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Organizing Knowledge to Compete

Impacts of Capacity Building Programs on Firm Organization

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Abstract

A growing literature aiming at explaining differences across firms in productivity and access to global export markets has focused on the internal organization of firms. This paper contributes to this literature by evaluating the impact of a program that focuses on enhancing competitiveness of small and medium enterprises in Brazil by providing coaching and consulting on management and production practices. Specifically, the paper tests whether the program induces treated firms to reorganize knowledge by adding more layers of different skills and competencies to their workforces. Using a unique firm-level dataset, the number of layers of the firms are compared before and after the program. The impact of the program is identified by relying on an instrumental variable approach, exploiting the quasi-experiment roll-out of its implementation, which was carried out at different times across Brazilian regions. The analysis finds that the program had an effect and that this effect is heterogeneous. The program is particularly effective in promoting the reorganization of firms with initially fewer layers. The results confirm another finding of the literature, namely that in re-organized firms inequality of wages increases, as firms pay higher wages in added higher layers than in pre-existing ones. Finally, these results are used to discuss how the change in firms' organization is positively correlated with export performance.

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Organizing Knowledge to Compete

Impacts of capacity building programs on firm organization*

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1 Introduction

Enhancing productivity is the key to achieve sustainable growth. Although our knowledge on the determinants of productivity is still limited (Syverson, 2011), there are strong reasons, supported by empirical evidence, suggesting that firms' organization matters. Production requires the organization of several inputs (e.g. land, machines, raw material, labor, information, among others), including the knowledge of workers. From a firm's perspective, optimizing its productivity means organizing these inputs efficiently. The lack of capacity for reaching this efficiency may explain important differences in productivity across firms and countries (see Bloom and Van Reenen (2007), Bloom and Van Reenen (2010) and Bloom et al. (2010)).

Since the pioneering work of Roberts and Tybout (1997), Clerides et al. (1998) and Melitz (2003), trade literature has emphasized that firms' productivity is heterogeneous not only across sectors, but also within them.[1] Caliendo and Rossi-Hansberg (2012) suggest differences in the way firms organize knowledge as one source of heterogeneity. Their model is built in the spirit of Garicano (2000) in which production requires organization of knowledge and inputs.[2] The model suggests that the way firms organize knowledge plays a key role in their capacity to compete with other firms, domestically and abroad. The moment firms introduce new products, their market size determines which organization is compatible with their scale of production. Larger demand will enable firms to reorganize their production by adding new layers of managers and economizing knowledge from production workers.[3]

By assuming that employees can act as production workers or managers, this framework can also be connected to the literature that finds a positive association between management's quality and firms' performance (see Bloom and Van Reenen (2007), Mion and Opromolla (2011) and Bloom et al. (2012)).[4] These findings have important implications by suggesting that firms' performance may be enhanced by policies that create incentives to improve management practices and change the way firms organize their knowledge for production.

Although there is an increasing empirical literature showing the importance of management and organization on firms' performance, there is limited evidence on the effectiveness of programs aiming to improve firms' organization. This paper aims to contribute to this literature by analyzing the effect of Peiex (Portuguese acronym for Industrial Extension Project for Exporting) on firms' organization,

[1] Firms' heterogeneity has been at the center of a rich theoretical and empirical literature focusing on explaining the relationship between firms' productivity and their export performance (Melitz and Trefler, 2012) .

[2] Knowledge is costly to acquire and organization is required to coordinate who learns what and how to solve different production problems in order to optimize gains from specialization in a firm.

[3] In their model the introduction of new products is randomly assigned.

[4] These authors suggest that lack of market competition, firms' ownership structure (e.g. family-managed companies where CEO succession is determined by primogeniture), labor regulation, multinational status, education, lack of delegation and barriers to access finance are among the reasons why some firms do not adopt management practices that optimize productivity, especially but not only in developing countries.

based on hierarchy of knowledge. Peiex is a program from the Brazilian Export Promotion Agency (Apex-Brasil) that focuses on enhancing Brazilian small and medium firms' (SMEs') competitiveness by providing coaching and consulting on best management and production practices.[5] This paper is closely related to Bloom et al. (2012), who find significant effects of a management consulting program on firms' performance in India.[6]

We measure the way firms organize knowledge based on occupations that require different levels of skills and competencies, following the conceptual framework in Garicano (2000) and Caliendo and Rossi-Hansberg (2012). Consistent with this framework we show that firms organize knowledge following a hierarchy in a pyramid shape, which is compatible with the hypothesis that production workers learn the standard production problems and managers deal with more exceptional ones. Our analysis uses a unique matched employer-employee firm-level data set covering the full manufacturing sector in Brazil with a panel of about 310,000 firms (an average of 236,645 firms per year), with information on more than 7 million employees, from 2007 to 2010, and more than 5,000 treated firms.

This measure of hierarchy of knowledge takes into account different levels of competencies and skills of workers limited to 4 layers. If a firm already has 2 layers and decides to hire more workers at the same layers, which means same occupations previously available at the firm, we assume that there is no change in the knowledge-based hierarchy of the firm. Hence, this is not about increasing the number of directors or manager positions itself; neither are we assuming that the more managers, the better. Instead, increasing the number of layers in this case means that a firm is incorporating workers with different levels of competency and specialized knowledge in solving different problems at the firm. The idea is that controlling for the number of employees, firms that expand reorganizing knowledge can become more competitive by having lower marginal cost as a function of the necessary knowledge among production workers and gains of productivity through specialization. Apart from the fact that workers in new layers have more average years of schooling, the concept of occupation also takes into account the use of their knowledge by considering their activities at the firm. Thus, we capture one type of organization, but one which matters for performance.

To identify the effect of the program, we rely on an instrumental variable approach and exploit the exogenous variation provided by a regional roll-out for its implementation. The program was implemented in late 2008/2009 through regional units around the country. A critical eligibility rule is that firms should

[5] Brazil has a long tradition of programs aiming to support small business, by providing training on entrepreneurship and management consulting. For example, SEBRAE (Portuguese acronym for the Brazilian Service of Support for Micro and Small Business), a private entity of public interest that offers courses, consultancy, training, and sectoral publication to SMEs, started its activities in 1972.

[6] In a randomized controlled trial (RCT), Bloom et al. (2012) show that receiving consulting on better management practices raised by 11% the productivity of treated firms. In addition, the decision making in these firms became less centralized and they also increased the use of computers.

submit an application form to its correspondent regional unit and be a "potential exporter," which means be part of a sector in which there is evidence of exporting activity. Our identification strategy exploit these rules to develop an exogenous instrument which is helped by the fact that only 10 out of 27 states had opened regional units in the first two years of the program. Given that we use state and firm fixed effects the crucial assumption for our identification comes from the randomness of the timing of the program implementation.

The results suggest that the program impacts the organization of the treated firms as following: 1) Firms that receive the program are more likely to reorganize their production by adding a layer of hierarchy of knowledge, which is measured by hiring a worker in an occupation for which similar knowledge did not appear previously in the firm employee structure; 2) The program increases the likelihood of a firm add a layer of hierarchy of knowledge for those firms that have no layer or one layer of hierarchy two years before the program started. Nonetheless, the result is not significant for those firms with two layers or more, suggesting some heterogeneous effects of the programs based on the initial number of layers; 3) The reorganization of those firms is associated with an expansion of hours hired on previously existed layers of knowledge and a rise in wage inequality between layers of hierarchy based on knowledge. We then explain the findings by emphasizing that adding layers of knowledge is an organizational change that is correlated with outcomes relevant to firms' performance. We show that controlling for numbers of employees, firms that have more layers of knowledge are more likely to be exporters. These results are supported by several robustness tests.

The remainder of this paper is structured as follows. Section 2 describes the data and provides some descriptive statistics. Section 3 explains how Peiex's program works and describes the identification strategy adopted to evaluate its effects. Section 4 shows the empirical results followed by the robustness check and a discussion on the meaning of these results for firms' performance. Section 5 concludes the paper.

2 Data and Descriptive Statistics

This paper is based on a unique firm-level data set that resulted from merging three different sources of information in Brazil: 1) the *Relações Anual de Informações Sociais* (RAIS), a linked employer-employee data set from the Brazilian Ministry of Labor;[7] 2) the SECEX/MDIC data set, which provides firms' exporting status and 3) the Peiex data, identifying the firms that received assistance from Peiex.[8]

The database was merged using a unique identifier at the firm level.[9] It covers the period between 2006 to 2010. We focused on manufacturing firms and adopted the sectoral definition of CNAE 2.0 (Portuguese acronym for National Economic Activity Classification) that is equivalent to the International Standard Industrial Classification of All Economic Activities (ISIC, Rev.4.).[10] Also, given that for the analysis we need information on firms for at least two subsequent years, we kept firms that are in RAIS for at least 2 years.[11] We measure firms' organization following Caliendo et al. (2012) and Helpman et al. (2012) to classify the number of layers. We use the *Classificação Brasileira de Ocupação* (CBO) definition of occupation, which is composed by 9 different categories according to similar level of authority and/or competencies.[12] Table 1 describes the original categories and the way we aggregated them for the analysis. This classification was used to define the number of "knowledge-based" layers in each firm. If a firm has employees belonging to only one of these categories (e.g. blue collars), this firm will have no layers of knowledge. If there are employees in two of these categories (e.g. blue collars and senior staff), this firm will have one layer of knowledge-based hierarchy. We provide further details on the proxy for hierarchy in the appendix (section 6.2).

Classification	**CBO**$^{(a)}$	**Occupation**	**Level**$^{(b)}$
CEOs, Directors, Managers	CG 1	CEOs, Directors and Managers	-
Professionals	CG 2	Art and Sciences - high level of experience	4
Technicians (middle-level)	CG 3	Quality control, technical, accounting	3
Clerks	CG 4	White color - internal administration services	2
	CG 5	White color -external administration services	2
Blue collars	CG 7 and CG 8	Welders, assemblers, machine operators	2
	CG 9	Maintanance workers	2

Table 1: CBO classification

Note: (a) CG 6 refers to agriculture and it was excluded; (b) Level of competency according to CBO.

[7] RAIS is a register of all formal firms in Brazil. It provides information about the size of the establishment, geographic distribution and workers, such as wage, education, age and gender.

[8] *Secretaria de Comércio Exterior* (SECEX) from the Ministry of Development, Industry and Trade (MIDC). A list of exporting firms by year is publicly available on www.mdic.gov.br.

[9] The information of the treatment is available at the firm level. Nonetheless, in Peiex's cases, the majority of treated firms are relatively small with a unique plant.

[10] The Peiex program targets manufacturing firms. We used CNAE 2.0, 2 digits, from 10 to 33, which defines manufacturing.

[11] For some of the estimations, it was necessary information from firms with two lags. Then, it was kept firms that are in RAIS in at least three subsequent periods (*t-2*, *t-1* and *t*).

[12] The concept of competence adopted by CBO has two dimensions: (1) It is a function of the complexity, scope and responsibility of activities in employment or another working relationship; (2) It is related to the characteristics of the work context as an area of knowledge, function, economic activity and production process.

The classification used to establish the number of layers embeds different levels of knowledge and competency according to these groups of occupations. For example, according to the International Standard Classification of Occupations (ISCO)[13] "Professionals" (CG 2) are workers that "increase the existing stock of knowledge, apply scientific or artistic concepts and theories, teach about the foregoing in a systematic manner, or engage in any combination of these three activities." Also, "Technicians and Associate Professionals" (GG 3) "perform mostly technical and related tasks connected with research and the application of scientific or artistic concepts and operational methods, and government or business regulations." Imagine a small firm composed by blue-collar workers and the firms' owner. The moment the firm hires workers classified as professionals from art and sciences (CG 2) or technicians (CG 3), it is incorporating a specialized level of knowledge in their structure that was not previously there.

