

Foreign acquisition and internal organization*

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Abstract

We study the effect of foreign takeovers on firm organization. Using a comprehensive data set of Portuguese firms and workers spanning two decades, we find that foreign acquisitions lead to: (1) an expansion in the scale of operations; (2) a higher number of hierarchical layers; (3) increased span of control among top managers; and (4) increased wage inequality across layers. These results accord with a theory of knowledge-based hierarchies in which foreign takeovers improve management practices and reduce communication costs within the acquired firms. Evidence from auxiliary survey data provides support to this mechanism by suggesting that acquired firms are more likely to use information technologies that reduce internal communication costs.

Keywords: Foreign direct investment, internal organization, wage inequality, information technologies.

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1 Introduction

Recent theories of knowledge-based hierarchies suggest that the decision of how to organize the acquisition, use, and communication of knowledge is central to understand issues such as the evolution of wage inequality, the growth and productivity of firms, and the gains from international trade (Garicano and Rossi-Hansberg, 2015). Drawing on a comprehensive data set of French manufacturing firms, Caliendo, Monte and Rossi-Hansberg (2015) show that reorganization, through changes in hierarchical layers of workers, is key to understand how firms expand and contract and the evolution of pay in each layer.¹

While this evidence establishes the basic empirical credibility of organization-based theories, relatively little is known about whether and how different economic or policy shocks can lead to firm reorganization and thereby impact labor market outcomes (Garicano and Rossi-Hansberg, 2015). In this paper, we exploit comprehensive data on Portuguese firms and their workers for the period 1991–2009 to study the effect of foreign takeovers on firm organization and pay structure. The focus on Portugal is well-suited for this purpose: following accession to the European Union in 1986, the country received sizable inflows of foreign investment from higher-income nations, where firms tend to have better management practices and make more extensive use of information technologies.²

Our empirical analysis proceeds in several steps. Following Caliendo, Monte and Rossi-Hansberg (2015), we first divide the employees of each firm into hierarchical layers using occupational categories. Focusing on firms that were domestically-owned in the first year of observation, we then examine if and how foreign takeovers affect their internal organization and wage structure. An important challenge in identifying the effects of foreign acquisitions is selection. If acquired firms are not representative of the universe of firms that were initially domestic, subsequent heterogeneity in the evolution of firm performance and organization across acquired and non-acquired firms might not be attributable to the change in ownership (Arnold and Javorcik, 2009; Guadalupe, Kuzmina and Thomas, 2012; Hijzen et al., 2013). To mitigate this threat to identification, we follow the standard approach in this literature and examine the effects foreign acquisitions using

¹In a recent related paper, Caliendo et al. (2015) find that Portuguese firms that reorganize and add a management layer experience a 4% rise in quantity based productivity, while also observing a 4% drop in revenue-based productivity.

²Leitão and Faustino (2008) report that between 1996 and 2005 the EU and the US accounted for 88.5% of foreign investment inflows in Portugal. The major investors in this period were the UK (16.4%), Germany (13.3%), France (12.5%), the Netherlands (13.7%) and Spain (11.8%). Bloom, Sadun and Van Reenen (2012, pp. 194) provide evidence that firms in several of these countries tend to have better people-management practices than firms in Portugal.

a difference-in-differences matching estimator.

We find that foreign acquisitions lead to: (1) an expansion in sales and employment levels; (2) higher labor productivity; (3) a higher number of layers; (4) increased span of control among top managers; and (5) increased wage inequality across layers. We find no evidence that changes in wages following foreign takeovers are driven by changes in the skill composition of the workforce within each layer.

These empirical results accord well with recent theories of knowledge-based hierarchies (Garicano and Rossi-Hansberg, 2006; Caliendo and Rossi-Hansberg, 2012). In this framework, the realization of output requires both labor and knowledge. More specifically, it requires successful problem solving, which in turn requires sufficient knowledge. Agents who do not know how to solve a problem, also do not know who else might be able to solve it, leading to an optimal pyramidal organization structure consisting of a bottom layer of production workers, and one or more successive layers of managers who specialize in problem solving. Agents are rewarded according to their knowledge, and hence workers in higher layers are rewarded with higher earnings. The number of layers is, all else equal, determined by a trade-off between economizing on knowledge acquisition (increasing the number of layers) and economizing on total communication costs within the organization (reducing the number of layers).

Takeovers from investors from higher-income nations improve management practices and reduce internal communication costs in the acquired firms. This leads to an increase in the value of hierarchical organization and therefore to a rise in the optimal number of layers. A reduction in communication costs also implies that the optimal distribution of knowledge shifts upwards in the hierarchy, implying not only that more problems are solved, but also that a larger share of problems are solved at the top of the organization—thus leading to higher wage inequality between agents at the top and bottom of the hierarchy. Finally, a reduction in internal communication costs following foreign acquisition unambiguously leads to a higher span of control of top managers, while its effect on the span of control of the other layers is *a priori* ambiguous.

While there is strong evidence in the literature that multinationals from higher-income countries tend to have superior management practices and make more extensive use of information technologies—and it is intuitive that these would lower communication costs within acquired firms—we inspect for evidence on this mechanism by using an auxiliary firm-level longitudinal survey. These data are available for a shorter period (2004-2009), and contain information on utilization of information technologies that would be expected to reduce internal communication costs, notably the intranet, the email, and internal net-

works. Using a similar identification strategy, we provide evidence that foreign acquisition has a positive and strongly significant effect on the use of the intranet. The point estimates for the use of the other technologies are also positive, but imprecisely estimated. We interpret this evidence as supportive of the precise mechanisms emphasized by the theory of knowledge-based hierarchies.

In addition to contributing to the growing empirical literature on firm organization, this paper complements and extends several other strands of existing research. A number of studies have provided evidence that foreign acquisitions lead to improvements in residual-based measures of productivity, employment, wages, innovation, and management practices, including important contributions by Griffith (1999), Conyon et al. (2002), Girma and Görg (2007), Almeida (2007), Arnold and Javorcik (2009), Guadalupe, Kuzmina and Thomas (2012), Bloom, Sadun and Van Reenen (2012) and Hijzen et al. (2013). While confirming that several of these outcomes also improve among Portuguese firms following foreign acquisition, we believe that this paper is the first to establish a causal link between foreign takeovers, internal communication, and the organization and pay structure of firms. In doing so, this paper also adds to the literature on the labor market consequences of new information technologies, including Autor, Katz and Kruger (1998), Bresnahan, Brynjolfsson and Hitt (2002), Acemoglu and Autor (2011), Beaudry, Doms and Lewis (2010) and Autor, Dorn and Hanson (2015).

The paper proceeds as follows. Section 2 describes the main data set used in the analysis. Section 3 presents the empirical strategy and results related to the acquisition decision. Section 4 outlines the empirical strategy for examining the impacts of foreign acquisition on the internal organization and pay structure of firms and reports the corresponding results. Section 5 discusses if and how our empirical results can be rationalized in the context of the theory of knowledge-based hierarchies. Section 6 provides additional empirical evidence on the specific channel of causation identified by the theory. Section 7 concludes the paper.

2 Data

The empirical analysis in this paper draws mainly on data from *Quadros de Pessoal* for the years 1991 to 2009. This data set is an administrative census that gathers information on firms and their workers for the corporate sector in Portugal. It is collected yearly by the Ministry of Employment and participation is compulsory for every firm with wage

earners.³ Each firm is required to provide information about its attributes and those of each employee. The firm-level records include information on number of employees, industry code, geographical location, and percentage of capital that is owned by foreign investors. We assume that a firm is foreign-owned if more than 50% of capital is owned by foreign investors.

The set of worker attributes includes monthly wages (base wage and other components of pay), gender, schooling, date of starting, occupation, and hours worked. The employee records may also be linked to those of the corresponding employer in each year. The administrative records in *Quadros de Pessoal* are recognized for their high reliability and are used by the Ministry of Employment for checking a firm’s compliance with labor law. The records must be made available to every worker in a public place of the establishment, which reduces the likelihood of misreporting.

Following Caliendo, Monte and Rossi-Hansberg (2015), we group employees into four hierarchical layers using detailed information on occupations: CEO and directors, top managers, supervisors, and operators.⁴ We also compute measures of the span of control for each layer, as well as firm-year and firm-layer-year averages of earnings, education levels and other observable worker attributes.

We are interested in examining the effects of foreign acquisitions on firm organization and pay structure. Hence we restrict our attention to firms that were domestically-owned in the first year of observation, and focus on changes from domestic to foreign ownership taking place within the same firm. Given our focus on internal organization, we exclude from the analysis very small firms, i.e. those with less than 10 employees. With these restrictions, we have data on 938 firms which were acquired by foreign investors during the period of analysis. Figures 1 and 2 illustrate how these acquisitions are distributed over time and across industries, respectively. We see that there were a sizeable number of acquisitions taking place in most years, but with a noticeable peak in 2002-2003. Foreign acquisitions also took place in almost every industry, but with a quite uneven distribution.

