

Adjustment costs and factor demand: new evidence from firms' real estate*

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Abstract

Adjustment costs impair the optimal allocation of production factor across firms. In this paper, we use the cost associated to corporate relocation to explore the effect of the adjustment costs of the premises size on factor demand. We rely on the tax on realised capital gains on real estate asset that entails varying real estate adjustment costs across firms to empirically study the effect of these frictions on firms' behaviour. We develop a general equilibrium model with heterogeneous firms that sheds light on the implication of the level of the fixed costs associated with the adjustment of real estate on the change in firms' labor demand following productivity shocks. This model predicts that employment growth of firms facing positive productivity shocks shrinks with the level of the frictions. Confronting these results using French firm-level data over the period 1994-2013, we find that higher adjustment costs constrain relocation and reduce job creation of the most dynamic firms. The highlighted frictions has noticeable macroeconomic effects.

JEL classification: D21, D22, H25, J21, O52, R30

Keywords: Corporate real estate; Firms' relocation; Adjustment costs; Misallocation of resources

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1 Introduction

This paper studies the effect of adjustment costs of corporate real estate on factor demand. By linking the adjustment of firms' premises to local relocations, we are able to empirically explore the impact of adjustment costs on firms' dynamics. These costs include a tax on realized capital gains, induced by the selling of the previous premises, that depend on the dynamics of local real estate prices since the acquisition date. Using a large firm-level database merged with local real estate prices, we document sizable effects of the adjustment costs on firms' labor demand and derive new results on the causes and implications of firms' local relocation.

There is a vast literature on the nature and the effect of adjustments cost on firms' factor demand (see [Hamermesh and Pfann, 1996](#) for a literature review). This literature explores the effect of different structures of costs and uses firm-level data to test their empirical relevance. For example, on the nature of capital adjustment costs, [Cooper and Haltiwanger \(2006\)](#) document that models that mix both convex and non-convex adjustment costs better fits the data. Adjustment costs are also related to a recent literature that has empirically documented to what extent misallocating resources toward less productive firms impairs aggregate productivity. Adjustment costs can indeed explain the distortions underlying these findings even though these distortions have been mainly imputed to regulations (see [Olley and Pakes, 1996](#); [Hsieh and Klenow, 2009](#) and in the case of France [Garicano et al., 2016](#)). Alternatively, [Asker et al. \(2014\)](#) relate the dispersion of static measures of capital misallocation to the dynamic choice of production inputs. More closely related to our study, [Duranton et al. \(2015\)](#) use micro data on Indian firms and find that misallocation of manufacturing output is mostly due from a sub-optimal allocation of land. This motivates our view that distortions on the corporate real estate market can be relevant at the macroeconomic level.

Our empirical identification relies on the equivalence between the alteration of the premises' volume and local relocation of single establishment firms. This equivalence matters because relocation costs vary across firms and across time and because the underlying determinants of those costs are observable for both non-relocating and relocating firms. This equivalence is warranted by the argument put forward by [Schmenner \(1980\)](#) that on-site expansion, out-site expansion (branching) and relocation are not substitute to one another and that the latter is the only option for many firms when it comes to altering the size of the premises.¹ Firms' relocation is actually a fairly frequent event: with definitions that

¹On-site expansion, especially in the non-manufacturing sector and/or in urban areas, is often an option that has to be discarded because access to adjacent land or premises is constrained. Informal talks with market participants indicate that sublease of unused premises has been at a very early stage of development over the studied period. Out-site expansion is potentially associated with additional on-going costs resulting from fixed expenses per establishment and important losses of synergies. This point is further discussed in Section 2.

will be clarified below, we find that 1.7% of the French firms relocate their activities to a neighbouring city, on average, each year. In line with our argument on the intertwining of factors' adjustment and relocation, this yearly propensity to relocate reaches more than 4% for firms at the upper workforce growth decile.