Layers	Number of Observations	Column share (%)	Share on total number of firms ≤500	≤100	≤20	≤10
Full sample						
0	309,523	32.78	99.96	99.93	98.59	93.99
1	312,065	33.04	99.99	99.85	90.99	72.69
2	174,937	18.52	99.99	98.84	71.72	41.46
3	86,425	9.15	99.86	92.92	40.83	15.54
4	61,426	6.50	89.33	54.57	9.56	2.20
Total	944,376	100.00	99.28	96.11	80.03	64.07
Exporters						
0	1,981	4.20	99.80	99.34	95.41	86.37
1	4,493	9.53	99.99	99.35	78.72	53.37
2	7,086	15.03	99.94	95.68	53.50	25.50
3	9,198	19.51	99.28	82.95	25.40	7.39
4	24,386	51.73	79.18	34.06	3.56	0.55
Total	47,144	100.00	89.07	61.83	26.35	14.28
Peiex						
0	950	16.03	99.79	99.79	98.53	91.47
1	1,867	31.50	99.99	99.68	85.75	62.13
2	1,438	24.26	99.99	98.96	68.22	35.74
3	978	16.50	99.80	92.94	40.49	12.07
4	694	11.71	95.10	64.27	11.38	3.31
Total	5,927	100.00	99.36	94.26	67.37	45.28

Table 2: Number of firms by exporting and treatment status and share of firms by number of employees (2007-2010)

Table 2 shows the distribution of firms by number of employees and layers. The large majority of firms in manufacturing have less than 100 employees and are non-exporters.[14] Also, there is more heterogeneity regarding how firms organize knowledge among the smaller ones. If we take firms with

[13]Further details on ISCO classification are available at the webpage of the International Labor Organization (ILO) at www.ilo.org.

[14]Indeed, the share of exporting firms in manufacturing (between 2007 and 2010) was only about 5% and the share of firms with less than 100 employees was about 96%.

more than 500 employees, the large majority will have more than 3 layers of management and many of them will be among the exporters.

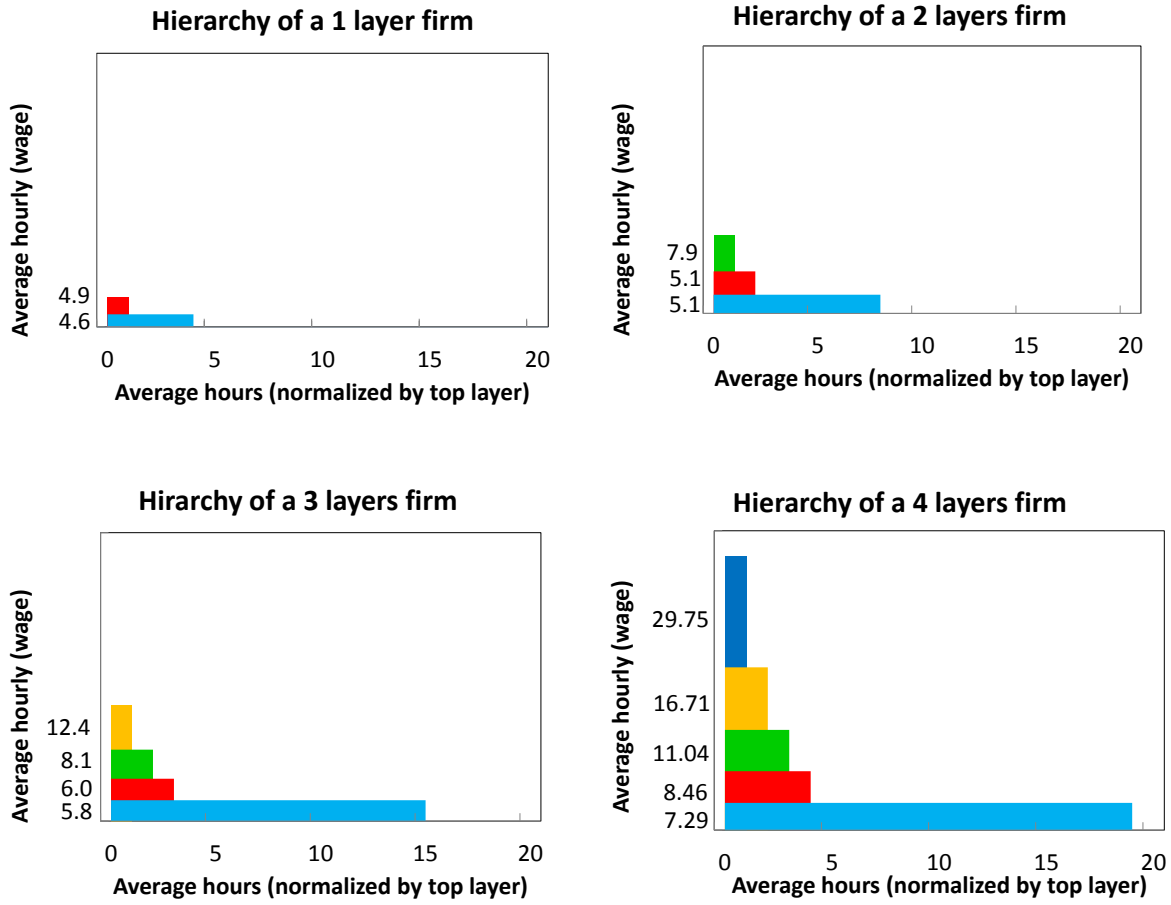


Figure 1: Hierarchies of Brazilian (manufacturing) firms normalized by the top layer (2007-2010)

Figure 1 shows the hierarchies of firms in Brazil.[15] The layers are represented using a square. The vertical axis reports the average hourly wage of employee in each layer and the horizontal axis represents the average hours employed normalized by the top layer, according to the number of layers of the firms.[16] Therefore, these axes are respectively the height and the length of the square, which represents the payroll of firms by layers. In Garicano (2000) they represent the hierarchical organization of firms with the shape of a pyramid, which he referred to as pyramidal organization. It results from the fact that knowledge is non-overlapping and the organization is characterized by the problem-solving ability of workers up to the top layer (Caliendo et al., 2012). Overall, the predicted shape is observed. Firms hire more producer workers (L0) and fewer managers (L1, L2, L3 and L4). On average, the higher the position of the manager in the hierarchy, the higher her wage, which suggests more knowledge associated with

[15] These are firms in the manufacturing sector that appear in RAIS at periods *t* and *t-1*, from 2007 to 2010. For further details see descriptive statistics in the previous subsection.

[16] It refers to the average number of hours with respect to the top layer for each firm.

problem solving skills.

Table 3 provides the descriptive statistics of the variables used in the empirical analysis. First, we present the number of employees, which is a critical variable in our analysis. This variable was built considering the number of employees hired in a year by the firm weighted by the period (number of months) they were hired. Therefore, if an employee was hired for six months she receives a weight of 0.5. Overall, as previously discussed, Peiex's firms have an average number of employees relatively close to firms that did not receive Peiex support (hereafter referred to as "untreated firms").

Firm's age is a proxy for the age of the firm that takes into account the maximum time of employees' experience working at firms available in RAIS over time. Peiex-treated firms have on average almost 13 years, while untreated firms have 12. Number of subsidiaries refers to the number of plants apart from the one with the largest number of employees, which we consider as being the firm's headquarters. Although the treated firms have almost twice as many subsidiaries than average it is noticeable that the median is zero for both groups, and it changes to 1 only for treated firms in the 90th percentile.

A second group of variables refers to employees' characteristics. Wage is the average monthly wage (in R$ of 2010), schooling is the average years of formal school attendance, workers experience is the average time (in years) of experience of employees and share of engineers and R&D workers is the share of employees classified in these occupations according to the CBO.

A third group of variables is related to managers' characteristics. Following Mion and Opromolla (2011) we build a variable to capture information related to potential spillovers brought from managers with previous experience in exporting firms. "Manager exp M_n" such that n={1,2,3} are dummy variables that identify those firms that hired managers (according to the based-knowledge hierarchy definition)[17] at period t who were working in another firm that exported at period *t-1*, according to different level of occupations.[18] The share of firms that hired these managers is small (less than 1%), but it is larger for Peiex's firms.

Furthermore, following Lazear et al. (2012) we build a proxy for managers' quality based on their wage distribution according to their occupation. These variables, (Manager M_n - Q_j) such that n={1,2,3} and j={Q_4, Q_3, Q_2}, are dummies that take the value of 1 if a firm has a manager in occupation M_n and quartile Q_j of wage's distribution and 0 otherwise. It is noticeable that managers in the fourth quartile[19] (top managers) are rare in both groups. The share seems relatively close between treated and untreated firms, with more prevalent cases of managers (M1) in the third quartile (Q_3).

[17] M1 for CEOs and directors; M2 for senior staff and M3 for supervisors.

[18] These variables take the value of 1 if a firm has hired a manager at period t who was working in an exporting firm at period *t-1* and 0 otherwise.

[19] They are more prevalent among large/exporting firms.

Untreated						
Variables	N	mean	sd	p50	p10	p90
Size (Employee)	927,770	25.63	208.02	5.83	1.00	38.67
Firm's age	927,894	11.94	8.94	9.83	3.16	22.80
Number of Subsidiaries (t-1)	927,894	0.11	1.51	0.00	0.00	0.00
Share Engenieers and R&D	927,770	0.003	0.03	0.00	0.00	0.00
Wage	927,770	879.79	631.44	739.47	502.68	1,371.99
Schooling	927,739	8.78	2.07	9.03	5.76	11.04
Worker Experience (t-1)	927,657	18.12	7.90	17.45	8.79	28.11
Manager exp M1	927,894	0.002	0.04	0.00	0.00	0.00
Manager exp M2	927,894	0.002	0.04	0.00	0.00	0.00
Manager exp M3	927,894	0.004	0.07	0.00	0.00	0.00
Manager M1 - Q_4	927,894	0.01	0.14	0.00	0.00	0.00
Manager M2 - Q_4	927,894	0.005	0.08	0.00	0.00	0.00
Manager M3 - Q_4	927,894	0.01	0.11	0.00	0.00	0.00
Manager M1 - Q_3	927,894	0.05	0.22	0.00	0.00	0.00
Manager M2 - Q_3	927,894	0.01	0.11	0.00	0.00	0.00
Manager M3 - Q_3	927,894	0.03	0.17	0.00	0.00	0.00
Manager M1 - Q_2	927,894	0.13	0.34	0.00	0.00	1.00
Manager M2 - Q_2	927,894	0.05	0.22	0.00	0.00	0.00
Manager M3 - Q_2	927,894	0.10	0.30	0.00	0.00	0.00
Number Exporters region*	927,894	25.93	53.91	4.00	0.00	76.00
(A) Number NO by State	927,894	1.05	2.25	0.00	0.00	6.00
(B) lag(dummy sector Apex state)	927,894	0.31	0.46	0.00	0.00	1.00
(A)*(B) Interaction term	927,894	0.61	1.82	0.00	0.00	3.00
Exporting Firms (share)	927,894	0.04	0.20	0.00	0.00	0.00
Treated (Peiex)						
variable	N	mean	sd	p50	p10	p90
Size (Employee)	5,926	32.63	125.31	11.50	2.08	62.08
Firm's age	5,928	12.97	9.17	10.99	3.49	23.91
Number of Subsidiaries (t-1)	5,928	0.23	2.13	0.00	0.00	1.00
Share Engineers and R&D	5,926	0.005	0.04	0.00	0.00	0.00
Wage	5,926	845.43	394.70	740.06	544.72	1273.48
Schooling	5,925	9.16	1.77	9.40	6.70	11.04
Worker Experience (t-1)	5,925	17.26	6.34	17.01	9.46	25.33
Manager exp M1	5,928	0.004	0.06	0.00	0.00	0.00
Manager exp M2	5,928	0.004	0.06	0.00	0.00	0.00
Manager exp M3	5,928	0.008	0.09	0.00	0.00	0.00
Manager M1 - Q_4	5,928	0.004	0.06	0.00	0.00	0.00
Manager M2 - Q_4	5,928	-	-	0.00	0.00	0.00
Manager M3 - Q_4	5,928	0.003	0.05	0.00	0.00	0.00
Manager M1 - Q_3	5,928	0.05	0.22	0.00	0.00	0.00
Manager M2 - Q_3	5,928	0.01	0.08	0.00	0.00	0.00
Manager M3 - Q_3	5,928	0.03	0.16	0.00	0.00	0.00
Manager M1 - Q_2	5,928	0.16	0.37	0.00	0.00	1.00
Manager M2 - Q_2	5,928	0.05	0.22	0.00	0.00	0.00
Manager M3 - Q_2	5,928	0.10	0.31	0.00	0.00	0.00
Number Exporters region*	5,928	12.89	23.91	3.00	0.00	42.00
(A) Number NO by State	5,928	5.07	2.42	6.00	1.00	8.00
(B) lag(dummy sector Apex - state)	5,928	0.68	0.47	1.00	0.00	1.00
(A)*(B) Interaction term	5,928	3.62	3.15	3.00	0.00	8.00
Exporting Firms (share)	5,928	0.09	0.29	0.00	0.00	0.00

Table 3: Descriptive statistics (2007-2010)

Note: The descriptive is based in a pooling data from 2007 to 2010. Treatment status is defined as firms that did not receive any support from Peix's programs at year t (Untreated) and firms that did receive Peiex at year t (Treated Peiex). Firms that received assistance from other Apex's programs were excluded from the descriptive.