[Figure 1 here]

[Figure 2 here]

Table 1 reports descriptive statistics on the full sample used in the estimation. Column (1) reports statistics on the universe of firms with more than 10 employees that were initially domestically-owned. The other two columns distinguish between firms that

³Data for 2001 were not collected, and hence the analysis excludes this year.

⁴See Table A1 in the Appendix for a more detailed definition of each layer.

remained domestic during the period of analysis (Column (2)) and firms that were eventually acquired by foreign investors (Column (3)). These statistics reveal that firms subject to acquisition tend to be larger, more productive, pay higher average wages, and have a larger number of layers. Notice that these differences reflect both initial heterogeneity in firm attributes among acquired and non-acquired firms, as well as future changes.

[Table 1 here]

To examine the effects of foreign acquisition on internal communication we merged *Quadros de Pessoal* with data from *Inquérito a Utilização de Tecnologias de Informação e da Comunicação nas Empresas*, a firm-level survey conducted by the National Statistical Institute that gathers information on the use of information technologies. Data from this survey are available since 2004 and cover about 4000 firms per year. Interestingly for our purposes, this survey collects information on whether the firm makes use of several information technologies that would be expected to stimulate efficient communication flows in the organization, notably the intranet, the e-mail, the extranet, and internal networks. Since the two data sets do not contain the same unique firm identifiers, we have matched firms using information on sales, location and industry code.⁵ We were able to match information for 1054 firms with more than 10 employees, of which 107 were acquired by foreign investors during the sample period.

3 The selection decision

Before turning to the analysis of the effects of foreign acquisition on firm organization and wage structure, we explore the patterns of selection into acquisition. Evidence from several previous studies suggests that foreign investors tend to "cherry pick" the largest and most productive firms in each industry. Below we inspect for evidence on the presence of such selection in our estimation sample.

3.1 Estimation strategy

The likelihood that firm i in industry s is acquired by foreign investors in year t can be estimated through a linear probability model of the form

$$Foreign_{it} = \beta X_{it-1} + \delta_s + \phi_t + \mu_{it}, \quad (1)$$

⁵Information on sales, location and industry code is available from an intermediate data set, *Sistema de Contas Integradas das Empresas*, a census of firms with the same unique firm identifiers.

where the dependent variable is a dichotomous variable that equals one if the firm is foreign-owned and X_{it-1} is a vector of lagged firm attributes (sales and labor productivity) that would be expected to influence the probability of acquisition in any given year (conditional on the firm being domestically-owned one year before). We also estimate models with industry-specific time trends to account for the role of idiosyncratic shocks at the industry-level. In all specifications, we cluster the standard errors at the firm-level.

3.2 Results

Before turning to the regression analysis, we visually inspect for the presence of selection. Figure 3 depicts the distribution of initial sales (top panel) and labor productivity (bottom panel) for two groups of firms: (i) firms that were taken over by foreign investors during the sample period; and (ii) firms that remained domestically-owned.^{6,7} To account for potential differences in firm size and labor productivity across industries, these measures are demeaned relative to the industry. Inspection of this figure reveals that the distribution of each of these variables for acquired firms lies clearly to the right of those that remain domestic, suggesting that foreign investors tend to target larger and more productive firms within each industry.

[Figure 3 here]

Table 2 reports the estimated coefficients from the linear probability model for the acquisition decision, as defined in equation (1). The dependent variable is the dummy variable for foreign ownership which is related to either lagged log sales or lagged log labor productivity, each relative to the industry mean. All regressions include industry and year dummies. The regressions in columns (2), (4), (6) and (8) additionally include industry trends that account for industry-specific idiosyncratic shocks.

[Table 2 here]

The results reported in this table provide evidence that larger or more productive firms are more likely to become foreign-owned. The coefficient in column (2) suggests that a one standard deviation increase in lagged log sales is associated with a 0.4 percent higher yearly probability of being acquired. Rather than a continuous measure of sales,

⁶Our chosen definition of "initial" is the year before takeover for acquired firms and the first year of observation for firms that always remain domestically owned.

⁷The densities are drawn using an Epanechnikov smoothing function with a bandwidth of 0.6.

Columns (3) and (4) include indicator variables for each quartile of log sales. The point estimates suggest that the probability of acquisition is significantly higher in the third and fourth quartiles than in the first quartile. The results in Columns (5)-(8) point to similar patterns of selection when using log labor productivity (and the corresponding dummy indicators for quartiles), instead of log sales. In sum, the evidence presented in this section suggest that larger and more productive firms are more likely to be acquired by foreign investors. In other words, it suggests that foreign investors tend to "cherry pick" the larger and better performing domestic firms within each industry.

4 Effects of foreign ownership on internal organization and pay structure

4.1 Estimation strategy

Our strategy for examining the effect of foreign takeovers on internal organization proceeds in two steps. First, we adopt a difference-in-differences approach to compare changes over time in performance and internal organization across acquired and non-acquired firms. Specifically, we estimate an equation of the form

$$Y_{it} = \beta Foreign_{it-1} + \gamma_i + \phi_t + \mu_{it}, \quad (2)$$

where i and t index firms and year, respectively; Y_{it} is the variable of interest for firm i in year t ; $Foreign_{jt-1}$ is the foreign ownership status of the firm in the previous year; γ_i is a firm fixed effect; ϕ_t is a year effect; and μ_{jt} is the error term. We also estimate models with industry-specific time trends to account for the role of idiosyncratic shocks at the industry-level. In all specifications, we cluster the standard errors at the firm-level.

The firm fixed-effects account for the influence of all observable and unobservable drivers of the acquisition decision that are constant or strongly persistent over time. If heterogeneity in entrepreneurial capability (or productivity) across firms is fixed over time, as in the Melitz (2003) model, this method accounts for the selection patterns documented in the previous section. Hence we can compare the evolution of Y_{it} at acquired firms with that in firms that remain in domestic hands.

However, if firm capability evolves over the life cycle (see, e.g., Arkolakis, 2016), this comparison may still be complicated by non-random selection. To address this issue, we combine the difference-in-differences approach with propensity score matching (DD-

PSM). The propensity score is the predicted probability of a firm being acquired by foreign investors as a function of firm attributes observed one year before the treatment occurs. We estimate a single model for the propensity score including all years and industries. We use sales, productivity and wage as explanatory variables, in addition to industry and year fixed-effects. We match treated firms by year and industry, using one-to-one nearest-neighbor matching without replacement and imposing common support. By using DD-PSM we essentially inspect for divergence in the path of Y_{it} between acquired firms and matched control firms that had similar observable attributes in the year prior to the acquisition.

Table A2 in the Appendix reports results from several tests of matching quality. The results reveal that our matching procedure succeeds in removing observable differences between domestic and acquired firms. All individual t-tests and the two-group Hotelling t-square test never reject the mean equality of observable attributes between domestic and acquired firms in the matched sample. In addition, the very small magnitude of the Pseudo R2 of the logit on the matched data, and the test of joint significance of regressors given by the Chi-square test, confirm the overall quality of the matching procedure.

[Table 3 here]

Table 3 reports the results from estimation of the propensity score. We use a multivariate logit specification in which foreign acquisition is explained by lagged values of sales, labor productivity and average labor earnings. The results confirm that foreign investors tend to target larger firms. They also indicate that, conditional on size and labor productivity, firms with higher labor earnings are more likely to be acquired. The negative sign of the point estimate on labor productivity is likely caused by the fact that, unlike in Table 2, the logit model includes simultaneously three different (but positively correlated) observable attributes of firms.⁸

4.2 Results

Table 4 reports summary statistics for the sample of matched firms, i.e., firms that prior to acquisition were similar among a number of key observable attributes. In comparison with Table 2, domestic and acquired firms in the matched sample are clearly more similar along the set of attributes measured. This would be expected since matching seeks to

⁸Although these variables tend to be positively correlated, they may well reflect relevant heterogeneity between acquired and non-acquired firms. To minimize these differences, we have include them simultaneously in the logit model used for estimation of the propensity score.

remove initial heterogeneity across firms along a number of observable attributes. Notice, however, that some differences remain, as would also be expected if foreign acquisition were to affect how these variables evolve over time.

[Table 4 here]

We proceed by examining the effects of foreign acquisitions on firm performance, internal organization and pay structure. For each outcomes of interest, we report the difference-in-differences estimates using the full and the matched sample, with and without industry specific time trends. All regressions include year dummies. In line with results of several studies reviewed above, the estimates reported in Panels A and B of Table 5 reveal that foreign acquisitions lead to an expansion in the scale of operations, as measured by sales and employment levels. We also observe that the point estimates remain fairly similar when using either the full or the matched sample, and when including industry-specific time trends. The effects on sales are larger than the effects on employment levels, and hence labor productivity (measured as the ratio of sales to employment) clearly increases following acquisition (Panel C). Finally, the results in the last panel reveal that average worker earnings also rise.

