SUPPLEMENTARY MATERIALS
Software Adoption and the Skill Content of Occupations in Chilean Firms

Section 1. Data

1.1 ELE Survey

The Encuesta Longitudinal de Empresas (ELE) was developed by the Sub-secretariat of Economy in the Ministry of Economy, Promotion, and Tourism and the University of Chile (Center of Microdata from the Economics Department) and implemented by the National Statistical Institute. ELE is representative of all economic activities in Chile captured by the International Standard Industry Classification (ISIC) Revision 3 except for public administration, health, education, domestic service, and extraterritorial organizations. The sampling frame from which firms are selected to be surveyed, with a stratification by sector and firm size, is the Directory from INE and a registry from the Chilean internal revenue service. In this study, we use the 2007 and 2013 rounds of the survey. In each round of the survey, a panel design establishes to select as many firms as possible from the immediately preceding round. If a threshold of 50 per cent of the cross-section size by sector and firm size cannot be reached with firms included in the immediately previous survey, the missing firms are replaced by firms that were present in the survey round prior to that. Our main firm-level sample is a balanced panel of 1,852 firms observed both in 2007 and in 2013.

1.1.1 Analysis of Switching Firms

Table I. Firms Switching Complex Software Use Status, 2007- 2013

	Share of firms using complex software in 2007	Share of firms switching software use status between 2007 and 2013
Overall panel sample	46.7%	25.4%
By firm size		
Micro	16.9%	40.6%
Small	44.8%	43.3%
Medium	66.6%	9.2%
Large	86.4%	6.9%
By sector		
Agriculture, hunting, fishing and forestry	27.3%	8.5%
Mining and quarrying	40.4%	0.7%
Manufacturing	45.4%	15.8%
Electricity, gas and water supply	95.3%	0.1%
Construction	39.4%	12.9%
Wholesale and retail trade	33.6%	30.0%
Hotels and restaurants	18.3%	4.8%
Transport, storage and communications	36.1%	7.7%
Financial intermediation	88.3%	0.1%
Real estate and business activities	57.2%	12.4%
Other service activities	61.1%	7.1%

Source: Authors' calculations based on ELE's 2007 and 2013 waves.

1.1.2 Analysis of correlates of firm use of complex software

We investigate the profile of complex software adoption across firms in the sample. Table II reports the estimated coefficients from reduced-form Probit regressions documenting interesting patterns. Larger firms, older firms, exporting and foreign-owned firms, firms not experiencing credit constraints are all more likely to use advanced technology, even after controlling for sector of activity and region. The quality of the managerial human capital is a critical determinant of technological use: firms with younger managers and/or with higher levels of formal education and past labor market experience are more likely to use complex software.

