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Exporting Firms and the Demand for Skilled Tasks*

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Abstract

This paper explores the link between exports and the demand for skilled tasks. Using the Chilean Encuesta Nacional Industrial Anual (ENIA), an annual census of manufacturing firms, we first show that Chilean exporters utilize more skills than Chilean non-exporters. More importantly, we establish a distinct pattern of task differentiation among exporters both within skilled and unskilled tasks. Exporting firms demand the services of skilled specialized workers (engineers) as opposed to skilled administrative workers and managers. In addition, exporters demand less unskilled labor, especially blue-collar operatives. This suggests that exporters substitute skilled engineers for unskilled blue-collar workers to perform export-related tasks.

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1 Introduction

There is widespread evidence of both a wage and an employment premium at exporting vis-à-vis non-exporting firms (Bernard and Jensen, 1999; Bernard, Jensen, Redding and Schott, 2007). In the literature, a leading mechanism behind these premia is the skilled labor utilization of exports. The production of goods for export utilizes skilled labor because exporting requires activities such as quality upgrades and operational services that are both intensive in high-quality labor (Verhoogen 2008; Matsuyama 2007). The supporting literature is large and includes Bernard and Jensen (1997), Brambilla, Lederman, and Porto (2012), Brambilla and Porto (2016), Caron, Fally and Markusen (2014), Fieler, Eslava and Xu (2017), Munch and Skaksen (2008), Serti, Tomasi and Zanfei (2010), Söderbom and Teal (2000), Verhoogen (2008), Yeaple (2005).[1] In this paper, we look within skills and explore the type of skilled tasks demanded by exporting firms in Chile. We investigate whether these firms hire higher skilled workers for all possible tasks or, rather, whether the utilization of skilled labor is concentrated on more specific tasks in production or non-production activities. The literature on differential impacts of exports across tasks is much more scant and is circumscribed to developed countries (Bernini, Guillou and Treibich 2016; Caliendo and Rossi-Hansberg 2012; Caliendo, Monte and Rossi-Hansberg 2015; Caliendo, Mion, Opromolla and Rossi-Hansberg 2016; Friedrich 2016; Spanos 2016; Tag 2013).

To study the behavior of Chilean exporters, we use the Encuesta Nacional Industrial Anual (ENIA)—an annual census of manufacturing firms—and exploit detailed information of the firm demand of employment categories such as directors, specialized workers (engineers, professionals), administrators, blue-collar operatives, and maintenance services workers. The firm data from the ENIA is combined with administrative customs data on firms' exports. This allows us to link the exporting status of a firm with the demand for skilled tasks and to track this link for several years. We show that Chilean exporters utilize more skills than Chilean non-exporters. However, the skill composition of employment matters. In particular, we show that exporters require the services of skilled specialized workers (engineers) as opposed to skilled administrative workers or managers. In addition, exporters demand less unskilled labor, especially blue-collar operatives. This suggests that exporters substitute skilled for unskilled labor in the provision of certain skill-intensive tasks used in production. We establish these results with an instrumental variable estimator, where we instrument the firm's exports (as a share of total sales) with the weighted average of the changes in the exchange rate of all the firm's international partners (Brambilla, Lederman, Porto 2012; Park, Yang, Shi and Jiang 2010; Verhoogen, 2008). We argue that our results thus estimated provide causal evidence of the skilled tasks demanded by exporters relative to non-exporters.

Our results contribute to a rather succinct literature on tasks utilized in exports. The theory on organizational structure and layers of employment launched by Caliendo and Rossi-Hansberg (2012) has been applied to French data (Caliendo, Monte and

[1] An extended version of this mechanism is the "quality-complementarity" hypothesis. Exports require higher quality products that need to be produced with high-quality inputs (labor, intermediate inputs, machines) at high-productivity firms. See Kugler and Verhoogen (2012) and Bastos, Silva and Verhoogen (2017).

Rossi-Hansberg 2015; Caliendo, Monte and Rossi-Hansberg 2017; Spanos 2016), Danish data (Friedrich 2016), Swedish data (Tag 2013), and Portuguese data (Caliendo, Mion, Opromolla and Rossi-Hansberg 2016). The only application for developing countries is Cruz, Bussolo, and Iacovone (2016), who study internal firm reorganization and export performance in Brazil. While Chile is at the low spectrum of developed countries, and it is therefore not a developing country, this experience and the evidence gathered here illustrate the possibilities that export opportunities offer for the demand of skills and tasks for developing countries down the road. Our paper is thus a contribution to this incipient empirical literature.

The rest of the paper is organized as follows. In section 2, we introduce the data, we present a set of stylized facts on exports and the demand for skilled tasks and we perform a detailed formal regression analysis. In section 3, we discuss our results in terms of the theoretical literature. Section 4 discusses extensions and concludes.

2 Exporting Firms and The Demand for Skilled Tasks

In this section, we study the most salient facts concerning the link between exporting firms and the demand for skilled tasks in Chile. We first describe the data and present the basic correlations between skills, tasks, and exports. Next, we turn to a detailed causal empirical analysis based on instrumental variables regressions.

We use two sources of data, firm-level data and customs records. The firm-level data come from the Encuesta Nacional Industrial Anual (ENIA), an annual industrial census run by Chile's Instituto Nacional de Estadística that interviews all manufacturing plants with 10 workers or more. The ENIA is a panel. The customs data provide administrative records on firm exports by destination. We manually matched both databases for the period 2001–2005. As a result, we built a 5-year panel database of Chilean manufacturing firms.

The data have several modules. The main module contains information on industry affiliation, ownership type, sales, exports, input use, imports of materials, workers and wages. Industry affiliation is defined at the 4-digit ISIC Revision 3 level, which totals 113 industries.