[Table 5 here]

Our main interest is in whether foreign takeovers also affect the internal organization and pay structure of firms. The results in Panel A of Table 6 reveal that acquired firms tend to experience an increase in the number of hierarchical layers of employees. Once again the difference-in-differences results are robust across different samples, and do not depend on the inclusion of industry-specific time trends. In panels B to D, we examine the extent to which foreign acquisitions also influence the span of control of each layer, defined as the ratio between the number of employees in a given layer and the number of employees in the layer immediately above (from an hierarchical perspective).⁹ The results suggest that foreign acquisitions lead to an increase in the span of control of top managers (Panel C). By contrast, the span of control of directors and supervisors remains unaffected following the foreign takeovers (Panels B and C).

[Table 6 here]

⁹Since not all firms have all layers, the number of observations in each panel is reduced.

We proceed by examining the effects of foreign takeover on the pay structure of firms. The results in Table 5 suggest that average wages go up following acquisition. But this leaves open the possibility that wages evolve differently across layers. In Table 7 we examine whether this is the case. The results reveal that average wages tend to increase in all layers following acquisition, but much more so in layers close to the top of the hierarchy. In particular, the results in Panel A suggest that wages of CEOs and directors increase by about 25% on average, significantly more than average earnings of top managers (which are estimated to rise by about 10%), and those of supervisors and operators (which increase only by about 3 to 4%). This evidence therefore suggests that foreign acquisitions tend to lead to higher wage inequality between agents at the top and bottom of the hierarchy.

[Table 7 here]

A potential explanation for this finding is that foreign acquisitions lead to a change in the skill composition of the workforce, which might then explain the observed changes in wages. To examine this possibility, Table 8 examines the impacts of foreign acquisition on the average schooling of workers in each layer. The results provide little support to the hypothesis that changes in wages following acquisition reflect this channel. In particular, the point estimates for the matched sample (columns (3) and (4)) are statistically insignificant and very close to zero.

[Table 8 here]

In Tables A3 to A5 (see Appendix), we examine whether foreign acquisitions lead to changes in other worker attributes in each layer that would also be expected to be positively associated with earnings, notably tenure in the firm and potential experience the labor market.¹⁰ The results in these tables suggest that tenure and experience tend to increase more at the bottom of the hierarchy following foreign takeovers. Since average wages tend to be positively associated with tenure and experience, the fact that foreign-owned firms tend to employ more experienced workers at the bottom of the hierarchy does not seem to provide a plausible explanation for the observed increase in wage inequality between agents at the top and bottom of the hierarchy following acquisition.

¹⁰The latter is defined as the difference between the worker's age and the number of years of schooling.

5 Discussion

How can our empirical results be rationalized? In this section we present a discussion of our main results in the context of recently developed theories of knowledge hierarchies, which allows us to identify potential mechanisms that could create a link between foreign acquisitions and the internal organization and wage structure of firms. We start out by giving a brief presentation of the main theoretical framework before suggesting a potential mechanism that could explain our results.

5.1 A theory of knowledge hierarchies

The theory of firms as knowledge hierarchies has been developed by Garicano (2000) and Garicano and Rossi-Hansberg (2004, 2006), and further extended by Caliendo and Rossi-Hansberg (2012). Here we will briefly present the main ingredients of the theory, as laid out in Garicano and Rossi-Hansberg (2006).

The starting point is that production requires both labor and knowledge. More specifically, the realization of output requires successful problem solving, which in turn requires sufficient knowledge. This is modeled as agents (workers) drawing one problem per unit of time, where output is one if the problem is solved and zero otherwise. However, some problems occur more often than others. If we rank problems according to their likelihood of occurring, problem z is characterized by a density function $f(z)$ and a corresponding cumulative distribution function $F(z)$, where $f'(z) < 0$. A problem can be solved by an agent who has enough knowledge. Assuming that knowledge is cumulative, i.e., knowledge \hat{z} implies that all problems $z \in [0, \hat{z}]$ can be solved, the proportion of all problems an agent with knowledge \hat{z} can solve is given by $q := F(\hat{z})$. An agent that encounters a problem that he does not know how to solve, can ask a more knowledgeable agent for help in solving the problem. However, each time a problem is passed from one agent to another, there is a communication cost of $h < 1$ units of time incurred.

A key assumption of the theory is that an agent who does not know how to solve a problem also does not know who else might be able to solve it. Under this assumption, the optimal organizational structure is a knowledge hierarchy consisting a bottom layer of production workers and one or more successive layers of managers who specialize in problem solving. The amount of knowledge increases as we move up in the hierarchical structure. Thus, production workers learn to solve the most common problems, whereas agents in higher layers in addition learn how to solve more exceptional problems. In each

layer, unsolved problems are passed on to the next layer until the problem is solved or until it reaches the top layer. Furthermore, the hierarchy has a pyramidal shape, where higher layers become successively smaller. In equilibrium, agents are rewarded according to their knowledge, which implies that wages are higher for agents working in higher layers of the organization.¹¹

When designing the optimal organizational structure, the firm has to decide on the number and size of layers, and on the required knowledge of agents in each layer. Suppose that a firm has L layers with n_0 production workers (the number of agents in Layer 0) with knowledge q_0 and $L - 1$ layers of problem solvers (managers), where the knowledge of managers in Layer i is q_i . This implies that the number of problems passed on to Layer 1 is $n_0(1 - q_0)$. Since it takes h units of time to communicate each problem, the number of managers in Layer 1 needed to deal with the problems passed on from Layer 0 is $n_1 = hn_0(1 - q_0)$. More generally, the size of Layer i is $n_i = hn_0(1 - q_{i-1})$. Thus, it is easy to see that $q_0 < q_1 < \dots < q_L$ implies $n_0 > n_1 > \dots > n_L$.

The value of more layers is to economize on knowledge acquisition in the organization. Since not all problems occur with the same frequency, it is more efficient that fewer agents learn how to solve the more infrequent problems. By adding layers in a knowledge hierarchy, the more knowledgeable problem solvers can be shielded from having to deal with simple (and frequently occurring) problems and can concentrate on solving the harder (and rarer) problems, which increases the value of acquiring knowledge. However, adding more layers is not without costs, since there are communication costs each time a problem is passed from one layer to another. Thus, the optimal organizational structure depends crucially on the size of communication costs relative to the costs of acquiring knowledge.

5.2 Foreign acquisition and firm reorganization

How can foreign ownership affect optimal firm (re)organization in the context of the theory presented above? Generally, the organization of the firm is determined by a number of factors, such as product demand and technology, in addition to the costs of communication and knowledge acquisition. A foreign acquisition might lead to an internal reorganization of the firm insofar as it directly affects one of the factors that determine the optimal organizational structure of the firm. Here we will focus on one potential mechanism that,

¹¹These general characteristics of the optimal organizational structure are similar if agents are *ex ante* identical, as in Garicano (2000) or Caliendo and Rossi-Hansberg (2012), or if they are *ex ante* heterogeneous, as in Garicano and Rossi-Hansberg (2006). The optimal structure is also qualitatively similar even if knowledge is not cumulative, as in Caliendo and Rossi-Hansberg (2012).

according to the above presented theory, will lead to internal reorganizations that are in line with our main empirical results.

One of the common explanations in the literature regarding the positive productivity effects of foreign takeovers is that such a takeover also implies the transfer of new (and better) management practices to the acquired firm (see, e.g., Bloom, Sadun and Van Reenen, 2012). A key element of good management practice is to secure efficient communication and information flows within the organization. Improvement in management practices along this dimension will reduce the cost of communication, as measured by h in the theoretical model. Our empirical analysis has produced three robust results on the effects of foreign ownership on internal organization and remuneration structure: (1) an increase in the number of layers, (2) an increase in the span of control of managers in Layer 2 ("top managers"), and (3) a strong increase in wage inequality across layers. These results are all consistent with a reorganization caused by lower communication costs within the firm.

First, as explained above, the optimal number of layers is, all else equal, determined by a trade-off between economizing on knowledge acquisition (increasing the number of layers) and economizing on total communication costs within the organization (reducing the number of layers). A reduction in the cost of communicating problems will increase the value of hierarchical organization and therefore (weakly) increase the optimal number of layers. In other words, since the cost of asking for help goes down, it is optimal to add more layers of problem solvers.

Second, a reduction in communication costs also implies that it is optimal for production workers (in Layer 0) to acquire less knowledge whereas more knowledge is acquired at the top of the organization; in other words, the optimal distribution of knowledge shifts upwards in the hierarchy (this is true even if the number of layers stay the same), implying not only that more problems are solved, but also that a larger share of problems are solved at the top (relative to the bottom) of the organization. This will, in turn, be reflected in higher wage inequality between agents at the top and bottom of the hierarchy. Notice here that, even though workers in the bottom of the organization acquire less knowledge, their wages might nevertheless increase, since lower communication costs implies that a larger share of problems will be solved, so that the expected value of production increases. Thus, our finding of a positive (but modest) effect of foreign ownership on wages in Layer 0 is not inconsistent with the hypothesis that the main effect of foreign takeover is a reduction in internal communication costs. The only clear prediction from the theory is that lower communication costs will lead to a higher wage inequality across layers, for which we find strong evidence.