The fourth group of covariates is related to firms' sector and regional environment. First, in order to control for potential exporting neighbourhood-effect we used the variable "export-spillover." This equal to the sum of the total number of other exporting firms by micro-region (a territory classification from IBGE that divides Brazil in 555 geographical areas). The number of Peiex regional units by state (Number NO by State) was built based on the year of implementation (see table 4) of Peiex regional units in the state of firms' headquarters. This is an important variable for the analysis as it is used as one of the instruments. Lag of dummy sector Apex by state refers to a dummy identifying sectors (at 5 digits CNAE) in which there were firms that received assistance from other Apex programs (excluding Peiex) in a previous year *(t-1)* in the state.

3 The Peiex Program and the Identification Strategy

Peiex was launched in late 2008/2009 as a program of assistance services offered for medium and small firms by Apex-Brasil.[20] According to their own definition, the program "aimed to boost competitiveness and raise the export awareness of micro, small and medium-sized enterprises" by providing capacity building and management coaching. The initiative was set up as a supplementary assistance for firms interested in taking part of export promotion services already provided by the agency (e.g. participation in trade fairs and business rounds–meetings with foreign buyers) but that were not prepared to take full advantage of these services yet (this could be seen as a pre-export preparation program).

The program offers consulting services in partnership with universities and institutes of technology in fields such as marketing, human resources management, finance, product design and trade. The existence of such a center locally is crucial for the program and this requires some time to be set up. Although Peiex does not charge firms for these services, their condition is that owners and managers of these firms must be committed in attending interviews and standard evaluations to verify management procedures adopted by them. After applying for the assistance, firms receive a visit from a Peiex extension agent who will explain them the methodology of the program. Once these firms confirm their interest in participating to the program, they receive a standard competitive strength assessment covering different areas of the enterprise (e.g. strategic organization, human capital, finance and costs, sales and marketing, international trade, product design, production and innovation) with a final report identifying their strengths and weaknesses. This assessment is followed by a plan with suggestions to be implemented focusing on improving firms' competitiveness.[21]

[20] See further details at www.apexbrasil.com.br.

[21] The role played by extension agents (in Portuguese, *técnico extensionista)* is widely known in Brazil as associated to specialists in agriculture who provide assistance to transfer knowledge on production best practices and new technologies available. In Brazil these services became popular with Embrapa (Portuguese acronym for the Brazilian Research Corporation) and Emater (Portuguese acronym for Institute for Technical Assistance and Knowledge Extension).

An important feature of eligibility which will be exploited in the identification is the fact that firms interested in receiving this assistance must complete a registration form made available by the Peiex team and their partner organizations[22] and submit the application to the nearest regional unit of attendance. These regional units - NOs (Portuguese acronym for Project Operational Units) - were opened in a staggered manner across few Brazilian states, starting in late 2008/2009. Table 4 shows the number of NOs in each state according to the semester-year they were implemented. More than half of the Brazilian states did not have a Peiex NO until 2010.

Region	Estado	2007		2008		2009		2010	
		First	Second	First	Second	First	Second	First	Second
Northeast	Ceará	-	-	-	1	1	1	1	1
Northeast	Pernambuco	-	-	-	1	1	1	1	1
Northeast	Alagoas	-	-	-	1	1	1	1	1
Northeast	Sergipe	-	-	-	1	1	1	1	1
Northeast	Bahia	-	-	-	1	4	4	4	4
Southeast	Minas Gerais	-	-	6	6	6	6	6	6
South	São Paulo	-	-	-	-	-	-	-	1
South	Paraná	-	-	-	3	3	3	3	3
South	Rio Grande do Sul	-	-	-	7	7	7	8	8
Center-West	Goiás	-	-	-	1	1	1	1	1
Center-West	Distrito Federal	-	-	-	1	1	1	1	1
Total		-	-	6	23	26	26	27	28

Table 4: Number and schedule of implementation of Peiex's regional units (NO).
Note: The units were implemented in different micro-regions inside the states. First and Second refer to the semester of the year in which the NO was implemented.

Most of these units are concentrated in the South and the Northeast (with the exception of the state of Minas Gerais in the Southeast). An interesting feature from the perspective of a quasi-experiment is that states like São Paulo, Santa Catarina and Rio de Janeiro, which together represent a large share of total firms (approximately 45%), exporting firms (almost 60%) and GDP in Brazil, received units only in December 2010, August 2011 and September 2011, respectively.[23]

These NOs are composed by a manager, an industrial extensionist manager, firms' extenstionists and trainees. After being selected, the staff are required to attend courses on Peiex's methodology and trade. The first step of the assistance is based on interviews with managers and visits to the plant in order to get further information for an assessment of the strengths and weaknesses of the firms following Peiex's standard methodology.

Based on this information, the extensionists propose a plan for introducing some improvements in fields related to strategic management, human resources, finance and cost, marketing, production, design and trade. In cases where the extensionists have no knowledge to give the necessary support for

[22] This includes industrial associations and universities in Brazil.

[23] Due to the fact that we are using annual data we considered the year of implementation based on the semester the NO was implemented in the state. It takes time for these agencies implement the program. Those NOs installed in the first semester of the year were considered as being over the year. São Paulo was installed in December 2010. Therefore, it is considered as implemented in 2011.

implementing the project, according to the program's methodology, external consultants from universities and technological centers would be hired to provide the assistance.[24]

Due to the fact that Peiex was not designed as a randomized experiment, the main issue for the identification of its impact on treated firms is potential selection bias. It may be that firms with higher probability of changing their organization's structure are more likely to ask for and receive the program and this is likely a source of endogeneity. Let us consider the following equation:

$$Y_{it} = \alpha + \beta T_{it} + \gamma X_{it} + \epsilon_{it} \tag{1}$$

Where Y_{it} is the outcome of interest of firm i at period t, T is treatment status (Peiex assistance), X_{it} is a matrix of covariates, ϵ_{it} is the error term. Assuming T as a binary variable, we can only observe $(Y_1|T = 0)$ or $(Y_1|T = 1)$ and this generates a missing data problem (Heckman (2001)). If (T) is correlated with (ϵ) there are unobservables that determine both treatment and outcome, β will be inconsistent and biased under the OLS estimation.

To address this issue, further knowledge with respect to the design and implementation of the program is necessary. In the case of Peiex, an important eligibility rule is that firms should complete a registration form and submit it at the regional units. Up to 2010, there were 28 units distributed around the country and these were opened in a staggered manner. Brazil has 27 states (including the Federal District, Brasília) and only 10 of them received Peiex's regional units up to November 2010. Table 5 shows their distribution and number of assisted firms by targeted state in Brazil. There is a strong correlation among these variables.

Given that firms' locations were not influenced by Peiex regional units (the firms were previously established) geographic proximity of these units is exogenous to the firm and we use the variation of the implementation of these regional units across Brazilian regions as an instrument to deal with selection into the program.[25] It could be that regions with a larger number of firms are those that benefited most by the number of regional units or that locations with more organized firms were able to lobby for receiving more units and this level of organization could be correlated with firms' organization. It also could happen that the program tries to compensate the lack of firms' organization and install regional units in regions with very few firms. Table 5 shows that this does not seem to be the case. São Paulo, which is by far the state with the largest number firms in Brazil, did not receive NOs over this period, neither many states in the North region, those that have a small share of firms and exporters.

[24] Figure 4 in section 6.1 of the appendix summarizes Peiex's methodology according to different steps.

[25] More than 99.6% of the observations are from firms that did not change state over the period of analysis among treated and untreated firms. In the main results we exclude these firms from the the sample. The results are very similar if we keep these firms in the sample.

Region	State	Firms (2007) (%)	Firms (2010) (%)	Unit NO (09-10)	Peiex's Treated (2009) (%)	(2010) (%)	Exporting Firms (07-08) (%)
North	Rondônia	0.61	0.63	-	*	*	0.51
North	Acre	0.13	0.13	-	*	*	0.06
North	Amazonas	0.45	0.48	-	*	*	1.10
North	Roraima	0.05	0.06	-	*	*	0.12
North	Pará	1.04	1.04	-	*	*	1.66
North	Amapá	0.07	0.07	-	*	*	0.03
North	Tocantins	0.26	0.29	-	*	*	0.02
Northeast	Maranhão	0.50	0.54	-	*	*	0.16
Northeast	Piauí	0.53	0.57	-	*	*	0.13
Northeast	Cear	2.52	2.80	1	6.06	6.74	1.24
Northeast	Rio Grande do Norte	0.80	0.88	-	*	*	0.26
Northeast	Paraíba	0.81	0.86	-	*	*	0.37
Northeast	Pernambuco	2.33	2.49	1	*	0.99	0.75
Northeast	Alagoas	0.36	0.39	1	0.75	0.82	0.15
Northeast	Sergipe	0.43	0.48	1	1.20	1.22	0.14
Northeast	Bahia	2.65	2.78	4	8.17	10.26	1.40
Southeast	Minas Gerais	12.48	12.58	6	24.69	23.62	6.86
Southeast	Espírito Santo	2.04	2.11	-	*	*	1.52
Southeast	Rio de Janeiro	4.88	4.95	-	*	*	3.89
Southeast	São Paulo	29.53	29.06	-	*	*	46.66
South	Paraná	8.89	9.35	3	16.72	17.20	8.26
South	Santa Catarina	9.49	9.86	-	*	*	8.46
South	Rio Grande do Sul	11.16	11.33	8	35.35	33.46	14.01
Center West	Mato Grosso do Sul	0.75	0.81	-	*	*	0.32
Center West	Mato Grosso	1.38	1.55	-	*	*	0.82
Center West	Goiás	3.00	3.27	1	4.44	3.92	1.04
Center West	Distrito Federal	0.56	0.63	1	2.16	1.48	0.05
Total (%)		100.00	100.00	-	100.00	100.00	100.00
Total		232,159	247,187	27	2,410	3,518	24,161

Table 5: Distribution of firms across states, by exporting and treatment status

Note: (*) States with less than 10 treated firms.

In addition, table 6 shows that there is a weak and not statistically significant correlation (at 5% confidence level) between the share of exporting firms or the average changes in number of layers and the share of Peiex regional units at the state level prior to the program's start. Nonetheless, there is a strong and significant correlation (at 1% confidence level) between the share of firms that received Peiex treatment and the share of Peiex regional units at the state level.

Correlation with number of NOs					
	Peiex	Number Exporters		Change Layer	
	2007-2010	2007	2008	2007	2008
corr	0.957	0.1786	0.1836	0.0451	0.1204
p-value	0.000	0.3727	0.3592	0.8232	0.5498

Table 6: Correlations with number of Peiex's regional units

Note: The columns show the correlations between number of Peiex regional units (NOs) and (1) number of treated firms (Peiex), (2) number of exporters in 2007, (3) number of exporters in 2008, (4) average change in the number of layers at state level in 2007, (5) average change in the number of layers at state level in 2007.

Assuming that the decision of Peiex regional units' location is exogenous to changes on firms' organization based on hierarchy of knowledge, we used the number of Peiex regional units (NOs) in the state of firms' headquarters as an instrument (A) for receiving Peiex assistance. Furthermore, the Peiex program targets firms with some potential to become an exporter. For this purpose, it uses as a reference the

information that is available related to those firms that receive other export promotion programs. In this regard, the program may work as a bridge for firms that have no access to other export assistance programs through industry association agreements. Thus, we have taken into consideration the existence of treated firms in other export promotion programs in similar sectors. We also used the number of firms that received other export promotion support in previous years by sector CNAE (5 digits) in each state, conditional on Peiex's existence, as an instrument (B).[26] Moreover, we also used the interaction term between (A) and (B) in the first stage. We used the following fixed effects instrumental variable (IV) specification with two-stage least square (2SLS) approach:

First stage

$$D_{isrt} = \alpha_i + \theta_{st} + \beta_1 Z_{srt} + \iota X_{isrt} + \zeta_{isrt} \tag{2}$$

Second stage

$$Y_{isrt} = \lambda_i + \kappa_{st} + \tau \hat{D}_{isrt} + \gamma X_{isrt} + \epsilon_{isrt} \tag{3}$$

Where D_{isrt} is the treatment status of firm i, in sector s, region r, at time t; Z_{srt} are the instruments for Peiex's treatment status (number of regional office units by state at time t and number of firms that received other Apex support by same sector and state at time *t-1*); $\hat{D}_{isrt}$ is the predicted D_{isrt} from the first stage; X_{it} are covariates used as control variables at the firm level (e.g. number of employees, employees' schooling, managers' characteristics - including previous experience in exporting firms, age of the firm, etc.); α_{isr} and λ_{isr} are the firm fixed effects; θ_{st} and κ_{st} are the sector-year fixed effects; ζ_{isrt} and ϵ_{isrt} are the error terms.

