Firm Export Diversification and Labor Organization *

Michele Bernini[1], Sarah Guillou[2], and Tania Treibich[2,3]

[1]National Institute of Economic and Social Research - London
[2]OFCE - SciencesPo Paris
[3]Maastricht University and Sant'Anna School of Advanced Studies

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Abstract

We investigate the relationship between a firm's organization of labor – defined as its number of hierarchical 'layers' – and the scope of its export portfolio in terms of product-destination varieties. The empirical analysis is based on a matched employer-employee dataset covering the population of French manufacturing firms over the period 2009-2013. Our analysis suggests that market expansion, and in particular export diversification, is associated with a change in firm labor organization, namely an increase in the number of hierarchical layers, in the share of managers and in wage dispersion. We show how these results are consistent with a simple model where the complexity of a firm's operations increases in the number of product-destination couples exported, and where managers' role is to address some of the problems arising from increased complexity of operations.

JEL classification: F16, E24, C14, D22.
Keywords: Occupations, Hierarchical layers, Employer-employee data, Export intensive margin.

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1 Introduction

The greatest achievement of the New-New Trade Theory is to provide an elegant framework to make sense of the overperformance of trading firms relative to non-trading ones. The two main cornerstones of this literature are: (i) the existence of ex-ante productivity differentials across firms, and (ii) the presence of sunk and fixed costs of accessing and serving foreign destinations. While productivity differentials between exporters and non-exporters are documented by a vast empirical literature, the sunk and fixed costs of exporting cannot be directly observed and their existence can only be inferred by imposing some structure on a firm's export choice.[1]

Yet, the nature of these costs are still to be determined. Some evidence on the country-specific nature of sunk costs suggests that these may be related to compliance with foreign regulations, with the establishment of distribution networks (Moxnes, 2010), with the costs of achieving higher quality standards (Kugler and Verhoogen, 2012), or with specific cultural and linguistic barriers (Egger and Lassmann, 2015). An element that is common to all these explanations is that they measure the external constraints the firm is faced with when exporting. Instead, the objective of this paper is to show that the fixed cost of exporting is due to the acquisition of new internal capabilities to deal with trade expansion, e.g. technology, processes or specialized labor. Indeed, a firm may overcome some of these barriers by hiring white-collar workers to establish new dedicated teams (Bernard and Jensen, 1997; Biscourp and Kramarz, 2007; Serti *et al.*, 2010; Iodice and Tomasi, 2015), or by decentralizing decisional processes to better deal with new production, marketing and distribution problems (Marin and Verdier, 2014). In general, we expect the sunk and fixed costs of exporting to be related to a shift in employment structure toward more skilled employees and to the increasing complexity of a firm's management structure. Firm export expansion can be realized at the extensive margin through the addition of products newly exported or destinations newly reached. We will refer to the addition of a product-destination couple as export diversification. The objective of reaching new customers and increasing the scale of sales motivates this expansion, provided that the cost of export diversification is lower than its expected revenue. In this paper, we focus on the organizational changes operated within the firm associated with export diversification.

Our empirical study is based on three French administrative datasets, and it focuses on the relationship between a firm's organization and export activity, exploiting employee-level data to reconstruct the management structure of individual firms.[2] Records of exporters' individual transactions are used to measure the scope of a firm's export portfolio.

[1] Some noticeable example of the literature estimating the sunk costs of exporting are Roberts and Tybout (1997), Das *et al.* (2007).

[2] As in Caliendo *et al.* (2012) we measure the 'management structure' as the number of occupational layers that compose a firm's workforce.

In addition, balance sheet data allow us to control for other firm-level characteristics. The main result of the empirical analysis is that a firm's hierarchical organization structure, as captured by its number of occupational layers, is positively related to the scope of its export portfolio (i.e., its number of product-destination export flows). More precisely we found static evidence of an association between the number of layers in a firm and its trade status and the degree of its diversification. Additionnally, we augment these results with dynamic evidence that the likelihood of adding hierarchical layers is increased by trade expansion through the addition of product-destination couples.

Our paper relates to the literature on the relation between export behavior and firms' skill structure and to the one describing multi-product firms' strategies. The theoretical literature has investigated the hypothesis that exporters benefit from increasing returns to skills, hence they have a greater incentive to adopt more advanced technologies of production (Yeaple, 2005; Helpman *et al.*, 2010; Amiti and Davis, 2012) or to produce higher quality products (Verhoogen, 2008). Closer to our framework, Caliendo and Rossi-Hansberg (2012) focused on the change of internal labor organization required to raise productivity in order to sustain the trade cost. In their model, firms that start exporting increase the number of layers of management. The empirical relation between trade and firms' skill structure has been studied in different contexts (Bernard and Jensen, 1997; Biscourp and Kramarz, 2007; Serti *et al.*, 2010; Iodice and Tomasi, 2015). Their results point to the fact that, because exporters demand more skilled workers, this induces a rise in their wage bill, explaining the wage premium.[3] Although these studies also investigate the labor characteristics of exporters with respect to non-exporters, their aim is to explain the overall differences in wages, skills and productivity. Thus they do not consider the way these different types of workers are organized within the firm, which instead requires detailed information on firms' *distribution* of wages and skills, recently made available in matched employer-employee datasets.

In the literature on multi-product firms, a firm's range of products is determined by both demand and supply elements. Bernard *et al.* (2010) consider stochastic shocks to firm productivity and to consumer taste, Eckel and Neary (2010) distinguish between the competition and market-size effects, and Mayer *et al.* (2014) study the effect of competition and distance of the products to the core competences of the firm. Caselli *et al.* (2014) follow Eckel and Neary (2010) and Mayer *et al.* (2014) by considering the distance to the plant's core expertise which defined its productivity level. The distance to the core competences is assumed to drive the cost of adding products up. Indeed the larger scope of the newly

[3]Technological upgrading following trade liberalization has also been documented by Bustos (2011) in the case of Argentina. In turn, Verhoogen (2008); Helpman *et al.* (2010); Baumgarten (2013) have shown that the extension of trade, as a consequence of trade liberalization for instance, increases wage inequality within industries.

added products actually reduces the productivity of the firm, given its knowldege level. We generalize this framework to the addition of destinations and enlarge it to the notion of complexity. The idea is that, by adding products and destinations, the firm is more likely to encounter production, distribution or marketing 'problems' that need to be dealt with at a higher management level. Indeed, reaching a new destination demands to face new administrative rules, to prospect new distribution networks, to fit with new customers habits and in consequence calls for additional competencies. The fit with local customers' taste and habits could also lead to adjust the product changing part of its characteristics. Then differenciation-per-destination is not far from adding a new product. In parallel, when a firm augments its number of products, it also augments the need for adapting both skills and production process. Trade diversification has also a scale dimension: it is costly because the firm has to manage a higher number – a larger scope – of different products-destination, raising the diversity to deal with. Both quantitative and qualitative aspects of trade diversification increase management complexity and should impact the internal labor organisation of the firm. Finally, trade diversification may hide different changes in the firm depending on the distance of theses changes with the past "business-as-usual" in the firm. We think all changes boils down to an increase in complexity that has to be dealt with in the firm. In our theoretical framework, firms' motivation to add varieties relates to economies of scope, which imply a decrease in the firm's average cost. Additionally, in our model, the marginal cost increases with the total number of varieties. In turn, export diversification adds costs associated with the organisational changes required in order to manage increased complexity of operations.

Our work contributes to the literature in two important ways. First, we generate new evidence that relates exporters wage premium to firms'restructuring in response to increased complexity of their operations. Indeed we show that firms with a greater number of export product-destination varieties have on average a greater number of management layers, and that this result still holds after controlling for firm size (total sales). We argue that the increasing complexity that comes with greater trade diversification may constitute an important component of the sunk and fixed costs of exporting. This is especially true if large upfront investments are required for restructuring a firm's organization, and if the cost of maintaining management layers is inelastic to variations in output volume. Second, we show that trade matters for a firm's hierarchical structure not only because it expands its market size (Caliendo and Rossi-Hansberg, 2012), but also because it increases the complexity of a firm's operations. Empirically, this is suggested by some evidence that both the share of workers in upper layers and their wage gap vis-à-vis lower-layer workers increases non-homothetically with export diversification. To illustrate this intuition more formally, we present a simple model where the complexity of a firm's operations depends on the number of product-destination flows generated, and where firms can choose to add

managers to deal more efficiently with this complexity. In the model, because the number of managers is less sensitive to the quantity produced than the number of blue-collar workers, it acts as a fixed cost.

The paper is structured as follows. Section 2 presents our rich dataset which compiles several data sources. Section 3 displays the descriptive statistics which illustrate our intuition regarding the relation between trade diversification and labor organisation. Section 4 outlines a simple theoretical framework of a multiproduct firm which supports our empirical evidence. Section 5 tests and discusses the results of further hypotheses suggested by the model. Section 6 concludes.