Finally, for a given number of layers, the effect of lower communication costs on the span of control in Layer $i \geq 1$ is somewhat more ambiguous. Suppose that a firm has all four layers, as defined in our empirical analysis (Layers 0, 1, 2 and 3). Denoting the span of control in Layer $i \geq 1$ by s_i , and using the other notation introduced above, the span of control in Layers 1 – 3 are given by

$$s_1 := \frac{n_0}{n_1} = \frac{1}{h(1 - q_0)}, \quad (3)$$

$$s_2 := \frac{n_1}{n_2} = \frac{1 - q_0}{1 - q_1}, \quad (4)$$

$$s_3 := \frac{n_2}{n_3} = n_0(1 - q_1)h, \quad (5)$$

where the number of agents in the top layer has been set equal to one ($n_3 = 1$).¹² As explained above, a reduction in communication costs (lower h) leads to lower knowledge acquisition in Layer 0. When it is less costly for workers to ask for help, it is optimal for them to acquire less knowledge to solve problems themselves (i.e., q_0 decreases). Conversely, the optimal knowledge acquisition in Layer 3 goes up (i.e., q_3 increases). Since lower communication costs imply that the manager at the top of the organization can deal with more problems, the value of acquiring knowledge to solve them increases. On the other hand, since agents in Layers 1 and 2 both solve problems and ask help for problems they cannot solve themselves, a reduction in communication costs has an ambiguous effect on their optimal knowledge acquisition. However, regardless of the sign of $\partial q_1 / \partial h$, it must surely be the case that $\partial q_0 / \partial h > \partial q_1 / \partial h$. Thus, as is evident from (3)-(5), the only clear-cut relationship between h and s_i is in Layer 2, where lower communication costs unambiguously lead to a higher span of control for the managers in this layer. For the two other layers, the effect is *a priori* ambiguous. In Layer 1, managers have to deal with more requests because of less problem solving in Layer 0 but, on the other hand, the cost of dealing with such requests are also lower. The span of control in the top layer depends entirely on the size of Layer 2, which in turn depends positively on communication costs and negatively on the amount of knowledge in Layer 1.

¹²In our data, more than 50% of the firms in which Layer 3 exists have only one person in this layer.

In sum, our discussion shows that, when interpreted in the context of the theory of knowledge hierarchies presented above, our main empirical results are all as expected if foreign ownership leads to lower internal communication costs. Although one should be careful about applying the theoretical framework too literally to the real-world data, in particular since there is only an approximate correspondence between the theoretical and the empirical definition of a "layer", it is nevertheless interesting to observe that our finding of a significantly positive relationship between foreign ownership and the span of control among top managers (in Layer 2) is also consistent with the above described mechanism.

6 Effects of foreign takeovers on use of information technologies

In this section we exploit an auxiliary firm-level data set for the period 2004-2009 to examine whether foreign acquisitions lead to the adoption of information technologies that would be expected to improve the information flow within the organization, and thereby reduce internal communication costs. As noted above, these data cover a smaller number of firms and contain information on whether the firm makes use of several information technologies that would be expected to stimulate efficient communication flows in the organization, notably the intranet, the e-mail, and internal networks. It also contains information on whether firms use the extranet, which might be expected to predominately improve information flows between the firm and outside parties. Summary statistics for these data are given in Table A6 in the Appendix.

[Table 9 here]

In order to examine whether foreign acquisitions influence the use of each of these technologies, we adopt the identification strategy outlined in Section 4. The results in Table 9 reveal that foreign acquisitions lead to a statistically significant increase in the propensity to use the intranet. The point estimates for the other technologies are also positive but imprecisely estimated. While the fact that this analysis is based on a smaller and less representative sample recommends caution in drawing strong conclusions from these results, it is interesting that they are well in line with the predictions of recent theories of knowledge-based hierarchies. In particular, since the intranet is essentially aimed at promoting more efficient communication flows inside organizations, the fact

that its use tends to increase following foreign acquisition can be interpreted as direct evidence for the precise mechanisms emphasized by this class of models, as explained and discussed in Section 5.

7 Concluding Remarks

Recent theories of knowledge-based hierarchies suggest that reorganization, through changes in hierarchical layers of employees, is key to understand how firms expand and contract and the evolution of pay in each layer. While existing evidence lends strong support to this class of models, relatively little is known about whether and how different economic or policy shocks can lead to firm reorganization and thereby influence labor market outcomes.

We exploited comprehensive data on Portuguese firms and their workers spanning the period 1991 to 2009 to study the effect of foreign takeovers on the internal organization and pay structure of firms. Our results provide evidence that foreign acquisitions lead to: (1) an expansion in the scale of operations; (2) a higher number of hierarchical layers; (3) increased span of control among top managers; and (4) increased wage inequality across layers. These results accord with a theory of knowledge-based hierarchies in which foreign takeovers improve management practices and reduce communication costs within the acquired firms. Using an auxiliary survey data set, we provided evidence that foreign acquisition has a positive and strongly significant effect on the use of the intranet. The effects on the use of the other technologies are also positive, but imprecisely estimated. We interpret this evidence as supportive of the precise mechanisms emphasized by the theory of knowledge-based hierarchies.

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A. Appendix

A.1. Definition of hierarchical layers

Following Caliendo, Monte and Rossi-Hansberg (2015), we use detailed information on workers occupation to construct four hierarchical layers of employees. Table A1 presents the definition of each layer.

[Table A1 here]

A.2. Propensity score matching

Tables A2 shows the tests of matching quality discussed in Section 4.1.

[Table A2 here]

A.3. Additional results

Tables A3-A5 show the effects of foreign ownership on worker attributes (within each firm layer) such as tenure (Table A3), the share of newly hired workers (Table A4) and potential labor market experience (Table A5).

[Table A3 here]

[Table A4 here]

[Table A5 here]

A.4. Summary statistics, auxiliary survey data

Table A6 reports summary statistics on the auxiliary survey data for 2004-2009.

[Table A6 here]