Table II. Correlates of Firm Use of Complex Software

	Dependent variable: Firm use of complex software (probit estimation)								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Small	0.815								0.825
	[0.0109]***								[0.0114]***
Medium	1.254								1.156
	[0.0153]***								[0.0158]***
Large	2.040								1.881
	[0.0195]***								[0.0206]***
Firm age (log)		0.150							0.0876
		[0.00708]***							[0.00824]***
Exporter			0.767						0.0658
			[0.0218]***						[0.0246]***
Foreign-owned				1.799					1.256
				[0.0800]***					[0.0970]***
Credit constrained					-0.278				-0.151
					[0.0249]***				[0.0264]***
Manager less than 50 years old						0.214			0.180
						[0.00983]***			[0.0116]***
Manager with more than 10 years of experience							0.0437		0.215
							[0.0115]***		[0.0135]***
Manager with secondary education								0.768	0.592
								[0.0295]***	[0.0311]***
Manager with college education								1.296	0.970
								[0.0290]***	[0.0305]***
Mining and quarrying	0.434	0.4	0.373	0.347	0.382	0.318	0.38	0.345	0.444
	[0.0526]***	[0.0468]***	[0.0466]***	[0.0468]***	[0.0465]***	[0.0466]***	[0.0467]***	[0.0472]***	[0.0540]***
Manufacturing	0.0643	0.013	-0.00677	0.0144	0.0202	-0.016	0.00932	0.0164	0.0753
	[0.0191]***	[0.0174]	[0.0175]	[0.0175]	[0.0175]	[0.0174]	[0.0174]	[0.0181]	[0.0197]***
Electricity, gas and water supply	1.885	2.077	2.113	2.076	2.065	2.01	2.084	1.805	1.657
	[0.169]***	[0.141]***	[0.140]***	[0.141]***	[0.141]***	[0.142]***	[0.141]***	[0.139]***	[0.162]***
Construction	-0.0539	0.173	0.182	0.139	0.138	0.11	0.132	0.0575	-0.0437
	[0.0207]***	[0.0192]***	[0.0192]***	[0.0190]***	[0.0191]***	[0.0190]***	[0.0190]***	[0.0192]***	[0.0210]**
Wholesale and retail trade	0.429	0.109	0.0995	0.0795	0.0844	0.0555	0.0868	0.0913	0.403
	[0.0176]***	[0.0160]***	[0.0161]***	[0.0160]***	[0.0160]***	[0.0160]***	[0.0160]***	[0.0169]***	[0.0185]***
Hotels and restaurants	-0.370	-0.283	-0.343	-0.311	-0.307	-0.356	-0.31	-0.268	-0.331
	[0.0251]***	[0.0236]***	[0.0238]***	[0.0236]***	[0.0236]***	[0.0236]***	[0.0236]***	[0.0243]***	[0.0258]***
Transport, storage and communications	0.357	0.31	0.312	0.267	0.28	0.212	0.277	0.241	0.322
	[0.0226]***	[0.0207]***	[0.0207]***	[0.0207]***	[0.0206]***	[0.0208]***	[0.0207]***	[0.0207]***	[0.0229]***
Financial intermediation	0.955	1.182	1.183	1.067	1.168	1.101	1.162	0.962	0.752
	[0.0825]***	[0.0659]***	[0.0665]***	[0.0709]***	[0.0655]***	[0.0658]***	[0.0656]***	[0.0659]***	[0.0875]***
Real estate and business activities	0.455	0.336	0.303	0.266	0.275	0.178	0.268	0.137	0.504
	[0.0193]***	[0.0178]***	[0.0174]***	[0.0174]***	[0.0174]***	[0.0178]***	[0.0175]***	[0.0179]***	[0.0208]***
Other service activities	0.609	0.453	0.48	0.416	0.432	0.412	0.439	0.283	0.474
	[0.0246]***	[0.0222]***	[0.0222]***	[0.0223]***	[0.0222]***	[0.0222]***	[0.0222]***	[0.0226]***	[0.0247]***
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	3,704	3,704	3,704	3,704	3,704	3,704	3,704	3,704	3,704
R-squared	0.218	0.077	0.079	0.078	0.070	0.073	0.069	0.108	0.249

Source: Authors' calculations based on ELE's 2007 and 2013 waves and 2014 Chile PIAAC survey.

Notes: Robust standard errors in brackets. ***, **, and * indicate significance at 1, 5, and 10 per cent confidence levels, respectively. All variables are defined in Appendix Table 1. The indicator variable for manager less than 50 years old is based on manager age and the indicator

variable for manager with more than 10 years of experience is based on the number of years of experience of the manager. The omitted size category are micro firms, the omitted manager education category is primary education, and the omitted sector is agriculture, hunting, fishing and forestry.

1.2 PIAAC Survey and Definition of Task Measures

We define the task content of occupations for three types of tasks, abstract, routine and manual tasks as in Autor and Handel (2013). We identify in the PIAAC survey the questions that are very similar to those used by other studies relying on the DOT, PDII, O*NET or STEP surveys. *Abstract* comprises abstract problem-solving and creative, organizational, interactive and managerial tasks which are associated with the following variables in the PIAAC survey: the frequency of reading material and of writing material at work; the frequency of math tasks involving at least high-school mathematics; the frequency of problem-solving tasks requiring at least 30 minutes to be solved; the frequency of interaction with other people at work; the frequency of learning at work; the frequency of making presentations or giving speeches, and an indicator for the supervision of other workers.[i] *Routine* involves codifiable tasks that follow explicit procedures and is associated with the following variables in the PIAAC survey: rigidities in the adjustment of the sequence of tasks at work; the rigidities in the adjustment of working hours at work; and the rigidities in the adjustment of the speed or rate of work.[ii] These variables capture the degree of autonomy a worker has in performing his job. Finally, *Manual* comprises tasks that require physical adaptability and manual dexterity and are associated with the following variables in the PIAAC survey: the frequency of working physically for a long period and the frequency of using accuracy with hands or fingers.[iii]

To construct the task content of occupations using the PIAAC survey we focus on 1,624 adult workers that are wage employees in the private sector employed in any of the sectors covered by ELE. We match the 262 detailed occupations in our PIAAC sample (classified at the 4-digit level of the International Standard Classification of Occupations (ISCO) 2008) to the four broad occupations in ELE: managers, administrative workers, professionals and technical workers and unskilled production and services workers.[iv] Finally, we combine the variables associated with each type of task in the PIAAC survey (shown in Table III below) into a single task content measure for each occupation in the ELE survey following the approach of Acemoglu and Autor (2011). We proceed in three steps:

1) For each variable associated with any of the three tasks we calculate the mean and standard deviation across the sample of 1,624 workers so as to be able to standardize the variable by subtracting the mean and dividing by the standard deviation.