For the identification of Peiex's effect, we assumed that $\text{cov}(Z_{srt}, \epsilon_{isrt}) = 0$ and $\text{cov}(Z_{srt}, \zeta_{isrt}) = 0$.[27] Hence, we assumed that the number of Peiex's regional offices does not affect firms' organization except through the fact that it increases the likelihood of receiving the program. Moreover, firms' fixed effects (α_i and λ_i) control for time invariant states' and firms' characteristics that could simultaneously affect the likelihood of receiving Peiex' regional units and changes on firms' organization. Even if some states are more likely to establish a Peiex regional unit for specific reasons that could be eventually correlated with firm performance, as long as these reasons are time invariant this would not affect our identification in the presence of firm or state fixed effects.[28]

[26] The idea is that, once controlled for time-constant heterogeneity and sector-year shocks, the number of Apex's excluding Peiex-treated firms in a similar sector, in previous years, should not impact firms' organization directly. In addition, We used an interaction term between both instruments. The fact that we have more than one instrument allows us to carry overidentification restrictions tests.

[27] This means that the instruments should be orthogonal to the error terms (ϵ_{isrt} and ζ_{isrt}) in the first and second stages.

[28] Also, there were no relevant changes in political power coming from elections at the state or federal levels over the 2007-2010 period in Brazil. The mandate of the president, state level government and congressmen elected in the general elections of 2006 went through the 2007-2010 period. Therefore, during the period of analysis there was no changes on key political positions such as president, state level government and congressmen at the state and federal levels.

Also, the fact that we are dealing with count data that might be correlated with previous years (hierarchy at t as function of hierarchy in *t-1*) demands additional cautions regarding non-linearity and dynamics.[29] We showed that firms' organization varies even after controlling for size (firms with the same number of workers have different number of layers).[30] Nonetheless, changes in hierarchy and size (measured by total number of workers) might be simultaneously determined which might result in $\text{cov}(X_{it}, \epsilon_{it}) \neq 0$. This might be a second source of endogeneity that may be an issue for identifying τ if $\text{cov}(X_{it}, D_{isrt}) \neq 0$.

Regarding the count data properties of the dependent variable, we applied a logarithmic transformation of Y (number of layers) keeping the full number of layers of the firm from 1 to 5. This transformation allowed us to estimate τ using a fixed-effect instrumental variable approach in order to control for time-invariant firms' characteristics. In order to check if the logarithmic transformation provides a reasonable approximation to deal with non-linearities, we compared the coefficients of a Poisson estimator and a standard panel fixed effects.[31] For the second source of endogeneity we instrumented the regressors (X_{it}) that could be simultaneously determined with Y_{isrt} using their own variables with 2 lags.[32] The main assumption is that $(X_{it-2}\ ,\ \epsilon_{it}) = 0$, once we controlled for firms' time-constant heterogeneity.

We complement the analysis by adopting a panel fixed effects procedure without instrumenting D_{it} and using a similar procedure to deal with potential endogeneity in X_{it}. We compared the results controlling for potential regional (state-year) and sectoral-year shocks. In this case the identification is based on a difference-in-difference (DID) approach, which assumes that there is no time-invariant unobservable that determines the access to the program and firms' organization simultaneously. The specification is the following:

$$log(Y_{isrt}) = \alpha_i + \sigma_{st} + \eta_{rt} + \psi D_{isrt} + \beta_n\ X_{isrt} + \epsilon_{isrt} \tag{4}$$

Where: Y_{isrt} is the outcome of interest (number of layers based on knowledge); α_i is a firm fixed effects intercept; σ_{st} is a time-sector fixed effects; η_{rt} is a time-region fixed effects; D_{it} is Peiex's treatment status at the firm-level; X_{it} is a vector with firms' control covariates and ϵ_{isrt} is the error term. The next section presents the empirical results.

[29] Observations in count data can take only non-negative integer values and these integers results from counting rather than ranking.

[30] We are interested in analyzing the impact of the program on firms' organization conditional on firms' size.

[31] See Cameron and Trivedi (1999).

[32] The covariates include number of employees, average employee's wage, average years of employee's schooling, share of engineers and R&D workers, average experience of employees, management quality based on the wage's distribution for the top layers, new managers hired with former experience in exporting firms and number of subsidiaries.

4 Empirical Results

4.1 Does Peiex assistance impact the organization of the firm?

In section 2 we showed that the definition of layers is economically meaningful and brings important information about the dynamics of firms (see also section 6.2 in the appendix). A key objective of Peiex is promoting firms' reorganization to make them more competitive.[33] Therefore, to check if the program impacted the organization of the firm in terms of hierarchy of knowledge we analyzed its impact on the change of the number of layers.

First, we carried an instrumental variable panel fixed effects estimation to control for time-constant heterogeneity among firms, allowing for $\text{cov}(\lambda_{isr}, \gamma X_{it}) \neq 0$. We instrumented treatment status D_{it} with Z's and X_{it-2} as discussed in the previous section. We used a sample conditioned on firms that had not exported in 2007 and 2008.[34]

Table 7 shows the results for the instrumental variable panel fixed effects. We followed the general specification described in equations (2) and (3). In order to test the sensitivity of the parameter for additional covariates we ran six different specifications with additional covariates X_{it-2}. The results for the second and first stages are presented in subsequent columns for each specification. In addition to controlling for time-invariant firms' heterogeneous characteristics, we also used sector-year fixed effects aiming to control for aggregated sectoral-year shocks (e.g. exchange rate, interest rate, tariff reduction).[35]

The Local Average Treatment Effect (LATE) of Peiex (τ) is positive and statistically significant at 5% for different specifications (table 7), controlling for a large amount of covariates. The dependent variable was log-transformed. In order to interpret the coefficient, we can take the exponential of both sides of equation (3) and analyze the outcome conditional on Peiex status. For τ=0.172 (see equation 3) - considering the estimations with covariates - the average impact is an increase of 18.8% of the probability of adding a layer.[36] Also, the variables "Manager exp M_1-M_3" are positive and statistically significant in the second stage. This suggests that firms that hire managers with previous experience in other exporting firms are also more likely to change the way they organize knowledge.

Regarding the results of the first stage, the effect of the instrumental variables on the probability of getting Peiex is statistically significant at 1%. The main instrument (number of NOs by state) has a positive sign. The larger the number of Peiex regional units in the state of the firm, the larger the

[33] Caliendo and Rossi-Hansberg (2012) suggest that in a dynamic perspective more competitive firms add more layers, which allows them to reach lower levels of marginal cost.

[34] Results are consistent for the full sample.

[35] Peiex coefficient is also significant when we control for state fixed effects, without controlling for firms fixed effects, using the same instruments.

[36] On average Peiex's treated firms have 1.73 layers of based-knowledge hierarchy.

Instrumental Variable Fixed Effects Estimator						
Dependent variable: Log(Number of layers)						
	(1)		**(2)**		**(3)**	
Variables	**2nd**	**1st**	**2nd**	**1st**	**2nd**	**1st**
Peiex	0.2010		0.1545		0.1720	
	(0.0543)		(0.0521)		(0.0500)	
(A) Number NO by State		0.0034		0.0036		0.0036
		(0.0003)		(0.0003)		(0.0003)
(B) lag(sector-region Apex)		-0.0046		-0.0047		-0.0047
		(0.0013)		(0.0014)		(0.0014)
Interaction Term (A)*(B)		0.0018		0.0018		0.0018
		(0.0005)		(0.0005)		(0.0005)
Other programs Apex	0.0371	-0.0635	0.0329	-0.0638	0.0240	-0.0639
	(0.0092)	(0.0148)	(0.0091)	(0.0149)	(0.0085)	(0.0149)
Firms' age	0.0098	0.0002	0.0116	-0.0008	0.0099	-0.0008
	(0.0010)	(0.0006)	(0.0010)	(0.0007)	(0.0010)	(0.0007)
Firms' age^2	-0.0002	0.00004	-0.0002	0.0000	-0.0002	0.0000
	(0.00002)	(0.00001)	(0.0000)	(0.0000)	(0.0000)	(0.0000)
log(number employees)$_{t-2}$	0.0288	0.0037	0.0268	0.0036	0.0202	0.0035
	(0.00121)	(0.00060)	(0.0012)	(0.0006)	(0.0012)	(0.0006)
log(wage)$_{t-2}$			0.0004	0.0011	0.0012	0.0011
			(0.0012)	(0.0003)	(0.0012)	(0.0003)
log(schooling)$_{t-2}$			-0.0122	-0.0031	-0.0126	-0.0031
			(0.0036)	(0.0011)	(0.0035)	(0.0011)
log(nbr exporters - region)			0.0021	0.0018	0.0023	0.0018
			(0.0017)	(0.0021)	(0.0016)	(0.0021)
share(engineer and R&D)$_{t-2}$			0.0229	0.0020	0.0171	0.0020
			(0.0075)	(0.0013)	(0.0062)	(0.0013)
average experience $_{t-2}$			-0.0039	-0.0001	-0.0038	-0.0001
			(0.0001)	(0.0000)	(0.0001)	(0.0000)
number of subsidiaries $_{t-2}$			0.0299	0.0042	0.0273	0.0042
			(0.0030)	(0.0016)	(0.0028)	(0.0016)
Manager exp M_1					0.0235	0.0030
					(0.0068)	(0.0044)
Manager exp M_2					0.0239	-0.0036
					(0.0065)	(0.0076)
Manager exp M_3					0.0244	-0.0024
					(0.0045)	(0.0032)
Manager M_1 N-Q_4					0.1701	0.0001
					(0.0113)	(0.0018)
Manager M_1 F-Q_4					0.0531	0.0006
					(0.0293)	(0.0020)
Manager M_2 N-Q_4					0.1176	-0.0010
					(0.0227)	(0.0012)
Manager M_2 F-Q_4					0.1175	0.0004
					(0.0585)	(0.0028)
Manager M_3 N-Q_4					0.2554	-0.0008
					(0.0098)	(0.0013)
Manager M_3 F-Q_4					0.0057	-0.0050
					(0.0282)	(0.0030)
Additional Manager's control* Managers Q_2-Q_3	NO	NO	NO	NO	YES	YES
Firms Fixed Effect	YES	YES	YES	YES	YES	YES
Sector-Year Fixed Effect	YES	YES	YES	YES	YES	YES
Number Obs.	729,340	729,340	729,272	729,272	729,272	729,272
Number of clusters (Firms)	240,009	617	207,415	616	207,415	616
Nbr Variables	76	76	82	82	103	103

Table 7: Instrumental variable fixed effects model. Dependent variable: number of layers

Note: Standard errors clustered at the state-sector level in the first stage and at the firm level in the second stage are reported in parentheses. Managers are classified by occupations equivalent to CEOs and Directors (M1), Senior staff (M2) and Supervisors (M3). N and F refer to their nationalities, where N(Nationals) and F(Foreigners). Additional Manager's control (Managers Q_2-Q_3) refers to dummy variables for managers in the second and third quartile of wage distribution. The variable lag(sector-region Apex) refers to the lag of the number of firms that were assisted by other Apex programs in the previous year. The variables used as instruments are also significant in the first stage when the standard errors are clustered at the state level.

probability of getting the assistance. A critical assumption in the identification is that this variable is orthogonal to the residuals in both stages.[37] In addition, we used as a covariate the log of the number of exporters at micro-region level (see columns 4 and 6).[38]

The second instrument aims to be a proxy for the fact that the program is targeting potential exporting firms that are interested in taking advantage of services for matching foreign buyers. For identifying this potential, Apex uses their own information on sectors for which these services have been provided. Peiex assistance is strongly correlated with states that received NOs. Therefore, we should expect a positive sign for this variable in these states. This is what we get from the interaction term. For the instrument itself the answer is ambiguous because we are interacting with information at the sector level (CNAE 5 digits) for states where Peiex was not available and we are controlling for sector-year shocks (CNAE 2 digits). Therefore if there were sectors (at 5 digits) attended by Apex in the past that are more prevalent in states where Peiex is not available, once we are controlling for a more aggregate sector-year shock the coefficient's sign will depend on this interaction.[39] We also tested for similar specifications keeping only two instruments (number of NOs by state and the lag of sectors(CNAE 5 digits) assisted in each state conditional on Peiex existence) and only one instrument (number of NOs by state).[40] The impact is still positive and significant. The advantage of using additional instruments is that it allows us to test for overidentification restriction, which is part of the robustness check.