Figure 1: Distribution of acquired firms over time

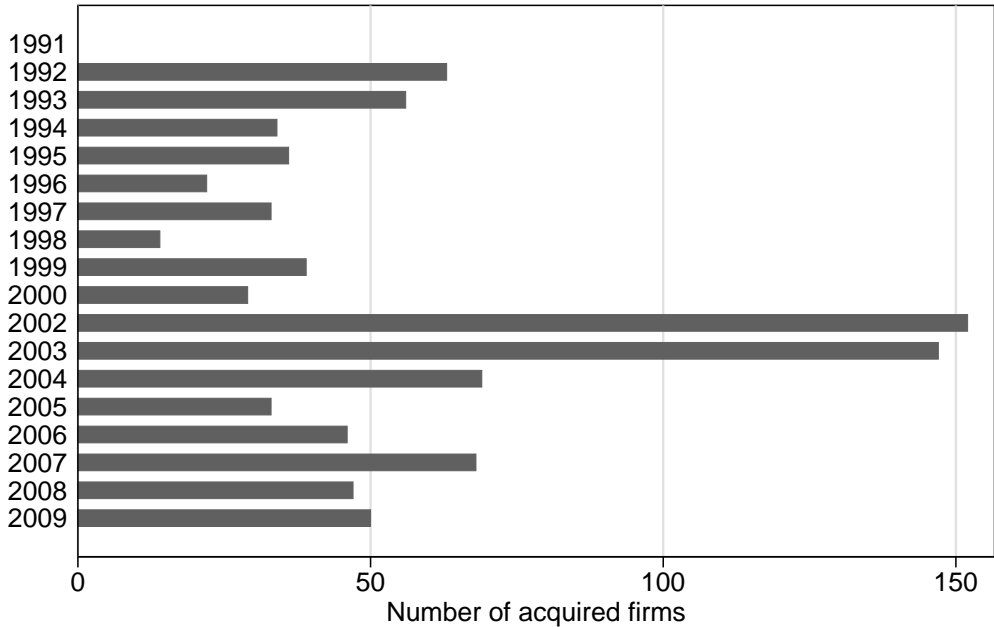


Figure 2: Distribution of acquired firms across industries

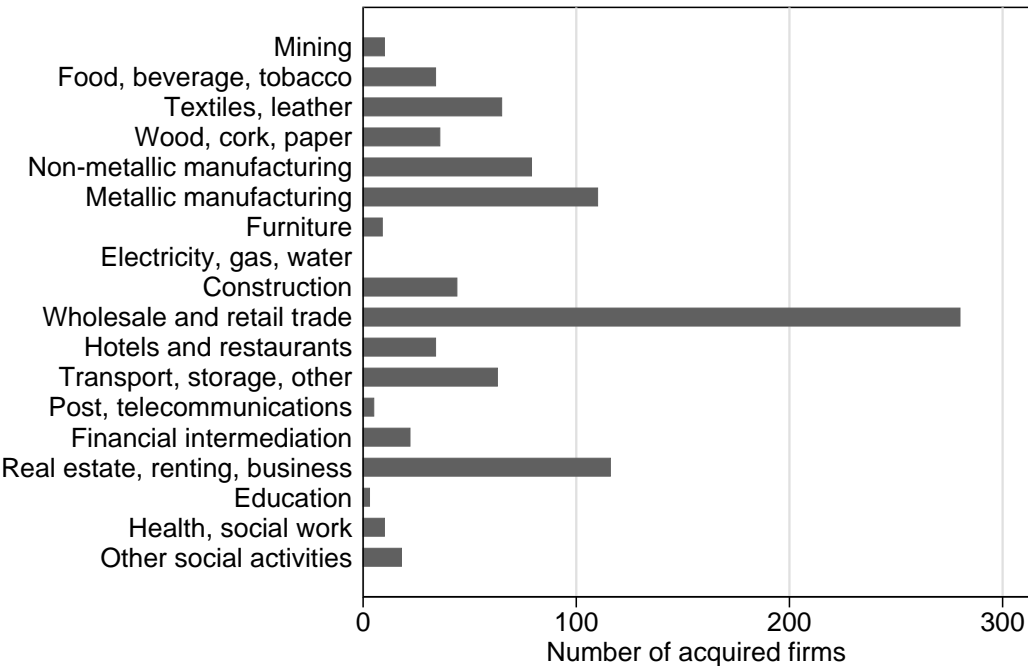


Figure 3: Distribution of firms according to size and productivity

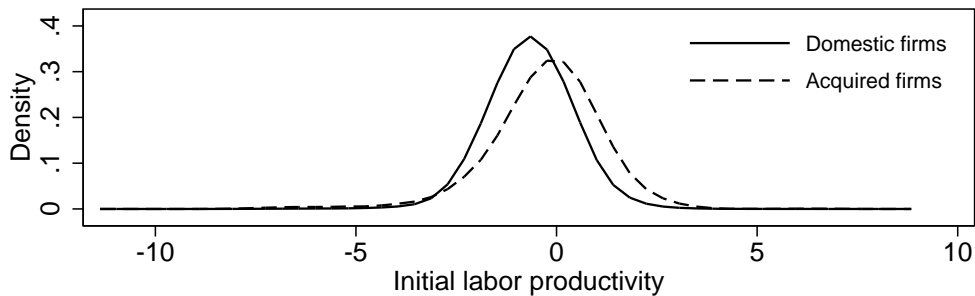
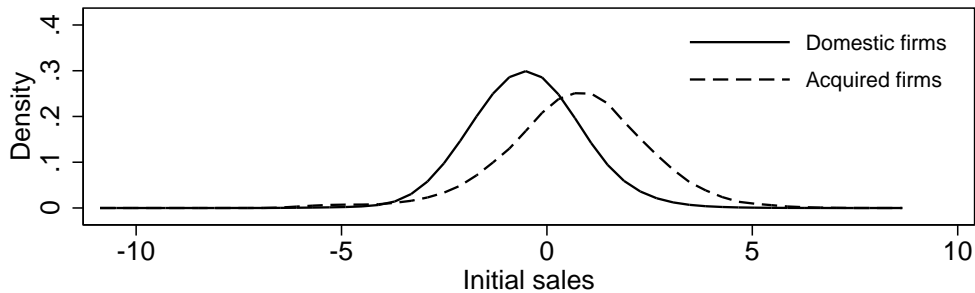


Table 1: Summary statistics, full sample

	All firms	Always domestic	Acquired by foreign investors
	(1)	(2)	(3)
Log sales	14.0677 (1.3365)	14.0411 (1.3169)	15.5926 (1.5529)
Employment	42.1986 (143.0868)	40.4140 (128.6462)	144.7823 (485.1442)
Log labor productivity	10.8681 (1.0532)	10.8561 (1.0453)	11.5595 (1.2592)
Log average labor earnings	6.4841 (0.3731)	6.4766 (0.3668)	6.9117 (0.4748)
Number of layers	2.0508 (0.7620)	2.0411 (0.7572)	2.6098 (0.8227)
Total management (share of employment)	0.1625 (0.1907)	0.1603 (0.1882)	0.2894 (0.2711)
Directors (share of employment)	0.0039 (0.0246)	0.0038 (0.0246)	0.0067 (0.0244)
Top managers (share of employment)	0.0634 (0.0903)	0.0636 (0.0903)	0.0513 (0.0862)
Supervisors (share of employment)	0.0953 (0.1706)	0.0959 (0.1680)	0.2314 (0.2455)
Directors' span of control (#top managers/#directors)*	2.9749 (6.5790)	2.7904 (5.8512)	4.8860 (11.5386)
Top managers' span of control (#supervisors/#top managers)*	3.5481 (7.2593)	3.4107 (7.0160)	7.1851 (11.4416)
Supervisors' span of control (#operators/#supervisors)*	11.4850 (20.0221)	11.4926 (19.5949)	11.2413 (30.7595)
Education (number of schooling years)	6.2147 (2.1079)	6.1780 (2.0792)	8.3235 (2.6149)
Tenure (number of years)	7.4826 (5.2359)	7.4883 (5.2356)	7.1516 (5.2389)
Workers with up to 1 year of tenure (share of employment)	0.1135 (0.1498)	0.1133 (0.1498)	0.1273 (0.1587)
Potential experience	25.8508 (6.5251)	25.9121 (6.5114)	22.3306 (6.3436)
N (obs.)	432,955	425,552	7,403
N (firms)	74,666	73,728	938

Notes: The table reports means and standard deviations (in parentheses) for firms with more than 10 employees over the period 1991-2009 (except 2001) that are not foreign owned in their first year in the sample. A firm is foreign owned if foreign investors hold at least 50% of capital. Column (1) refers to all firms, column (2) refers to firms that did not change ownership during the sample period, column (3) refers to firms that changed foreign ownership status only once during the sample period. For variables marked with an asterisk, the number of observations/firms varies as firms are not required to have all four layers. Monetary variables are in 2009 prices.

Table 2: The acquisition decision

	Dependent variable: foreign ownership							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log sales	0.0029*** (0.0004)	0.0031*** (0.0004)						
2nd quartile			0.0004 (0.0004)	0.0006 (0.0004)				
3rd quartile			0.0017*** (0.0007)	0.0021** (0.0007)				
4th quartile			0.0061*** (0.0011)	0.0064*** (0.0011)				
Log labor productivity					0.0021*** (0.0004)	0.0023*** (0.0004)		
2nd quartile							0.0015*** (0.0005)	0.0015** (0.0005)
3rd quartile							0.0024*** (0.0006)	0.0028*** (0.0007)
4th quartile							0.0041*** (0.0009)	0.0048*** (0.0009)
Industry trends	N	Y	N	Y	N	Y	N	Y
R ²	0.772	0.773	0.772	0.773	0.772	0.773	0.772	0.773
F-stat	11.480	7.762	10.718	7.429	11.305	7.664	10.682	7.381
N (obs.)	432,955	432,955	432,955	432,955	432,955	432,955	432,955	432,955
N (firms)	74,666	74,666	74,666	74,666	74,666	74,666	74,666	74,666

Notes: Standard errors in parentheses clustered at firm level. *10% level, **5% level, and *1% level. Log sales and log labor productivity are relative to the industry mean and lagged one year relative to the dependent variable.

Table 3: Propensity score estimates

Dependent variable: Foreign ownership

Log sales	0.5191*** (0.0392)
Log labor productivity	-0.4915*** (0.0655)
Log monthly labor earnings	2.2956*** (0.104)
Industry effects	Yes
Year effects	Yes
N (obs.)	426,110
N (firms)	74,382

Notes: All independent variables are lagged one year (prior to acquisition). Standard errors in parentheses clustered at the firm-level. *10% level, **5% level, and ***1% level.