We are mostly interested in the employment information. The data on workers are presented at detailed categories, which allows us to explore the demand for different skills and tasks. To do this, we base our empirical analysis on recent models of international trade where goods are produced with tasks using assignment rules (Acemoglu and Zilibotti 2001; Acemoglu and Autor 2011; Costinot and Vogel 2010). Production involves many different tasks, such as managing, accounting, clerical activities, design, packaging, logistics, sales representation, operational production, input control, monitoring, supervision, services. Tasks can be executed by workers with different skills. We argue that the most skill-intensive tasks, such as managing or directing, are typically filled with skilled workers. In turn, the most unskill-intensive tasks, such as cleaning services, are instead performed by unskilled workers. The remaining tasks, mostly involving production and design, can be done by either skilled or unskilled workers. This depends on factor prices as well as on firm characteristics such as productivity. Because of this, exporters and non-exporters may choose different skill employment composition even for similar tasks. For instance, a machine at an exporting firm may be operated by a skilled engineer, while the same task could instead be performed

by an unskilled operative at a non-exporting firm.

From the detailed employment records of the ENIA, we define the following production activities or tasks: management (directors), administrative services (accountants, lawyers), production services (engineers, blue-collar workers), and general maintenance services (unskilled non-production workers). We define skills according to formal education. We assume that directors, accountants, lawyers, engineers comprise skilled labor (because these workers need to obtain a college degree). To enrich the analysis, we also define a highly-skilled group, which includes managers and engineers. Unskilled workers are blue-collar, non-specialized and general maintenance workers (assuming these type of workers typically have lower formal educational levels). Finally, we let production workers include engineers and blue-collar operatives, while non-production workers include managers, administrative workers and maintenance workers.

Table 1 presents some key summary statistics. We report the unconditional averages as well as averages for exporting firms and non-exporting firms. On average, 39% of workers in Chilean firms are skilled workers and 61% are unskilled workers. As expected, exporters utilize a higher share of skilled workers (41%) than non-exporters (39%). Exporters are much larger and they hire, on average, more workers in all skilled and unskilled categories than non-exporters. Production workers account for 73% of employment of all Chilean firms, but 70% of the employment of exporters. In addition, exporters employ more managers, engineers and administrative services workers than non-exporters. Employment of unskilled blue-collar workers is less, while maintenance employees are slightly more, among exporters. Finally, the average exporter ships around 32% of its sales abroad. Among all firms, exports accounts for only 5% of total firm sales.

2.1 Regression Analysis

We begin our empirical analysis with the following regression model

$$y_{ijt} = \gamma E_{ijt} + \mathbf{x}'_{ijt}\beta + \phi_i + \phi_{jt} + \epsilon_{ijt}, \tag{1}$$

where i indices firms, t, time, and j, an industry. Outcomes are denoted by y_{ijt} and export intensity (the ratio of exports to total sales) is E_{ijt}. We add a control vector $\mathbf{x}$, which includes firm level variables such as log total employment and initial conditions (initial sales) interacted with year dummies to account for firm-specific trends. The regression includes firm fixed effects, ϕ_i and industry-year effects, ϕ_{jt}.

Results from OLS-FE models are presented in Table 2. In column 1, we show the basic correlation of log employment and export intensity (conditional only on firm fixed-effects and year-effects). In column 2, we add log employment to control for size. This means we compare firms of equal size, with different export intensity. As it can be seen in these models, the correlation between exports and highly-skilled and skilled employment is positive and statistically significant. The results show that a firm with 10 percentage points higher export intensity hires 1.9% more highly-skilled workers and 1.6% more skilled workers than a similar-size firm. Exporters tend to hire less unskilled labor, but this coefficient is weak statistically. Exports are positively correlated with both production and

non-production employment (Panel B, column 1), but, conditional of total firm employment, these associations become statistically insignificant (Panel B, column 2).

These correlations may be driven by industry trends, such as industry-specific growth processes. To account for those trends, we add in column 3 interactions between year dummies and industry dummies. In column 4, we also add initial conditions, the level of log sales in 2001 interacted with year dummies, to account for firm-specific trends (Brambilla, Lederman, and Porto, 2012). In all these specifications, the results are robust and the magnitudes of the coefficients are stable across models.

In terms of employment categories (Panel C), we find that exporters hire more engineers and administrative service workers and hire less maintenance service workers than non-exporters. There is no statistically discernible difference in managerial and unskilled blue-collar employment.

While these correlations are very robust, they are still correlations, not necessarily causal effects. This is because, for instance, there might be omitted variables creating biases. More productive firms are, for example, more likely to export and, at the same time, to be more efficient in the use of skilled labor. There might also be measurement errors (Brambilla, Lederman, and Porto, 2012). To get to these causal effects, we instrument the variable E_{ijt} with the average firm-level bilateral exchange rate. This strategy follows Revenga (1992), Bastos, Silva and Verhoogen (2017), Brambilla, Lederman and Porto (2012), Brambilla and Porto (2016), and Park, Yang, Shi and Jiang (2010), among others. Intuitively, the argument is that exogenous export opportunities for a firm are likely to arise when its foreign export markets expand and this will happen when exchange rate changes make Chilean exports relatively cheaper. Given these exogenous changes, a firm will be more likely to take advantage of these export opportunities if it is exposed to those markets. A natural measure of destination exposure in this case is the share of a firm's exports to that destination in total firm sales. Access to the administrative customs records allows us to do this for the Chilean ENIA firms. Formally, we define the instrument z^0 as

$$z^0_{ijt} = \sum_d s_{dij} \ln r_{dt}, \tag{2}$$

where s_{dij} is the share of exports of firm i (in industry j) to export destination d at the initial time period (year 2001), and r_{dt} is the bilateral exchange rate between Chile and country d at t. Hence, z^0_{ijt} is a weighted average of the real exchange rate faced by Chilean exporters, where the firm-specific weights are the initial shares of exports in sales. As in Brambilla, Lederman and Porto (2012), we also interact z^0 with initial firm sales (i.e., log sales in 2001) to include any firm advantages in profiting from export opportunities based on firm size. Averages for the value of these instruments are reported in panel E) of Table 1.[2]

The statistical validity of the instrument can be checked with first-stage results for the

[2]In all our specifications, we use both z^0 and its interaction with initial sales as instruments. We do this to maintain consistency with the literature that utilizes a similar approach as ours. However, all the results in the paper remain unaltered by a specification that keeps only the average firm-level exchanger rate, z^0, and drops the interaction with initial sales. These results are reported in an Online Appendix available at the authors' websites.

same four specifications used in the OLS-FE model. The results are in Table 3. As it can be seen in this first stage, the instruments have a lot of explanatory power. Quantitatively, when Chilean exporters become, on average, less competitive in their export market destinations, they sell less abroad. Also, it is reassuring that the instruments easily satisfy the test of joint significance. Further, the inclusion of firm and year fixed effects (columns 1-4), industry-specific trends (columns 3-4) and firm-specific trends (column 4) makes the validity of the exclusion restrictions more credible (Bastos, Silva and Verhoogen 2017; Brambilla, Lederman and Porto 2012; Brambilla and Porto 2016).