Heterogeneous effects

We also test if there is evidence of heterogeneity of the program effects across different firms, based on their initial number of layers of knowledge. We run a specification that is similar to our baseline for two group of firms: 1) Firms that had between 0 and 1 layer in 2007 and 2008; 2) Firms that had between 2 and 3 layers in 2007 and 2008.[41] On average, firms that did not export between 2007 and 2008 (2

[37] We showed in section 3 that the null hypothesis that the correlation between number of NOs by state and average changes on firms' organization is different than zero in the period previous to the treatment is not rejected (see table 6).

[38] This variable aims to control for potential exogenous shocks (e.g. external demand) that might impact exporters at the regional level and could affect production hierarchy of firms in the same region. However, we see that this variable is significant in the first stage, but not in the second stage.

[39] We tested for many different specifications in order to identify what is leading the negative sign of this instrument in the first stage (results are available upon request). Indeed, it is led by the incidence of firms that are in sectors (CNAE 5 digits) that received assistance in a previous year in states that were not eligible for Peiex, until 2010. Nonetheless, conditional on being in a state eligible for Peiex the effect is positive. The average for lag (dummy sector Apex state) is 0.318, while the average value for the interaction term is 0.635. Therefore, if we multiply these values by the coefficients, the net effect of being in a sector (CNAE 5 digits) that received other Apex services (non-Peiex) treatment in *t-1* is that it increases the probability of receiving Peiex by 0.45%, ceteris paribus. It means that if there are two similar firms in a given sector (CNAE 2 digits), and only one of them is in a sector that received previous Apex support in the same state, this will increase its probability of receiving the program by 0.45%, on average. We also ran a panel fixed effects assuming a weight equals zero for states that did not receive NOs. In this case, if we drop the interaction term, the coefficient becomes positive. Although the interaction between the sector (CNAE 2 digits) year dummies and this instrument makes its interpretation less straightforward, the advantage is that it is very unlikely that it is correlated with the residuals due to the sector-year controls.

[40] These results are available upon request.

[41] This period refers to two years before the implementation of the program.

years previous the implementation of the program) had 1.1 layers of knowledge. For the period 2009, both groups had a median of 1 layer of knowledge.[42] The likelihood of adding a layer of hierarchy of knowledge increases with Peiex's support for those firms that had between 0 and 1 layer in 2007 and 2008. The coefficients are similar to our baseline model (Table 8). However, we found no evidence of significant effect for a sub-sample of firms that had between 2 and 3 layers of hierarchy of knowledge and were non-exporting in 2007 and 2008. These findings suggest that Peiex's effect was heterogeneous and more significant among firms with lower number of hierarchies in their initial condition.

Variable	0 or 1 Layer in 2007-2008			2 or 3 Layers in 2007-2008		
	(1)	(2)	(3)	(4)	(5)	(6)
Peiex	0.202	0.191	0.194	-0.001	-0.014	-0.006
	(0.079)	(0.079)	(0.075)	(0.065)	(0.065)	(0.059)
Firms' age	0.016	0.018	0.017	-0.014	-0.011	-0.015
	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)
Firms' age^2	-0.00035	-0.00035	-0.00033	0.00011	0.00009	0.00015
	(0.00003)	(0.00003)	(0.00003)	(0.00003)	(0.00003)	(0.00003)
log(number employees)$_{t-2}$	0.031	0.029	0.022	0.053	0.050	0.038
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Covariates						
X1		Yes	Yes		Yes	Yes
X2			Yes			Yes
N	540,644	540,585	540,585	203,383	203,380	203,380
Number of firms	152,923	152,923	152,923	54,309	54,309	54,309

Table 8: Heterogeneous effect

Note: Results refer to the second stage. Standard errors clustered at the firm level in the second stage are reported in parentheses. Instrumental variables are statistically significant in the first stage with standard errors clustered at the state-sector level. The variables used as instruments are also significant in the first stage when the standard errors are clustered at the state level. The following additional controlling variables are included in the models: X1(Other programs Apex, log of wage, log of schooling, dummy for multinational, share of engineers and R&D workers, lag of average experience, lag of additional plants), X2(dummy Manager export M1-M3, TOP managers by nationality status M1-M3).

In addition, we tested for heterogeneity regarding the timing that Peiex program affects firms' organization. We also found a positive effect of the program one year after it started. All in all, Peiex have a positive effect on firms' organization based on hierarchy of knowledge. The results seems robust with heterogeneous effect. Under IV identification assumption, Peiex increases the likelihood of a firm add a layer of hierarchy of knowledge for those firms that have lower level of organization (0 or 1 layer) before the program started. Nonetheless, the result is not significant for those firms with two layers or more before the program started.

[42]Only 10% of the firms that received Peiex were exporting between 2007 and 2008. These (exporting) firms has 2.9 layers on average and a median of 3 layers. Exporting firms that were never assisted by Peiex had 4.01 layers on average and a median of 4 layers, between 2007 and 2008.

4.2 Robustness check

A critical assumption in the identification is the exclusion restriction, which means that the instruments are orthogonal to the residuals in the first and second stages. While we cannot test this assumption directly, there are some standard robustness checks that provide additional support to the results. First, table 9 shows the F statistic for joint significance of the instruments Z in the first stage. It is noticeable that we reject the null hypothesis that all excluded instruments are not significant at 1% significance. Stock-Yogo shows the critical value for the null hypothesis that the bias of 2SLS is less than a given fraction (e.g. 5%) of the bias of OLS. Based on the F-statistics of the first stage we can reject the null hypothesis at 5% of maximal IV relative bias.

Also, due to the fact that we used two variables and the interaction among them as instruments, we can test if at least one of the instruments is exogenous (see Hansen J test on table 9). We do not reject the null hypothesis that all instruments are valid and conclude that the overidentifying restrictions are valid. In addition, we ran the specification using two instruments (number of NOs by state and the lag of sectors (CNAE 5 digits) assisted in each state weighted by Peiex existence) without the interaction term and the null hypothesis is rejected.

Test	(1)	(2)	(3)
F test of excluded instruments:			
F-stat	61.37	72.72	73.03
Prob>F	0.00	0.00	0.00
Stock-Yogo weak ID test critical values:			
5% maximal IV relative bias	13.91	13.91	13.91
10% maximal IV relative bias	9.08	9.08	9.08
20% maximal IV relative bias	6.46	6.46	6.46
30% maximal IV relative bias	5.39	5.39	5.39
10% maximal IV size	22.3	22.3	22.3
15% maximal IV size	12.83	12.83	12.83
20% maximal IV size	9.54	9.54	9.54
25% maximal IV size	7.8	7.8	7.8
Hansen J statistic :			
Overidentification test of all instruments	0.22	2.69	2.33
Chi-sq(2) P-val	0.89	0.26	0.31
Underidentification test			
(Kleibergen-Paap rk LM statistic):	39.6	47.64	47.51
Chi-sq(3) P-val	0.00	0.00	0.00

Table 9: Overidentification test: Fixed effects instrumental variable

Note: Columns (1), (2) and (3) refer respectively to the three specifications used for the results presented on table (7).

We also ran a Poisson panel fixed effects estimator. In this case, Peiex's treatment effect is identified under DID assumptions. An advantage of this method is that it takes into consideration the non-linearity

of the dependent count variable.[43] We ran a similar specification using panel fixed effects, to check if the logarithm transformation provides a good approximation for the Poisson estimators. Also, we controlled for regional year (state-year dummies) shocks that play an important role in the IV identification strategy. First of all, the coefficient of Peiex's treatment is not sensitive to state-year fixed effects. Table 10 shows that adding these controls change the coefficients very little (from 0.041 to 0.039) and also the standard errors (from 0.0054 to 0.0055). Results are similar if we use panel fixed effects or Poisson estimation. The coefficients are still positive and significant.

The estimation confirms that Peiex-assisted firms had changed their organization, adding additional layers (this difference is significant at 1%), after controlling for time-constant heterogeneity, a large set of firms' covariates (including proxies for quality of management). The coefficient is smaller than the LATE from the IV. Finally, the results using Poisson fixed effects estimators are relatively close to the ones obtained with logarithm transformation (table 10), which suggests that the adopted procedure provides a good approximation of the non-linearity presented in the dependent count variable. In both cases (Poisson fixed effects and Panel fixed effects), Peiex's coefficients are still positive and significant, though the magnitude is smaller.

We also ran a panel fixed effect, using a DID identification approach, to analyze the effect of Peiex conditional on initial number of layers, the coefficients for Peiex treatment are positive and statistically significant. Under DID assumption the coefficients for Peiex program is positive and statistically significant at 5% of confidence for all the sub-groups of initial level of layers. In other words, if we compare a sample of firms that have the same number of layers of knowledge two years previously the program's implementation, those firms that received Peiex were more likely to add a layer of knowledge.

Last, but not least, since Peiex started in 2008, there were no treated firms in 2007. We ran a placebo test moving the variables used as instruments and the treatment status in the first year of treatment to 2007 and test if there is a positive effect of the program between 2007 and 2008. We found that the effect of Peiex on number of layers are non-statistically significant in this case. Thus, there is no evidence that results are driven by previous performance of treated firms.

4.3 Peiex and hierarchy of knowledge: What does this means for firms' performance?

The hierarchy based on knowledge measures different levels of competencies of workers limited to 4 layers. Hence, this is not about increasing the number of directors or manager positions itself; neither

[43] This method was made popular by Hausman et al. (1984).

Variable	Fixed Effects Poisson			Fixed Effects		
	(1)	(2)	(3)	(4)	(5)	(6)
Peiex	0.0390	0.0376	0.0325	0.0463	0.0448	0.0405
	(0.0051)	(0.0051)	(0.0050)	(0.0059)	(0.0059)	(0.0058)
Apex(other programs)	0.0229	0.0202	0.0116	0.0278	0.0245	0.0142
	(0.0067)	(0.0066)	(0.0061)	(0.0085)	(0.0084)	(0.0078)
Firms' age	0.0118	0.0122	0.0100	0.0155	0.0156	0.0134
	(0.0013)	(0.0013)	(0.0012)	(0.0017)	(0.0017)	(0.0016)
Firms' age^2	-0.00021	-0.00022	-0.00018	-0.00025	-0.00027	-0.00023
	(0.0000)	(0.0000)	(0.0000)	(0.00002)	(0.00002)	(0.00002)
log(number employees)$_{t-2}$	0.0183	0.0174	0.0130	0.0170	0.0161	0.0124
	(0.0008)	(0.0008)	(0.0008)	(0.0008)	(0.0008)	(0.0008)
log(wage)$_{t-2}$		0.0034	0.0042		0.0013	0.0019
		(0.0016)	(0.0015)		(0.0013)	(0.0012)
log(schooling)$_{t-2}$		-0.0108	-0.0115		-0.0117	-0.0121
		(0.0037)	(0.0035)		(0.0036)	(0.0035)
log(nbr exporters - region)		0.0006	0.0008		0.0016	0.0018
		(0.0015)	(0.0014)		(0.0016)	(0.0016)
share(engenieer and R&D)$_{t-2}$		0.0193	0.0147		0.0241	0.0189
		(0.0062)	(0.0051)		(0.0073)	(0.0063)
average experience $_{t-2}$		-0.0045	-0.0043		-0.0039	-0.0038
		(0.0001)	(0.0001)		(0.0001)	(0.0001)
number of subsidiaries $_{t-2}$		0.0056	0.0049		0.0109	0.0095
		(0.0032)	(0.0030)		(0.0057)	(0.0053)
Manager exp M_1			0.0156			0.0239
			(0.0049)			(0.0067)
Manager exp M_1			0.0189			0.0259
			(0.0047)			(0.0066)
Manager exp M_3			0.0193			0.0248
			(0.0034)			(0.0045)
Manager M_1 N-Q_3			0.1595			0.1717
			(0.0080)			(0.0112)
Manager M_1 F-Q_3			0.0335			0.0621
			(0.0180)			(0.0284)
Manager M_2 N-Q_3			0.1224			0.1201
			(0.0148)			(0.0221)
Manager M_2 N-Q_3			0.0828			0.1245
			(0.0333)			(0.0557)
Manager M_3 N-Q_3			0.2021			0.2582
			(0.0073)			(0.0097)
Manager M_3 N-Q_3			0.0135			0.0089
			(0.0160)			(0.0272)
Additional Manager's control*						
Managers QII-QIII	NO	NO	YES	NO	NO	YES
FIXED EFFECT						
FIRMS	YES	YES	YES	YES	YES	YES
Sector-Year	YES	YES	YES	YES	YES	YES
Region(State)-Year	YES	YES	YES	YES	YES	YES
N	731,265	731,265	731,265	779,356	779,278	779,278
Firms (cluster)	207,415	207,415	207,415	255,428	255,428	255,428

Table 10: Dependent variable: Number of layers. Poisson panel fixed effects

Note: Standard errors clustered at firm level are reported in parentheses. Managers are classified by occupations equivalent to CEOs and Directors (M1), Senior staff (M2) and Supervisors (M3). N and F refer to their nationalities, where N(Nationals) and F(Foreigners). Additional Manager's control (Managers QII-QIII) refers to dummy variables for managers in the second and third quartiles of wage distribution. Sector (CNAE 2 digits).

are we assuming that the more managers, the better. Instead, increasing the number of layers in this case means that a firm is incorporating workers with different levels of competency and specialized knowledge in solving different problems at the firm. For example, if a firm already has 3 layers and decides to

hire more workers at the same layers we assume that there is no change in the way firms organize their knowledge of production, even if these new workers have managers' positions. Thus, we capture one type of organization, but one which matters for performance.