2) For each worker we obtain scores for each of the three types of tasks by adding all the standardized variables obtained in 1) associated with abstract tasks (8 variables), associated with routine (3 variables), and associated with manual tasks (2 variables). For all final task scores to have a zero mean and standard deviation of one, we do one additional standardization of the three task scores by subtracting their mean and dividing by their standard deviation.

3) For each of the four occupations in ELE, we calculate a weighted average of the value of each of the three final standardized task scores obtained in 2) using as weights the contribution of each detailed occupation mapped to that broad occupation to total hours of work in the

previous week, as reported in the PIAAC survey.[v] Since the resulting task content measures cannot be compared across occupations, we standardize them using the mean and standard deviation taken across the four occupations in ELE. These normalized task content measures are an input for the firm-level task indexes.

The advantage of this methodology is that the scale of the abstract, routine, and manual task content measures is comparable across tasks and across occupations in ELE. Table 1 in the main text provides for each occupation in ELE the average of each task content measure. Higher values of the task content measure indicate that that type of tasks is more important for that occupation. For managers, the most important tasks are abstract, followed by manual tasks, while routine tasks are the least important. This ranking is very intuitive as managers are expected to perform the problem-solving tasks included in the definition of abstract tasks. The relative importance of manual tasks for managers is in line with Messina et al. (2016) who find for Latin American countries other than Chile that occupations with a high content of manual tasks include high-level occupations like database and network professionals, managing directors and chief executives. As expected, routine tasks are of lesser relevance for managers, who typically have more freedom to decide the way they work. For administrative workers, the most important tasks are routine, which again is a finding in line with expectations. For professionals and technical workers, the most important tasks are abstract, followed by routine tasks – these are the set of tasks we expect to be replaced by the complex software. Finally, for unskilled production and services workers the most important tasks are manual followed by routine.

Table III. Variables Associated with Four Types of Tasks in the PIAAC Survey

Tasks measures	Variables
Abstract	(1) Frequency of reading material (1 to 5)
	(2) Frequency of writing material (1 to 5)
	(3) Frequency of math tasks involving at least high school mathematics (1 to 5)
	(4) Frequency of problem solving tasks requiring at least 30 min to be solved (1 to 5)
	(5) Frequency of interaction with other people (1 to 5)
	(6) Frequncy of learning at work (1 to 5)
	(7) Frequency of making presentations or giving speeches (1 to 5)
	(8) Supervising other employees (Yes/No)
Routine	(1) Rigidities in adjustment of sequence of tasks (1 to 5)
	(2) Rigidities in adjustment of working hours (1 to 5)
	(3) Rigidities in adjustment of speed or rate of work (1 to 5)
Manual	(1) Frequency of using accuracy with hands or fingers (1 to 5)
	(2) Frequency of working phisically for a long period (1 to 5)

Source: 2014 Chile PIAAC Survey.

Notes: Variables measuring the frequency of a particular activity are expressed on a scale ranging from 1 (indicating very low frequency) to 5 (indicating very high frequency). Variables measuring the rigidity of a particular activity are expressed on a scale ranging from 1 (indicating little rigidity) to 5 (indicating strong rigidity).

1.3 CASEN Survey

Table IV. Summary Statistics on Regional Variables from CASEN

	Computer		Cell Phone	
	2006	2013	2006	2013
	(1)	(2)	(5)	(6)
Tarapacá	35.10	61.62	63.80	90.94
Antofagasta	43.56	72.23	68.42	93.86
Atacama	36.72	58.16	64.75	92.88
Coquimbo	26.37	54.25	59.12	92.16
Valparaíso	32.91	59.45	61.78	89.85
O'Higgins	24.81	51.26	59.40	89.84
Del Maule	20.74	43.24	58.82	90.36
BioBío	28.33	55.54	56.53	88.77
Araucanía	23.83	43.28	56.34	89.16
Los Lagos	23.74	51.13	63.82	89.37
Aysén	26.27	59.05	62.68	92.53
Magallanes y Antártica	46.75	68.48	57.69	89.36
Región Metropolitana	43.47	63.99	62.86	89.21
Los Ríos	23.79	47.79	53.22	88.75
Arica y Parinacota	32.40	59.56	52.61	87.48
Country Avg.	31.25	56.60	60.12	90.30

Source: CASEN's 2006 and 2013 waves.