Economically, the exclusion restriction holds only if the changes in exchange rates affect firm employment only via their effects on exports. In our case, this assumption may fail if firms differ in the use of imported inputs. In the literature, imported inputs are generally higher quality inputs that can work as substitutes (or complements) for skilled workers (Kugler and Verhoogen 2012; Fieler, Eslava and Xu 2017). If the use of imported inputs depends on the exchange rates, then part of the effect of the instrument can be transmitted to this channel rather than exclusively via exports. To account for this, we further control in columns 5 for the share of imported inputs used by each firm. This share is the ratio of the value of the imported intermediate inputs and the value of total expenditures in intermediate inputs. We find that this does not affect the mechanism captured by our instruments.[3]

The causal impacts of export intensity on employment are reported in Table 4. Results for the demand of skills are in Panel A. Conditional of firm-fixed effects, larger exporters demand more skilled workers (column 1). They also demand more highly-skilled workers. These effects are highly statistically significant. Higher exports are associated with lower unskilled labor employment, but this effect is not statistically significant. In column 2, we find that, conditional on size and firm fixed effects, firms that export a higher share of their total sales utilize more skilled (and also highly-skilled) workers, and less unskilled workers. Both effects are statistically significant. This implies that an exogenous increase in exports induces firms to specialize in skilled intensive activities and tasks. The results remain unaffected by the inclusion of industry- and firm-specific trends (columns 3 and 4) or by the intensity of use of imported inputs (column 5). In these regressions, however, there is no discernible causal impact of exports on production or non-production employment.

The composition of tasks is, in contrast, different, as we show in panel C. Among skilled tasks, exporters utilize significantly more engineers (specialized workers)—see columns 1 to 5. Employment of specialized service workers tends to be higher but this is not statistically significant (especially conditional of size, columns 2 to 5). Among unskilled tasks, the bulk of the difference takes place among non-specialized blue-collar workers. Taken together, this suggests that exporters tend to utilize more specialized workers and engineers relative to blue-collar, lower skilled operatives.

To give some context to these estimates, we calculate the fraction of within firm employment growth that can be explained by increasing exports. On average, firm skilled employment increased by 0.65% during the sample period, 2001-2005. The intensity of

[3]Another reason why the exclusion restrictions may fail if exchange rates have direct effects on the valuation of quality and the demand for quality in partner countries. As in Verhoogen (2008) and Brambilla, Lederman and Porto (2012), we assume these potential effects are absent or are negligible in practice.

exports grew, on average, by 0.36%. Using the estimated coefficient in column 5, 0.27, exports would cause skilled employment to grow by 0.10%. This means that export growth can account for about 15% of total firm skilled employment growth. These magnitudes appear sizeable. Similar calculations reveal that exports can account for a smaller fraction, about 3.6%, of the employment growth of engineers at the firm level. By contrast, while firm employment of unskilled workers increased by 2.2% during this period, exports contributed negatively, reducing employment but only slightly, by 0.1%.

As a robustness check, Table 5 reports results using shares of employment, instead of log employment. We confirm that the share of skilled (and highly-skilled) labor is statistically higher among exporters. Instead, the shares of production and non-production workers are not statistically different. The share of engineering employment is much higher among exports. This is compensated with lower shares of blue-collar employment, while the shares of all other types of employments are not statistically different.

The distinction between the demand for skilled labor and the demand for tasks raises an interesting question, namely whether the impacts of exports on the demand for skills depends on the occupational structure of the firm (Caliendo, Monte and Rossi-Hansberg 2015; Caliendo, Monte and Rossi-Hansberg 2017). The argument is that the demand of skilled and unskilled labor (and production and non-production labor) may depend on whether firms already employ directors, engineers, and other types of workers. If a firm, for example, has a team of engineers in its workforce, it may need to expand the demand for skilled labor differently when facing an export shock. To explore this, we measure the occupational structure with the shares of employment of different categories and we run regressions of the demand for skills (in log levels) conditional on this occupational structure. Results are in Table 6. In column 1, we control for firm and year fixed effects, industry-specific trends and firm-specific trends, we include a vector of employment shares but we omit firm size (total employment). We find that in response to higher exports, firms with similar occupational structure expand skilled employment (and high-skilled employment as well, but marginally so). There is, however, no effect on unskilled labor employment. When we condition on firm employment as well (in column 2), the results show that firms of similar size and similar occupational structure only expand skilled employment, with no response of both highly-skilled or unskilled employment. This can happen because larger exporting firms respond more at the upper tiers of skilled employment than smaller firms (Caliendo, Monte and Rossi-Hansberg 2015; Caliendo, Monte and Rossi-Hansberg 2017). For robustness, we check whether these findings depend on the use of imported inputs, again because of possible complementarities or substitutabilities. Results in columns 3 and 4 show that our estimates are robust to this specification.