2 Data

2.1 Datasets

Three main sources of data are required. The first one, the 'Déclaration Annuelle de Données Sociales' (DADS), gathers compulsory information provided by firms each year to the social administration about their employees. Each observation corresponds to a combination of a worker and an establishment, both with a unique identifier. The variables of interest are the workers' gross wage, number of hours worked, type of contract (mainly used for data cleaning purposes) and occupational category (PCS, 'Professions et Catégories Socioprofessionnelles', 2003) at the 4-digit level. The second dataset gathers balance-sheet and performance variables per firm (FARE). Both DADS and FARE are provided by the French National Institute of Statistics (INSEE) and cover the universality of French firms, with the exception of firms with no employees, or belonging to the agricultural or banking and financing sectors. The third dataset is provided by the French customs administration (Custom-DGDDI) and records all flows of imports and exports by product, destination and firm. Such "customs dataset" reports, at the product-firm level, the quantity (in Kg), the country of destination, the product category (CN8), and the value of the export flow. This dataset allows us to trace more precisely firms' performance in foreign markets (i.e., their portfolio of exported products, their prices proxied by their unit-values, patterns of entry and exit to/from foreign markets, and variations in exported value over time).

All three datasets can be matched by using the firm identifier (SIREN) into a longitudinal dataset covering the period 2009-2013. Note that we restrict our analysis to the manufacturing sectors (NACE rev.2 sectors 10-33) to provide results comparable with the existing literature.[4] Finally we end up with two samples of firm-level data: the larger

[4]In a second stage, we will check whether our results stand when we enlarge sectors to tradable sectors defined as the sectors which are registered by the customs administration. The tradable sector is identified through a data-driven approach (instead of an assumption-based approach as in Moretti, 2010). Indeed, we

Table 1: Observations description across samples, after cleaning, manufacturing sector.

Year	DADS & FARE (sample 1)			sample 1 & Customs (sample 2)
	All	Non-exporters	Exporters	Exporters
2009	126,305	88,599	37,706	24,494
2010	120,249	83,869	36,380	23,944
2011	117,112	83,108	34,004	22,322
2012	115,031	81,497	33,534	22,182
2013	112,843	79,909	32,934	21,955
Total nb. obs.	591,540	416,982	174,558	114,897
Total nb. firms	162,768	130,253	57,602	35,223

sample includes all manufacturing firms present in FARE and DADS (sample 1); when we focus on exporters only we use a smaller subset of these firms which are also present in the Customs dataset (sample 2). Table 1 gives the description of the population in these two samples.

2.2 Construction of variables

Our aim is to assess the structure of firms' labor organization, based on the available information about employees' occupational category, following Caliendo *et al.* (2015). Each employee in the DADS database is assigned a "hierarchical layer" based on the first digit of his occupational category. Coherently with the definition of Caliendo *et al.* (2015), we identify four possible layers from the bottom of the hierarchy (layer 1) to the top (layer 4). The first layer corresponds to clerks and production workers (blue collar workers); layer 2 corresponds to intermediate professions and technicians (supervisors); layer 3 corresponds to white collars (executives or senior staff) and layer 4 is the top management (CEOs, directors). We drop firms which do not have the first layer of occupations (which amount to 9% of observations), as we expect that manufacturing firms should have clerks or production workers. Starting from the DADS employee database, we then construct firm-level variables (e.g. the number of employees in each layer, or the average hourly wage per layer) by aggregating the information over each firm-SIREN. We then merge such variables with the FARE and Customs dataset at the firm level.

We have two sources of information regarding exporters, with different sample size

keep the sectors which represent a significant number of observations in the CUSTOMS dataset (i.e. more than 100 firm-year observations). As a consequence, the tradable sector is composed of Manufacturing (sector C in the NACE classification), Trade, Information and communication (J) and M (specialized and scientific services, e.g R&D, accounting). Note that contrary to the assumption-based approach, we keep some service sectors.

and variables. The FARE dataset registers the total value of exports for all firms, with no legal obligation. Instead, firms are legally bound to provide the customs institution information about their trade flows (by product and destination) above a specified value threshold.[5] For this reason, we define as exporters those firms declaring export sales to the custom administration, or firms declaring in the FARE dataset export sales below the binding declaration threshold.[6] In others words, the export status is taken from the Customs dataset if firms declare export revenues above the threshold, else it is associated with the information from the FARE dataset.

3 Empirics about labor organization and export behavior

Starting from the model of Caliendo and Rossi-Hansberg (2012), Caliendo *et al.* (2015) brought a large amount of empirical evidence on production hierarchies. Focusing on the case of French manufacturing firms over the period 2002-2007, they find support to the theoretical model by Caliendo and Rossi-Hansberg (2012): firms' important growth events are associated with an increase in their number of hierarchical layers. Following a pyramidal firm structure, growth in number of employees in the existing layers requires to strengthen the hierarchy at the firm level, e.g. by assigning new managerial positions.

Although our data are coming from the same source, we cover a more recent period. After checking that the results by Caliendo *et al.* (2015) are also validated in our data, we bring additional evidence regarding the organizational structure of *exporting firms*. Our focus is put on exporters' trade diversification in terms of products and destinations and its impact on changes in the organization of their labor force not only by observing the change in the stratification of hierarchical layers but also by looking at the share of managers relative to workers.

3.1 Firm characteristics and hierarchical structure

We describe below how the firms in our sample are distributed according to the structure of their hierarchical layers, by aggregating over firms' employee characteristics. The presence of a layer within a firm is defined by at least one employee belonging to the corresponding occupation level. We observe heterogeneity across firms along two dimensions: their total number of layers (as described in Table 2) and the structure of layers i.e. the pattern of the 1 to 4 layers in a firm (as described in Table 3). About the former, we observe that if most firms have only a layer of "blue collars" (1-layer),[7] 8.24% have a complete set of hierarchical

[5] Indeed, export sales within the European Union need to be declared only if the yearly firm export sales are above €460,000 for years 2011 and 2012, and €150,000 before 2011.

[6] Note that we also find exporters in FARE that we do not retrieve in the Customs data irrespective of the threshold.

[7] Note that in our cleaned sample all firms have at least one layer constrained to be the lowest one.

layers (4-layers) in our sample. The 1-layer firms are predominantly observed in the food sector ("Manufacture of food products", NAF rev.2 sector 10, 57.5%) while the highest number of 4-layer firms is observed in the metal industry ("Manufacture of fabricated metal products, except machinery and equipment", NAF rev.2 sector 25, 18.61%). Table 2 also shows that the distribution of firms conditional on their number of layers differs for exporting firms : most of exporters have 3 or 4 layers. Thus the hierarchical structure of exporting firms seems to be more elaborated than the one of non-exporting firms.

Table 2: Number of firm-observations by number of layers, 2009-2013, sample 1.

# Layers	All firms		Exporters	
	# Obs	%	# Obs	%
1-layer firms	291,663	49.31	30,360	17.39
2-layer firms	135,703	22.94	38,335	21.96
3-layer firms	115,437	19.51	68,617	39.31
4-layer firms	48,737	8.24	37,246	21.34
Total	591,540	100	174,558	100

Table 3 informs us, conditional on firms' total number of layers, how these are associated. We focus here on the 2-layer and 3-layer types because other types (1 and 4 layers) are obvious in their structure. Following a pyramidal model, employees in 1-layer firms fall in the lowest occupational category. We expect that additional layers would be added in a sequential manner. Although the pyramidal structure is dominant in our sample (for example it corresponds to 58% of 2-layer firms and 76% of 3-layer ones), other patterns are also quite frequent. In particular, the top-layer is often present without the preceding layers. This could indeed depend on the type of skills the top-management needs. The only pattern at odds with the pyramidal structure is the last pattern displayed in Table 3 (layers 1;3;4). It is found in 7% of the cases.

Table 3: Structure of layers, 2009-2013 (consecutive layers in bold).

