PPP**
lwdi_inflation			**Log of inflation rate**
lopeness			**Log of openness**
linf_index			**Log of physical infrastructure index**
lmwtova_pw			**Log MW to VA per worker**
lrest_oecd			**Log OECD measure of regulation (epl)**
lrest_ilo			**Log ILO measure of regulation (eplex)**
lepl_db			**Log of EPL - DB index (PCA)**
	dif_hir_idx		**Log Difficulty of hiring index (PCA)**
		v01	Are fixed-term contracts only allowed for fixed-term tasks?
		v02	What is the maximum duration of fixed-term contracts (in months)?
	rig_hours		**Log Rigidity of hours index (PCA)**
		v05	50 hour weeks for 2 months?
		v06	(5j-) Are there restrictions on night work?
		v07	(5k-) Are there restrictions on 'weekly holiday' work?
		v08	(5f-) What is the maximum number of working days per week?
	dif_firing_idx		**Log Difficulty of firing index (PCA)**
		v12	Must the employer notify a third party before dismissing one redundant employee?
		v13	Does the employer need the approval of a third party to dismiss one redundant worker?
		v14	Must the employer notify a third party prior to dismissing 9 or more redundant workers?
		v15	Does the employer need the approval of a third party prior to a collective dismissal
		v16	Does the law mandate retraining or reassignment prior to dismissal?
		v17	Are there priority rules applying to dismissal or lay-offs?
		v18	Are there priority rules applying to re-employment?
	firing_cost_idx		**Log Firing cost index (PCA)**
		v34	Paid annual leave (working days) - 10 years
		v37	Notice period for redundancy dismissal after 10 years of continuous employment
		v40	Severance pay for redundancy dismissal after 10 years of continuous employment
loads_emp			Log of Old age, disability, and survivors' pension contribution, employer
loads_ins			Log of Old age, disability, and survivors' pension contribution, insured worker
lossp_emp			Log of All social insurance programs contribution, employer
lossp_ins			Log of All social insurance programs contribution, insured worker

3.b. Descriptive statistics

Table 3 provides summary statistics of the variables used in our analysis. The table demonstrates the added value -in terms of greater country coverage- of recent efforts by OECD-IADB and ILO to broaden the set of de jure labor market policy indicators beyond the member countries of the OECD. OECD-IADB's (2016) measure EPL covers 71 countries. ILO's EPLex covers 92 countries, albeit with a different methodology (see ILO 2016). We contribute to this extension in coverage of de jure labor policy measures with our PCA variables of employment protection legislation constructed from the World Bank's Doing Business Labor Market Regulation (LMR) indicators covering 180 countries. Readers should note, we are using the Doing Business LMR indicators from 2010-2014, constructed with the pre-2015 methodology. The methodology by the Doing Business unit from 2015 onwards measures labor market regulation in areas of hiring, working hours, redundancy rules and cost, as well as job quality, depending on the subset of questions used for construction of various indices.

Table 3. Variable summary statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
lint_usage	175	3.718	1.166	0.551	5.100
ldig_bus_pca	183	3.072	2.578	-2.729	8.389
lgdppcppp	188	9.210	1.202	6.462	11.804
lwdi_infla~n	162	1.214	0.826	-1.928	3.400
lopeness	181	4.433	0.477	3.198	6.093
linf_index	155	0.989	0.248	0.385	1.490
lmwtova_pw	148	-1.168	0.693	-3.498	0.703
lrest_oecd	71	0.759	0.278	0.020	1.253
lrest_ilo	92	-0.885	0.269	-1.894	-0.323
lepl_db	177	1.257	0.511	-0.260	2.105
ldif_hir_idx	180	3.892	0.736	1.865	4.450
lrig_hours	180	-0.441	0.683	-2.939	0.562
ldif_firin~x	178	-0.495	1.185	-2.303	0.915
lfiring_co~x	177	3.394	0.611	-2.335	4.035
loads_emp	153	2.127	0.654	-0.117	3.503
loads_ins	151	1.637	0.665	-1.079	2.996
lossp_emp	154	2.504	0.656	-0.105	3.597
lossp_ins	153	1.819	0.673	-0.105	3.126

A larger and more diverse sample of countries is critical to the value of our analysis, as there is very little variation in labor market policies in each country over time, but substantial variation across the sample. This said, coverage of the social insurance contribution measures compiled by the United States Social Security Administration, ranges from 151 to 154 countries, which reduces the number of countries that we are able to include in the full, multivariate analysis discussed in the next section. To keep further shrinkage of our country sample to a minimum, as well as to control for outliers in the data, in the full analysis we use the median value of observations of each variable over the period 2010 to 2014.

Of particular interest are the relationships between the composite variables we have constructed using PCA to measure the use of digital technology (*lint_usage* for general, household usage, and *ldig_bus_pca* for business usage), and employment protection legislation (the full composite of the Doing Business indicators *lepl_db*, and four other PCA variables that each capture different dimensions of employment protection, *dif_hir_inx*: difficulty of hiring; *rig_hours*: rigidity of hours; *dif_firing-idx*: difficulty of firing index; *firing_cost_idx*: dismissal cost index). Readers should note that our overall employment protection composite variable *lepl_db*, is the result of PCA applied to 16 labor market regulation indicators of the Doing Business database, and not to the four other PCA composite variables. Each of the four that describes difficulty of hiring, rigidity of hours, etc., results from applying PCA to a relevant sub-set of labor market regulation indicators from Doing Business database. In electing which variables to include in each PCA index, we followed the Doing Business classifications, with one exception: we grouped v34 "Paid annual leave (working days) - 10 years" in our dismissal costs index, since in many countries firms are obliged to cash out unused leave as part of the total severance entitlement due to a dismissed worker.