Section 2. Additional Results

2.1 OLS Estimates

Table V. OLS Impact of Complex Software Use on Firm Occupation Shares and Task Indexes

Dependent variable:	Panel A. Firm employment shares			
	Managers	Professionals & technical workers	Administ. workers	Unskilled production & services workers
	(1)	(2)	(3)	(4)
Firm complex software use	0.0176	0.0212	-0.00171	-0.0372
	[0.0156]	[0.0300]	[0.0276]	[0.0343]
Dependent variable:	Panel B. Firm task indexes			
	Abstract	Routine	Manual	
	(1)	(2)	(3)	
Firm complex software use	0.0642	-0.0466	-0.0591	
	[0.0526]	[0.0410]	[0.0499]	
Observations	3,704	3,704	3,704	

Source: Authors' calculations based on ELE's 2007 and 2013 waves and 2014 Chile PIAAC survey.
Notes: Robust standard errors in brackets. ***, **, and * indicate significance at 1, 5, and 10 per cent confidence levels, respectively. All regressions control for firm and year fixed effects and include time-varying firm characteristics (firm size categories, firm age (in logs), exporter, foreign-owned, and credit constrained indicators, age of the main manager (in logs), number of years of experience of the main manager (in logs) and indicators for the degree of education of the main manager), time-varying region characteristics (average per capita household income in the

region (in logs), share of urban population, average number of years of education of population in the region (in logs)), number of computers used by firms in the region-sector, as well as region-specific time trends.

2.2 Robustness Checks

We test the robustness of the main findings in the paper to different concerns. First, we consider an alternative methodology to compute the firm-level task indexes, following Autor and Handel (2013). We are interested in assessing whether changing the methodology used to define the task measures results in different task content of occupations and different impacts of the adoption of complex software. The average of each task measure for each occupation using Autor and Handel (2013) methodology is presented in Table VI below. Second, we use an alternative measure of the regional adoption of new technologies in the first-stage of the IV estimation. Our objective is to test whether regional household computer use is capturing the regional adoption of new technologies or is capturing other regional trends. The alternative measure is the share of households in the region with at least one cell phone.[vi] Third, we explore an alternative to the use of ELE's cross-sectional sampling weights (exploited in our main results) consisting in using no sampling weights. Fourth, we test the robustness of our results to the inclusion of the group of 140 firms exhibiting very large changes in employment composition between 2007 and 2013 (which are excluded from the estimating sample used in the main analysis). Fifth, we explore whether our results are driven by the fact that only a small share of firms in our sample (25%) change their status in the adoption of complex software over time. We re-estimate our main models ignoring the panel structure of the data, including region and sector fixed effects instead of firm fixed effects. Sixth, we explore the possibility that our main results are driven by sector-specific trends related for instance to the commodity boom experienced by Chile over the same period. Finally, we expand the measurement of task content of occupations to allow variation also across sectors.[vii] Table VII reports the average of each task measure for each occupation in each aggregate sector.

Table VI. Task Content Measures based on the PIAAC Survey by Occupation in ELE Following Methodology of Autor and Handel (2013)

	Abstract	Routine	Manual
Managers	0.883	-0.940	-0.501
Administrative workers	-0.052	0.121	-0.044
Professionals and technical workers	0.358	-0.473	-0.481
Unskilled production and services workers	-0.154	0.185	0.203

Source: Authors' calculations based on ELE's 2007 and 2013 waves and 2014 Chile PIAAC survey.

Table VII. Task Content Measures based on the PIAAC Survey by Occupation and Sector of Activity in ELE Following Methodology of Autor and Acemoglu (2011)

	Abstract	Routine	Manual
Managers	**1.081**	**-1.320**	**-1.137**
Primary sector	0.935	-1.239	0.337
Manufacturing	1.174	-1.218	-0.912
Services	1.073	-1.346	-1.251
Administrative workers	**-0.127**	**0.556**	**0.274**
Primary sector	-0.215	0.136	-0.306
Manufacturing	-0.331	0.672	0.415
Services	-0.091	0.621	0.295
Professionals and technical workers	**0.347**	**-0.191**	**-0.362**
Primary sector	0.593	-0.096	-1.197
Manufacturing	0.340	-0.404	-0.718
Services	0.333	-0.156	-0.189
Unskilled production and services workers	**-1.302**	**0.955**	**1.225**
Primary sector	-1.314	1.199	1.166
Manufacturing	-1.182	0.950	1.216
Services	-1.315	0.882	1.145

Source: Authors' calculations based on ELE's 2007 and 2013 waves and 2014 Chile PIAAC survey.