Table 4: Summary statistics, matched sample

	All firms	Always domestic	Acquired by foreign investors
	(1)	(2)	(3)
Log sales	15.3816 (1.5823)	15.1765 (1.5450)	15.6631 (1.5898)
Employment	121.3401 (376.5269)	93.1199 (194.6533)	159.8928 (530.4888)
Log labor productivity	11.4403 (1.1599)	11.3356 (1.0677)	11.5844 (1.2618)
Log average labor earnings	6.8093 (0.4455)	6.7447 (0.4121)	6.8979 (0.4736)
Number of layers	2.5115 (0.8295)	2.4387 (0.8264)	2.6115 (0.8234)
Total management (share of employment)	0.2405 (0.2428)	0.2110 (0.2211)	0.2810 (0.2644)
Directors (share of employment)	0.0054 (0.0234)	0.0050 (0.0243)	0.0060 (0.0220)
Top managers (share of employment)	0.0482 (0.0746)	0.0491 (0.0747)	0.0469 (0.0743)
Supervisors (share of employment)	0.1869 (0.2208)	0.1569 (0.1994)	0.2282 (0.2411)
Directors' span of control (#top managers/#directors)*	4.4016 (10.3146)	3.4440 (5.0909)	5.2639 (13.3206)
Top managers' span of control (#supervisors/#top managers)*	6.1587 (9.0227)	5.3019 (7.8254)	7.1699 (10.1667)
Supervisors' span of control (#operators/#supervisors)*	12.0196 (26.8166)	12.4470 (20.7892)	11.5018 (32.6559)
Education (number of schooling years)	7.4964 (2.5567)	6.9800 (2.4731)	8.2051 (2.4993)
Tenure (number of years)	9.2992 (5.7170)	10.7991 (5.6011)	7.2407 (5.2121)
Workers with up to 1 year of tenure (share of employment)	0.1009 (0.1332)	0.0830 (0.1135)	0.1254 (0.1560)
Potential experience	25.0404 (6.8019)	26.9171 (6.6342)	22.4648 (6.1560)
N (obs.)	11,964	6,821	5,143
N (firms)	1230	606	624

Notes: The table reports means and standard deviations (in parentheses) for firms with more than 10 employees over the period 1991-2009 (except 2001) that are not foreign owned in their first year in the sample. A firm is foreign owned if foreign investors hold at least 50% of capital. Columns (1) and (3) refer to firms that did not change ownership during the sample period. Columns (2) and (4) refer to firms that changed foreign ownership status only once during the sample period. For variables marked with an asterisk, the number of observations/firms varies as firms are not required to have all four layers. Monetary variables are in 2009 prices.

Table 5: Effects of foreign acquisition on firm size

	(1)	(2)	(3)	(4)
A. Dependent variable: log sales				
Foreign ownership	0.3752*** (0.0452)	0.3771*** (0.0452)	0.3291*** (0.0543)	0.3271*** (0.0546)
Industry trends	N	Y	N	Y
Matched sample	N	N	Y	Y
R ²	0.858	0.858	0.806	0.806
N (obs.)	432,955	432,955	11,964	11,964
N (firms)	74,691	74,691	1,230	1,230
B. Dependent variable: log employment				
Foreign ownership	0.1346*** (0.0280)	0.1331*** (0.0279)	0.1391*** (0.0304)	0.1362*** (0.0301)
Industry trends	N	Y	N	Y
Matched sample	N	N	Y	Y
R ²	0.908	0.908	0.904	0.905
N (obs.)	432,955	432,955	11,964	11,964
N (firms)	74,691	74,691	1,230	1,230
C. Dependent variable: log labor productivity				
Foreign ownership	0.2406*** (0.0380)	0.2440*** (0.0380)	0.1900*** (0.0460)	0.1910*** (0.0463)
Industry trends	N	Y	N	Y
Matched sample	N	N	Y	Y
R ²	0.797	0.798	0.681	0.682
N (obs.)	432,955	432,955	11,964	11,964
N (firms)	74,691	74,691	1,230	1,230
D. Dependent variable: log total earnings per employee				
Foreign ownership	0.0613*** (0.0097)	0.0625*** (0.0097)	0.0435*** (0.0111)	0.0431*** (0.0109)
Industry trends	N	Y	N	Y
Matched sample	N	N	Y	Y
R ²	0.826	0.826	0.849	0.850
N (obs.)	432,955	432,955	11,964	11,964
N (firms)	74,691	74,691	1,230	1,230

Notes: Foreign ownership status is lagged one year. All regressions include year dummies. Standard errors in parentheses clustered at firm level. *10% level, **5% level, and *1% level.

Table 6: Effects of foreign acquisition on internal organization

	(1)	(2)	(3)	(4)
A. Dependent variable: number of layers				
Foreign ownership	0.0981*** (0.0274)	0.1000*** (0.0274)	0.0849*** (0.0311)	0.0791*** (0.0308)
Industry trends	N	Y	N	Y
Matched sample	N	N	Y	Y
R ²	0.676	0.676	0.655	0.656
N (obs.)	432,955	432,955	11,964	11,964
N (firms)	74,691	74,691	1,230	1,230
B. Dependent variable: directors' span of control (#top managers/#directors)				
Foreign ownership	1.6455 (1.6910)	1.6765 (1.6999)	1.1357 (2.0551)	1.3089 (2.1303)
Industry trends	N	Y	N	Y
Matched sample	N	N	Y	Y
R ²	0.647	0.647	0.431	0.432
N (obs.)	10,452	10,452	1,180	1,180
N (firms)	4,508	4,508	347	347
C. Dependent variable: top managers' span of control (#supervisors/#top managers)				
Foreign ownership	2.9365*** (0.9058)	2.9311*** (0.9065)	2.3762** (1.0279)	2.3728** (1.0305)
Industry trends	N	Y	N	Y
Matched sample	N	N	Y	Y
R ²	0.708	0.708	0.527	0.530
N (obs.)	111,024	111,024	6,061	6,061
N (firms)	27,303	27,303	891	891
D. Dependent variable: supervisors' span of control (#operators/#supervisors)				
Foreign ownership	-0.4781 (0.6657)	-0.5367 (0.6642)	-0.3345 (0.8060)	-0.3946 (0.7940)
Industry trends	N	Y	N	Y
Matched sample	N	N	Y	Y
R ²	0.743	0.744	0.781	0.782
N (obs.)	201,368	201,368	9,135	9,135
N (firms)	41,235	41,235	1,082	1,082

Notes: Foreign ownership status is lagged one year. All regressions include year dummies. Standard errors in parentheses clustered at the firm-level. *10% level, **5% level, and *1% level.

Table 7: Effects of foreign acquisition on pay structure

	(1)	(2)	(3)	(4)
A. Dependent variable: log average directors' earnings				
Foreign ownership	0.2638** (0.1283)	0.2639** (0.1283)	0.2662* (0.1362)	0.2526* (0.1335)
Industry trends	N	Y	N	Y
Matched sample	N	N	Y	Y
R ²	0.890	0.891	0.776	0.789
N (obs.)	13,016	13,016	1,332	1,332
N (firms)	5,544	5,544	401	401
B. Dependent variable: log average top managers' earnings				
Foreign ownership	0.1401*** (0.0283)	0.1407*** (0.0283)	0.0946*** (0.0334)	0.0937*** (0.0331)
Industry trends	N	Y	N	Y
Matched sample	N	N	Y	Y
R ²	0.815	0.815	0.686	0.688
N (obs.)	95,027	95,027	5,641	5,641
N (firms)	26,554	26,554	881	881
C. Dependent variable: log average supervisors' earnings				
Foreign ownership	0.0446*** (0.0165)	0.0456*** (0.0164)	0.0372* (0.0193)	0.0362* (0.0191)
Industry trends	N	Y	N	Y
Matched sample	N	N	Y	Y
R ²	0.730	0.731	0.672	0.673
N (obs.)	196,750	196,750	9,050	9,050
N (firms)	40,407	40,407	1,076	1,076
D. Dependent variable: log average operators' earnings				
Foreign ownership	0.0427*** (0.0104)	0.0438*** (0.0104)	0.0319*** (0.0108)	0.0314*** (0.0107)
Industry trends	N	Y	N	Y
Matched sample	N	N	Y	Y
R ²	0.780	0.780	0.784	0.785
N (obs.)	432,955	432,955	11,964	11,964
N (firms)	74,666	74,666	1,230	1,230

Notes: Foreign ownership status is lagged one year. All regressions include year dummies. Standard errors in parentheses clustered at firm level. *10% level, **5% level, and *1% level.