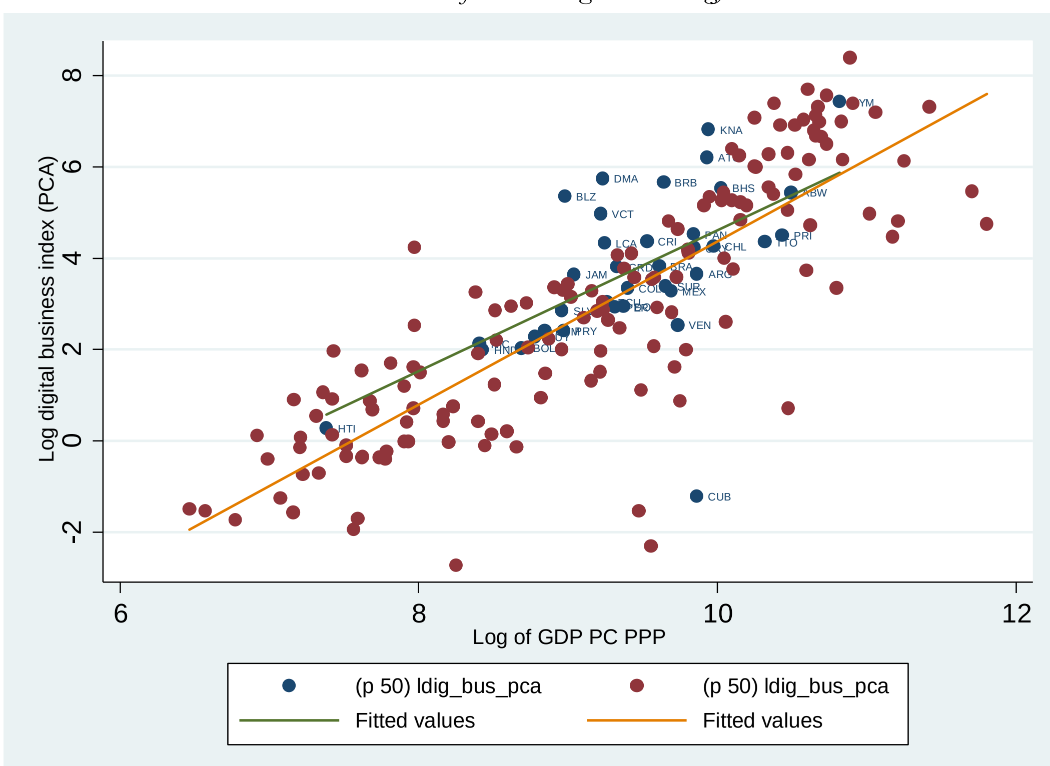
As is reasonable to expect from the application of a new technique to construct composite measures of countries' existing labor regulations, our PCA variables of employment protection policies from Doing Business are significantly similar -but not identical- to the de jure labor regulation measures of the earlier-established OECD and ILO methodologies.

Before turning to our results, an analysis of simple visual representations of the relationship between key variables helps to establish the quality of the data, particularly the variables resulting from our application of PCA (additional figures are provided in the annex). Figure 1 presents how our two PCA composite measures of digital technology use are related to countries' levels of development, as proxied by the level of GDP per capita (in 2011 PPP US$), general household usage in the top panel and business usage in the bottom panel. As is reasonable to expect for a very diverse sample of countries, both measures of digital technology usage are strongly and positively associated with a country's level of economic development. The countries of the Latin America and Caribbean region do not exhibit a very different relationship from the rest in our sample. Although the strong, positive relationship comes as little surprise, it gives us confidence in the index variables we have constructed with PCA.

Figure 1. PCA Indices of Digital Technology Usage and Level of Development

a. PCA index of general (hh) digital technology use

b. PCA index of business digital technology use



Source: Authors' application of PCA using data from ITU, QoG and WEF

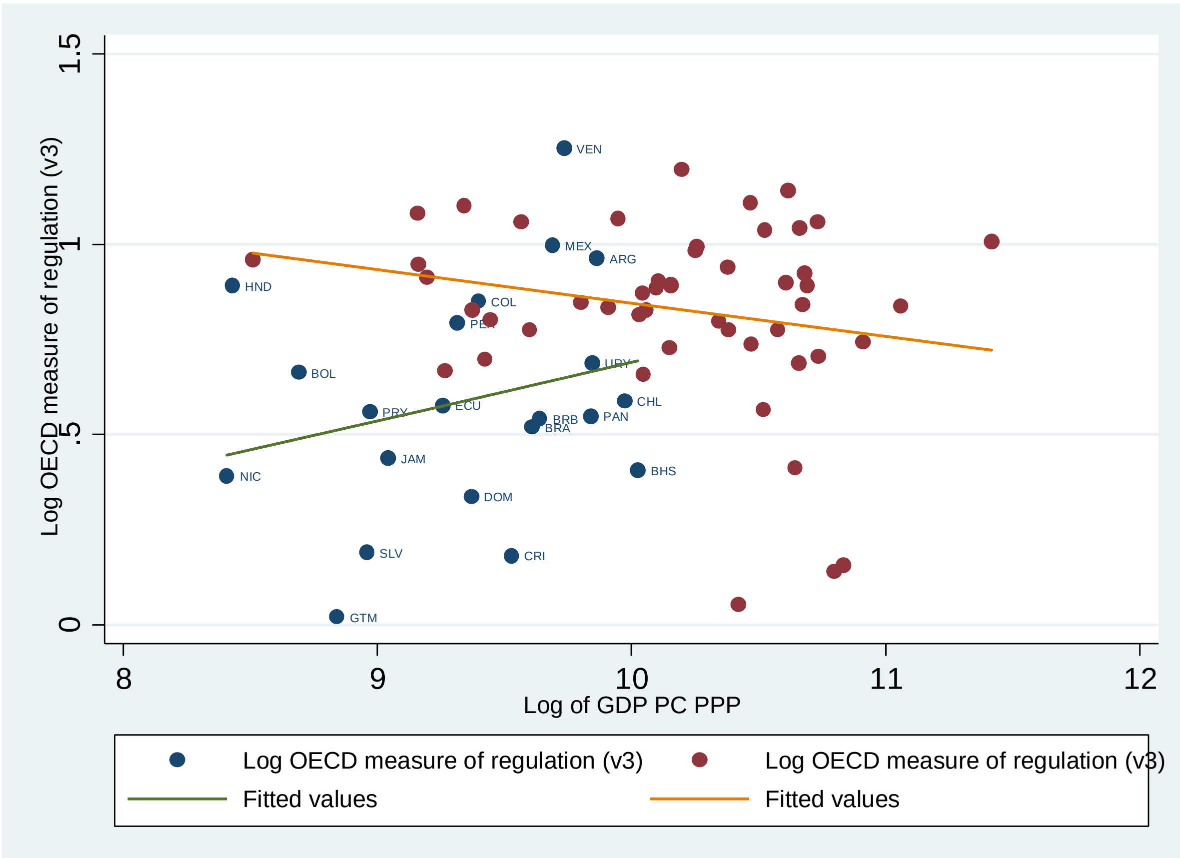
Turning to the de jure measures of labor market regulation, Figures 2, 3 and 4 present prior published indicators of policy: the statutory minimum wage (as a share of average per-worker value added); the OECD's employment protection legislation (EPL) index, as expanded by that organization in partnership with IADB to non-member countries of OECD in Latin America and the Caribbean; and ILO's EPLEX measure of employment protection. Mainly as a validation exercise, the figures benchmark these variables by countries' level of development.

Figure 2. Statutory Minimum Wage (Ratio to Average Worker Value Added) and Level of Development

Source: Authors using WDI Jobs Database

The level of countries' statutory minimum wages, normalized by average value added per worker, has a downward slope when plotted against income per capita. This is to be expected given the positive correlation between value added per worker and gross domestic product per capita. Capturing workers' output in the minimum wage variable also helps to contextualize countries where the distortions to the market-price of labor from a high statutory minimum wage are minimized by higher worker productivity. Although the slope of the curve fitted for countries in Latin America and the Caribbean is slightly steeper than that for the full sample, this difference is not statistically significant.