To guide our empirical investigations, we build a general equilibrium model with heterogeneous firms to derive predictions on the effect of the level of the fixed costs associated with real estate adjustment on the workforce growth across the productivity shocks distribution. In this framework, profit-maximizing firms are heterogeneous with respect to their productivity level and make decisions on labor and real estate inputs in a context of adjustable real estate inputs conditional on paying a fixed cost. Because of the complementarity between real estate and labor in the production process, the level of the adjustment costs that deter some firms from optimally adjusting real estate inputs to their new productivity level also affects the firms' labor demand. We derive the existence of an interval of inaction for the productivity shocks in which firms prefer not to adjust their real estate inputs. Such an interval is a classical result of the literature on investment with non-convex adjustment costs. In our framework, this non-relocating interval entails that firms affected by low positive productivity shocks operate in sub-optimally small premises whereas those affected by low negative productivity shocks operate in sub-optimally large premises. The complementarity between real estate and labor leads the first ones to restrain employment growth as compared to the counter-factual employment growth that we would observe if those firms had adjusted real estate whereas the second ones reduce less their workforce as compare to the same counter-factual. We show that the interval of inaction widens with the level of the adjustment costs and so do the number of firms affected. We also show that the non-relocating interval is not centered in zero and that a rise in the fixed adjustment costs has asymmetrical effects on the bounds of the interval. The effect of such a rise is larger in absolute value on the positive bound of the interval than the effect on the negative bound which implies that an increase in the fixed adjustment cost has an overall negative impact on mean firm-level employment growth.

To test these predictions, we rely on data on French firms and their location from 1994 to 2013.² Our empirical study focuses on inter-municipality relocations occurring over a short distance, or equivalently on relocations that leave the economic environment of the firm (e.g, localized aggregate increasing return, real estate prices or wages) largely unaltered and are more likely to be primarily triggered by the inappropriateness of the site's characteristics.³ We study the effect of adjustment costs of real estate by exploiting two

²We ensure an equivalence between the notion of firm and establishment by focusing on the behaviour of single-establishment firms. This is a restriction imposed by the nature of our dataset where we can only observe firm-level data and have no information whatsoever on establishments, in particular on their location.

³Focusing on local relocations is also justified by the fact that in such cases, employees are more likely to remain in the firm; which is not the case for relocations over longer distances: [Weltevreden et al. \(2007\)](#)

peculiarities of the relocation costs. First, firms that own their premises and firms that rent them face markedly different relocation costs. Second, to deal with the potentially important unobserved differences between these two groups of firms, we restrict to real estate owners and exploit the heterogeneity introduced by the latent tax on realised capital gains affecting real estate assets that owning firms must pay when they relocate.⁴ In a nutshell, the tax base is determined by the size of the real estate assets, the acquisition date and the dynamic of local prices since this acquisition. This scheme introduces important variability across firms and across time in the level of the relocation costs. We document that higher relocation costs lower firms' propensity to relocate and constrain employment growth of the growing firms. Our baseline results suggest that a reduction of the relocation costs, through a decrease of the share of the real-estate market value that would be paid as a tax on capital gains of 1 standard deviation, would double the yearly propensity to relocate of affected firms and would raise the yearly employment growth rate of the growing firms by 5%. Such reduction in the adjustment costs would therefore result in an important increase in job creation in productive firms. Additional empirical evidences suggest that this reduction in the adjustment costs would foster optimal allocation of factor inputs.

Our identification strategy shares similarities with the emerging literature on the effect of tax friction on real estate transactions and households' mobility. [Dachis et al. \(2012\)](#), [Best and Kleven \(2013\)](#) and [Hilber and Lyytikäinen \(2013\)](#) all study the effect of transaction tax on residential real estate dynamic and find large aggregate effects. [Hilber and Lyytikäinen \(2013\)](#) exploit cut-off values in the tax associated with housing transactions to claim that an increase in transaction cost by 2 to 3 percentage points reduces mobility by 30%; this is only true for short distance relocations, suggesting that frictions may lead to misallocation of dwellings in the housing market.

The paper is organized as follows: section 2 presents stylised facts on the interaction between relocation behaviour and employment dynamics. Section 3 presents a theoretical framework development to formulate testable predictions on firms' behaviour. Section 4 presents our empirical analysis, findings and comments and section 5 concludes.

2 Background

Little is known about firms' local relocations and their connection to firms' employment dynamism. Most of the existing literature has rather focused on explaining the determinants of relocation and the choice of the destination. It is acknowledged that, although external factors (characteristics of potential new sites) are at play in the choice of the place of relo-

shows that when the relocation distance exceeds 20km, most employees quit there jobs in anticipation of the relocation decision.

⁴For single-establishment firms holding the real estate assets in which they operate, a relocation is necessarily associated with the sale of previously occupied premises if we make the reasonable assumption that limited access to funding prevents the firms from concomitantly owning various premises.

cation, internal factors (size, age, tenure status, sector and growth) are the main predictors of firms' relocation decision (see for example [Pellenbarg et al., 2002](#) and [Brouwer et al., 2004](#)). This first section sheds light on stylized facts supporting our views that there exists a close relationship between firms' local relocation and factors' adjustment. After briefly presenting the databases, we look at some general characteristics of firms' relocation. We then document that employment dynamics and local relocations are closely intertwined.