To end our analysis, we explore in what follows separate responses on the extensive and intensive margins. So far, we have measured exposure with the intensity of exports, the ratio of exports to sales. This includes responses of both exporters that increase their sales abroad and non-exporters that begin to export. To study the extensive margin, we re-do our analysis and replace the exporter intensity variables with an exporter dummy. With a panel, this strategy captures the role of transitions into and out of exporting on employment. Table 7 shows results for our basic five specifications. The same patterns emerge. An exporter, for instance, hires more highly-skilled and skilled workers than a non-exporter. The magnitudes

are large: skilled employment, for instance, is 44% higher at an exporting firm. Conditional on total employment, unskilled labor is much lower, 57%, at exporters. This shows that exporting firms do employ more skills and sometimes at the expense of unskilled workers, a result that is consistent with the observation that exporters utilize higher quality inputs, including higher quality labor (Verhoogen 2008; Bastos, Silva and Verhoogen 2017). In Panel C), we confirm that these patterns also translate to the employment of skilled tasks found before. In particular, exporters hire more engineers and less blue-collar workers than non-exporters. Becoming an exporter requires the set up a large tier of skilled workers, essentially engineers, while in closing export operations the re-structuring of firms involves higher employment of unskilled workers, mostly blue-collar.

To focus exclusively on the intensive margin, we run all these regressions using only firms with positive exports. The results are reported in Table 8. As expected, since we are now ignoring the extensive margin, the estimated impacts are somewhat milder but the overall qualitative conclusions are still observed. In particular, increasing the export intensity is associated with an expansion of skilled employment, especially of engineers. It is noteworthy that the reduction of blue-collar employment is not statistically significant. This suggests that the substitution of blue-collar workers for engineers is more prevalent among firms that become exporters rather than on active exporting firms.

3 Discussion and Theoretical Mechanisms

We can think about our empirical results as providing evidence on two related, but different, features of exporting firms. We establish that exporters demand higher skills than non-exporters. We also show that exporting firms choose a different composition of skilled employment, hiring more engineers at the expense of blue-collar workers. These observations have implications for theories of exports and employment. While our results confirm the link between exports and skills, they also suggest a role for tasks differentiation in exports. In particular, our evidence suggests specific skills that are demanded for exporters, namely the skills of specialized operatives such as engineers rather than specialized administrative workers. Furthermore, these engineers replace unspecialized blue-collar workers, rather than maintenance or services workers. As a consequence, the differentiation of tasks for exports has implications for both the demand of skilled and unskilled tasks. In what follows, we review the literature to document theories that can help rationalize these results.

The link between exports and the demand of skilled labor belongs to a larger literature that links exports to the demand of high quality inputs more generally. Supporting evidence can be found in Verhoogen (2008), Manova and Zhang (2012), Brambilla, Lederman and Porto (2012), Kugler and Verhoogen (2012), Bastos, Silva and Verhoogen (2017), Fieler, Eslava and Xu (2017), among others. To explain how this link works, the literature has offered several interpretations. In all these interpretations, there is a distinct feature of the act of exporting that plays a role.

A strand of literature emphasizes the role of the valuation of quality in export markets. Hallak (2006), Baldwin and Harrigan (2011) and Johnson (2012) show a positive correlation between export unit values and the level of income of the country of destination; Manova and

Zhang (2012), Bastos and Silva (2010), and Görg, Halpern and Muraközy (2010) show that exporting firms charge higher prices in export markets. Quality valuation matters because if firms want to exploit export opportunities, then they may need to upgrade the quality of their products. The link to skilled utilization is a technological issue and the literature assumes that the provision of quality is inherently a skilled intensive activity. Evidence in support of this assumption can be found in Schott (2004), who reports higher U.S. import unit values for varieties originating in capital- and skill-abundant countries, and Hummels and Klenow (2005), who show that these unit values also positively correlate with the per capita income of the exporting country. Similarly, Caron, Fally, and Markusen (2014) establish a positive correlation between the income elasticity of a good and its skilled-labor intensity. Using cross-country data, Brambilla and Porto (2016) show that both the quality valuation and the quality provision mechanisms operate, on average, worldwide for a panel of 82 countries.

A different interpretation is provided by Matsuyama (2007) and Brambilla, Lederman, and Porto (2012). Their argument is that exports require a set of specific activities, such as international marketing and commercialization, transportation and distribution, and advertising that are inherently skilled intensive. As a result, reaching export markets is associated with a higher skilled labor utilization. Evidence in support of this "required services" argument is in Brambilla, Lederman, and Porto (2012).

To tell apart the quality mechanism from the required services mechanism, we combine the regression specification in previous sections with ideas from Brambilla and Porto (2016). Following this approach, we construct a measure of the average per capita GDP of the destination of a firms' exports, using destination export shares as weights. Assuming that high income countries demand higher quality products, this variable captures the quality mechanism. The intensity of exports (the ratio of exports over sales) can capture the residual impact of the required services mechanism. We present the results in Table 9. To simplify the exposition, we run the most comprehensive specification where the control for firm and year fixed-effects, employment, firm-specific trends and the share of imported inputs. As in Brambilla and Porto (2016), we instrument the average per capita GDP of a firms' destination with the average partner country per capita GDP using bilateral real exchange rates as weights. To see how this works, consider a scenario where conditions induce firms to shift exports from a low income to a high income country and to sell products of higher quality. The value of the average firm-level per capita GDP of destinations should increase and the demand for skills should also increase in response to the quality mechanism. Thus, the instrument in effect captures arguably exogenous changes in exports shares to different destinations GDP. In columns 1 and 2 of Table 9, we report the estimated impacts of export intensity and of the average per capita GDP for different skill employment and different tasks. Regarding export intensity, all our previous results persist. In particular, we find positive impacts on skilled employment relative to unskilled employment, and positive impacts on engineers relative to blue-collar workers. Interestingly, similar patterns emerge in response to increases in the average per capita GDP of a firm's export destinations. In column 2, we see that skilled employment increases while unskilled employment decreases. Furthermore, the demand for engineers goes up and the demand for blue-collar workers goes down, as before. In columns 3 and 4, we explore results for the extensive margin. Concretely, we include a dummy variable for exporting in general, as in Table 7, and we add a dummy variable for

firms exporting to high-income countries—a dummy that takes a value of one when a firm exports to a country at the top 25% of the per capita GDP spectrum. As it can be seen, the results are qualitatively similar as before. Exporting is associated with higher skilled employment and in particular higher utilization of engineers, and there is an additional effect on the demand of skills and of skilled tasks for firms that export to high-income, rich countries.