We found evidence that Peiex has an effect on firms' organization based on hierarchy of knowledge (see section 4.1). This means that the program increases the propensity of a treated-firm adding workers with level of knowledge not previously available in its structure. The majority of firms already have producer workers. Hence, by increasing the number of layers they are adding workers in new occupations that require additional and specialized knowledge. Apart from the fact that these workers have more average years of schooling (see section 6.2 of the appendix), the concept of occupation does not take into consideration only the education background of the worker, but also her activity at the firm.[44] Therefore, the layers of hierarchy measure specialization of knowledge at the firm (see Caliendo et al. (2012)).

Figure 2 shows that for the same amount of employees there are firms with different number of layers. There are almost the same number of firms with 0 and 4 layers of management based on knowledge among those firms between 19 and 20 employees (approximately log of 3) (see table 18 in section 6.2 of the appendix). Nonetheless, on average those firms with larger number of layers of knowledge are more likely to be exporters. Figure 3 plots the propensity to export against the number of employees according to number of layers for firms with less than 150 workers.[45] It is noticeable that the propensity to export is larger for firms with more layers based on knowledge given the same amount of workers.

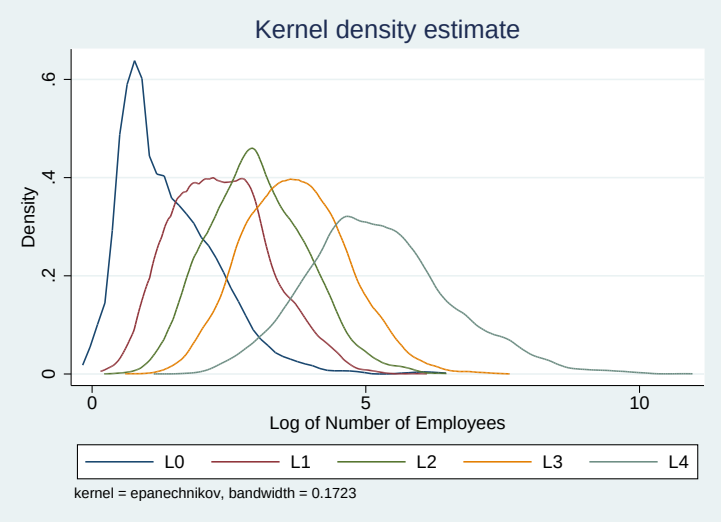


Figure 2: Kernel density estimate of number of employees by number of layers

Note: L0 refers to the distribution of the number of workers across firms without hierarchy of knowledge. Usually those firms have only employees with occupations classified as blue collars. L1 refers to the distribution of the number of workers across firms with one layer of hierarchy of knowledge. Those are firms that have employees in two different occupations according to the classification in table 1 (e.g. blue collars and technicians). L2, L3 and L4 refer to the distribution of the number of workers across firms with 2, 3, and 4 layers of hierarchy of knowledge. Those are firms that have employees in 3, 4, and 5 different occupations according to the classification in table 1.

[44] A firm can hire workers with higher level of education in occupations that do require lower level of knowledge.
[45] More than 98% of firms that received Peiex's support in 2009 and 2010 had less than 150 employees.

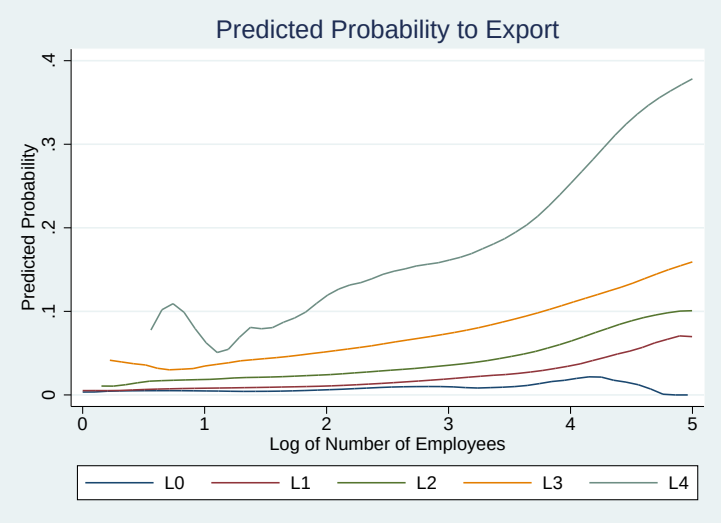


Figure 3: Export propensity plotted against number of employees according to number of layers of management

Note: L0 refers to the propensity to export according to total number of workers for firms without hierarchy of knowledge. Usually those firms have only employees with occupations classified as blue collars. L1 refers to the propensity to export according to total number of workers for firms with one layer of hierarchy of knowledge. Those are firms that have employees in two different occupations according to the classification in table 1 (e.g. blue collars and technicians). L2, L3 and L4 refer to the to the propensity to export according to total number of workers for firms firms with 2, 3, and 4 layers of hierarchy of knowledge. Those are firms that have employees in 3, 4, and 5 different occupations according to the classification in table 1.

These findings are supported by Cruz (2014), who shows that non-exporting firms that received export promotion assistance, including Peiex, are more likely to become exporters. Also, table 11 shows the relationship between the transition of exporting status and organization.[46] Firms are divided in three groups: non-exporters (firms that did not export at periods t and $t+1$); new exporters (firms that did not export at period t but become an exporter at period $t+1$) and continuing exporters (firms that continuously exported from 2007 to 2010). The rows show the number of layers at period t and the columns show the number of layers the same firms have at period $t+1$. The main diagonal shows the share of firms that kept the same number of layers.

When analyzing non-exporting firms, almost 70% of them have no more than one layer of hierarchy. Among them, the majority (82% of those firms without layers and 74% of those with one layer) did not change the number of layers. Also, among those firms with between 1 and 3 layers the share of firms that increase the number of layers is always smaller than the share of firms that decrease them. It is noticeable that the scenario for new exporters is different. Among them, the share of firms that add an additional layer is always larger than those ones that decrease it if we take into consideration firms that had between 1 and 3 layers in t.[47] Moreover, approximately 91% of the firms with 4 layers in t_0 kept this organization design after switching from non-exporting to exporting status. Hence, firms that become

[46] The dynamic year by year from 2007 to 2010 is relatively similar.
[47] Having between 1 and 3 layers is a condition that allows firms to add or subtract at least one layer.

Non-Exporting firms								
	Number	Year 2009 - 2010 (year t+1)					Firms (2009)	
	of Layers	0	1	2	3	4	Number	Share*
	0	**81.66**	15.75	2.23	0.32	0.05	80,628	35.42
year t	1	12.59	**73.64**	12.06	1.53	0.18	77,335	33.97
(2010)	2	2.81	16.67	**67.74**	11.59	1.19	41,815	18.37
	3	1.17	3.46	18.42	**65.70**	11.26	18,960	8.33
	4	0.63	0.77	3.46	16.80	**78.34**	8,904	3.91
Firms	Number	77,027	77,341	43,250	20,239	9,785	227,642	-
(2010)	Share*	33.84	33.97	19.00	8.89	4.30	-	100.00
New exporters firms								
	Number	Year 2009 - 2010 (year t+1)					Firms (2009)	
	of Layers	0	1	2	3	4	Number	Share*
	0	**57.24**	28.97	9.66	1.38	2.76	145	8.02
year t	1	4.61	**70.72**	17.76	5.26	1.64	304	16.80
(2010)	2	1.30	6.74	**68.91**	17.88	5.18	386	21.34
	3	-	0.50	13.03	**67.17**	19.30	399	22.06
	4	-	-	0.70	7.30	**91.83**	575	31.79
Firms	Number	102	286	390	397	634	1809	-
(2010)	Share*	5.64	15.81	21.56	21.95	35.05	-	100.00
Continuing firms								
	Number	Year 2009 - 2010 (year t+1)					Firms (2009)	
	of Layers	0	1	2	3	4	Number	Share*
	0	**75.21**	17.36	3.31	2.48	1.65	121	1.90
year t	1	9.28	**73.65**	13.77	2.10	1.20	334	5.24
(2010)	2	0.87	10.14	**69.13**	16.67	3.19	690	10.82
	3	0.56	1.21	8.22	**70.84**	19.16	1,070	16.78
	4	0.12	0.10	0.34	3.46	**95.99**	4,163	65.27
Firms	Number	139	354	629	1,027	4,229	6,378	-
(2010)	Share*	2.18	5.55	9.86	16.10	66.31	-	100.00

Table 11: Distribution of layers at t+1 conditional on layers at t (by year)

exporters are more likely to change their organization and add new layers.

Regarding continuing exporters, the share of firms that add new layers is much larger than firms that reduce them, which is similar to new exporters. Also, the majority of the firms have already 3 or 4 layers and among the former, almost 95% keep the same structure. Therefore, the structure of exporting firms is composed of more layers than non-exporting firms and new exporters are more likely to add layers of managers than non-exporting firms.[48] Figure 6 in section 6.2 of the appendix shows the dynamic of firms that become exporters regarding their average wage and hours hired.[49]

[48] What is interesting in these findings is that depending on adding layers or not, new exporters react differently in terms of how they distribute production knowledge within the firm when they expand and this can be observed by the average wage in different layers.

[49] Overall, we found that the prediction of their theory holds in most of the cases when the transition of the same firms that become exporters and add additional layers in the same year is compared. It means that the same firms that switch export status (from non-exporting to exporting) and add one layer usually pay lower wages for workers at previously existing layers.

4.4 Expansion, reorganization and wage inequality

Another relationship between the firms' organization and competitiveness is related to within wage inequality and hours hired among producer workers. According to Caliendo and Rossi-Hansberg (2012), a reorganization of the firm by adding additional layers of knowledge-based hierarchy would lead to a decrease in the average wage in layers previously existent, even though the average wage for the whole firm may increase. Because the new top layers of management have an average wage that is higher than the previous layer and the average wage for producer workers decreases, we would expect the ratio of average wage in the top layer divided by the average wage in L0 to increase for those firms that receive Peiex's support.

We ran similar specifications with panel fixed effects for log of wage's inequality. Table 12 shows the results (first three columns). Overall, we observed Peiex treatment is associated with an increasing in wage inequality between layers and its coefficient is statistically significant at 5%. Also, the theoretical reference predicts that the number of hours on previously existing layers would increase. Table 12 shows that the coefficients are positive and significant at 1% confidence (last three columns). These results are consistent with the theory that firms reorganize their knowledge on production by adding new occupations with relatively higher wages, used here as a proxy of larger knowledge, which allows them to keep relatively lower marginal cost of production.