Figure 3. OECD Employment Protection Legislation (EPL) Index and Level of Development

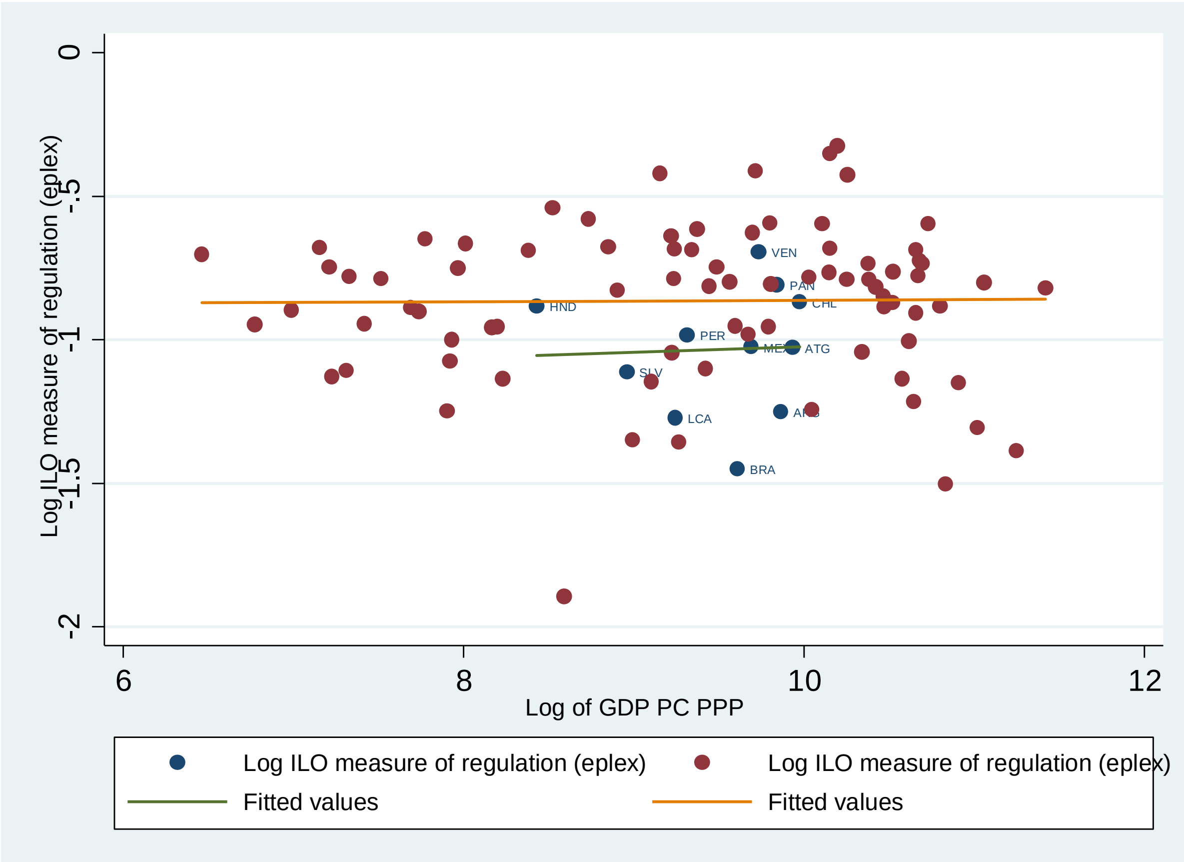


Source: Authors using IADB-OECD (2016)

While the ILO's EPlex indicator does not appear to be significantly related to level of development, the OECD-IADB EPL measure presets intriguingly contrasting relationships. The restrictiveness of employment protection legislation in OECD-member countries (excluding Mexico and Chile) is inversely related to level of development. This relationship is most likely reflecting labor policy reforms in several European countries since 2000 (most notably, in Germany, Spain and Italy) which have generally loosened constraints on firms' choices (Gill, Packard and Koettl, 2013).

However, among the countries of Latin America and the Caribbean, the level of restrictiveness of employment regulation is positively related to level of development. For these countries, the observed relationship may reflect geographical differences of timing of transition of from mainly agrarian economies to industrial and service economies, and employer-employee relationships becoming more common. This step in the structural transformation of an economy is likely to increase societies' interest in regulating the labor market. The figure may also reflect the relative wealth in the Southern part of the region which underwent this structural transformation and urbanization earlier, and where larger waves of migrants from Europe settled, bringing with them social norms and political and regulatory institutions mainly from Portugal, Spain and Italy.

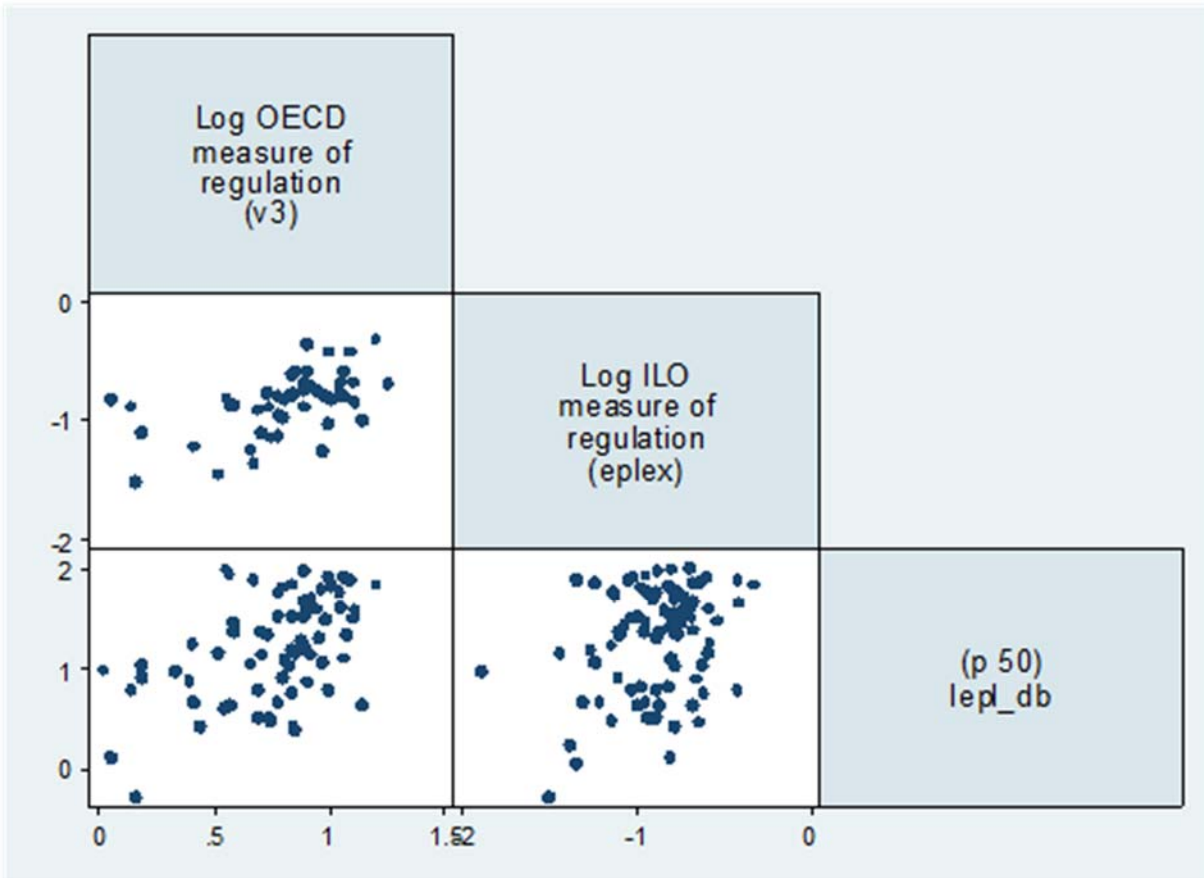
Figure 4. ILO's Employment Legislation (EPlex) and Level of Development