Table 8: Effects of foreign acquisition on average education

	(1)	(2)	(3)	(4)
A. Dependent variable: log average directors' education				
Foreign ownership	-0.0651*** (0.0199)	-0.0632*** (0.0200)	-0.0008 (0.0210)	-0.0008 (0.0210)
Industry trends	N	Y	N	Y
Matched sample	N	N	Y	Y
R ²	0.948	0.948	0.902	0.906
N (obs.)	22,049	22,049	1,633	1,633
N (firms)	10,423	10,423	495	495
B. Dependent variable: log average top managers' education				
Foreign ownership	0.0151 (0.0133)	0.0146 (0.0133)	0.019 (0.0146)	0.0192 (0.0147)
Industry trends	N	Y	N	Y
Matched sample	N	N	Y	Y
R ²	0.905	0.905	0.829	0.829
N (obs.)	231,512	231,512	7,304	7,304
N (firms)	50,762	50,762	1,022	1,022
C. Dependent variable: log average supervisors' education				
Foreign ownership	0.0062 (0.0131)	0.0062 (0.0130)	0.0068 (0.0166)	0.0071 (0.0165)
Industry trends	N	Y	N	Y
Matched sample	N	N	Y	Y
R ²	0.770	0.770	0.660	0.661
N (obs.)	201,277	201,277	9,134	9,134
N (firms)	41,203	41,203	1,082	1,082
D. Dependent variable: log average operators' education				
Foreign ownership	0.0035 (0.0074)	0.0041 (0.0074)	-0.0075 (0.0081)	-0.0059 (0.0080)
Industry trends	N	Y	N	Y
Matched sample	N	N	Y	Y
R ²	0.852	0.852	0.872	0.873
N (obs.)	432,780	432,780	11,962	11,962
N (firms)	74,646	74,646	1,230	1,230

Notes: Foreign ownership status is lagged one year. All regressions include year dummies. Standard errors in parentheses clustered at firm level. *10% level, **5% level, and *1% level.

Table 9: Effects of foreign acquisition on the use of information technologies

	(1)	(2)	(3)	(4)
A. Dependent variable: use of intranet				
Foreign ownership	0.2231*** (0.0758)	0.2543*** (0.0767)	0.2996*** (0.0919)	0.3693*** (0.0988)
Industry trends	N	Y	N	Y
Matched sample	N	N	Y	Y
R ²	0.699	0.703	0.728	0.741
N (obs.)	2,870	2,870	133	133
N (firms)	1,054	1,054	33	33
B. Dependent variable: use of email				
Foreign ownership	0.0121 (0.0705)	0.0239 (0.0751)	0.0750 (0.0826)	0.0735 (0.0938)
Industry trends	N	Y	N	Y
Matched sample	N	N	Y	Y
R ²	0.894	0.894	0.852	0.860
N (obs.)	2,870	2,870	133	133
N (firms)	1,054	1,054	33	33
C. Dependent variable: use of extranet				
Foreign ownership	0.0582 (0.1145)	0.0536 (0.1170)	0.0147 (0.1253)	0.0508 (0.1301)
Industry trends	N	Y	N	Y
Matched sample	N	N	Y	Y
R ²	0.626	0.627	0.642	0.647
N (obs.)	2,870	2,870	133	133
N (firms)	1,054	1,054	33	33
D. Dependent variable: use of internal networks				
Foreign ownership	0.0149 (0.0137)	0.0145 (0.0136)	0.0000 (n.d.)	0.0000 (0.0002)
Industry trends	N	Y	N	Y
Matched sample	N	N	Y	Y
R ²	0.932	0.932	1.000	1.000
N (obs.)	2,870	2,870	133	133
N (firms)	1,054	1,054	33	33

Notes: Foreign ownership status is lagged one year. All regressions include year dummies. Standard errors in parentheses clustered at firm level. *10% level, **5% level, and *1% level.

Table A1: Definition of layers

	Occupations	Correspondence in CNP94
Layer 3: CEO and Directors	"General directors" and "directors and managers of small firms"	121; 131
Layer 2: Top managers	"Directors of production, finance or other"	122, 123
Layer 1: Supervisors	"Specialists in scientific and intellectual jobs"; "Intermediate-level technicians and professionals"	between 200 & 400
Layer 0: Operators	"Administrative staff"; "Service and sales staff"; "Workers and craft"; "Machine operators"; "Unskilled workers"	above 400

Notes: Table displays definition of occupations included in each layer using the 1994 National Classification of Occupations (CNP94)

Table A2: Indicators of the covariate balancing before and after matching

Panel A: t-test before and after matching							
Variable	Sample	Mean		% bias	% reduct bias	t-test	p-value
		Treated	Control				
Log sales	Unmatched	15.111	13.981	71.900		20.690	0.000
	Matched	15.111	15.213	-6.400	91	-1.080	0.281
Log labor productivity	Unmatched	11.322	10.798	41.200		11.930	0.000
	Matched	11.322	11.352	-2.300	94	-0.410	0.685
Log monthly labor earnings	Unmatched	6.856	6.453	93.700		27.210	0.000
	Matched	6.856	6.835	4.900	95	0.790	0.430
Food, beverage, tobacco	Unmatched	0.034	0.048	-7.000		-1.630	0.104
	Matched	0.034	0.034	0.000	100	0.000	1.000
Textiles, leather	Unmatched	0.080	0.125	-14.800		-3.380	0.001
	Matched	0.080	0.080	0.000	100	0.000	1.000
Wood, cork, paper	Unmatched	0.034	0.049	-7.600		-1.750	0.081
	Matched	0.034	0.034	0.000	100	0.000	1.000
Non-metallic manufacturing	Unmatched	0.101	0.049	19.800		6.000	0.000
	Matched	0.101	0.101	0.000	100	0.000	1.000
Metallic manufacturing	Unmatched	0.123	0.083	13.100		3.610	0.000
	Matched	0.123	0.123	0.000	100	0.000	1.000
Furniture	Unmatched	0.011	0.028	-12.100		-2.540	0.011
	Matched	0.011	0.011	0.000	100	0.000	1.000
Construction	Unmatched	0.051	0.129	-27.200		-5.760	0.000
	Matched	0.051	0.051	0.000	100	0.000	1.000
Wholesale and retail trade	Unmatched	0.309	0.240	15.500		4.030	0.000
	Matched	0.309	0.309	0.000	100	0.000	1.000
Hotels and restaurants	Unmatched	0.030	0.073	-19.400		-4.100	0.000
	Matched	0.030	0.030	0.000	100	0.000	1.000
Transport, storage, other	Unmatched	0.061	0.035	11.900		3.440	0.001
	Matched	0.061	0.061	0.000	100	0.000	1.000
Post, telecommunications	Unmatched	0.005	0.001	8.000		4.030	0.000
	Matched	0.005	0.005	0.000	100	0.000	1.000
Financial intermediation	Unmatched	0.016	0.007	8.900		2.890	0.004
	Matched	0.016	0.016	0.000	100	0.000	1.000
Real estate, renting, business	Unmatched	0.115	0.076	13.300		3.680	0.000
	Matched	0.115	0.115	0.000	100	0.000	1.000
Education	Unmatched	0.003	0.015	-12.700		-2.460	0.014
	Matched	0.003	0.003	0.000	100	0.000	1.000
Health, social work	Unmatched	0.006	0.021	-12.700		-2.570	0.010
	Matched	0.006	0.006	0.000	100	0.000	1.000
Other social activities	Unmatched	0.010	0.013	-3.000		-0.700	0.483
	Matched	0.010	0.010	0.000	100	0.000	1.000
1991	Unmatched	0.101	0.050	19.500		5.860	0.000
	Matched	0.101	0.101	0.000	100	0.000	1.000
1992	Unmatched	0.074	0.051	9.600		2.630	0.009
	Matched	0.074	0.074	0.000	100	0.000	1.000
1993	Unmatched	0.042	0.048	-3.000		-0.730	0.468
	Matched	0.042	0.042	0.000	100	0.000	1.000
1994	Unmatched	0.045	0.051	-2.900		-0.700	0.483
	Matched	0.045	0.045	0.000	100	0.000	1.000
1996	Unmatched	0.022	0.050	-15.000		-3.190	0.001
	Matched	0.022	0.022	0.000	100	0.000	1.000
1997	Unmatched	0.046	0.052	-2.400		-0.590	0.555
	Matched	0.046	0.046	0.000	100	0.000	1.000

Table A2: Indicators of the covariate balancing before and after matching (cont.)

Panel A: t-test before and after matching (cont.)