Panels A to G in Table VIII report results from all these robustness checks.[viii] For brevity we report only the impacts on firm-level task indexes in Table VII but we also include in the discussion of results below those for the impacts on firm-level occupation shares.[ix] Most estimations show a decrease in the abstract task index along with increases in the routine and the manual indexes.[x] The main findings reported in the paper's Section 5 are robust to changes in sample size, instrumental variable definition, measurement of task indexes, weighting scheme, and inclusion of sector-specific time trends as control variables. The estimated reduction in the abstract task index and increases in routine and manual indexes reflect adjustments in the occupational composition, where the professionals and technical category --intensive in abstract and routine tasks performed by the complex software-- loses share and the unskilled production and services category gains share in firm total employment.

One additional threat to our identification strategy is that the growing demand for computers by households in a region could directly impact the output and employment of firms involved in the production or sale of computers. To address this threat, we exclude from our sample two sectors -- IT producers (manufacturing) and IT sellers (wholesale and retail trade).[xi] The results, reported in Panels H and I of Table VIII, indicate that our main findings remain robust.

Table VIII. Robustness Tests – Impact of Firm Complex Software Use on Task Indexes

Dependent variable:	Second-stage - Firm Task indexes		
	Abstract	Routine	Manual
	(1)	(2)	(3)
	Panel A: Autor & Handel (2013) method		
Firm complex software use	-0.550	0.669	0.519
	[0.219]**	[0.246]***	[0.173]***
Observations	3,704	3,704	3,704
	Panel B: IV based on share of households with cell phone		
Firm complex software use	-1.286	1.203	1.313
	[0.535]**	[0.508]**	[0.530]**
Observations	3,704	3,704	3,704
	Panel C: Without weights		
Firm complex software use	-4.481	4.010	4.399
	[2.668]*	[2.434]*	[2.599]*
Observations	3,704	3,704	3,704
	Panel D: Complete sample		
Firm complex software use	-2.680	2.030	2.722
	[1.476]*	[1.119]*	[1.424]*
Observations	3,984	3,984	3,984
	Panel E: Ignoring panel structure of the data		
Firm complex software use	-0.749	0.665	0.784
	[0.495]	[0.368]*	[0.466]*
Observations	3,704	3,704	3,704
	Panel F: Including sector-specific time trends		
Firm complex software use	-1.327	1.222	1.349
	[0.574]**	[0.541]**	[0.571]**
Observations	3,704	3,704	3,704
	Panel G: Task measures by occupation and sector		
Firm complex software use	-1.248	1.089	1.238
	[0.507]**	[0.447]**	[0.523]**
Observations	3,704	3,704	3,704
	Panel H: Excluding manufacturing sector		
Firm complex software use	-0.963	0.890	0.991
	[0.437]**	[0.396]**	[0.426]**
Observations	3,124	3,124	3,124
	Panel I: Excluding wholesale and retail trade sector		
Firm complex software use	-1.681	1.511	1.695
	[0.808]**	[0.778]*	[0.813]**
Observations	3,178	3,178	3,178

Source: Authors' calculations based on ELE's 2007 and 2013 waves and 2014 Chile PIAAC survey.
Notes: Robust standard errors in brackets clustered by region-sector. ***, **, and * indicate significance at 1, 5, and 10 per cent confidence levels, respectively. All regressions control for firm and year fixed effects and include time-varying firm characteristics (size categories, age (in logs), exporter, foreign-owned, and credit constrained indicators, age of the main manager (in logs), number of years of experience of the main manager (in logs) and indicators for the degree of education of the main manager), time-varying region characteristics (average per capita household income (in logs), share of urban households, and average number of years of education of households (in logs)), number of computers used by firms in the region-sector, as well as region-specific time trends.

We also test whether our main results are led by regions or economic sectors with a high share of complex software use in 2007 and 2013. We proceed by re-estimating our main specifications eliminating from the sample the sectors or regions that may appear as outliers in Figure 1 in the main test. The results presented in Tables IX and X are unchanged.