Source: Authors using ILO (2016)

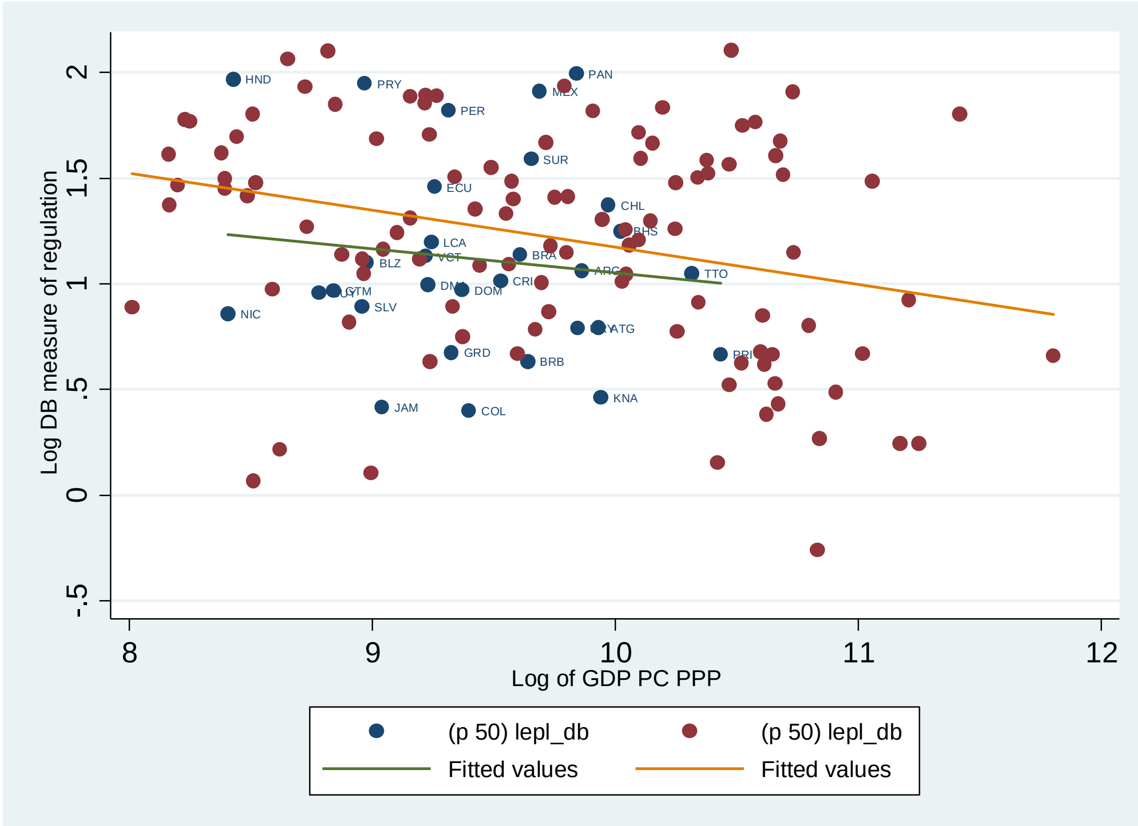
Finally, Figure 5 shows the close relationship between our new PCA index of employment protection constructed with the Doing Business data, and that of IADB-OECD and ILO. Figure 6 presents our composite PCA index of employment protection and how the new measure relates with level of development. Interestingly, and in contrast to IADB-OECD's EPL, our Doing Business PCA measure of employment protection shows a uniformly inverse relationship with countries' income per capita (Figure 6).

Figure 5. De jure measures of employment protection regulation form OECD-IADB, ILO and PCA on Doing Business data



Source: OECD-IADB, ILO 2016 and authors application of PCA to Doing Business Labor Market Regulation, and WDI

Figure 6. PCA of Employment Protection from Doing Business and Level of Development



Source: Authors application of PCA to Doing Business Labor Market Regulation, and WDI

IV. Results

Two sets of multivariate conditional correlations are presented in Tables 4 and 5. In Table 4 we present the estimates of how *de jure* labor market policy variables relate with the extent of general (that is, household) use of digital technology (*lint_usage*). In Table 5, we show how these estimates differ when the focus narrows on businesses' use of digital technology (*ldig_bus_pca*). For both general and business usage of digital technology, we show 17 specifications in each table. This allows full presentation of how the digital technology usage variables relate to: first, a set of key, contextual control variables; then to the published labor market regulation composite indices of the OECD-IADB and ILO; and different combinations of our PCA measures of employment protection from the Doing Business LMR indicators. The last specification at the right-hand side of Table 5 is our preferred.

In both tables, the relevant contextual control variables in logs, are: (i) GDP per capita (*lgdppcppp*) to capture a country's level of economic development; (ii) the rate of inflation (*lwdi_inflation*) to account for economic stability and its effect on agents' confidence to invest in new technology; (iii) the log of available physical infrastructure (*linf_index*) capturing the importance of connectivity, transport and other physical infrastructure to the readiness of a country for broad-band roll-out and widespread availability of digital technology;[3] and (iii) openness to trade (*lopeness*), given the likelihood of greater adoption and usage of technology in more economically, globally-integrated countries, per the arguments of endogenous growth theory made by Grossman and Helpman (1992) and Harrison (1996).

For both sets of multivariate conditional correlations, level of development is positively and significantly associated with digital technology usage of households and businesses. However, the sign and significance of the estimated coefficients on the other three control variables is weakly and erratically related to household digital technology use. This contrasts sharply with the strong, significant and stable estimated coefficients on the same variables when considering digital technology usage by businesses. There are subtle points here worth emphasizing: prior to inclusion of the physical infrastructure index, the estimated coefficients on the rate of inflation were consistently negative and strongly significant. With the inclusion of the physical infrastructure index, although the estimated coefficients on the inflation variable are negative across all specifications, only in specification 3 is the coefficient statistically significant, and then only at the 10 percent level. In almost all the specifications the control variables measuring trade openness and a country's available physical infrastructure are both highly significant and positively associated with businesses' use of digital technology.

Turning to the first labor market policy variable of specific interest to our research questions, the level of the statutory minimum wage (*lmwtova_pw*), the sign and significance of the estimated coefficient on this variable shift across specifications and is weak when related to household usage of digital technology. However, the sign and significance of the coefficient on the statutory minimum wage is consistent and robust to changes in specification in our analysis of businesses' usage: a higher statutory minimum wage is significantly, positively associated with the extent of digital technology use by businesses.