	LOG INEQUALITY			LOG HOURS L0		
Variable	model1	model2	model3*	model1	model2	model3*
Peiex	0.017	0.017	0.013	0.149	0.144	0.142
	(0.007)	(0.007)	(0.007)	(0.012)	(0.012)	(0.012)
apex(EP)	0.034	0.033	0.026	0.090	0.077	0.074
	(0.012)	(0.012)	(0.012)	(0.022)	(0.022)	(0.022)
log(number employees)t-2	0.012	0.012	0.009	0.013	0.009	0.008
	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)
Firms' age	0.004	0.004	0.002	0.033	0.033	0.032
	(0.003)	(0.003)	(0.002)	(0.005)	(0.004)	(0.004)
Firms' age$\hat{2}$	0.000	0.000	0.000	-0.001	-0.001	-0.001
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
log(wage)t-2		-0.001	0.000		0.009	0.009
		(0.001)	(0.001)		(0.003)	(0.003)
log(schooling)t-2		0.003	0.003		-0.007	-0.006
		(0.003)	(0.003)		(0.008)	(0.008)
log(nbr exporters - region)		-0.002	-0.002		-0.008	-0.008
		0.002	0.002		0.004	0.004
share(engenieer and R&D)t-2		(0.021)	(0.017)		(0.012)	(0.008)
		0.008	0.008		0.014	0.014
average experience t-2		-0.001	-0.001		-0.012	-0.012
		(0.000)	(0.000)		(0.000)	(0.000)
number of subsidiaries t-2		0.015	0.013		0.042	0.042
		(0.003)	(0.003)		(0.015)	(0.015)
Manager exp M_1			0.073			0.049
			(0.016)			(0.026)
Manager exp M_2			-0.004			0.128
			(0.017)			(0.028)
Manager exp M_3			0.010			0.071
			(0.011)			(0.017)
Manager M_1 N-Q_4			0.153			-0.139
			(0.023)			(0.035)
Manager M_1 F-Q_4			0.097			0.218
			(0.054)			(0.106)
Manager M_2 N-Q_4			0.025			-0.356
			(0.048)			(0.080)
Manager M_2 F-Q_4			-0.018			0.378
			(0.085)			(0.266)
Manager M_3 N-Q_4			0.058			-0.111
			(0.023)			(0.035)
Manager M_3 F-Q_4			0.028			0.430
			(0.069)			(0.162)
Constant	0.106	0.126	0.107	8.821	9.024	9.012
	(0.027)	(0.029)	(0.028)	(0.052)	(0.053)	(0.052)
FIXED EFFECT						
FIRMS	YES	YES	YES	YES	YES	YES
Sector-Year	YES	YES	YES	YES	YES	YES
Region(State)-Year	YES	YES	YES	YES	YES	YES
N	767,572	767,495	767,495	779,356	779,278	779,278
R2 (within)	0.003	0.003	0.041	0.014	0.019	0.022
Firms (cluster)	255,428	255,428	255,428	255,428	255,428	255,428
F stat	5.810	6.210	32.190	32.230	38.850	38.480
F-prob	0.000	0.000	0.000	0.000	0.000	0.000

Table 12: Dependent variables: Log(Number of within inequality) and Log(Hours hired in L0) - Panel fixed effects

Note: Note: Standard errors clustered at the firm level are reported in parentheses. We exclude outliers (equivalent to 1% of extreme values). Managers are classified by occupations equivalent to CEOs and Directors (M1), Senior staff (M2) and Supervisors (M3). N and F refer to their nationalities, where N(Nationals) and F(Foreigners). Additional Manager's control (Managers -Q_3–Q_1) refers to dummy variables for managers in the second and third quartile of wage distribution. Sector (CNAE 2 digits). Log Inequality refers to the ratio of the average real wage at the top hierarchy (Ln) and production workers (L0). Log hours L0 refers to the log of total hours hired of production workers.

5 Conclusion

This paper evaluates the impact of the Peiex program, a consulting service on management and production practices provided by Apex-Brasil aimed at improving the competitiveness of small and medium firms. We found a positive impact of Peiex on firms' organization. On average, Peiex treated firms have one layer of hierarchy. Based on the IV identification strategy, firms that received the program increased by approximately 18.8%, on average, the propensity to add an additional layer of knowledge-based hierarchy, measured by number of layers.

In addition, we find that the program increases the likelihood of a firm adding a layer of hierarchy of knowledge for those firms that have no layer or one layer of hierarchy two years before the program started and results are significant for those firms with two layers or more previous to the program's intervention. In addition, Peiex firms have expanded the hours hired of workers in occupations belong to previously existent layers. The reorganization of those firms is associated with an increase in the likelihood of being an exporter and a rise in wage inequality between layers of hierarchy based on knowledge. Our findings are consistent with the theoretical models by Garicano (2000) and Caliendo and Rossi-Hansberg (2012). According to these models, this option for reorganization suggests that these firms are likely to be more competitive because the increase in management knowledge allows them to reach a lower marginal cost by economizing on the necessary knowledge for production workers.

6 Appendix

6.1 Peiex-treated firms by year and methodology

Table 13 shows the total number of firms, the number of exporters and the number of Peiex-treated firms by year.

year	Nbr Firms	Exporters	(%)	Peiex	(%)
2007	226,765	12,194	5.38	-	-
2008	232,159	11,967	5.15	-	-
2009	240,470	11,629	4.84	2,410	1.00
2010	247,187	11,363	4.60	3,518	1.42
Total	946,581	47,153	4.98	5,928	0.63

Table 13: Number of manufacturing firms by year (2007-2010)

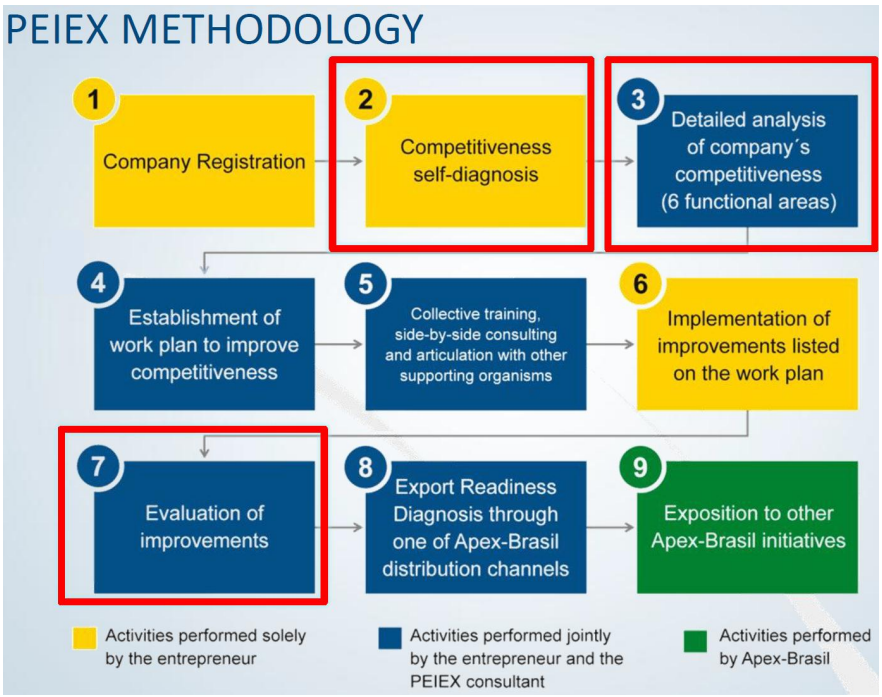


Figure 4: Peiex methodology

Source: Replicated from Borges (2010).

6.2 A proxy for firms' organization

The proxy for firms' organization based on hierarchy of knowledge was build in the spirit of Garicano (2000) and Caliendo and Rossi-Hansberg (2012) theoretical frameworks. In Caliendo and Rossi-Hansberg (2012), heterogeneity on productivity and other firms' outcome results from the way firms organize their

knowledge given the level of demand for their products (economies of scale), which is randomly drawn by an entrepreneur. The production function requires labor and knowledge. Employees can act as production workers (layers $l = 0$) or managers (layers $l \geq 1$). While workers use their unit of time to generate production possibility and solve standard problems for which they are trained, managers use their time on solving exceptional problems that require greater knowledge. Adding an additional layer of knowledge-based hierarchy (layers $\partial l > 0$) results in an additional fixed cost, which allows firms to economize in the knowledge acquisition of their employees, who generate production possibility and determine the marginal cost. This allows firms to reach lower average costs conditional on a sufficiently large scale of production.

This section provides additional descriptive statistics for the variable "layers" based on hierarchy of knowledge, which is used as proxy for firms' organization. To begin with, we analyzed the distribution of wages of workers among the classification we followed in order to check if this criteria matches differences on wages between and within layers. Table 14 shows the distribution of average hourly wage and total amount of hours hired over a year in 2010.[50]

Wage/Hour	CEOs/ Directors	Senior staff	Supervisors	Clerks	Blue collars
mean	14.74	12.71	8.27	5.33	5.13
sd	18.61	12.98	7.02	3.95	3.35
p 01	2.56	2.75	2.50	2.07	1.15
p 05	3.31	3.00	3.04	2.90	2.90
p 10	3.99	3.41	3.43	3.00	3.06
p 25	5.63	4.99	4.59	3.42	3.56
p 50	8.74	9.20	6.81	4.37	4.44
p 75	15.98	17.10	10.17	6.00	5.83
p 90	29.58	26.19	14.51	8.54	7.88
p 95	49.92	32.71	18.16	10.78	9.61
p 99	95.88	49.76	28.23	18.42	14.85
Hours hired (year)					
mean	5,978	12,478	18,882	12,078	41,109
sd	28,371	98,286	125,637	87,285	403,867
p 01	176	176	176	176	352
p 05	528	384	528	672	1,232
p 10	880	704	960	1,056	2,112
p 25	2,112	1,760	2,112	2,112	4,048
p 50	2,112	2,112	3,168	3,696	9,328
p 75	4,224	4,928	8,448	8,096	24,464
p 90	8,976	15,312	26,752	19,008	63,360
p 95	16,368	33,264	57,552	34,672	119,680
p 99	59,488	175,504	258,032	137,456	476,960
Nbr. Firms	67,790	37,029	66,727	166,164	219,980
Share	27.42	14.98	26.99	67.22	88.99

Table 14: Distribution of average hourly wage by occupation (in 2010)

Firstly, the distribution is ranked, the higher the level of competency in the position the higher the

[50]The distribution is relatively similar to the other years in the data.

average wage.[51] Secondly, wages are heterogeneous not only between layers, but also within them. The higher the position, the larger the within variation. The difference on the mean wage between the CEO's, Directors and Managers category to blue collars is more than 6 times and it goes to almost 15 times if p95 is compared with p5 in the same category. Hence, there is more heterogeneity among higher level positions.

Table 15 shows the level of schooling according to different layers. The first layer includes Self-employed entrepreneurs, CEOs, Directors and Managers, which results in more heterogeneity in terms of demanded skills. For the other layers there is a clear correlation between the level of competency and schooling degree.[52] For example, if we compare two extreme cases it is noticeable that the share of employees with higher education is the majority among senior staff (78% in 2010) while almost 55% of blue collars had not completed the secondary degree in 2010.[53]

Classes	**No degree**	**Prim.**	**Second.**	**Higher Ed.**	**Posgrad**	**Total**	**Growth**
year = 2010							
CEOs, Directors	6.12	11.06	37.66	43.96	1.20	190,899.92	7.25
Senior staff/manager	2.21	2.87	16.77	77.00	1.14	228,782.08	12.67
Supervisors	5.53	12.98	64.28	17.03	0.18	601,766.08	8.05
Clerks	13.08	22.47	55.93	8.44	0.08	1,214,824.92	8.08
Blue collars	23.44	30.99	44.45	1.10	0.02	5,154,415.00	8.47
Total	19.17	26.74	46.92	7.06	0.11	7,390,688.00	8.47

Table 15: Schooling level by layers (2010)

After analyzing some employees' characteristics according to different layers we investigated how this is translated in terms of hierarchies inside firms. Following the occupation's hierarchy presented in table 1 we classified firms in 4 layers of management (from L0 - a firm with 0 management hierarchy - to L4). Table 14 shows that a large share of firms (about 89%) have blue collars employees, classified as producer workers (L0). If we consider blue collars and clerks together, all firms in the sample have employees in at least one of them.[54]

Table 16 shows the average number of hours hired by firms and their number of layers. It is noticeable that between 2007 and 2010 there was a trend of increasing the number of layers and wages.[55] On average, these firms have between 1.2 and 1.26 layers, but this number is larger for exporting firms.

[51] This is consistent with previous findings, see Caliendo et al. (2012).

[52] We also can control for years of experience.