# Layers	Layer 1	Layer 2	Layer 3	Layer 4	Share of cases (%)
2-layer firms	X	X			**58.13**
	X		X		20.37
	X			X	21.50
	Total				100
3-layer firms	X	X	X		**75.92**
	X	X		X	16.86
	X		X	X	7.22
	Total				100

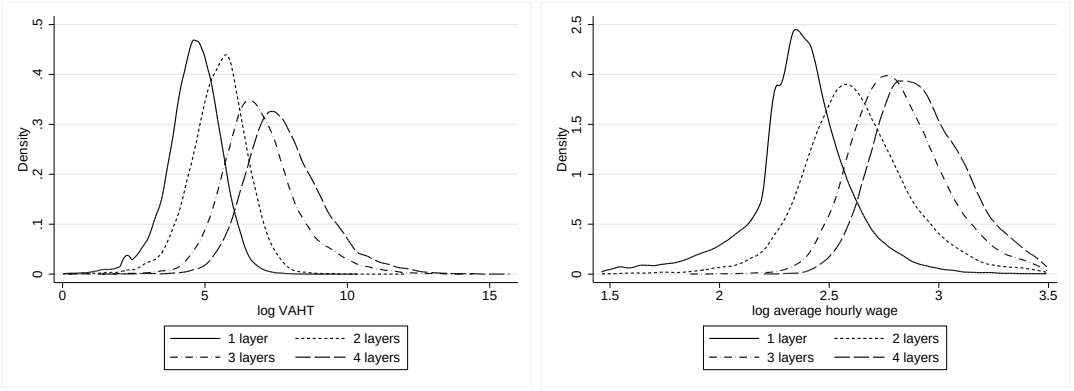
Table 4 displays firm characteristics conditional on their number of layers. Not surprisingly, firms with a higher number of layers are larger and this, considering different size proxies. They also have a higher probability to export, and conditional on exporting, have a higher export intensity. Relatedly, and given the well-known size-wage and export-wage premia, we also find a positive correlation between the number of layers and mean hourly wage. Figure 1 complements such information by providing the distribution of value added and hourly wage by firm number of layers. We can clearly observe the shift of both the size and the hourly wage distributions when increasing the number of layers. These descriptive results are in line with those of Caliendo *et al.* (2015). Interestingly, we also observe (Figure 1) the overlapping of the distributions which means that neither size nor hourly wage strictly determine the hierarchical structure of the firm. In order to disentangle the role of size and export behavior in explaining the number of layers per firm, we redo the analysis by size class (based on firms' number of employees). Results shown in Table 19 in the appendix confirm the positive correlation between export propensity, export intensity as well as hourly wage with the number of hierarchical layers in a firm, whichever the size class it belongs. We summarize this first set of results as follows:

Empirical fact 1 *The organisational structure of exporting firms is more complex than that of non-exporting firms, as they present a higher number of hierarchical layers on average.*

Table 4: Mean characteristics of firms by number of layers, 2009-2013, sample 1.
(value added, wages and sales are deflated at the 2-digit level.)

# Layers	Firm size proxies			Export performance		Labor charact.
	Nb. employees	Value added	Sales	Exp. propensity	Exp. intensity	Hourly wage
1-layer	5.4	138.0	321.8	0.10	0.13	10.4
2-layers	10.5	348.3	1,018.4	0.28	0.12	13.6
3-layers	63.6	2,866.5	11,450.4	0.59	0.19	16.3
4-layers	141.9	7,734.2	29,296.3	0.76	0.24	17.8

Figure 1: Distribution of value added (left) and mean hourly wage (right) per number of layers, 2013, manufacturing firms.



3.2 Employee characteristics per layer, and export status

As a second exercise, pooling together all employees, we look at the characteristics of workers in each occupational layer. Considering that non-exporting firms are the degree zero of trade diversification (only one destination market), we are interested in measuring whether the distribution of wages is affected by the export status of the firm.

We first describe in Table 5 how employees are distributed across the four layers for the year 2013. The table also shows the average wage in relation to employees' hierarchical position and the export status of their employer. We observe a pyramidal distribution of number of workers, with almost 10 times as many individuals pertaining to layer 1 as they do in layer 4. Instead, the hourly wage displays the opposite pattern. Thus the upper layers consist of a smaller number of employees who are paid higher hourly wages. Note also that the wage variance is much more important in upper layers of the hierarchy. Besides differences at the mean, such ordering of wages according to layers is found at all locations of the wage distribution.

Table 5: Number of employees in each layer, 2013, sample 1.

	Layer 1 Blue Collar-clerks	Layer 2 Supervisors	Layer 3 Senior Staff	Layer 4 CEO-directors	All
All employees	2,231,505	647,919	491,291	23,584	3,394,299
– in exp	1,563,673	547,181	459,913	13,654	2,603,421
– in non exp.	667,832	81,738	31,378	9,930	790,878

Notes: Sample 1 with all employees. Wage figures are given in 2013 euros.

Table 6 provides additional evidence that firms' export status is associated with a diverging hierarchical structure which is not solely explained by the size premium of exporters (exporting firms are larger and therefore, automatically, have a higher number

of layers). Exporting firms have a lower number of production workers and clerks and instead a higher share of middle-management. Thus the supervision rate (that is, the staff-to-worker ratio) is higher in exporting firms. Additionnally we compute the share of occupations per layer. Remind that we have the information about the occupation of each employee in a firm, which allows us to compute the layer information. Then the distribution of occupations in each layer gives an idea of the variety of jobs within layer. Following the number of employees, the share of occupations is bigger in the second and third layers of management.

Table 6: Workforce composition by export status, 2009-2013.

Layers	Layer 1	Layer 2	Layer 3	Layer 4	# Obs.
Share nb. employees					
Non-exporters	0.65	0.19	0.11	0.06	11,491
Exporters	0.63	0.20	0.14	0.04	37,246
t-test	***	***	***	***	
Share nb. occupations					
Non-exporters	0.52	0.21	0.17	0.10	11,491
Exporters	0.48	0.24	0.22	0.06	37,246
t-test	***	***	***	***	

Notes: Manufacturing firms, sample 1, 2009-2013, subsample of 4-layers firms.

Empirical fact 2 *Exporting is associated with a higher share of workers and occupations in the second and third layers of management. Thus the ratio of managers relative to workers is larger in exporting firms.*

By splitting our sample of individuals across exporting and non-exporting firms, we find that irrespective of the layer, employees in exporting firms are paid higher wages, in line with the literature on the average wage export premium.

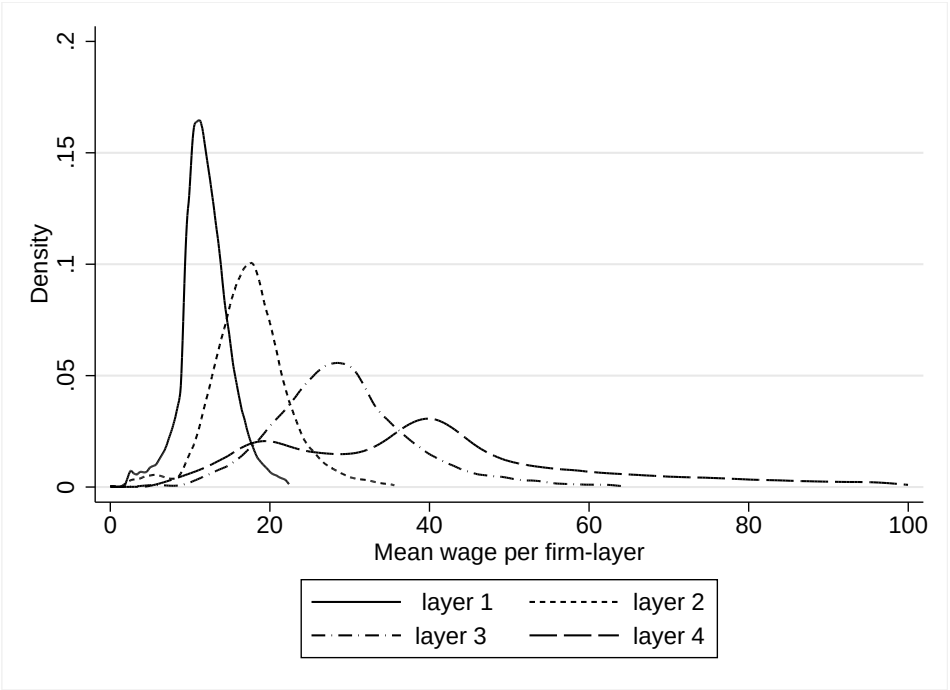
As expected, the range of wages increases with the hierarchical layer : upper layers have a more dispersed distribution as shown by the values of the interquartile range in parenthesis. But given that, exporting firms display a more dispersed distribution of their wage whichever the hierarchical layer. Figure 2 shows the kernel density distribution of hourly wages per layer to which the employee belongs. It provides a straightforward image of previous statistics. First, the higher the layer, the higher the wage. Second, the higher the layer, the more dispersed the distribution of wages in the layer is. Note that the distribution of wages in layer 4 is bimodal. Further tests show that this is explained by firm size: the first mode is associated to the wages of very small firms' owners (i.e. below 10 employees); the second mode to top-management in larger firms.

Table 7: Distribution of average hourly wage per layer, 2013, sample 1.