There are two simple economic explanations for the sign and significance of this relationship, and one that may purely be statistical. First, a higher statutory minimum wage is more likely to bind, particularly at the lower-end of the labor force distribution by skill and productivity levels. Therefore, at higher levels, the statutory minimum wage could increase firms' incentives to invest in digital technology that substitutes for labor inputs and thus saves on labor costs. Second, faced with a policy-mandated lower bound on wages, firms will have an incentive to make investments that combine labor more efficiently with tools to raise marginal labor product above the mandated minimum wage. The purely statistical explanation is that in lower-income countries -even after controlling for income level- the statutory minimum wage may really only effectively cover employment in the public sector and state-owned enterprises. In such countries, beyond these segments of the working population, there is very little formal (i.e. regulated) employment and few firms with the inclination or resources to invest in digital technology. That our estimated relationships are statistically strong and of the economically expected sign for digital technology use by businesses (and substantially less stable and significant for usage by households), provides support for the economic interpretations of the results.

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[3] We are grateful to Klaus Adolfo Koch-Saldarriaga for suggesting this control. As documented in World Bank (2016) much of the literature on the 'digital divide' shows that a country's physical infrastructure is a key enabling factor to making internet and digital technologies accessible to households and firms.

Turning to our next set of labor policy variables, we experiment with each of the three composite *de jure* measures of employment protection separately. Since each on its own is intended to be a comprehensive index of labor market regulation, including more than one at the same time, introduces multicollinearity. The estimated coefficients on the ILO's measure are small and never reach conventional thresholds of statistical significance. The estimated coefficient on the EPL measure constructed by OECD-IADB, however, is large and statistically strongly associated with digital technology use by businesses, but not by households: more restrictions on the employment decisions of firms are associated with lower levels of digital technology usage. With respect to the size of estimated coefficient, our PCA index of employment protection from the Doing Business data performs similarly to the OECD-IADB measure, and shows the same levels of statistical significance (at the 1 percent level). A more restrictive regulatory framework on firms' human resource decisions, as measured by Doing Business LMR composite variable, is strongly associated with less use of digital technology by firms. While the sign of the estimated coefficient on our PCA measure is also negative with respect to household usage, it is considerably smaller and the significance (at the 5 percent level) is not as strong.

A valid concern is that the strength and statistical significance of our Doing Business LMR PCA measure of employment protection might be driven by the much larger sample size of countries that it covers relative to the number covered by OECD-IADB's EPL and ILO's index. We test the robustness of our results to changes in the sample, by estimating the multivariate correlation using each of the three measures (along with the contextual control variables) but for a sample of the same countries. The OECD-IADB and our PCA measures cover 60 countries in common. The coverage overlap between our measure and that of the ILO is 71 countries. Running our multivariate correlations for our measure of digital technology use by businesses in a country, we find that our Doing Business PCA measure of employment protection remains negative and significant (at 1 percent) to this change in sample (see Table 6).

However, as discussed in prior sections, the composite measures of employment protection are useful, but blunt instruments for analysis. It is likely that different dimensions of employment regulation will affect firms' decisions in different ways. This is clear in Alesina, et al., (2015) and in the differing signs on the coefficients we estimate for the statutory minimum wage and employment protection. There is further nuance in the effects of regulatory instruments to be found. We examine this possibility by replacing our PCA composite measure of employment protection with the four separate measures constructed from the Doing Business LMR data. Of the four, the strongest and most consistently significantly, negatively associated with firms' digital technology use, is our measure of procedural difficulty of dismissing workers (*ldif_firing_idx*). This contrasts with our PCA measure of the financial costs of dismissal, which is positive but does not appear statistically significant in any of the specifications.

As with the level of the statutory minimum wage, the possible economic explanation for this statistical relationship is straightforward. All other things equal, more onerous procedures on firms' choices of productive inputs impede businesses' ability to adopt and adjust to new technologies. If firms are more constrained in their human resource decisions, they will find it more difficult to embed new technologies into their production models, to adopt the processes that the new technologies entail, and to find the complementary labor and human capital they require to reach a new optimal level of operation. And although none of our other three PCA measures of employment regulation perform as consistently or as significantly as the measure of difficulty of dismissal procedures, there are also straightforward economic explanations for why they could relate differently to firms' digital technology use decisions. Firms and workers might welcome the certainty of an up-front, dismissal payment to technologically-displaced workers in order to speed the adjustment process. Restrictions on hours and limits on the use of fixed-term and temporary workers could constrain a firms' ability to experiment and adapt to new technology and changes to its production function.

Finally, the level of contributions for social insurance required from employees and employers, present conflicting relationships with digital technology use by households and businesses. We experiment with different specifications, at times separating the mandatory contribution for old-age, disability and survivors' pensions ('*oads*' which added together, typically make up the largest portion of total social insurance contributions), from the total ('*ossp*'), and then with alternating variables that specify the statutory responsibility of employers ('*loads_emp*' and '*loss_emp*') from that of insured workers ('*loads_ins*' and '*lossp_ins*'). Curiously, mandatory social insurance contributions appear statistically significant only in relation to households' digital technology use. However, the size, signs and level of significance of the estimated coefficients on our variables shift substantially across specifications.

This said, the largest estimated coefficient is in the specification (Table 5, column 17) with the most control and variables of interest, and specifically on the variable capturing employers' full statutory contribution for social insurance. Although it does not reach a level of statistical significance, a higher mandatory contribution on employers for the social insurance coverage of employees appears to be associated with lower levels of digital technology usage by businesses. Again, there is a straightforward economic explanation for the sign on the estimated coefficient: when combined with a binding minimum wage, employers are less likely to pass on the costs of mandatory contributions to workers in the form of lower take home pay.

We summarize the results presented in this section, with the economic significance of our variables of interest, with reference to our preferred specification (Table 5, column 17). Starting with the minimum wage, a 1 percent increase in the statutory minimum wage (as a share of value added per worker), is associated with a 0.35 percent increase in our measure of digital technology use by firms. With respect to employment protection, a 1 percent increase in the difficulty of dismissal procedures is associated with a decrease of 0.37 percent in the use of digital technology by firms.

Table 4. Non-business use of digital technology and labor market regulations: Multivariate correlations