These results suggests that both the quality and the required services mechanisms are present in the Chilean case. The presence of the quality mechanism is consistent with the widespread support for it listed above. The presence of the required services mechanism is also expected. Pellandra (2017), for instance, finds support for the Matsuyama interpretation using similar Chilean data. Building on Brambilla, Lederman and Porto (2012), Pellandra includes fixed costs of reaching different export destinations and those fixed costs are essentially covered with skilled workers. This suggests that the required services mechanism is also present. Incidentally, this is consistent with the results in Brambilla, Lederman, and Porto (2012), who also find support for both mechanisms using Argentine data.

The most novel result of this paper is, however, the finding that exporting requires the skills of specific tasks within skilled labor, namely those performed by engineers rather than by directors or administrative workers. The quality provision and quality valuation mechanisms just discussed can rationalize these findings by assuming for example a technology to produce quality that is more intensive in those specific skilled tasks. In the working paper version of this paper (Brambilla, Lederman, and Porto 2016), we develop a model with some of these features. We combine elements from the literature on quality and skilled utilization with element from theories of trade and tasks. In particular, we build on recent models of international trade where goods are produced with tasks using assignment rules (Acemoglu and Autor 2011; Costinot and Vogel 2010). Production involves many different tasks, such as managing, accounting, clerical activities, design, packaging, logistics, sales representation, operational production, input control, monitoring, supervision, services. Tasks are executed by workers with different skills, some tasks are skill-intensive, while others are unskilled-intensive. Firms produce goods of varying quality and exporters tend to produce higher quality goods. In turn, the production of quality is intensive in skilled tasks relative to the production of physical output. Firms are heterogeneous and differ in the efficiency of factor use: some firms are more productive in skill-intensive tasks than others. More productive firms become exporters and hire more skilled workers overall. The demand for skilled workers will, however, be biased towards those skilled tasks required to produce exportable higher-quality goods.

A different strand of literature that is related to our results on tasks builds on the organizational structure of firms and their export orientation. Lileeva and Trefler (2010) argue that export opportunities induce firms to reorganize and adopt better technologies, thus becoming more productive. Caliendo and Rossi-Hansberg (2012) develop a theory of firms that choose layers of employees to organize production in the most efficient, less costly way. In this theory, the bottom layer (blue-collar workers) produces output while consecutive upper layers (supervisors, management) solve problems associated with production. Adding a layer of "problem solving" reduces the marginal cost of production but incurs a fixed cost. Consequently, a demand shock (such as an export shock in our empirical analysis) may

(or may not) induce firms to reorganize production, adding layers and increasing overall productivity. Empirical evidence related to this theory can be found in Tag (2013), Bernini, Guillou and Treibich (2016), Caliendo, Monte and Rossi-Hansberg (2015), Caliendo, Monte and Rossi-Hansberg (2017), Caliendo, Mion, Opromolla and Rossi-Hansberg (2016), Cruz, Bussolo and Iacovone (2016), Friedrich (2016) and Spanos (2016).

Our results for Chile can be rationalized by this theory. The lower layer of production would include the non-specialized blue-collar workers. Engineers supervise blue-collar workers and, plausibly, can work in production as well. Exposed to increases in export opportunities, firms reorganize their structure by expanding the layer of engineers needed to supervise blue-collar workers (and, again, possibly to substitute some of them in production as well). This would explain why exporters demand more skilled tasks and, in turn, why the utilization of engineers increases more than the utilization of directors or administrative skilled workers. These impacts may be particularly large at the extensive margin. In this context, our paper contributes to this literature by providing evidence of these mechanisms using less detailed data for lower developed or advanced middle-income countries rather than the employer-employee datasets used in the studies referenced above. This can shed light on the role of exporting and employment in relatively more advanced developing countries.

4 Conclusions

In this paper, we have explored the link between exports and the demand for skilled tasks using a panel of Chilean firms. We have found that exporting raises the demand for specific sets of skills, favoring technical skills such as engineering skills over other profession skills such as "desk" skills. In addition, engineers seem to replace blue-collar unskilled labor in certain tasks associated with exporting.

Our findings have implications for trade theory and should illustrate the importance of recent assignment models of factors to tasks in international trade. The results have implications for empirical research and policy design as well. The notion that trade, and exports in particular, affects the wage premium and thus wage-inequality needs to be carefully assessed. Our results should contribute to our understanding of the skilled tasks needed to exports, the role of potential education policies consistent with a successful long-run export performance (e.g., fostering technical careers), and the design of social policies to reduce wage inequality and help the losers from trade. Finally, we have provided evidence on the link between trade and the employment structure of exporting firm in Chile, which is useful to illustrate the interplay between exports, firm reorganization, and efficiency at the firm level in middle-income/developing countries.

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TABLE 1
Summary statistics
National Annual Industrial Survey
Chile 2001 - 2005

	All Firms	Exporters	Non-Exporters
A) Skilled and Unskilled Labor			
skilled employment	28.09	76.20	18.35
highly-skilled employment	19.83	51.72	13.31
unskilled employment	56.33	142.04	38.96
share skilled employment	38.69	40.62	38.53
share highly-skilled employment	25.95	26.79	25.88
share unskilled employment	61.31	59.38	61.47
B) Production and Non-Production Labor			
share production employment	73.21	70.15	73.47
share non-production employment	26.79	29.85	26.53
C) Tasks			
share managerial employment	7.17	8.68	7.04
share engineering employment	18.78	18.11	18.84
share services employment	12.74	13.84	12.65
share blue-collar employment	54.42	52.04	54.63
share maintenance employment	6.88	7.33	6.85
D) Exports			
exports/sales	0.05	0.32	0.00
E) Instruments			
exchange rate	-0.19	-1.11	0.00
exchange rate * sales	-2.81	-16.23	0.00

SOURCE: averages calculated from the Encuesta Nacional Industrial Anual (National Annual Industrial Survey), Chile 2001-2005.