	Layer 1 Blue Collar-clerks	Layer 2 Supervisors	Layer 3 Senior Staff	Layer 4 CEO-directors	All
Wage per hour worked					
Mean all employees	14.6 (5.2)	21.0 (7.9)	35.5 (11.8)	48.8 (26.9)	19.1 (10.0)
– in exp.	15.8 (5.5)	21.7 (7.9)	35.3 (11.7)	55.9 (29.9)	20.7 (10.7)
– in non exp.	12.4 (3.5)	17.7 (6.5)	28.8 (10.7)	32.1 (21)	13.8 (4.6)
p1	2.4	3.7	7.7	9.6	2.5
p25	11.4	16.1	26.1	25.3	12.2
p50	13.6	19.7	31.2	38.8	15.7
p75	16.6	24.1	37.8	52.2	21.9
p99	35.4	49.4	98.5	173.7	65.1
Wage ratio: Wage Layer l **/ Wage Layer** 4					
Non-exporters	0.25	0.35	0.56	1	
Exporters	0.32	0.43	0.67	1	
t-test	***	***	***	***	

Notes: Sample 1 with all employees. Wage figures are given in 2013 euros.
Interquartile range is given in parenthesis.

Figure 2: Wage distribution per layer, 2013, all firms



Firms with a more complex structure – as exporters – are likely to exhibit a higher dispersion of their wages because wages are more dispersed in upper layers. In consequence, exporters' distribution of wages should be more dispersed because of their more complex organisation. In fact, differentiating the distribution of hourly wage per layer on export status shows a systematic difference between exporters and non exporters. Then it appears, additionally, that within each layer, unconditional on the total number of layers of the firm, exporters have, on average, a more dispersed distribution of wages, hence more wage inequality, per layer. It leads to state an additional empirical fact.

Empirical fact 3 *Within-firm wage dispersion – wage inequality – is more pronounced among exporters relative to non-exporters.*

3.3 Number of products, destinations and layers

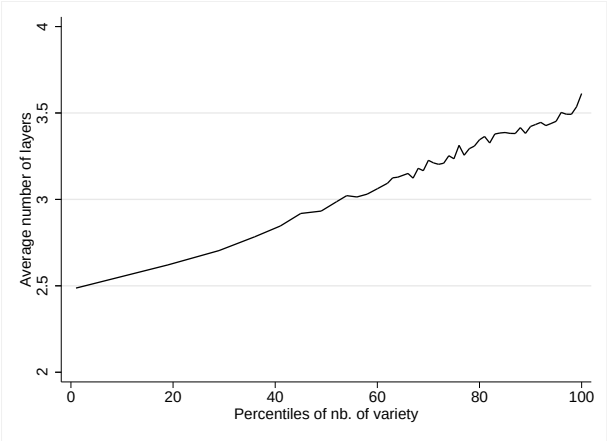
In a next step, we measure more precisely the *diversification intensity* of exporters, with the aim of linking the cost of diversification to firms' labor organization. Indeed, two exporting firms with similar overall export sales would differ in their diversification intensity if they serve a different number of product-destination couples, which we label as *varieties*. Thus the number of export varieties delivers information about a firm's structure of export sales, irrespectively of its export intensity. A firm which sells one product (defined at the 8-digit level) to two different destinations exports two varieties. By using export data coming from the French customs (referring to our sample 2), we compute the total number of product-destination couples (i.e. varieties) a firm exports.[8]

The number of varieties per firm ranges from 1 to 17455, with 50% of exporters shipping less than 7 varieties and 95% less than 163.[9] To complement the information about the number of varieties, we compute a Herfindahl-Hirschmann Index (HHI) at the level of the firm to appreciate the reality of the product or destination diversity in terms of exported value. For instance, a firm that exports toward two destinations such as it splits its export value in two equal shares is more destination-diversified than a firm which exports 98% of its sales in a destination A and 2% in destination B. Identically, a firm that exports two different products in equal shares is more product-diversified than a firm which export 98% of its total export in the first product and only 2% of its export in the second product. The

[8] In order to check that our results are not solely driven by the characteristics of the product or of the destination portfolio, we also run our analyses, shown in the appendix, using as diversification measure firms' total number of exported products or destinations.

[9] The number of products per firm ranges from 1 to 835, with 50% of exporters shipping less than 4 products and 95% less than 45. The number of destination per firm ranges from 1 to 168, with 50% of exporters shipping to less than 4 destinations and 95% less than 42 destinations. We also group the destinations by geographical area. Geographical areas are: Europe, Africa, Asia, North-America, Central and South America, Middle-East, Oceania and Others. The number of areas per firm ranges from 1 to 8, with 50% of exporters shipping to less than 2 areas and 95% less than 7 areas.

Figure 3: Average number of layers per percentile of number of varieties



higher the HHI, the lower the diversification (either in terms of product or destination). By construction, the HHI ranges between 0 and 1. We then cross the information on product and destination numbers with the information on the number of layers. We expect that a larger number of products or of destinations is positively correlated with a demand in complex management. It follows that we should find a positive correlation between the number of layers and the number of products/destinations. In other words, a more diversified exporting firm should have a higher number of layers.

After ranking firms per percentile of number of varieties, we compute the average number of layers in each group of firms. Figure 3 illustrates the clear positive relationship among exporters between the number of layers and the degree of diversification. This is confirmed by considering products and destinations separately in Figure 5 in the appendix.

Table 8 confirms that a firm with a more complex organization exports more products and ships to more different destinations. As expected, all indicators of diversification are positively correlated with the number of layers. Moreover, the HHI in terms of products or destinations both decrease with the number of layers (recalling that a high HHI value is a signal of weak diversification). This evidence confirms our intuition that a more diversified firm – which really splits its production and shipment over several product-destination couples in equal weights – needs a higher number of layers. Finally, we also show that the positive relation between exporters' number of destinations, products and varieties and their number of layers remains after controlling for the firm size class (see Table 20 in the appendix).

Empirical fact 4 *Among exporters, the number of hierarchical layers is associated with trade diversification.*

As a further step, we group exporting firms per quartile of number of varieties. Table

Table 8: Average firms export diversification indicators by number of layers

	Mean Value of:					
# Layers	# Prod.	# Dest.	# Variety.	# Area.	HHI prod.	HHI dest.
1-layer firms	2.90	2.49	4.68	1.52	0.76	0.82
2-layer firms	4.30	3.80	8.43	1.80	0.72	0.75
3-layer firms	11.62	10.89	41.03	2.81	0.63	0.56
4-layer firms	18.32	16.16	75.27	3.44	0.58	0.47

Notes: Manufacturing firms, sample 2, 2009-2013.

9 shows that the average number of layers increases with the quartiles. By looking more precisely at what drives such differences, we compute the share of firms with a layer 2, 3 or 4 in each quartile. We find that the difference is mostly explained by an increase in the presence of the second and third layers. The last column of Table 9 presents the ratio of the number of managers versus workers. This statistic also increases with the number of varieties a firm exports, indicating that such diversification is associated with a modification of its internal labor organization.

Table 9: Quartiles of number of varieties and hierarchical structure, 2009-2013, sample 2.

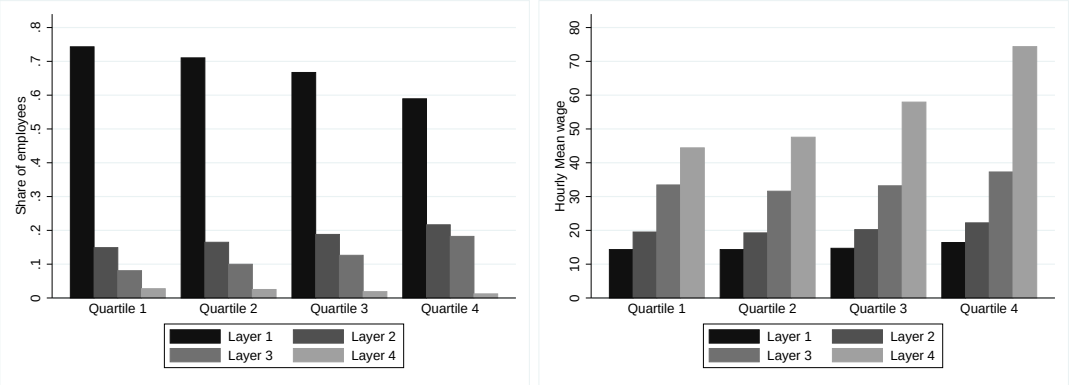
		Share of firms with:			
	# layers	layer 2	layer 3	layer 4	Ratio
Q1 # varieties	2.52	0.66	0.56	0.28	0.11
Q2 # varieties	2.80	0.78	0.69	0.33	0.12
Q3 # varieties	3.10	0.89	0.83	0.38	0.14
Q4 # varieties	3.40	0.97	0.95	0.49	0.18

Notes: Manufacturing firms, sample 2, 2009-2013.

The variable "Ratio" computes the ratio of the number of employees in layers 3 and 4 and the number of employeesin layers 1 and 2.