VARIABLES	Non business use of the internet: linf_index																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
lgdppcppp	0.875***	0.849***	0.874***	0.869***	0.901***	0.897***	0.861***	0.898***	0.866***	0.886***	0.762***	0.806***	0.805***	0.865***	0.728***	0.797***	0.803***
	(15.63)	(9.223)	(10.71)	(13.49)	(14.13)	(14.01)	(13.13)	(13.94)	(12.90)	(9.303)	(9.112)	(12.67)	(11.78)	(9.334)	(8.176)	(12.32)	(11.55)
lwdi_inflation	0.105*	-0.0860	0.0645	0.125**	0.114*	0.107*	0.117*	0.131**	0.135**	-0.0392	0.0773	0.140**	0.130**	-0.0383	0.145*	0.173***	0.169***
	(1.867)	(-1.390)	(0.832)	(2.076)	(1.916)	(1.794)	(1.956)	(2.100)	(2.168)	(-0.635)	(1.042)	(2.442)	(2.143)	(-0.624)	(1.847)	(2.997)	(2.813)
lopeness	0.0444	0.0316	0.142	0.0674	0.0796	0.0683	0.0700	0.0294	0.0520	0.0372	0.220*	0.0771	0.0782	0.00876	0.186	0.102	0.0882
	(0.460)	(0.409)	(1.173)	(0.662)	(0.775)	(0.667)	(0.694)	(0.280)	(0.492)	(0.490)	(1.860)	(0.773)	(0.751)	(0.115)	(1.484)	(1.011)	(0.835)
linf_index	0.362	-0.393	0.126	0.437	0.362	0.349	0.457*	0.338	0.443	-0.450	0.223	0.484*	0.489*	-0.304	0.509	0.508*	0.501*
	(1.374)	(-1.520)	(0.341)	(1.597)	(1.327)	(1.270)	(1.660)	(1.220)	(1.579)	(-1.538)	(0.537)	(1.761)	(1.725)	(-1.132)	(1.223)	(1.883)	(1.788)
lmwtova_pw		-0.00364	-0.0180	0.120*	0.121*	0.114	0.114	0.117	0.129*	-0.0109	0.0624	0.112	0.111	0.0110	0.0605	0.111	0.112
		(-0.0477)	(-0.206)	(1.696)	(1.680)	(1.574)	(1.611)	(1.621)	(1.775)	(-0.139)	(0.736)	(1.611)	(1.537)	(0.144)	(0.687)	(1.588)	(1.543)
lrest_oecd		0.0976								-0.0441				0.00887			
		(0.730)								(-0.306)				(0.0616)			
lrest_ilo			0.103								-0.0744				-0.0226		
			(0.488)								(-0.358)				(-0.102)		
lepl_db				-0.217**								-0.251**				-0.230**	
				(-2.296)								(-2.577)				(-2.266)	
lrig_hours					-0.0734				-0.0594				-0.0348				-0.0472
					(-1.022)				(-0.804)				(-0.381)				(-0.523)
ldif_hir_idx						0.0232			-0.0136				0.0134				0.000858
						(0.385)			(-0.209)				(0.215)				(0.0133)
ldif_firing_idx							-0.0815**		-0.0813**				-0.0861**				-0.0694*
							(-2.102)		(-2.002)				(-2.106)				(-1.690)
lfiring_cost_idx								0.113	0.0979				-0.0288				0.0314
								(1.063)	(0.929)				(-0.277)				(0.306)
loads_ins										0.0528	0.117	0.0986	0.112				
										(0.976)	(1.117)	(1.327)	(1.436)				
loads_emp										0.104*	0.280***	0.179**	0.170**				
										(1.817)	(2.723)	(2.242)	(2.010)				
lossp_ins														0.121*	0.168	0.188**	0.192**
														(1.734)	(1.476)	(2.423)	(2.364)
lossp_emp														0.0221	0.124	0.0609	0.0316
														(0.338)	(0.994)	(0.734)	(0.357)
Constant	-5.087***	-3.684***	-5.071***	-4.755***	-5.322***	-5.284***	-5.033***	-5.437***	-5.291***	-4.304***	-5.379***	-4.797***	-5.129***	-4.144***	-5.094***	-4.869***	-5.254***
	(-9.808)	(-4.666)	(-6.419)	(-7.932)	(-8.934)	(-8.160)	(-8.724)	(-8.450)	(-7.263)	(-5.528)	(-7.227)	(-8.519)	(-7.384)	(-5.301)	(-6.059)	(-8.331)	(-7.060)
Observations	135	62	70	113	116	116	114	113	113	54	58	96	96	56	59	99	99
R-squared	0.826	0.822	0.836	0.827	0.819	0.817	0.826	0.820	0.828	0.865	0.873	0.863	0.861	0.862	0.860	0.857	0.855

t-statistics in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 5. Business use of digital technology and labor market regulations: Multivariate correlations

VARIABLES	Business use of the internet: lint_usage: ldig_bus_pca																
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
lgdppcppp	1.254***	2.270***	1.664***	1.338***	1.448***	1.432***	1.287***	1.431***	1.302***	2.296***	1.499***	1.248***	1.213***	2.297***	1.512***	1.242***	1.192***
	(10.28)	(11.08)	(11.02)	(10.33)	(10.69)	(10.42)	(9.941)	(10.37)	(9.874)	(9.655)	(8.522)	(8.536)	(7.893)	(10.08)	(8.511)	(8.593)	(7.890)
lwdi_inflation	-0.140	-0.165	-0.242*	-0.123	-0.131	-0.152	-0.144	-0.115	-0.0879	-0.124	-0.208	-0.0725	-0.0482	-0.111	-0.227	-0.0954	-0.0895
	(-1.079)	(-1.205)	(-1.686)	(-0.940)	(-0.967)	(-1.112)	(-1.117)	(-0.802)	(-0.666)	(-0.806)	(-1.334)	(-0.505)	(-0.326)	(-0.736)	(-1.446)	(-0.679)	(-0.636)
lopeness	0.590***	0.352**	0.622***	0.786***	0.747***	0.703***	0.752***	0.640***	0.745***	0.385**	0.780***	0.958***	0.907***	0.376*	0.742***	0.930***	0.856***
	(2.652)	(2.043)	(2.776)	(3.533)	(3.186)	(2.982)	(3.470)	(2.647)	(3.323)	(2.020)	(3.132)	(3.818)	(3.580)	(1.988)	(2.960)	(3.776)	(3.439)
linf_index	3.339***	0.940	2.145***	3.551***	3.358***	3.348***	3.657***	3.318***	3.627***	0.721	2.827***	3.843***	3.886***	0.858	2.710***	3.657***	3.742***
	(5.852)	(1.646)	(3.125)	(6.437)	(5.788)	(5.671)	(6.710)	(5.571)	(6.566)	(0.993)	(3.242)	(6.115)	(6.151)	(1.309)	(3.262)	(6.021)	(6.122)
lmwtova_pw		0.591***	-0.0834	0.361**	0.357**	0.337**	0.346**	0.352**	0.377**	0.593***	-0.0516	0.368**	0.367**	0.609***	-0.0701	0.366**	0.350**
		(3.479)	(-0.515)	(2.409)	(2.242)	(2.088)	(2.352)	(2.175)	(2.515)	(3.012)	(-0.290)	(2.191)	(2.165)	(3.248)	(-0.399)	(2.226)	(2.120)
lrest_oecd		-0.979***								-1.088***				-1.100***			
		(-3.325)								(-3.034)				(-3.116)			
lrest_ilo			-0.303								-0.323				-0.195		
			(-0.776)								(-0.738)				(-0.441)		
lepl_db				-0.893***								-0.886***				-0.832***	
				(-4.416)								(-3.670)				(-3.396)	
lrig_hours					-0.270*				-0.254				-0.128				-0.0675
					(-1.670)				(-1.644)				(-0.589)				(-0.324)
ldif_hir_idx						0.0647			-0.130				-0.121				-0.172
						(0.469)			(-0.948)				(-0.801)				(-1.139)
ldif_firing_idx							-0.387***		-0.389***				-0.392***				-0.372***
							(-4.730)		(-4.579)				(-3.997)				(-3.899)
lfiring_cost_idx								0.359	0.267				0.205				0.205
								(1.480)	(1.196)				(0.816)				(0.851)
loads_ins										0.0174	-0.0548	-0.00495	0.0541				
										(0.128)	(-0.249)	(-0.0265)	(0.284)				
loads_emp										0.161	0.0812	-0.00463	-0.107				
										(1.123)	(0.376)	(-0.0233)	(-0.527)				
lossp_ins														0.0129	0.107	0.202	0.244
														(0.0750)	(0.471)	(1.062)	(1.275)
lossp_emp														0.182	-0.181	-0.0538	-0.241
														(1.128)	(-0.726)	(-0.267)	(-1.164)
Constant	-14.37***	-18.75***	-17.24***	-14.57***	-16.50***	-16.29***	-15.41***	-16.99***	-16.02***	-19.27***	-17.31***	-14.86***	-15.90***	-19.49***	-16.67***	-14.79***	-15.04***
	(-12.31)	(-10.64)	(-11.78)	(-11.65)	(-12.60)	(-11.21)	(-12.95)	(-11.66)	(-10.49)	(-9.857)	(-11.07)	(-11.08)	(-9.549)	(-10.10)	(-9.937)	(-10.90)	(-8.744)
Observations	138	63	70	116	119	119	117	116	116	55	58	99	99	57	59	102	102
R-squared	0.802	0.895	0.894	0.842	0.819	0.815	0.846	0.818	0.852	0.894	0.900	0.842	0.849	0.895	0.901	0.843	0.851