[53] When we compare these variables (see table 15) over time the increase of the share of workers with more schooling from 2007 to 2010 is remarkable. The number of blue collar employees increased from 4.63 to about 5.15 million and the share of them with secondary or higher schooling jumped from 37% to 45%. These changes are even more significant if we compare them, starting from 2006, when there were 4.36 million blue collar workers and only 34% with secondary schooling.

[54] The CBO's definition suggests that clerks and blue collars have similar levels of competencies. Table 14 shows that their average wages are relatively similar. However, we found differences with respect to schooling and hours hired among clerks. In addition, when we compare firms with one layer of hierarchy (L0 and L1) against those ones without (only L0) under this classification, we find differences among them regarding size and share of exporters, among other variables. Therefore, we kept 4 layers of hierarchy of knowledge and used the alternative classification (3 layers) as a robustness check. Results are qualitatively similar under both classifications.

[55] All nominal values are in R$ of 2010, using the IPCA (Portuguese acronym for the National Consumer Price Index), the official inflation index used by Brazilian Central Bank for inflation target.

year	N	hours	wage	layer
mean				
2007	226,188	51,471	4.91	1.20
2008	231,583	54,265	5.02	1.24
2009	239,931	51,213	5.24	1.24
2010	246,674	53,420	5.38	1.26
median				
2007	226,188	11,440	4.01	1.00
2008	231,583	11,968	4.12	1.00
2009	239,931	11,440	4.34	1.00
2010	246,674	11,616	4.48	1.00

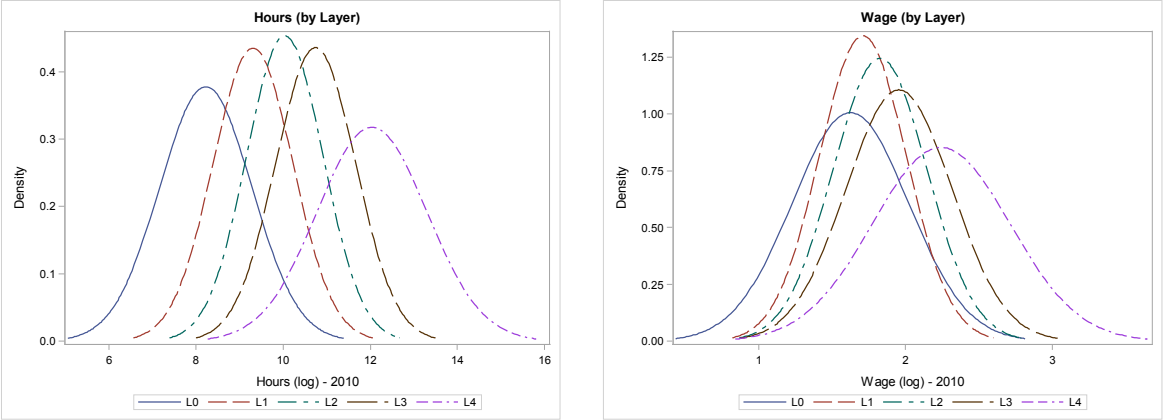
Table 16: Average hours hired, wage and number of layers, by year - in R$ of 2010

Table 17 compares the number of firms, number of employees, average wages and number of layers between exporting and non-exporting firms. The differences among them are evident: 73% of exporting firms have 3 or more layers (54.5% have 4 layers); about 85% of non-exporting firms have 2 layers or less. Also, mean and median wages are larger for exporting firms than non-exporting firms.

Number of	Firms		Number Employees		Real Wage	
Layers	N	(%)	Mean	Median	Mean	Median
Non-Exporting Firms						
0	78,565	33.39	3.35	2.00	4.53	3.92
1	80,084	34.04	8.73	5.50	4.79	4.27
2	44,901	19.08	17.65	11.75	5.53	4.88
3	21,165	9.00	36.20	23.25	6.38	5.62
4	10,565	4.49	133.51	61.25	7.89	6.92
Total	235,280	100.00	16.71	5.58	5.13	4.40
Exporting firms						
0	415	3.65	5.47	2.00	6.48	4.58
1	1,018	8.96	15.30	8.88	6.52	5.33
2	1,619	14.25	30.27	17.50	7.52	6.37
3	2,117	18.64	64.02	38.00	9.11	7.31
4	6,191	54.50	551.36	168.08	12.78	10.13
Total	11,360	100.00	318.30	66.75	10.55	8.23

Table 17: Data description by number of layers in the firm (2010)

Moreover, it is important to highlight that even after controlling for total number of employees (or hours hired), firms have different organization in terms of knowledge-based hierarchy. Although it is clear that the number of layers is positively correlated with firms' size (in terms of number of employees), there is a lot of heterogeneity regarding how firms organize knowledge in their production when they expand, even conditioned to firms' size.



(a) Distribution of hours - 2010

(b) Distribution of wages - 2010

Figure 5: Distribution of log(hours) and wages by layers

To reinforce the argument, the literature using firm-level data often uses the concept of micro, small, medium and large firms based on number of employees.[56] Table 18 shows that even in a narrow interval regarding number of employees (e.g. common thresholds for differentiating firms by size) firms differ significantly in terms of organization of knowledge. For example, the first two columns present the frequency of firms of size between 9 and 10 employees in 2010.[57] The majority of them have 1 or 2 layers of management, but there are firms in all layers. The same thing is observed among firms between 19 and 20 employees, 99 and 101 or 150 and 450. In addition, this heterogeneity also happens within sector.

Layers	$9 \geq L \geq 10$		$19 \geq L \geq 20$		$99 \geq L \geq 101$		$150 \geq L \geq 450$	
	Obs	(%)	Obs	(%)	Obs	(%)	Obs	(%)
0	4,181	14.66	561	5.83	5	0.62	37	0.21
1	12,968	45.48	2,874	29.85	38	4.73	111	0.64
2	8,539	29.95	3,705	38.49	109	13.57	659	3.78
3	2,491	8.74	1,983	20.60	253	31.51	2,576	14.79
4	336	1.18	504	5.24	398	49.56	14,031	80.57
Total	28,515	100	9,627	100	803	100	17,414	100

Table 18: Number of firms by different layer in a narrow interval of firms' size difference (2007-2010)

Next, table 19 shows the average size of firms (regarding number of employees) by exporting and Peiex treatment status in different regions. First, it's noticeable that Peiex-treated firms are closer to the average non-exporting firms in terms of size. Second, while almost 60% of exporting firms are concentrated in the Southeast, the distribution of the treatment is relatively larger in the South and the Northeast. This is explained by the previous discussion about the geographic distribution of Peiex regional units (NO). Indeed, one of the targets of the program was to decentralize Apex's activities.

[56] This is also a common concept used for tax purposes in different countries.
[57] Results are very similar for the other years in the sample.

This is important because We used geographic and time variation for NO's implementation as part of the identification strategy. This table also shows that although exporting firms represent about only 5%, they represent approximately half of employment in manufacturing (49%). Finally, figure 6 compares the shape of firms' hierarchies graphically for those firms that switched from non-exporting to exporting status and increased the number of layers.

Region	N	mean	sd	median	share job	share firms
Full sample						
North	25,396	37.11	183.45	7.58	3.30	2.68
Northeast	108,670	31.08	321.49	5.58	11.81	11.48
Southeast	467,988	32.66	267.03	6.75	53.45	49.45
South	287,350	26.21	306.44	5.00	26.34	30.36
Center-West	57,051	25.58	376.01	5.08	5.10	6.03
Total	946,455	30.21	291.67	6.00	100.00	100.00
Exporters						
North	1,549	260.03	613.45	66.42	1.41	3.29
Northeast	2,116	638.21	1936.24	110.54	4.72	4.49
Southeast	28,080	272.28	1025.19	58.83	26.74	59.55
South	14,384	277.19	1332.12	61.67	13.94	30.51
Center-West	1,022	589.55	2708.47	59.33	2.11	2.17
Total	47,151	296.67	1230.53	61.17	48.92	100.00
Peiex	N	mean	sd	median	share job	share firms
North	-	-	-	-	-	-
Northeast	1,099	35.16	158.07	14.33	0.14	18.55
Southeast	1,433	33.25	79.79	13.17	0.17	24.18
South	3,039	31.09	130.71	10.17	0.33	51.28
Center-West	355	35.51	113.52	11.08	0.04	5.99
Total	5,926	32.63	125.31	11.50	0.68	100.00

Table 19: Number of firms and average size by export and Apex status (2007-2010)

Note: Share job refers to the share on the total job in Brazil and share firms refers to the share of firms in each group (total, exporters, Apex, Peiex).

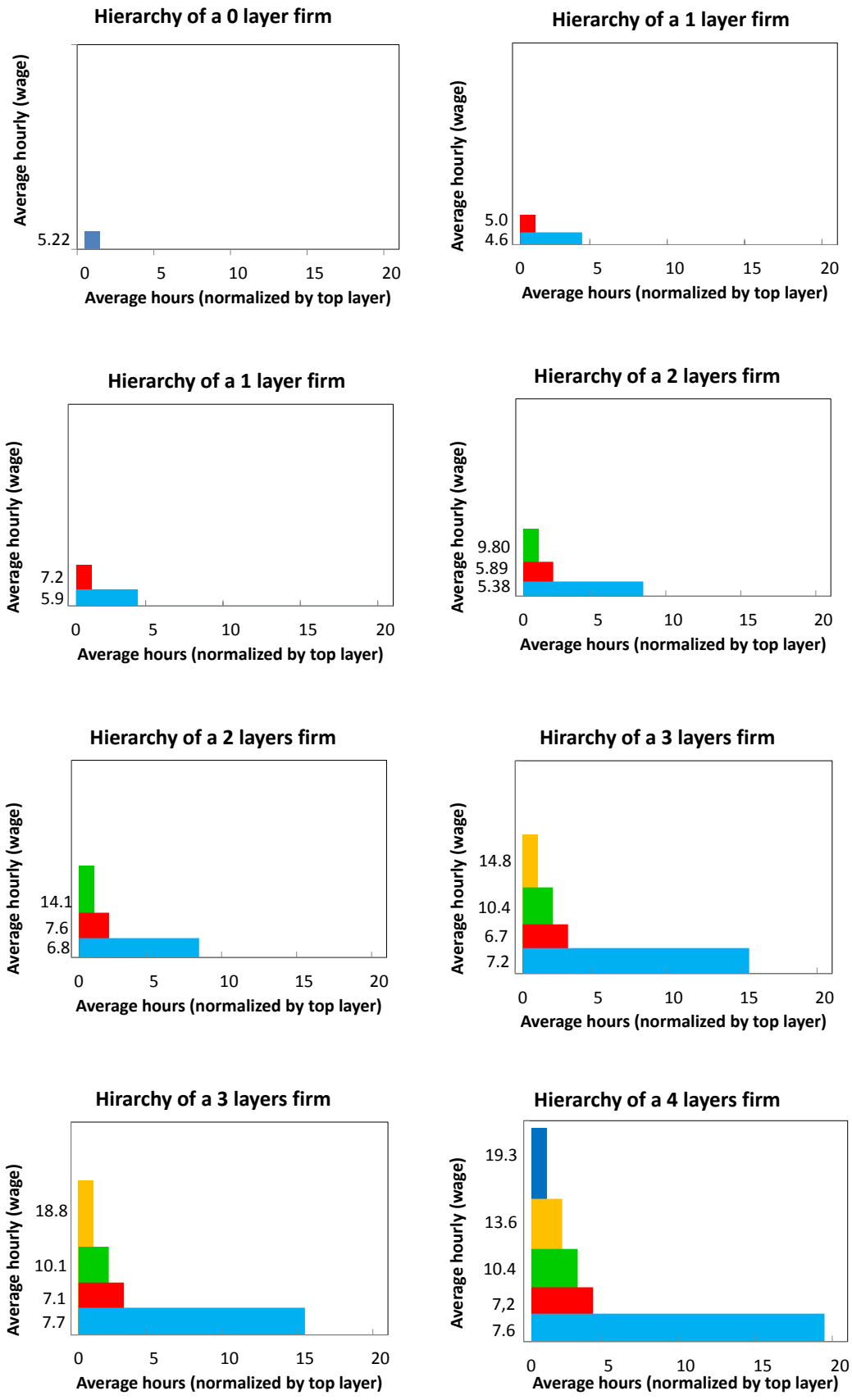


Figure 6: Hierarchies of new exporting firms' transition from t-1 to t (2007-2010)

Note: Average hourly wage in R$ of 2010. New exporting firms defined as firms that have exported at period t, but have not exported at periods t-1 and t-2.

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