Using the same groupings of firms per quartile of the number of varieties, Figure 4 (left) represents the share of employees in each layer within each firm. The share of employees in layer 1 decreases with the quartile, while the shares in layers 2 and 3 increase with the quartiles. Interestingly, the share of employees in layer 4 decreases with the quartile going from 2.6% in quartile 1 to 1.2% in quartile 4. This is explained by the fact that the number of top managers does not increase with firm expansion, as also assumed in the model by Caliendo and Rossi-Hansberg (2012). Overall, we find that the diversification process implies a flattening of the distribution of employees into layers: the weights of employees per layer converge when firms are more diversified.

Figure 4: Share of employees (left) and average hourly wage (right) in each layer per quartile of number of varieties.



Besides differences in the employment structure shown above, we evaluate differences in the average wage per layer. We can expect that a more diversified firm will raise its average wage as shown by the literature on wage and productivity export premia. Still, we are interested in defining whether the firm does so at all levels of the hierarchical structure, or, as implied by the theoretical framework of Caliendo and Rossi-Hansberg (2012), do we observe differences in average wage per layer? Figure 4 (right) reveals that a higher diversification in terms of products and destinations is associated with a higher hourly wage, but only in the case of the highest layer (i.e. layer 4). In the lower layers, the hourly wage rise with the quartile is less sharp.[10] This means here, that contrary to the employee structure which flattens with firm export diversification, the distribution of wages is broadening when firms are more diversified. It suggests that the source of trade-inequality nexus takes its roots in layer 4.

Empirical fact 5 *Firms in the upper quartiles of varieties are more likely to be of a 4-layer type. Relative to firms in lower quartiles of varieties, they have a more compact structure of layers (i.e. a higher ratio of managers relative to blue-collar workers) and a more dispersed distribution of wages.*

The next section proposes a theoretical framework which links multiproduct firms' labor organisation with their trade diversification decisions.

[10]These results closely mirror the evolution of the wage structure of exporting firms at different quartiles in terms of destinations, see Fig. 7 in the appendix. For products, only the wage in the fourth layer, in the fourth quartile is significantly higher than the rest. Thus the diversification in terms of number of products or destinations has a differentiated impact on wages.

4 Model

Our aim is to assess the impact of an increase in trade diversification on the labor organization of the firm. We define export diversification as the addition of a new product-destination couple to the firm portfolio of products and destinations. Export diversification is very close to an increase in export performance but may be different in terms of organization than just a rise in the export intensive margin.

Mayer *et al.* (2014) have modeled how a firm's range of exported products is affected by competition across market destinations. They find that firms react to increased competition by focusing on their "core", best performing products. This evidence indicates that the product mix and destination portfolio of exporters are not independent but coevolve. We augment the model by Mayer *et al.* (2014) with the hindsights from Caliendo and Rossi-Hansberg (2012) on the relation between market expansion and firm reorganization and from Ottaviano and Thisse (1999) to model the firm's revenue side. Caliendo and Rossi-Hansberg (2012) propose a model of the organization of knowledge and labor within a firm in response to an exogenous demand for differentiated products. The organization of knowledge and labor consists of deciding the number of managers to solve problems encountered by the employees of the firm. Contrary to Caliendo and Rossi-Hansberg (2012), we model only two layers of employees: workers and managers. Given an exogenous distribution of problems faced by the firm, its productivity level depends on the number of hierarchical layers of managers it decides to set.

In what follows, we describe the demand (section 4.1) and the supply sides (section 4.2) of the model. The predictions of our theoretical framework will then be tested in our empirical analysis (section 5 below).

4.1 The demand side

We model the demand as in Mayer *et al.* (2014). The utility function of an individual consumer c depends on the consumption of a numeraire good q_0^c and on the consumption of differentiated products q_i^c distributed over a continuum Ω:

$$U = q_0^c + \alpha \int_{i\in\Omega} q_i^c di - \frac{1}{2}\gamma \int_{i\in\Omega} (q_i^c)^2 di - \frac{1}{2}\eta \left(\int_{i\in\Omega} q_i^c \right)^2 di \tag{1}$$

where the demand parameters α, γ and η are all positive. The larger is γ, the greater is consumers' love for variety, and the faster their utility increases when they smooth consumption over varieties in Ω. The parameter η determines the degree to which the aggregate consumption of all varieties reduces the marginal utility from the consumption of individual varieties. This utility function generates the following inverse demand for individual varieties:

$$p_i = \alpha - \gamma q_i^c - \eta Q^c \tag{2}$$

where p_i is the price of variety i and Q^c is the consumer's aggregate consumption of all differentiated varieties. By inverting (2) we obtain the following linear demand:

$$q_i \equiv Lq_i^c = \frac{\alpha L}{\eta N + \gamma} - \frac{L}{\gamma} p_i + \frac{\eta N}{\eta N + \gamma} \frac{L}{\gamma} \bar{p} \tag{3}$$

where q_i is the aggregate consumption of variety i across L consumers in the market. N is the number of differentiated varieties in that market, and $\bar{p} = \frac{1}{N} \int_{i \in \Omega^*} p_i di$ is the average price for differentiated goods. Ω^* is the subset of varieties in the market whose price p_i is low enough not to drive demand in eq. (3) to 0. Notice that only varieties with price $p_i < p^{MAX}$, where $p^{MAX} \equiv \frac{1}{\eta N + \gamma}(\gamma \alpha + \eta N \bar{p})$, have positive demand.

4.2 The supply side

We model the product portfolio of a firm as a set of product-destination couples $\Theta = [1, \ldots, \theta]$ where elements are indexed by a continuous series of integers increasing in the cost of producing each variety. By assuming that it is easier for the firm to operate in the domestic market, a firm which sells only on the domestic market has a narrower set of product-destination couples. An exporter has at least two product-destination items: one product and two destinations (domestic and foreign). The last element of the set Θ represents the product-destination with the highest cost of production for the firm. The same product exported to different markets may have different positions in Θ, reflecting adjustment costs to meet destination-specific tastes.[11] This model also includes economies of scope through a fixed cost G which drives the decision on the product range. More precisely, the product range is the firms' number of varieties, θ, which is also the level of diversification and product-complexity of the firm.

We assume that exporters follow a pecking order when adding new product-destination couples to their portfolio: they initially export the 'easy' product-destinations and later on they add more difficult items to their portfolio.[12] This assumption allows us to relate an exporters' optimal managerial structure to the most difficult product exported θ. In addition to the fixed cost G we model the cost associated with the difficulty of producing additional varieties. In what follows, we model a representative firm j and we drop the exponent j to lighten the presentation. Note however that variables are firm-specific.

Each production possibility is associated with a random level of difficulty. Therefore the blue-collar worker must solve each problem in order to deliver one unit of output. The probability that a worker solves the problem is described by the function:

$$F(z, \theta) = 1 - e^{-(\frac{1}{\theta})z} \tag{4}$$

[11] The cost side of this section is based on Mayer *et al.* (2014) with the hindsights from Caliendo and Rossi-Hansberg (2012). The revenue side is based on the framework from Ottaviano and Thisse (1999).

[12] This assumption is supported by empirical evidence on Mexican multi-product exporters provided by Iacovone and Javorcik (2010).

where z is the skill level of each blue-collar worker. If the skill of the firm's worker increases, the probability to encounter an unsolved problem decreases. As the firm extends its export portfolio toward more difficult product-destination items (i.e, larger θ), the last item exported generates more difficult problems to solve. This is reflected by the fact that $F(z,\theta)$ decreases in θ. A greater number of unsolved problems determines a greater number of wasted production possibilities, and a larger marginal cost.

Let's assume that the firm can hire a number of managers n_m that are more skilled than workers such that $z_m > z$. With an additional organization layer, the problems unsolved by the blue-collar workers can be passed on to at least one manager in each firm, who would use h units of time to solve the problem. Thus z_m determines the production constraint at the firm level:

$$n_w A(1 - e^{-(\frac{1}{\theta})z_m}) > q^j \tag{5}$$

where A is the firm-specific average productivity that is common across all products produced by the firm. More specifically, A is the average number of 'production possibilities' generated by a worker of the firm in one unit of time. q is the total production of the firm. If z_m is high then the quantity, q, that can be produced is higher for a given number of workers, n_w.

If the reception of the problem costs h units of a manager's time, the firm needs at least n_m managers to deal with the expected number of problems that cannot be dealt with directly by workers:

$$n_m = (h)(n_w)e^{-(\frac{1}{\theta})z} \tag{6}$$

The need of managers to face the problems unsolved, which increases with the number of varieties, is stronger when the firm diversifies. This leads to:

Lemme 1 *The need for managers increases with the number of varieties produced by the firm for a given skill, z, of workers.*

Moreover the manager-to-worker ratio then increases in the number of product-destinations m and decreases with z:

$$\frac{\partial(n_m/n_w)}{\partial\theta} = \frac{z}{\theta^2}(h)e^{-(\frac{1}{\theta})z} > 0 \tag{7}$$

$$\frac{\partial(n_m/n_w)}{\partial z} = \frac{-1}{\theta}(h)e^{-(\frac{1}{\theta})z} < 0 \tag{8}$$

'Difficult' product-destinations generate a greater number of production-distribution problems that are beyond workers' skills, implying a higher manager-to-worker ratio.[13]

[13]Note that this result is independent of the size or scale of the firm for a given θ.