t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 6. Tests for changes in country sample size

VARIABLES	Business use of the internet: ldig_bus-pca		
	18	19	20
lgdppcppp	2.238***	1.645***	1.611***
	(6.997)	(10.55)	(11.09)
lwdi_inflation	-0.271	-0.218	-0.214
	(-1.186)	(-1.423)	(-1.493)
lopeness	0.371*	0.608***	0.605***
	(1.800)	(2.678)	(2.932)
inf_index	0.316	0.754***	0.769***
	(1.141)	(3.220)	(3.506)
lmwtova_pw	0.450*	-0.0920	-0.0211
	(1.910)	(-0.565)	(-0.138)
lrest_oecd	-1.174***		
	(-2.891)		
lrest_ilo		-0.226	
		(-0.564)	
lepl_db			-0.568***
			(-2.976)
Constant	-18.41***	-16.93***	-15.61***
	(-7.155)	(-11.44)	(-12.47)
Observations	39	68	68
R-squared	0.891	0.896	0.908

t-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

V. Conclusions, caveats and possible future lines of research

In this paper, we examine the relationship between businesses' use of digital technology and labor market policies: statutory minimum wages, employment protection, and social insurance contributions.

Although requiring caution in how results are presented and interpreted, a country-level analysis is critically important to our investigation. Typically, there is little variation in a country's labor code over time. Nor are there very frequent or substantial changes in labor regulations. This raises the value of variation across countries. Furthermore, in most countries firms and workers experience labor policies as a single package, which is applied uniformly across regions and industries. With a few exceptions -such as firms in special economic zones, or particular industrial promotion policies – businesses cannot legally opt out. While variation in the ability of local administrative authorities to enforce policies can be usefully exploited (as shown by Almeida and Carneiro, 2008 and Almeida, Corseuil and Poole, 2017), the opportunities to do so are rare.

Not all instruments of labor market regulation are the same. Nor should their expected impact on firms' decisions to innovate by using digital technology be the same. Different regulatory instruments can contribute differently to the prospective costs and benefits of firms' decisions to use digital technologies. For this reason, the variation across countries in whether and how intensively the different instruments are deployed is also tremendously valuable. Only with a large sample of countries can sufficient variation in the application of several regulatory instruments (viz. restrictions on hours, financial costs of dismissals, regulation of the use of different contract types, required procedures for dismissals) be observed.

By adopting an empirical strategy from Alesina, *et al.* (2015) but substantially increasing the number and diversity of countries in our analysis, we show that *de jure* labor market policies are significantly associated with businesses' use of digital technology, but we provide greater granularity to their significance.

Our results are consistent with those of Alesina, *et al.* (2015), but we believe they are stronger and more reliable, for three reasons: (i) our larger and more diverse sample of countries provides greater variation to exploit; (ii) by using more nuanced measures of employment protection, we capture important differences in labor regulation; and (iii) our results are robust to the inclusion of variables that control for the context in which firms make their decision to use digital technology, namely countries' level of income, economic stability, available physical infrastructure and global economic integration. Despite most of these contextual controls being strong and statistically significant, we find an important association between digital technology use by firms and labor market policies. The strength and implications of this significant association are underscored by the lack of a strong relationship between labor market policies and our measure of general household use of digital technology.

There are several useful extensions of this analysis. The most obvious is to more fully exploit the longitudinal dimension in the Doing Business LMR extending back to 2005, even if this requires efforts to ensure comparability of the indicators over time. Also, a fuller picture of countries' labor market interventions could yield lessons on how to speed process innovations to achieve higher productivity – specifically, inclusion in the analysis of policies and programs such as job search assistance and skills training, designed to help working people navigate transitions in the labor market.

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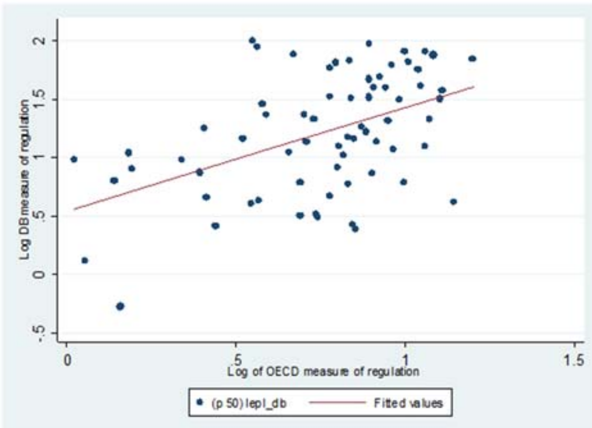
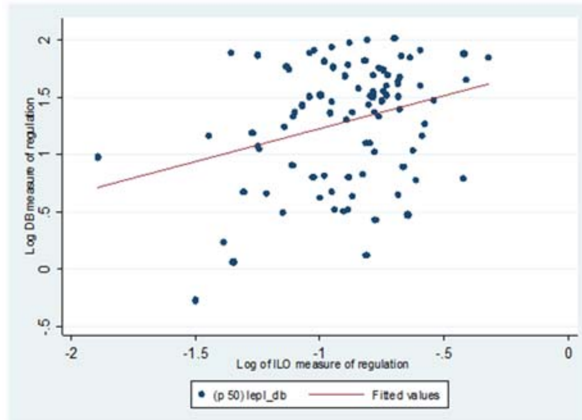
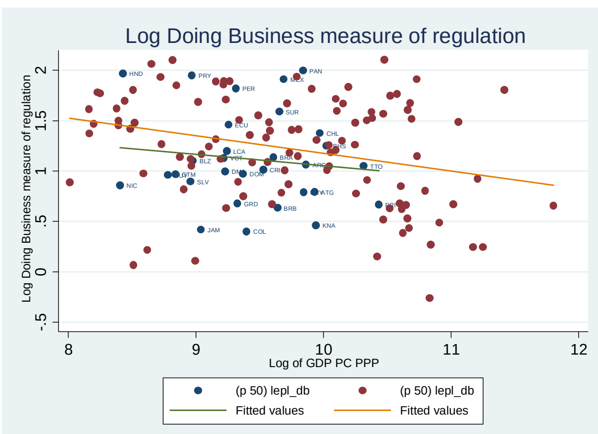
Annex: Separate Measures of Labor Market Regulation using PCA on data from Doing Business