TABLE 2
The demand for tasks and exports
(log employment)
OLS-FE

	export intensity			
	(1)	(2)	(3)	(4)
A) Skilled and Unskilled Labor				
log highly-skilled	0.33***	0.19***	0.19**	0.19***
	(0.087)	(0.073)	(0.073)	(0.073)
log skilled	0.31***	0.16***	0.16***	0.16***
	(0.074)	(0.058)	(0.058)	(0.058)
log unskilled	0.11	-0.13	-0.13	-0.13
	(0.101)	(0.082)	(0.082)	(0.082)
B) Production and Non-Production Labor				
log production	0.27***	0.00	0.009	0.009
	(0.073)	(0.015)	(0.015)	(0.015)
log non-production	0.14**	0.03	0.03	0.03
	(0.056)	(0.041)	(0.041)	(0.041)
C) Tasks				
log managers	0.09	0.02	0.01	0.01
	(0.073)	(0.067)	(0.067)	(0.067)
log engineers	0.37***	0.22**	0.22**	0.22**
	(0.103)	(0.089)	(0.090)	(0.090)
log services	0.29***	0.16**	0.15**	0.15**
	(0.083)	(0.070)	(0.070)	(0.069)
log blue-collar	0.14	–0.11	–0.11	–0.11
	(0.111)	(0.093)	(0.093)	(0.093)
log maintenance	–0.15*	–0.20***	–0.20***	–0.20***
	(0.080)	(0.078)	(0.077)	(0.077)
N	20544	20544	20544	20544
Firms	5226	5226	5226	5226
firm and year FE	Yes	Yes	Yes	Yes
log employment	No	Yes	Yes	Yes
industry-specific trends	No	No	Yes	Yes
firm-specific trends	No	No	No	Yes

NOTES: OLS-FE regressions of (log) employment on export intensity (exports/sales). Column (1): firm fixed-effects and year fixed-effects; column (2): adds log total employment (firm size); column (3): adds controls for industry-specific trends (i.e., interactions between year dummies and industry dummies); column (4): adds initial conditions to control for firm-specific trends. Data are from the Encuesta Nacional Industrial Anual (National Annual Industrial Survey), Chile 2001-2005.

TABLE 3
First stage results
(exports /sales on z^0)

	export intensity				
	(1)	(2)	(3)	(4)	(5)
exchange rate	–0.149***	–0.148***	–0.149***	–0.149***	–0.150***
(z^0_{jt})	(0.023)	(0.023)	(0.022)	(0.022)	(0.022)
exchange rate * initial sales	–0.0029*	–0.0030*	–0.0029*	–0.0029*	–0.0029*
($z^0_{jt} * s_{j0}$)	(0.0017)	(0.0017)	(0.0016)	(0.0016)	(0.0017)
R^2	0.4129	0.4147	0.4144	0.4146	0.4165
F-statistic	888.09	882.96	888.42	884.31	884.60
Prob > F	0.0000	0.0000	0.0000	0.0000	0.0000
firm and year FE	Yes	Yes	Yes	Yes	Yes
log employment	No	Yes	Yes	Yes	Yes
industry-specific trends	No	No	Yes	Yes	Yes
firm-specific trends	No	No	No	Yes	Yes
imported inputs	No	No	No	No	Yes

NOTES: First-stage results of IV-FE regressions of (log) employment (for various types of skilled and unskilled workers) on export intensity (exports/sales). Column (1): firm fixed-effects and year fixed-effects; column (2): adds log total employment (firm size); column (3): adds controls for industry-specific trends (i.e., interactions between year dummies and industry dummies); column (4): adds initial conditions to control for firm-specific trends; column (5): adds the share of imported inputs. Data are from the Encuesta Nacional Industrial Anual (National Annual Industrial Survey), Chile 2001-2005.

TABLE 4
The demand for tasks and exports
(log employment)
IV-FE

	export intensity				
	(1)	(2)	(3)	(4)	(5)
A) Skilled and Unskilled Labor					
log highly-skilled	0.41***	0.32***	0.32***	0.33***	0.33***
	(0.136)	(0.110)	(0.111)	(0.111)	(0.112)
log skilled	0.38***	0.28***	0.28***	0.27***	0.27***
	(0.115)	(0.084)	(0.085)	(0.085)	(0.085)
log unskilled	–0.20	–0.35***	–0.35***	–0.35***	–0.35***
	(0.134)	(0.134)	(0.135)	(0.135)	(0.135)
B) Production and Non-Production Labor					
log production	0.20**	0.02	0.02	0.02	0.02
	(0.097)	(0.018)	(0.020)	(0.020)	(0.020)
log non-production	0.07	–0.01	–0.01	–0.01	–0.01
	(0.067)	(0.049)	(0.048)	(0.048)	(0.048)
C) Tasks					
log managers	–0.08	–0.13	–0.13	–0.13	–0.13
	(0.114)	(0.105)	(0.105)	(0.104)	(0.104)
log engineers	0.52***	0.43***	0.42***	0.42***	0.42***
	(0.165)	(0.137)	(0.138)	(0.139)	(0.139)
log services	0.25**	0.16	0.15	0.14	0.14
	(0.122)	(0.112)	(0.111)	(0.111)	(0.111)
log blue-collar	–0.20	–0.37**	–0.37**	–0.36**	–0.36**
	(0.147)	(0.150)	(0.151)	(0.151)	(0.151)
log maintenance	–0.06	–0.09	–0.09	–0.09	–0.09
	(0.112)	(0.114)	(0.113)	(0.112)	(0.112)
N	20544	20544	20544	20544	20544
Firms	5226	5226	5226	5226	5226
firm and year FE	Yes	Yes	Yes	Yes	Yes
log employment	No	Yes	Yes	Yes	Yes
industry-specific trends	No	No	Yes	Yes	Yes
firm-specific trends	No	No	No	Yes	Yes
imported inputs	No	No	No	No	Yes

NOTES: IV-FE regressions of (log) employment on export intensity (exports/sales). The instruments are the weighted average the real exchange rate of a firm export partners and the weighted average of the real gdp of a firm export destinations. Column (1): firm fixed-effects and year fixed-effects; column (2): adds log total employment (firm size); column (3): adds controls for industry-specific trends (i.e., interactions between year dummies and industry dummies); column (4): adds initial conditions to control for firm-specific trends; column (5): adds the share of imported inputs. Data are from the Encuesta Nacional Industrial Anual (National Annual Industrial Survey), Chile 2001-2005.