Table IX. Firm Complex Software Use, Employment Composition and Task Indexes Excluding "Outlier" Sectors Utilities and Financial Intermediation

Dependent variable:	Panel B: Second-stage - Firm employment shares			
	Managers	Professionals & technical workers	Administ. workers	Unskilled production & services workers
	(1)	(2)	(3)	(4)
Firm complex software use	-0.258	0.283	-0.594	0.569
	[0.222]	[0.211]	[0.256]**	[0.259]**
Dependent variable:	Panel C: Second-Stage - Firm task indexes			
	Abstract	Routine	Manual	
	(1)	(2)	(3)	
Firm complex software use	-1.262	1.155	1.283	
	[0.507]**	[0.470]**	[0.499]**	
Observations	3,372	3,372	3,372	

Notes: Robust standard errors in brackets clustered by region-sector. ** indicates significance at a 5 per cent confidence level. The table reports the 2SLS estimates of the second-stage given by Equation (4). All regressions control for firm and year fixed effects and include time-varying firm characteristics (size categories, age (in logs), exporter, foreign-owned, and credit constrained indicators, age (in logs), number of years of experience (in logs) and indicators for the degree of education of the main manager), time-varying region characteristics (average per capita household income (in logs), share of urban households, and average number of years of education of households (in logs)), number of computers used by firms in the region-sector, as well as region-specific time trends.

Table X. Firm Complex Software Use, Employment Composition and Task Indexes Excluding "Outlier" Sectors Utilities and Financial Intermediation and Region Antartica

Dependent variable:	Panel B: Second-stage - Firm employment shares			
	Managers	Professionals & technical workers	Administ. workers	Unskilled production & services workers
	(1)	(2)	(3)	(4)
Firm complex software use	-0.250	0.232	-0.560	0.578
	[0.219]	[0.200]	[0.254]**	[0.258]**
Dependent variable:	Panel C: Second-Stage - Firm task indexes			
	Abstract	Routine	Manual	
	(1)	(2)	(3)	
Firm complex software use	-1.247	1.118	1.259	
	[0.498]**	[0.452]**	[0.487]***	
Observations	3,322	3,322	3,322	

Notes: Robust standard errors in brackets clustered by region-sector. *** and ** indicate significance at 1 and 5 per cent confidence levels, respectively. The table reports the 2SLS estimates of the second-stage given by Equation (4). All regressions control for firm and year fixed effects and include time-varying firm characteristics (size categories, age (in logs), exporter, foreign-owned, and credit constrained indicators, age (in logs), number of years of experience (in logs) and indicators for the degree of education of the main manager), time-varying region characteristics (average per capita household income (in logs), share of urban households, and average number of years of education of households (in logs)), number of computers used by firms in the region-sector, as well as region-specific time trends.

2.3 Complex Software Adoption, Training and Outsourcing

Can the reallocation of employment away from professionals and technical workers toward unskilled production and services workers due to the adoption of complex software lead firms to change their investments in worker training? Columns (1) to (3) of Table XI show that firms that

adopt complex software do not significantly change their behavior regarding training provided to workers. However, following adoption, firms do increase the likelihood of providing ICT-specific training to the manager by approximately 20 percentage points. We ask whether firms adopting complex software engage in a reorganization process. One example is the extent of outsourcing activities as the adoption of complex software could require hiring services of workers for IT implementation and support.[xii] Column (4) of Table XI reports the results of our main specification when the dependent variable is an indicator variable for whether the firm engages in outsourcing. Interestingly, there is a positive, though insignificant, relation across adoption and outsourcing.

Table XI. Firm Complex Software Adoption, Training and Outsourcing

Dependent variable:	Worker training	Manager training	Manager training on ICT	Outsourcing
	(1)	(2)	(3)	(4)
Firm complex software use	0.0479	0.164	0.195	0.140
	[0.344]	[0.248]	[0.0988]**	[0.124]
Observations	3,704	3,704	3,704	3,704

Source: Authors' calculations based on ELE's 2007 and 2013 waves and 2014 Chile PIAAC survey.

Notes: Robust standard errors in brackets clustered by region-sector. ***, **, and * indicate significance at 1, 5, and 10 per cent confidence levels, respectively. All regressions control for firm and year fixed effects and include time-varying firm characteristics (size categories, age (in logs), exporter, foreign-owned, and credit constrained indicators, age (in logs), number of years of experience (in logs) and indicators for the degree of education of the main manager), time-varying region characteristics (average per capita household income (in logs), share of urban households, and average number of years of education of households (in logs)), number of computers used by firms in the region-sector, as well as region-specific time trends. The dependent variables are defined in Table A1 (Appendix).