This result can be formulated as follows:

Proposition 1 *The number of managers relative to workers is increasing with the scope of a firm's export portfolio θ, and decreasing with the skill level of the workers z.*

This proposition is in line with our empirical fact number 2, supported by the evidence presented in Table 6 and Figure 4 (left) in the previous section.

4.3 The cost function

Production uses labor as the only variable factor of production. The variable cost function is then:

$$C(\theta, A, z) = n_w\omega + n_m k\omega \tag{9}$$

where ω is the unit-cost of labor for a skill level of workers z. We also suppose that the cost of the skill of workers, z is embedded in their wage, ω, which leads to understand k as the cost premium of managers relative to workers.

The cost minimization in order to choose n_w is subject to two constraints, (6) and (5), and gives rise to the marginal cost of producing and exporting varieties up to item θ (see Proof in the Appendix) :

$$\upsilon(\theta, A, z) = \phi = \frac{\omega}{A(1 - e^{-\frac{z_m}{\theta}})} \tag{10}$$

$$\upsilon(\theta, A, z) = \phi = \omega\left(A - Ae^{-\frac{z_m}{\theta}}\right)^{-1} \tag{11}$$

In contrast to (4), the relevant skill parameter at the numerator of (11) is the managers' skill level z_m. This reflects the fact that when workers are assisted by managers, any problem unsolved by workers can be passed through the organization structure up to the upper layer. It is also important to notice that the marginal cost is associated with the total amount of production at the firm level, q.

(12) below shows that the marginal cost is increasing with θ and decreases with the managers' skill z_m.

$$\frac{\partial \upsilon(\theta, A, z)}{\partial \theta} = \omega\left(A - Ae^{-\frac{z_m}{\theta}}\right)^{-2}\left(\frac{z_m}{\theta^2}\right)Ae^{-\frac{z_m}{\theta}} > 0 \tag{12}$$

4.4 The optimal production level

In our setting, domestic producers choose to produce a single variety ($\theta = 1$) because they do not benefit from economies of scope. Then, the profit function of domestic producers

is $\pi(A,z) = \frac{L}{4\gamma}\left\{v_D - \frac{\omega}{A(1-e^{-\frac{z_m}{\theta}})}\right\}^2$. Instead, when $\theta > 1$, the firm is no longer a single-variety type. Production requires to pay a fixed entry cost to enter the foreign market, G, regardless of the number of varieties, inducing that firms benefit from economies of scope. Following Ottaviano and Thisse (1999), multi-product firms face an aggregate demand for several varieties, where q_i corresponds to the demand for each variety. Thus firm j is facing $q = \int_{i\in\Theta_j} q_i di$ where Θ_j is the set of varieties which a firm j produces and $\Theta_j \in \Omega^*$. Then, θ_j is the number of varieties in this set.

Compared to single-product firms, multi-product firms interact with each other through their decision regarding the scope of their varieties relative to the market. The total number of varieties Ω^* is distributed among J firms facing an identical entry cost G in addition to their labor cost depending on managers skill as in (18).

The profit function for multi-product firms is then:

$$\pi(m,A,z) = \int_{i\in\Theta_j} p_i q_i di - n_w\omega - n_m\omega k - G \tag{13}$$

We suppose that p_i is given to the firm and firms choose to produce a certain number of varieties determining its market share over Ω^*. We first do not consider any impact on price, because the set of varieties is large enough to prevent any firm, clustering a subset of varieties, to affect the market average price.

From (14), we have:

$$p_i = \frac{\alpha\gamma}{\eta N+\gamma} - \frac{\gamma}{L}q_i + \frac{\eta N}{\eta N+\gamma}\bar{p} = p_{max} - \frac{\gamma}{L}q_i \tag{14}$$

Then, introducing (14) in (13)

$$\pi(\theta,A,z) = \int_{i\in\Theta}\left(p_{max} - \frac{\gamma}{L}q_i\right)q_i di - n_w\omega - n_m\omega k - G \tag{15}$$

$$\pi(\theta,A,z) = p_{max}\int_{i\in\Theta} q_i di - \frac{\gamma}{L}\int_{i\in\Theta} q_i^2 di - n_w\omega - n_m\omega k - G \tag{16}$$

Maximizing the profit function relative to q we get the optimal quantity.

$$q^* = \frac{\theta L}{2\gamma}\left[p_{max} - \frac{\omega}{A\left(1-e^{-\frac{z_m}{\theta}}\right)}\right] \tag{17}$$

It shows that the size of the firm is increasing with θ and also with the manager skill z_m. As expected, size increases with productivity and with the size of the market L.

Proposition 2 *The optimal size increases with trade diversification. It also increases with the managers skill.*

The optimal level of θ is going to be determined by the manager skill z_m which the firm picks from a distribution of managers skill Z. This will create productivity heterogeneity which will determine the firm ability to trade diversify. At the equilibrium, this distribution Z drives the total number of varieties and finally the competitiveness of the country and its world market share.

In conclusion, the model provides supports to previous empirical findings. It explains that labor organisation is associated with trade diversification because the latter implies additional problems to deal with. It displays a clear trade-off between the scale effect which motivates the addition of varieties and the organisational cost which implies a higher manager-to-worker ratio. This trade-off is affected by the cost of managers and by their skill relative to workers. Although dynamics are not directly studied, the model provides insights regarding the change in labor organisation in response to the decision to increase trade diversification. Indeed we expect than the complexity of labor organization and the manager-to-worker ratio are explained by trade diversification. We would also expect that a change in the number of hierarchical layers is associated with a change in trade diversification and specifically that the probability to add a layer of managers is more frequent when firms add new varieties to their portfolio. In the next section, we present some econometric tests of the dynamics suggested by the model.

5 Does trade diversification explain labor organisation?

5.1 Explaining the number of hierarchical layers

We run a series of cross-section and panel OLS regressions to measure the effect of export behavior and export diversification on firms' number of layers while controlling for other factors in Tables 10-11. Specifications vary with respect to the control for firm size. We use the log of the number of employees, the log of total sales and the log of value added alternatively. We also include 2-digit sector dummies, time dummies and we cluster the errors at the firm level.

For the year 2013 (Table 10), we find that the positive effects of export status (columns 1-3) and, among exporters, of their number of export varieties (columns 4-6) on the number of layers remain highly significant after including these controls. The choice of the size indicator does not change the 'layer-premium' induced by the export status or by the firm's trade diversification level. We conclude that, at the cross-sectional level, export behavior is a determinant of internal labor organization.

Then, pooling all years and computing a panel regression, we obtain similar results (Table 11). The coefficients are weaker given that we additionally account for firm fixed-effects.

Alternatively, we run a multinomial logit in which the dependent variable is the prob-

Table 10: Cross-section on the determinants of the number of layers, 2013.

2-digit sector dummies are included in all specifications. Stars indicate coefficients significant at the 1% (***), 5% (**) and 10% (*) level.

	dep var: # Layers					
	(1)	(2)	(3)	(4)	(5)	(6)
Export propensity	0.327***	0.340***	0.326***			
Log Nb. Varieties				0.031***	0.047***	0.038***
Log Nb. Employees	0.417***			0.349***		
Log Total sales		0.288***			0.277***	
Log Value added			0.361***			0.315***
R2	0.598	0.518	0.552	0.390	0.348	0.374
Nb. Observations	112,843	100,496	97,708	21,955	16,417	16,055

Table 11: Panel regression on the determinants of the number of layers, 2009-2013.

Firm fixed effects, 2-digit sector and time dummies are included in all specifications. Stars indicate coefficients significant at the 1% (***), 5% (**) and 10% (*) level.

	dep var: # Layers					
	(1)	(2)	(3)	(4)	(5)	(6)
Export propensity	0.008***	0.009***	0.009***			
Log Nb. Varieties				-0.002	0.011***	0.011***
Log Nb. Employees	0.205***			0.349***		
Log Total sales		0.062***			0.067***	
Log Value added			0.063***			0.056***
Nb. Observations	590,540	523,165	512,992	114,897	85,714	84,090

ability that the firm has 1, 2, 3 or 4 layers of hierarchy. We suppose that $Prob(y_i = j) = F_{ij}(x, \beta)$, where i is the firm and j is the number of layers of the firm, x is a vector of independent variables including export propensity and number of varieties. β is the vector of estimated coefficients. As $\sum_j = Prob(y_i = j) = 1$, results in Table 12 give estimates relative to the probability that the firm has one layer (our baseline). Hence the probability a firm is a two-layer rather than a one-layer type is higher for exporters than non-exporters. The impact of export status on the probability to be a high-layer firm increases with the number of layers reached. The number of varieties is also a significant determinant of the number of layers.