TABLE 5
The demand for tasks and exports
(shares of employment)
IV-FE

	export intensity				
	(1)	(2)	(3)	(4)	(5)
A) Skilled and Unskilled Labor					
share highly-skilled	0.08***	0.09***	0.09***	0.09***	0.09***
	(0.031)	(0.032)	(0.032)	(0.032)	(0.032)
share skilled	0.08**	0.09***	0.09***	0.09***	0.09***
	(0.032)	(0.033)	(0.034)	(0.034)	(0.034)
B) Production and Non-Production Labor					
share production	0.03**	0.01	0.01	0.01	0.01
	(0.012)	(0.009)	(0.009)	(0.009)	(0.009)
C) Tasks					
share managers	–0.01**	–0.01	–0.01	–0.009	–0.009
	(0.006)	(0.005)	(0.005)	(0.005)	(0.005)
share engineers	0.09***	0.10***	0.10***	0.10***	0.09***
	(0.031)	(0.031)	(0.032)	(0.032)	(0.032)
share services	–0.009	0.009	0.009	–0.009	–0.009
	(0.008)	(0.007)	(0.007)	(0.007)	(0.007)
share blue-collar	–0.07**	–0.08**	–0.08**	–0.08**	–0.08**
	(0.031)	(0.033)	(0.034)	(0.034)	(0.034)
share maintenance	–0.01**	–0.01*	–0.01*	–0.01*	–0.01*
	(0.005)	(0.004)	(0.004)	(0.004)	(0.004)
N	20544	20544	20544	20544	20544
Firms	5226	5226	5226	5226	5226
firm and year FE	Yes	Yes	Yes	Yes	Yes
log employment	No	Yes	Yes	Yes	Yes
industry-specific trends	No	No	Yes	Yes	Yes
firm-specific trends	No	No	No	Yes	Yes
imported inputs	No	No	No	No	Yes

NOTES: IV-FE regressions of log employment and employment shares on export intensity (exports/sales). The instruments are the weighted average of the real exchange rate of a firm export partners, z^0, and its interaction with initial sales (in 2001). Column (1): firm fixed-effects and year fixed-effects; column (2): adds log total employment (firm size); column (3): adds controls for industry-specific trends (i.e., interactions between year dummies and industry dummies); column (4): adds initial conditions to control for firm-specific trends; column (5): adds the share of imported inputs. Data are from the Encuesta Nacional Industrial Anual (National Annual Industrial Survey), Chile 2001-2005.

TABLE 6
The demand for tasks and exports
Occupational structure
(log employment)
IV-FE

	export intensity			
	(1)	(2)	(3)	(4)
A) Skilled and Unskilled Labor				
log highly-skilled	0.13*	0.05	0.13*	0.05
	(0.072)	(0.045)	(0.073)	(0.046)
log skilled	0.16**	0.07**	0.16**	0.07**
	(0.069)	(0.030)	(0.069)	(0.030)
log unskilled	-0.00	-0.09	0.00	-0.09
	(0.075)	(0.057)	(0.075)	(0.057)
B) Production and Non-Production Labor				
log production	0.10	-0.00	0.10	-0.00
	(0.072)	(0.011)	(0.072)	(0.011)
log non-production	0.12*	0.03	0.12*	0.03
	(0.071)	(0.032)	(0.071)	(0.032)
N	20544	20544	20544	20544
Firms	5226	5226	5226	5226
log employment	No	Yes	No	Yes
occupational structure	Yes	Yes	Yes	Yes
imported inputs	No	No	Yes	Yes

NOTES: IV-FE regressions of (log) employment on export intensity (exports/sales). The instruments are the weighted average of the real exchange rate of a firm export partners, z^0, and its interaction with initial sales (in 2001). Columns (1) and (3): controls for occupational structure measured with a vector of employment shares by task; columns (2) and (4): add log total employment (firm size); column (3) and (4): add the share of imported inputs. All regressions include firm fixed-effects and year fixed-effects; industry-specific trends (i.e., interactions between year dummies and industry dummies); firm-specific trends. Data are from the Encuesta Nacional Industrial Anual (National Annual Industrial Survey), Chile 2001-2005.

TABLE 7
The demand for tasks and exports
Exporter dummy
(log employment)

	exporter dummy				
	(1)	(2)	(3)	(4)	(5)
A) Skilled and Unskilled Labor					
log highly-skilled	0.67***	0.53***	0.53***	0.53***	0.53***
	(0.238)	(0.197)	(0.198)	(0.199)	(0.197)
log skilled	0.61***	0.45***	0.45***	0.44***	0.44***
	(0.196)	(0.146)	(0.146)	(0.147)	(0.146)
log unskilled	-0.32	-0.58***	-0.58**	-0.58**	-0.57**
	(0.219)	(0.225)	(0.227)	(0.227)	(0.226)
B) Production and Non-Production Labor					
log production	0.32**	0.03	0.03	0.03	0.03
	(0.161)	(0.031)	(0.034)	(0.034)	(0.034)
log non-production	0.11	-0.01	-0.01	-0.02	-0.02
	(0.104)	(0.081)	(0.079)	(0.080)	(0.080)
C) Tasks					
log managers	-0.13	-0.20	-0.21	-0.21	-0.20
	(0.185)	(0.174)	(0.174)	(0.174)	(0.173)
log engineers	0.84***	0.69***	0.69***	0.69***	0.68***
	(0.291)	(0.248)	(0.249)	(0.250)	(0.248)
log services	0.40**	0.25	0.24	0.22	0.22
	(0.185)	(0.174)	(0.172)	(0.175)	(0.174)
log blue-collar	-0.33	-0.61**	-0.60**	-0.60**	-0.59**
	(0.240)	(0.249)	(0.251)	(0.251)	(0.250)
log maintenance	-0.08	-0.14	-0.13	-0.14	-0.14
	(0.183)	(0.186)	(0.185)	(0.185)	(0.184)
N	20544	20544	20544	20544	20544
Firms	5226	5226	5226	5226	5226
firm and year FE	Yes	Yes	Yes	Yes	Yes
log employment	No	Yes	Yes	Yes	Yes
industry-specific trends	No	No	Yes	Yes	Yes
firm-specific trends	No	No	No	Yes	Yes
imported inputs	No	No	No	No	Yes