2.4 Complete Results for Main Regressions

Table XII. Complete Results for Main Regressions

	Panel A. Firm employment shares				Panel B. Firm task indexes			Panel C. Firm log of employment levels			
Dependent variable:	Managers	Prof. & technical workers	Administ. workers	Unskilled prod. & serv. workers	Abstract	Routine	Manual	Managers	Prof. & technical workers	Administ. workers	Unskilled prod. & serv. workers
Firm complex software use	-0.270	-0.583	0.282	0.571	-1.273	1.170	1.294	-0.764	-1.243	1.462	2.799
	[0.228]	[0.258]**	[0.209]	[0.256]**	[0.506]**	[0.473]**	[0.499]***	[0.481]	[0.869]	[0.814]*	[1.136]**
=1 if micro firm	0.0303	-0.188	0.0659	0.0921	-0.161	0.121	0.165	-0.602	-1.193	-0.496	-0.637
	[0.0796]	[0.127]	[0.0635]	[0.116]	[0.211]	[0.181]	[0.207]	[0.141]***	[0.442]***	[0.227]**	[0.440]
=1 if small firm 1	0.0524	-0.118	0.0573	0.00803	-0.00200	-0.00707	0.00864	-0.382	-1.053	-0.464	-0.753
	[0.0457]	[0.102]	[0.0591]	[0.107]	[0.188]	[0.154]	[0.185]	[0.121]***	[0.354]***	[0.224]**	[0.412]*
=1 if small firm 2	0.0554	-0.0441	0.0263	-0.0375	0.0901	-0.0859	-0.0858	-0.334	-0.706	-0.545	-0.727
	[0.0388]	[0.0805]	[0.0431]	[0.0679]	[0.120]	[0.102]	[0.119]	[0.108]***	[0.298]**	[0.158]***	[0.285]**
=1 if medium-size firm	0.0430	0.0342	-0.0216	-0.0557	0.134	-0.128	-0.135	-0.175	-0.252	-0.531	-0.672
	[0.0218]**	[0.0473]	[0.0288]	[0.0509]	[0.0909]	[0.0754]*	[0.0894]	[0.0763]**	[0.204]	[0.128]***	[0.197]***
Log of firm's age	-0.00257	0.0718	0.00637	-0.0756	0.120	-0.0790	-0.114	0.112	0.249	0.0215	-0.267
	[0.0283]	[0.0492]	[0.0286]	[0.0522]	[0.108]	[0.0966]	[0.108]	[0.0733]	[0.105]**	[0.150]	[0.257]
=1 if exporting firm	-0.0781	-0.0252	0.0269	0.0765	-0.196	0.196	0.199	-0.152	0.130	0.239	0.418
	[0.0398]**	[0.0602]	[0.0380]	[0.0603]	[0.131]	[0.121]	[0.131]	[0.116]	[0.205]	[0.200]	[0.272]
=1 if foreign firm	-0.00440	0.142	-0.0483	-0.0889	0.166	-0.133	-0.168	0.0363	0.679	-0.215	-0.338
	[0.0387]	[0.0745]*	[0.0433]	[0.0872]	[0.159]	[0.128]	[0.154]	[0.173]	[0.383]*	[0.205]	[0.418]
=1 if firm is credit constraint	0.0895	-0.146	0.00728	0.0496	-0.0196	-0.0388	0.0140	0.00158	-0.506	0.0204	0.169
	[0.0820]	[0.102]	[0.0322]	[0.0436]	[0.0915]	[0.108]	[0.0946]	[0.112]	[0.291]*	[0.112]	[0.169]
Log of managers's age	-0.0236	0.0795	0.0525	-0.108	0.136	-0.0583	-0.120	-0.117	-0.144	-0.0862	-0.541
	[0.0583]	[0.120]	[0.0935]	[0.131]	[0.254]	[0.220]	[0.252]	[0.212]	[0.331]	[0.280]	[0.566]
Log of managers's years of experience	0.0245	-0.00448	-0.0251	0.00513	0.0214	-0.0405	-0.0268	0.0663	-0.00143	-0.100	-0.0266
	[0.0181]	[0.0317]	[0.0203]	[0.0316]	[0.0621]	[0.0536]	[0.0613]	[0.0504]	[0.108]	[0.0660]	[0.132]
=1 if manager has medium level of education	-0.0326	-0.0267	0.0644	-0.00512	-0.0460	0.0791	0.0581	-0.0432	-0.119	0.156	0.191
	[0.0369]	[0.0678]	[0.0339]*	[0.0764]	[0.141]	[0.116]	[0.138]	[0.0863]	[0.151]	[0.139]	[0.280]
=1 if manager has high level of education	-0.0720	-0.0214	0.0684	0.0250	-0.126	0.161	0.139	-0.0742	-0.0490	0.146	0.300
	[0.0459]	[0.0796]	[0.0439]	[0.0963]	[0.178]	[0.145]	[0.173]	[0.112]	[0.180]	[0.156]	[0.346]
Log of regional avg. per capita hhld income	0.0228	-1.553	0.258	0.394	-2.376	1.683	1.787	-2.816	-6.731	0.796	-0.598
	[0.592]	[1.514]	[0.840]	[2.593]	[2.379]	[1.839]	[2.196]	[1.782]	[4.583]	[2.863]	[3.840]
Regional share of urban households	-10.07	26.56	1.076	-4.929	18.67	-7.149	-24.68	3.624	70.80	-0.292	44.15
	[7.804]	[17.83]	[9.472]	[31.92]	[29.45]	[23.87]	[30.48]	[17.31]	[57.59]	[31.36]	[45.30]
Log of regional avg. years of education	1.118	-4.916	-2.209	-1.189	-6.628	3.493	10.35	-2.904	-0.866	-0.405	-7.001
	[3.010]	[5.114]	[3.314]	[15.19]	[8.815]	[7.856]	[11.88]	[6.712]	[23.04]	[8.746]	[13.05]
Observations	3,704	3,704	3,704	3,704	3,704	3,704	3,704	3,704	3,704	3,704	3,704