Table 12: Cross-section on the determinants of the number of layers, multinomial logit, 2013.

2-digit sector dummies are included in all specifications. Stars indicate coefficients significant at the 1% (***), 5% (**) and 10% (*) level.

		dep var: # Layers					
j		(1)	(2)	(3)	(4)	(5)	(6)
2	Export propensity	0.450***	0.309***	0.444***			
3	Export propensity	1.063***	0.660***	0.911***			
4	Export propensity	1.478***	0.978***	1.216***			
2	Log Nb. Varieties				0.204***	0.185***	0.218***
3	Log Nb. Varieties				0.426***	0.330***	0.412***
4	Log Nb. Varieties				0.515***	0.420***	0.469***
	Size control	Empl.	Sales	VA	Empl.	Sales	VA
	Nb. Observations	112,843	100,496	97,708	21,955	16,417	16,055

These results support the fact that export diversification, in particular the number of exported varieties, is associated with a higher number of layers.

5.2 Explaining the change in the number of hierarchical layers

We here start by exploring the marginal effect of trade status on the dynamics of layer. We then follow by econometric regressions to explain the probability of adding a layer including different controls.

5.2.1 Trade status and dynamics of layers

We want to understand what drives the dynamics of firms' number of layers. We expect that part of the explanation lies in firms' decision to expand their export portfolio. Going beyond cross-sectional differences as shown in the previous section, we are interested in evaluating whether we see a change in the organization of the labor force when firms start to export or add export varieties (thus, increase their export diversification).

Tables 13 to 15 present the marginal effect of export entry, adding varieties or adding new products on the probability to have 1,2,3 or 4 layers in year $t+1$, conditional on the number of layers in year t from a probit regression. We obtain these results by defining dummy variables that are equal to one in case of the studied event (export entry, adding varieties or adding new products) and zero otherwise

We find that our group of interest, the firms expanding their export portfolio, have a higher probability to add hierarchical layers, and a lower probability to remove them. Indeed, the coefficients are often positive and significant in the case of the values on the upper triangle of the matrices, and negative in the lower triangle.

Our preliminary results support the main features described by the model. A firm which decides to augment its number of varieties has to implement organisational changes to face the complexity raised by the enlargement of its varieties scope.

Table 13: Marginal effect of export entry on the probability to be in each cell – 2009-2013, sample 1.

	Nb of layers in t+1				
	1 layer	2 layers	3 layers	4 layers	N
Nb of layers in t					
1 layer	-0.070***	0.058***	0.012***	0.000	180,845
2 layers	-0.070***	-0.002	0.064***	0.004***	70,125
3 layers	-0.015***	-0.055***	0.058***	0.012***	34,826
4 layers	-0.003**	-0.015***	-0.025**	0.043***	8,878

Table 14: Marginal effect of adding varieties on the probability to be in each cell – 2009-2013, sample 2.

	Nb of layers in t+1				
	1 layer	2 layers	3 layers	4 layers	N
Nb of layers in t					
1 layer	-0.054***	0.047***	0.007	0.000	4,821
2 layers	-0.004	-0.005	0.010	0.000	11,762
3 layers	-0.001	-0.020***	0.013***	0.008***	35,954
4 layers	0.000	-0.004***	-0.013***	0.017***	23,723

Table 15: Marginal effect of new products on the probability to be in each cell – 2009-2013, sample 1.

	Nb of layers in t+1				
	1 layer	2 layers	3 layers	4 layers	N
Nb of layers in t					
1 layer	-0.067***	0.051***	0.013**	0.002	3,517
2 layers	-0.026***	-0.013	0.035***	0.003	9,331
3 layers	-0.003***	-0.044***	0.030***	0.016***	31,762
4 layers	-	-0.009***	-0.037***	0.047***	21,840

5.2.2 Trade status and addition of layers

In a final step, we want to disentangle the "pure" growth from the export diversification channels explaining the change in the number of layers. To do so, we add as explanatory variables the log growth of value added, as well as an interacction effect between firm growth and three export diversification indicators. The dependent variable is a dummy variable which takes the value one when the firm adds at least one layer to its organisational structure. First, we control fo export entry defined as the dummy taking the value one in year t when the firm enters the export market in year t. Second, we control for adding varieties defined as the dummy taking the value one in year t when the firm adds a variety to its portfolio in year t. Last we use the share of new products in the export portfolio which is the continuous information of previous dummy. The share indeed gives the degree of change in the portfolio of firm's varieties. We present our results in Tables 16 to 18 below.

Table 16 shows that in all specifications, the probability to add a layer increases with an increase in growth and with an entry into the export market.

Table 16: Impact of firm growth and export entry on the probability to add layers – 2009-2013, sample 2.

Initial # layers	1 layer		2 layers		3 layers	
	OLS	Probit	OLS	Probit	OLS	Probit
Log Growth VA	0.020***	0.146***	0.025***	0.154***	0.006*	0.054*
Exp. entry	0.037***	0.206***	0.051***	0.254***	0.011***	0.089***
Gr VA * Exp	0.017**	0.028	-0.002	-0.064	0.018*	0.103*
Nb. obs	166,717	166,717	61,916	61,915	29,737	29,731

Then we focus on exporters and investigate how the probability to add layers is affected by trade diversification: first, by looking at an addition of varieties (Table 17) and second

by controlling for the share of new exported products (Table 18).

Table 17: Impact of firm growth and increase in export varieties on the probability to add layers – 2009-2013, sample 2.

Initial # layers	1 layer		2 layers		3 layers	
	OLS	Probit	OLS	Probit	OLS	Probit
Log Growth VA	0.028*	0.105***	0.027***	0.108***	0.008	0.049
Adding varieties	0.050***	0.169***	0.004	0.013	0.005	0.036
Gr VA * Adding Var.	-0.004	-0.029	0.006	0.015	-0.004	-0.029
Nb. obs	3,903	3,902	9,165	9,164	25,275	25,275

Table 18: Impact of firm growth and new export products on the probability to add layers – 2009-2013, sample 2.

Initial # layers	1 layer		2 layers		3 layers	
	OLS	Probit	OLS	Probit	OLS	Probit
Log Growth VA	0.031*	0.117	0.027**	0.115**	0.008	0.051
Share new products	0.062**	0.211**	0.045***	0.162**	0.007	0.048
Gr VA * Sh. new	-0.028	-0.117	0.004	-0.016	-0.002	-0.021
Nb. obs	2,875	2,847	7,245	7,253	22,164	22,164

6 Conclusion

Our first empirical evidence support the model regarding the positive relation between number of varieties and number of layers, number of varieties and share of upper layers (proposition 1 and 2).

Our preliminary results support the main features described by the model. A firm which decides to augment its number of varieties has to implement organisational changes to face the complexity raised by the enlargement of its varieties scope. We found that the organisational structure of exporting firms is more complex than that of non-exporting firms, as they present a higher number of layers on average. Exporting is associated with a higher share of workers in the second and third layers of management.

Higher diversification in terms of products and destinations is associated with a higher hourly wage, but only in the case of the highest layers. In the lowest layers, the rise of the hourly wage with the quartile is less sharp. This means here, that contrary to the employee structure which flattens with firm trade diversification, the distribution of wages is broadening when firms are more diversified.

The econometrics, which explores the dynamics suggested by the model, supports the positive relationship between behaviour reflecting trade diversification and the likelihood to change the labor organisation. We find that the firms expanding their export portfolio have a higher probability to add hierarchical layers, and a lower probability to remove them. Additional results support the idea that trade status has a different impact on labor organization than merely a change in size in value added. More specifically, export entry and, once exporter, trade diversification, augment the probability to add a layer when firms are of 1-layer or 2-layers type.

Overall, we obtain a body of evidence wich supports a positive relation between trade diversification and change in labor organisation through the addition of layers of management.

Further improvement of the model is to be done to include predictions regarding wage dispersion and labor organization. We suspect that firms' trade commitment and specifically trade diversification increase intra-firm wage inequality. In other words, another channel through which trade increases wage inequality is through the need for managers which increases their share relative to workers. Further empirical investigations should explore the wage dimension of the change in the ratio of managers in relation with the change in complexity. Additionnally, the import activity of the firm, which may have a non-negligible effect on its labor organisation, is a parallel and complementary agenda of research.