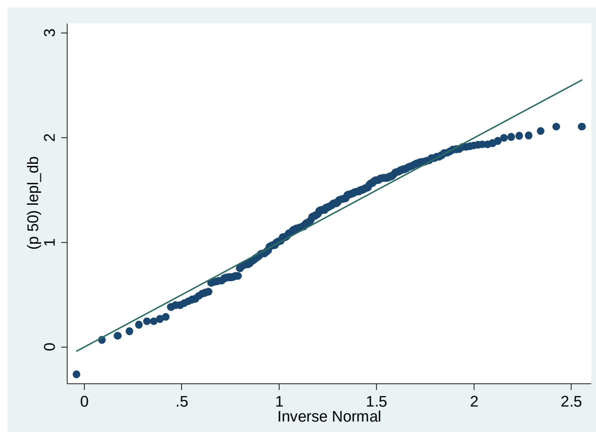
A1. Correlation between Doing Business PCA and OECD and ILO employment protection indices



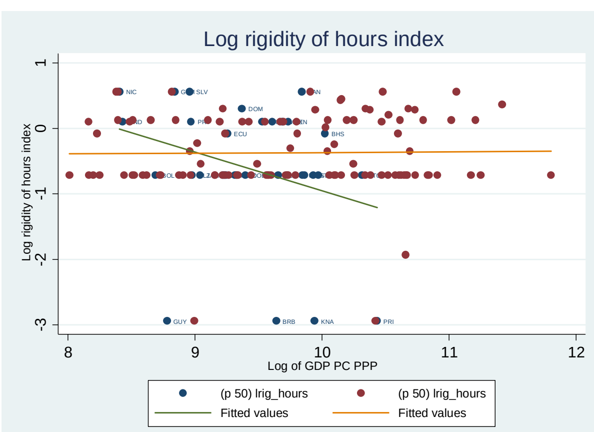


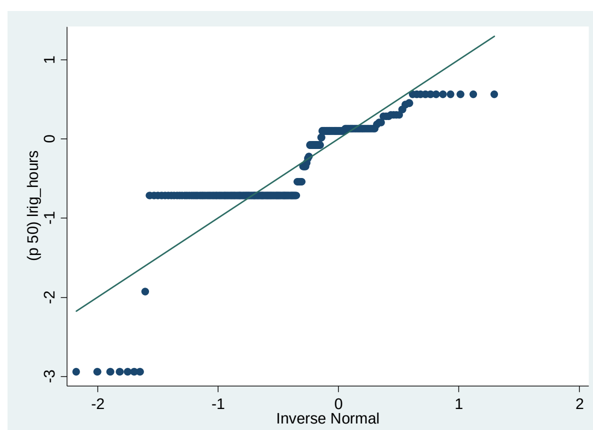
A2. Composite PCA measure of labor market regulation



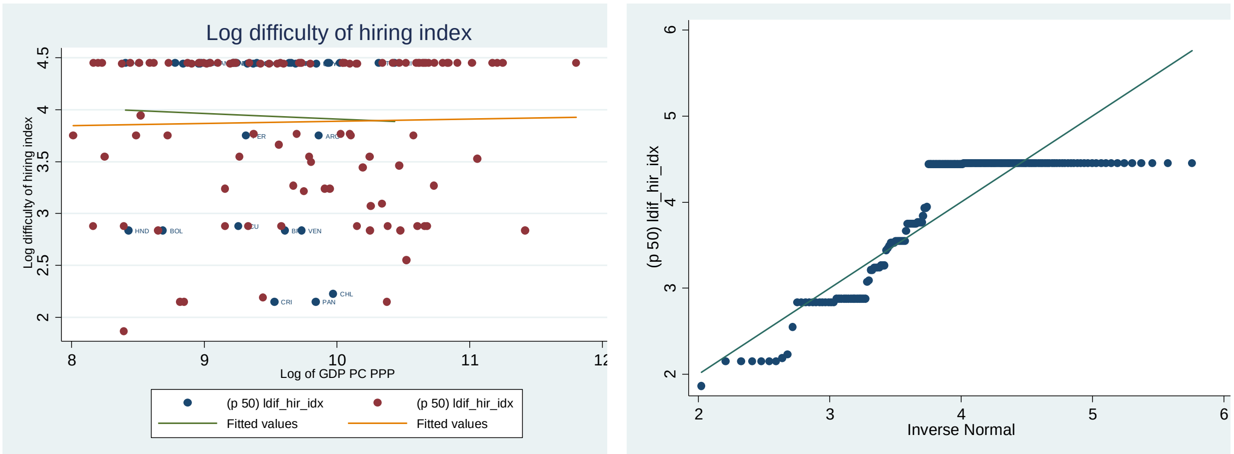


A3. Rigidity of hours PCA

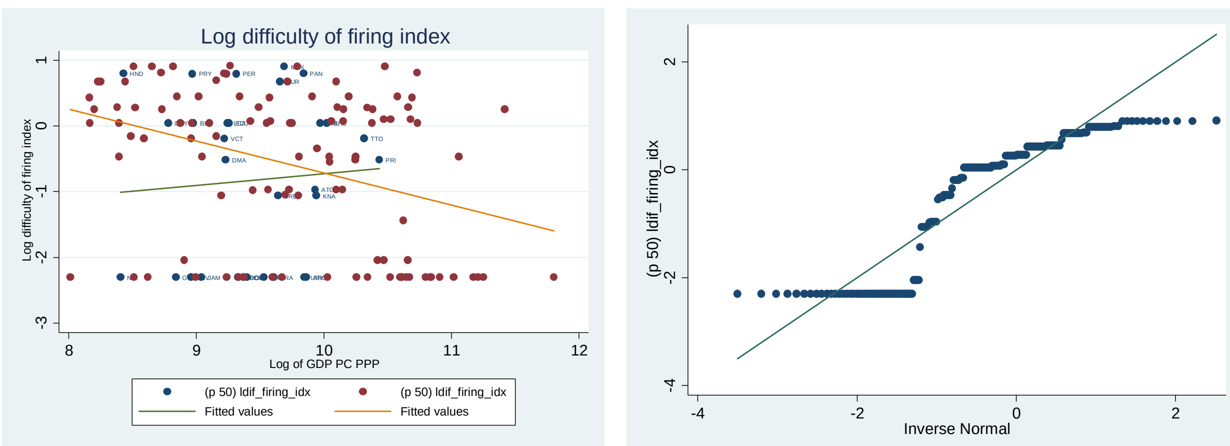




A4. Difficulty of hiring PCA



A5. Difficulty of firing PCA



A6. Firring costs PCA