NOTES: IV-FE regressions of (log) employment on an exporter dummy. Column (1): firm fixed-effects and year fixed-effects; column (2): adds log total employment (firm size); column (3): adds controls for industry-specific trends (i.e., interactions between year dummies and industry dummies); column (4): adds initial conditions to control for firm-specific trends; column (5): adds the share of imported inputs. Data are from the Encuesta Nacional Industrial Anual (National Annual Industrial Survey), Chile 2001-2005.

TABLE 8
The demand for tasks and exports
Only exporters
(log employment)

	export intensity				
	(1)	(2)	(3)	(4)	(5)
A) Skilled and Unskilled Labor					
log highly-skilled	0.37**	0.26**	0.25*	0.24*	0.25*
	(0.170)	(0.128)	(0.130)	(0.131)	(0.131)
log skilled	0.30**	0.19*	0.18*	0.17*	0.18*
	(0.146)	(0.100)	(0.100)	(0.101)	(0.102)
log unskilled	-0.09	-0.24	-0.23	-0.23	-0.24
	(0.144)	(0.152)	(0.150)	(0.150)	(0.150)
B) Production and Non-Production Labor					
log production	0.22*	0.04	0.04**	0.04**	0.04**
	(0.121)	(0.024)	(0.022)	(0.022)	(0.022)
log non-production	-0.01	-0.09*	-0.09*	-0.10*	-0.10*
	(0.079)	(0.053)	(0.053)	(0.053)	(0.052)
C) Tasks					
log managers	-0.17	-0.23*	-0.22*	-0.23*	-0.22*
	(0.145)	(0.131)	(0.130)	(0.128)	(0.128)
log engineers	0.47**	0.35**	0.35**	0.34**	0.35**
	(0.208)	(0.164)	(0.166)	(0.168)	(0.168)
log services	0.06	-0.03	-0.04	-0.05	-0.05
	(0.117)	(0.097)	(0.098)	(0.097)	(0.097)
log blue-collar	-0.08	-0.25	-0.23	-0.23	-0.23
	(0.158)	(0.169)	(0.168)	(0.168)	(0.168)
log maintenance	-0.01	-0.04	-0.03	-0.03	-0.04
	(0.130)	(0.132)	(0.140)	(0.140)	(0.140)
N	20544	20544	20544	20544	20544
Firms	5226	5226	5226	5226	5226
firm and year FE	Yes	Yes	Yes	Yes	Yes
log employment	No	Yes	Yes	Yes	Yes
industry-specific trends	No	No	Yes	Yes	Yes
firm-specific trends	No	No	No	Yes	Yes
imported inputs	No	No	No	No	Yes

NOTES: IV-FE regressions of (log) employment on export intensity (exports/sales) only for exporting firms (the intensive margin). Column (1): firm fixed-effects and year fixed-effects; column (2): adds log total employment (firm size); column (3): adds controls for industry-specific trends (i.e., interactions between year dummies and industry dummies); column (4): adds initial conditions to control for firm-specific trends; column (5): adds the share of imported inputs. Data are from the Encuesta Nacional Industrial Anual (National Annual Industrial Survey), Chile 2001-2005.

TABLE 9
The demand for tasks, exports and export destinations
(log employment)
IV-FE

	(1) export intensity	(2) average per capita GDP	(3) exporter dummy	(4) high-income exporter dummy
A) Skilled and Unskilled Labor				
log highly-skilled	0.33***	0.15***	0.53***	1.91***
	(0.111)	(0.055)	(0.197)	(0.619)
log skilled	0.27***	0.12**	0.44***	1.56***
	(0.085)	(0.050)	(0.146)	(0.556)
log unskilled	-0.36***	-0.34***	-0.57**	-3.95***
	(0.136)	(0.041)	(0.226)	(0.461)
B) Production and Non-Production Labor				
log production	0.02	0.01	0.03	0.15
	(0.020)	(0.017)	(0.034)	(0.175)
log non-production	-0.02	-0.09*	-0.02	-0.95**
	(0.048)	(0.046)	(0.080)	(0.466)
C) Tasks				
log managers	-0.13	-0.01	-0.20	-0.21
	(0.104)	(0.043)	(0.173)	(0.486)
log engineers	0.43***	0.15**	0.68***	2.08***
	(0.139)	(0.064)	(0.248)	(0.716)
log services	0.13	-0.18***	0.22	-1.68***
	(0.111)	(0.060)	(0.174)	(0.603)
log blue-collar	-0.37**	-0.38***	-0.60**	-4.37***
	(0.151)	(0.046)	(0.250)	(0.516)
log maintenance	-0.09	0.07	-0.14	0.63
	(0.112)	(0.066)	(0.184)	(0.728)
N	20544	20544	20544	20544
Firms	5226	5226	5226	5226
firm and year FE	Yes	Yes	Yes	Yes
log employment	Yes	Yes	Yes	Yes
industry-specific trends	Yes	Yes	Yes	Yes
firm-specific trends	Yes	Yes	Yes	Yes
imported inputs	Yes	Yes	Yes	Yes

NOTES: IV-FE regressions of (log) employment on export intensity (exports/sales) and the average per capita GDP of a firm' export destination. Columns (1): estimates of export intensity; column (2): estimates of average per capita GDP; column (3): estimates of an export dummy; column (4): estimates of a high-income export dummy. All regression include firm fixed-effects and year fixed-effects, log total employment (firm size), firm-specific trends, and the share of imported inputs. Data are from the Encuesta Nacional Industrial Anual (National Annual Industrial Survey), Chile 2001-2005.