Notes: Robust standard errors in brackets clustered by region-sector. ***, **, and * indicate significance at 1, 5, and 10 per cent confidence levels, respectively. All regressions control for firm and year fixed effects, , number of computers used by firms in the region-sector, as well as region-specific time trends. The dependent variables are defined in Table A1 (Appendix).

[i] Variables measuring the frequency of a particular abstract activity are expressed on a scale ranging from 1 (indicating very low frequency) to 5 (indicating very high frequency). We follow Autor et al. (2003) in including interactive tasks (interaction with other people at work) in the definition of abstract tasks.
[ii] Variables measuring the rigidity of a particular activity are expressed on a scale ranging from 1 (indicating little rigidity) to 5 (indicating strong rigidity). Our definition of routine tasks follows the definition used by other papers using the PIAAC surveys (Marcolin et al., 2016; Pouliakas and Russo, 2015).
[iii] Our definition of manual tasks follows Autor and Handel (2013) in including a proxy for manual dexterity.
[iv] A matrix with the matches between detailed occupations and occupation categories is available upon request.
[v] Total hours of work in the previous week are obtained as the sum of hours of work in the previous week by all existing detailed occupations (regardless of which occupation category in ELE they are mapped to).
[vi] This variable is interacted with the sector ICT intensity in 2003 obtained from the Chilean Input-Output matrix.
[vii] We identify in the PIAAC survey three aggregate sectors (primary, manufacturing and services) and we measure the abstract, routine, and manual task content for the four occupations separately in each of these sectors.
[viii] The first-stage coefficients corresponding to the various robustness checks are all positive and significant at standard confidence levels.
[ix] These results are available from the authors upon request.
[x] The impacts are significant in most robustness checks with the exception being the specification estimated ignoring the panel structure of the data where there is no statistically significant impact for the abstract index.
[xi] ELE does not identify for each firm in the manufacturing or wholesale and retail sectors the sub-industry in which it operates, hence we can only exclude those very broad sectors in this exercise.
[xii] Of course, such IT implementation and support services can also be provided by in-house services workers.

References

Acemoglu, D., & Autor, D. (2011). Skills, Tasks and Technologies: Implications for Employment and Earnings. In Orley Ashenfelter and David Card (eds.) *Handbook of Labor Economics*, Vol. 4, Part B, 1043-1171. Amsterdam: Elsevier.

Autor, D., Levy, F., & Murnane, R. (2003). The Skill Content of Recent Technological Change: An Empirical Exploration. *Quarterly Journal of Economics*, 118(4), 1279-1333.

Autor, D., & Handel, M. J. (2013). Putting Tasks to the Test: Human Capital, Job Tasks, and Wages. *Journal of Labor Economics*, 31(2), 59-96.

Marcolin, L., Miroudot, S., & Squicciarini, M. (2016). The Routine Content of Occupations: New Cross-Country Measures Based On PIAAC. OECD Trade Policy Papers 188, Paris, France.

Messina, J., Oviedo, A.M., & Pica, G. (2016). Job Polarization in Latin America. Mimeo, The World Bank, Washington, DC.

Pouliakas, K., & Russo, G. (2015). Heterogeneity of Skills Needs and Job Complexity: Evidence from the OECD PIAAC Survey. IZA Discussion Paper 9392, IZA Institute of Labor Economics.