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A Supplementary Tables

Table 19: Firm characteristics by number of layers conditional on size classes

Size class	1-layer	2-layers	3-layers	4-layers	all
	Export Propensity				
$[1-5[$	0.11	0.22	0.35	0.34	0.13
$[5-10[$	0.11	0.28	0.42	0.52	0.20
$[10-20[$	0.11	0.33	0.50	0.59	0.31
$[20-50[$	0.14	0.39	0.63	0.71	0.53
$[50-250[$	0.16	0.41	0.80	0.86	0.79
$[250-500[$	-	0.19	0.89	0.95	0.91
$[500-+[$	-	0.60	0.95	0.98	0.96
	Export Intensity				
$[1-5[$	0.18	0.17	0.19	0.30	0.27
$[5-10[$	0.12	0.15	0.17	0.19	0.24
$[10-20[$	0.12	0.15	0.17	0.19	0.22
$[20-50[$	0.14	0.15	0.16	0.18	0.24
$[50-250[$	0.21	0.17	0.25	0.28	0.28
$[250-500[$	-	0.19	0.34	0.36	0.36
$[500-+[$	-	0.10	0.40	0.39	0.39
	Hourly Wage				
$[1-5[$	10.5	14.6	18.4	21.0	14.7
$[5-10[$	10.4	13.8	17.4	20.9	16.3
$[10-20[$	10.6	13.4	16.4	18.8	16.6
$[20-50[$	10.9	13.2	16.2	17.9	17.0
$[50-250[$	11.6	13.1	16.9	18.3	17.9
$[250-500[$	-	13.0	16.9	18.3	19.5
$[500-+[$	-	14	21.0	21.8	21.7

Notes: Manufacturing firms, 2009-2012.

Sample 2 except export propensity.

Table 20: Firm Diversification by number of layers conditional on size classes

Size class	1-layer	2-layers	3-layers	4-layers	all
	Average Number of destinations				
$[1-5[$	2.45	3.19	3.81	5.38	2.68
$[5-10[$	2.54	3.53	4.59	5.47	3.66
$[10-20[$	3.00	3.88	5.37	6.49	4.75
$[20-50[$	4.41	4.93	7.92	8.98	7.62
$[50-250[$	5.09	6.40	14.29	16.82	15.06
$[250-500[$	-	9.20	23.73	27.57	25.53
$[500-+[$	-	10.00	36.83	42.76	39.7
	Average Number of products				
$[1-5[$	2.98	3.79	4.26	6.08	3.18
$[5-10[$	2.89	3.95	5.06	5.54	4.03
$[10-20[$	3.36	4.28	5.62	6.80	5.12
$[20-50[$	4.13	5.23	7.75	8.45	7.42
$[50-250[$	4.91	7.08	14.06	16.38	14.76
$[250-500[$	-	25	25.72	31.1	28.41
$[500-+[$	-	7	52.5	68.57	60.68
	Average Number of varieties				
$[1-5[$	4.35	5.98	7.27	12.09	5.23
$[5-10[$	4.60	7.27	9.92	11.78	7.85
$[10-20[$	5.89	8.45	11.94	15.26	10.89
$[20-50[$	8.53	11.68	20.16	23.08	19.76
$[50-250[$	10.00	15.03	47.22	57.43	51.17
$[250-500[$	-	38.00	100.69	128.24	114.97
$[500-+[$	-	15.33	272.77	364.21	321.96

Notes: Manufacturing firms, sample 2, 2009-2012.

B Supplementary Graphs

Figure 5: Average number of layers per percentile of destinations and of products

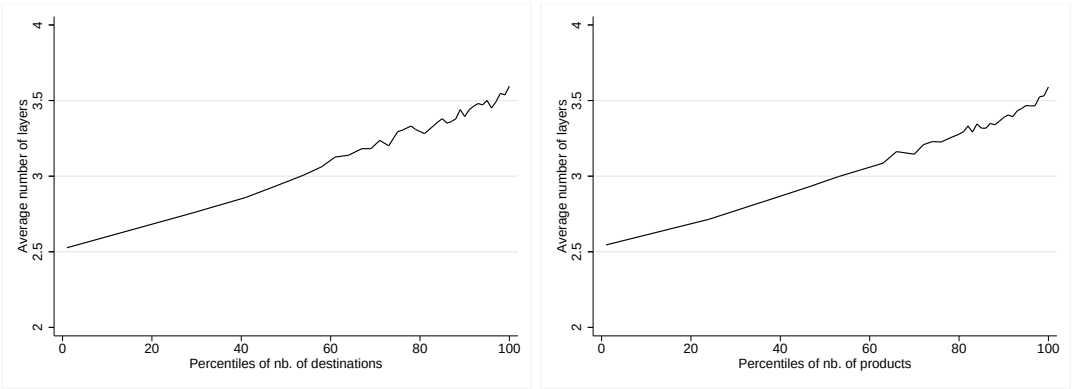


Figure 6: Share of employees in each layer per quartile of destinations and per quartile of products

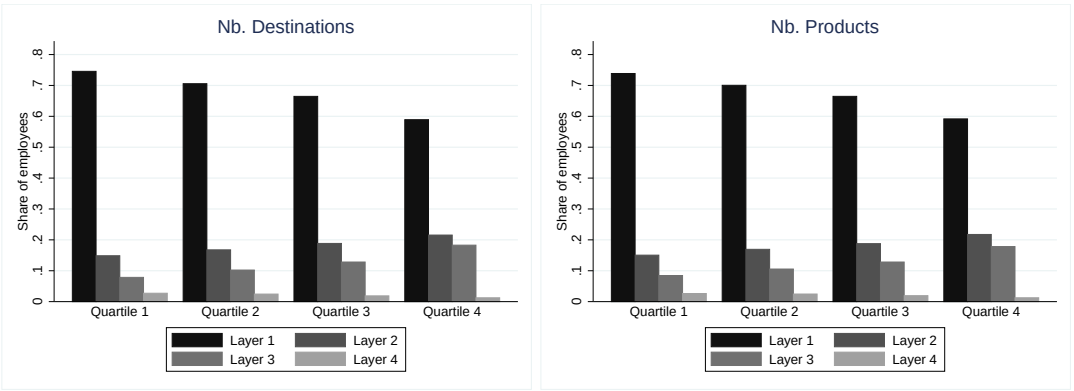
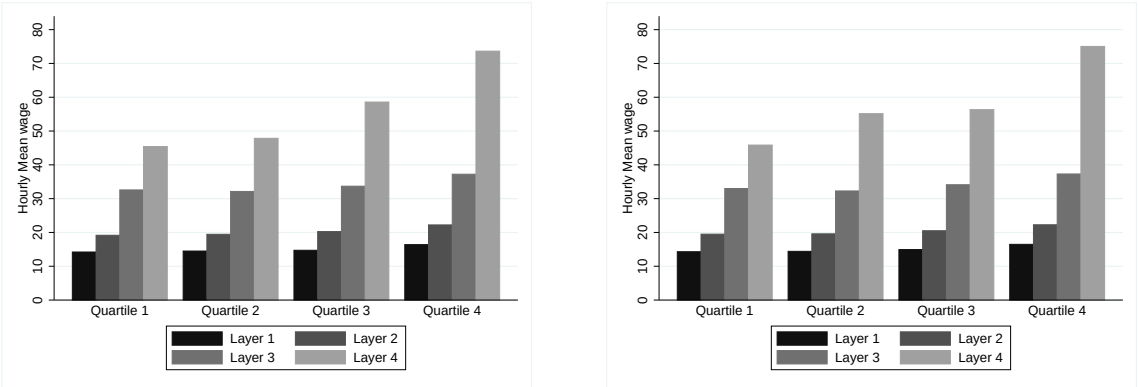


Figure 7: Average hourly wage in each layer per quartile of destination (left) and per quartile of products (right)



Notes: Manufacturing firms, 2012, All wages of exporting firms.

C Proof of (18)

Starting from the following cost function:

$$C(\theta, A, z) = n_w\omega + n_m k\omega \tag{18}$$

We minimise the cost function relative to n_ω under two constraints, given by (5) and (6). The Lagrangian to minimize is then :

$$min\{L(\theta, A, z)\} = min\left\{ n_w\omega + n_m k\omega + \phi\left[q^j - A\left(1 - e^{-\frac{z_m}{\theta}}\right)n_w\right]\right\} \tag{19}$$

Let suppose that $n_m = 1$, then n_w is the number of workers per manager. The relation between managers and workers are then:

$$n_w = \frac{1}{h}e^{(\frac{1}{\theta})z} \tag{20}$$

Substituting in (21), we get:

$$min\{L(\theta, A, z)\} = min\left\{ n_w\omega + k\omega + \phi\left[q - A\left(1 - e^{-\frac{z_m}{\theta}}\right)\frac{e^{\frac{z}{\theta}}}{h}\right]\right\} \tag{21}$$

$$\frac{\partial L}{\partial n_w} = \omega - \phi A\left(1 - e^{-\frac{z_m}{\theta}}\right) = 0 \tag{22}$$

Hence, from this equation, we can extract the value of ϕ, the marginal cost of production ($\frac{\partial L}{\partial q}$):

$$\upsilon(\theta, A, z) = \phi = \frac{\omega}{A\left(1 - e^{-\frac{z_m}{\theta}}\right)} \tag{23}$$

Note that it increases with θ and decreases with the managers' skill.