	Sample	Mean		%reduct		t-test	p-value
		Treated	Control	%bias	bias		
1998	Unmatched	0.019	0.053	-18.400		-3.800	0.000
	Matched	0.019	0.019	0.000	100	0.000	1.000
1999	Unmatched	0.037	0.056	-9.100		-2.080	0.037
	Matched	0.037	0.037	0.000	100	0.000	1.000
2000	Unmatched	0.038	0.062	-10.800		-2.430	0.015
	Matched	0.038	0.038	0.000	100	0.000	1.000
2002	Unmatched	0.183	0.069	34.600		11.110	0.000
	Matched	0.183	0.183	0.000	100	0.000	1.000
2003	Unmatched	0.083	0.071	4.500		1.170	0.243
	Matched	0.083	0.083	0.000	100	0.000	1.000
2004	Unmatched	0.035	0.075	-17.400		-3.750	0.000
	Matched	0.035	0.035	0.000	100	0.000	1.000
2005	Unmatched	0.053	0.076	-9.600		-2.210	0.027
	Matched	0.053	0.053	0.000	100	0.000	1.000
2007	Unmatched	0.095	0.078	5.900		1.540	0.124
	Matched	0.095	0.095	0.000	100	0.000	1.000
2008	Unmatched	0.061	0.080	-7.300		-1.720	0.086
	Matched	0.061	0.061	0.000	100	0.000	1.000

Panel B: Two-group Hotelling T-squared test

Sample	T-squared	F-test	p-value
Matched	3.232	0.093	1.000

Panel C: Pseudo R2 and test of joint significance of regressors

Sample	Pseudo R2	Chi2	p-value
Unmatched	0.120	-4131	0.000
Matched	0.002	-863	1.000

Table A3: Effects of foreign acquisition on average tenure

	(1)	(2)	(3)	(4)
A. Dependent variable: log average directors' tenure				
Foreign ownership	0.1494 (0.1305)	0.1495 (0.1309)	0.0445 (0.1333)	0.0402 (0.1343)
Industry trends	N	Y	N	Y
Matched sample	N	N	Y	Y
R ²	0.8545	0.8551	0.7792	0.7827
N (obs.)	21,118	21,118	1,554	1,554
N (firms)	10,120	10,120	481	481
B. Dependent variable: log average top managers' tenure				
Foreign ownership	0.0199 (0.0463)	0.0229 (0.0462)	0.1370*** (0.0487)	0.1391*** (0.0487)
Industry trends	N	Y	N	Y
Matched sample	N	N	Y	Y
R ²	0.794	0.794	0.665	0.667
N (obs.)	227,364	227,364	7,148	7,148
N (firms)	50,027	50,027	1,009	1,009
C. Dependent variable: log average supervisors' tenure				
Foreign ownership	0.1138*** (0.0347)	0.1154*** (0.0346)	0.1829*** (0.0397)	0.1772*** (0.0398)
Industry trends	N	Y	N	Y
Matched sample	N	N	Y	Y
R ²	0.751	0.751	0.703	0.705
N (obs.)	192,066	192,066	8,981	8,981
N (firms)	39,654	39,654	1,071	1,071
D. Dependent variable: log average operators' tenure				
Foreign ownership	0.1376*** (0.0255)	0.1409*** (0.0254)	0.2579*** (0.0268)	0.2559*** (0.0268)
Industry trends	N	Y	N	Y
Matched sample	N	N	Y	Y
R ²	0.858	0.858	0.831	0.831
N (obs.)	431,492	431,492	11,939	11,939
N (firms)	74,482	74,482	1,230	1,230

Notes: Foreign ownership status is lagged one year. All regressions include year dummies. Standard errors in parentheses clustered at firm level. *10% level, **5% level, and *1% level.

Table A4: Effects of foreign acquisition on the share of newcomers

	(1)	(2)	(3)	(4)
A. Dependent variable: share of directors with tenure up to 1 year				
Foreign ownership	-0.0174 (0.0395)	-0.0186 (0.0396)	0.0064 (0.0410)	0.0093 (0.0415)
Industry trends	N	Y	N	Y
Matched sample	N	N	Y	Y
R ²	0.548	0.549	0.408	0.416
N (obs.)	22,051	22,051	1,633	1,633
N (firms)	10,425	10,425	495	495
B. Dependent variable: share of top managers with tenure up to 1 year				
Foreign ownership	0.0001 (0.0091)	0.0003 (0.0091)	0.0091 (0.0110)	0.0096 (0.0110)
Industry trends	N	Y	N	Y
Matched sample	N	N	Y	Y
R ²	0.388	0.388	0.283	0.286
N (obs.)	231,535	231,535	7,304	7,304
N (firms)	50,771	50,771	1,022	1,022
C. Dependent variable: share of supervisors with tenure up to 1 year				
Foreign ownership	-0.0077 (0.0078)	-0.0088 (0.0078)	-0.0241*** (0.0087)	-0.0233*** (0.0088)
Industry trends	N	Y	N	Y
Matched sample	N	N	Y	Y
R ²	0.401	0.402	0.349	0.351
N (obs.)	201,368	201,368	9,135	9,135
N (firms)	41,235	41,235	1,082	1,082
D. Dependent variable: share of operators with tenure up to 1 year				
Foreign ownership	-0.0276*** (0.0055)	-0.0283*** (0.0055)	-0.0361*** (0.0064)	-0.0356*** (0.0064)
Industry trends	N	Y	N	Y
Matched sample	N	N	Y	Y
R ²	0.542	0.542	0.488	0.489
N (obs.)	432,955	432,955	11,964	11,964
N (firms)	74,666	74,666	1,230	1,230

Notes: Foreign ownership status is lagged one year. All regressions include year dummies. Standard errors in parentheses clustered at firm level. *10% level, **5% level, and ***1% level.

Table A5: Effects of foreign acquisition on average experience

	(1)	(2)	(3)	(4)
A. Dependent variable: log average directors' experience				
Foreign ownership	0.0386 (0.0558)	0.0354 (0.0561)	0.0167 (0.0587)	0.0284 (0.0593)
Industry trends	N	Y	N	Y
Matched sample	N	N	Y	Y
R ²	0.853	0.853	0.782	0.790
N (obs.)	22,049	22,049	1,633	1,633
N (firms)	10,425	10,425	495	495
B. Dependent variable: log average top managers' experience				
Foreign ownership	0.0103 (0.0201)	0.0109 (0.0201)	0.0117 (0.0223)	0.013 (0.0222)
Industry trends	N	Y	N	Y
Matched sample	N	N	Y	Y
R ²	0.775	0.775	0.662	0.663
N (obs.)	231,531	231,531	7,303	7,303
N (firms)	50,770	50,770	1,022	1,022
C. Dependent variable: log average supervisors' experience				
Foreign ownership	0.0291 (0.0196)	0.0299 (0.0196)	0.0295 (0.0231)	0.0289 (0.0229)
Industry trends	N	Y	N	Y
Matched sample	N	N	Y	Y
R ²	0.722	0.723	0.636	0.638
N (obs.)	201,349	201,349	9,135	9,135
N (firms)	41,232	41,232	1,082	1,082
D. Dependent variable: log average operators' experience				
Foreign ownership	0.0350*** (0.0097)	0.0346*** (0.0097)	0.0482*** (0.0105)	0.0472*** (0.0104)
Industry trends	N	Y	N	Y
Matched sample	N	N	Y	Y
R ²	0.8101	0.8102	0.8124	0.8132
N (obs.)	432,946	432,946	11,964	11,964
N (firms)	74,445	74,445	1,230	1,230

Notes: Foreign ownership status is lagged one year. All regressions include year dummies. Standard errors in parentheses clustered at firm level. *10% level, **5% level, and *1% level.

Table A6: Summary statistics, auxiliary survey data

	Full sample			Matched sample		
	All firms	Always domestic	Acquired by foreign investors	All firms	Always domestic	Acquired by foreign investors
	(1)	(2)	(3)	(4)	(5)	(6)
Use of intranet (yes=1)	0.2885 (0.4531)	0.2803 (0.4492)	0.3488 (0.4773)	0.3066 (0.4628)	0.3030 (0.4633)	0.3099 (0.4657)
Use of e-mail (yes=1)	0.4108 (0.4921)	0.4113 (0.4922)	0.4070 (0.4920)	0.4234 (0.4960)	0.4545 (0.5020)	0.3944 (0.4922)
Use of extranet (yes=1)	0.1679 (0.3739)	0.1607 (0.3674)	0.2209 (0.4155)	0.2117 (0.4100)	0.1818 (0.3888)	0.2394 (0.4298)
Use of internal networks (yes=1)	0.3226 (0.4676)	0.3199 (0.4665)	0.3430 (0.4754)	0.3431 (0.4765)	0.3333 (0.4753)	0.3521 (0.4810)
Log sales	17.0979 (1.3605)	17.0466 (1.3580)	17.4743 (1.3210)	17.8790 (1.4685)	18.1133 (1.1148)	17.6611 (1.7136)
Employment	387.9286 (764.4519)	355.7696 (601.5651)	624.0727 (1469.8740)	420.3869 (392.6394)	417.8636 (323.7705)	422.7324 (449.6676)
Log labor productivity	11.8582 (1.4559)	11.8373 (1.4522)	12.0118 (1.4765)	12.2915 (1.5010)	12.46804 (1.0713)	12.1274 (1.8041)
Log average labor earnings	6.8362 (0.4395)	6.8092 (0.4234)	7.0342 (0.5013)	7.0515 (0.3404)	7.0128 (0.2765)	7.0874 (0.3891)
N (obs.)	2,870	2,526	344	133	62	71
N (firms)	1,054	947	107	33	16	17

Notes: The table reports means and standard deviations (in parentheses) for firms with more than 10 employees over the period 2004-2009 that are not foreign owned in their first year in the sample. A firm is foreign owned if foreign investors hold at least 50% of capital. Columns (1) and (4) refer to all firms, column (2) and (5), refer to firms that did not change ownership during the sample period, columns (3) and (6) refer to firms that changed to foreign ownership status only once during the sample period. Monetary variables are in 2009 prices.