2.1 Data

To derive the following results, we use a firm level database with information on a large number of French firms over the period 1994-2013 called **FiBEn** that we merged with local real estate prices. The firm level database, **Fiben**, is built by the Banque de France from fiscal documents and contains detailed information on flow and stock accounting variables, notably on real estate assets, as well as information on firms' activities, location and workforce. We restrict to single-establishment firms that remain below 250 employees⁵ and are left with more than 100,000 firms observed over an average period of 10 years. For this size threshold, 85.7% of the firms are single-establishment. The firm reports the code of its current municipality and we use changes in this code to detect inter-municipality relocations. We use the *Notaires*-INSEE⁶ apartment price indices built by [Fougère and Poulhes \(2012\)](#) which are based on the data collected by French *notaires* to derive capital gains on real estate assets. We describe our dataset and the variable construction in more detail in [Appendix A](#).

2.2 Firms' mobility in France

Our firm-level database allows to identify inter-municipality relocations of single-establishment firms between 1994 and 2013. We observe 112,128 single-establishment firms over an average period of 9.75 years. Among these firms, 17,830 have relocated their activities to another municipalities over the period of observation; that is approximately 16% of the firms. Half of the relocations concerns a relocation where the municipality of departure and the municipality of settlement are distant by less than 7.5km. For almost 75% of the relocations, this distance is inferior to 15km. These first empirical results are in line with other studies that report statistics on the distance between the place of departure and the place of settlement of relocating firms. They find that local relocations account for the large majority of the relocations ([Pen and Pellenbarg, 1998](#); [Delisle and Laine, 1998](#); [Weltevreden et al., 2007](#) and [Knoben et al., 2008](#)). In France, [Delisle and Laine \(1998\)](#) document that 6.2% of the firms had relocated between 1989 and 1992, with more than three quarters of

⁵This size restriction is made to limit measurement errors in real estate volume, see [Appendix A](#) for more details.

⁶Solicitor is the English equivalent for the French word *notaire* and INSEE is the French National Statistical Bureau.

the inter-municipality relocations being characterized by a distance inferior to 23km. Similarly, in Netherlands, [Weltevreden et al. \(2007\)](#) shows that between 1999 and 2006, most relocations are made within the same labor market area. We hereafter define as “local” a relocation that is characterized by a distance of less than 15km, between the municipality of departure and the municipality of settlement.⁷ The distribution of the relocating distance is given in Figure A1 in Appendix A.

Table 1 presents some basic descriptive statistics to compare relocating firms to a control group made of static firms.⁸ We notice that relocating firms do not differ much by their size, their employment level and their profitability (even if some of those differences are statistically significant). Slightly larger differences are observed for the age of the firm; static firms being in average 2.1 year older than relocating firms. However, sizeable and statistically significant differences are observed regarding two characteristics: (i) the yearly mean employment growth over the observation period: while the mean yearly workforce growth of relocating firms is equal to 5.2%, it is 2.2% for static firms; (ii) the tenure status of the firm: 28% of the relocating firms report real estate holdings while this share is equal to 41% for static firms.

2.3 Relocating behaviour and workforce growth

The average workforce growth of relocating firms reported in table 1 suggests that relocation is markedly related to factors’ adjustment. In order to explore this relationship, we rank firms according to their mean yearly workforce growth rate over the observation period. In each percentile of this average workforce growth distribution, we compute the propensity to relocate by dividing the number of observed local relocations by the number of observations in this percentile. The results are presented in Figure 1 where average employment growth has been residualized on a complete set of sector-*département* dummies. We find that firms located in the first two deciles (*resp.* in the three last deciles) in the workforce growth distribution, which corresponds to an average yearly workforce growth rate below -4.0% (*resp.* above 1.5%), have a much higher propensity to relocate than firms characterized by limited change in their workforce size.

These results are robust to restricting to different sectors or areas. One could for example believe that service firms are more prone to relocate than manufacturing ones and are in larger quantities in major cities which are rich and dynamic areas where firms grow faster. In

⁷Following this definition 73.4% of the relocations observed in our sample are local. There is of course a degree of arbitrariness in setting such a threshold. As mentioned before, it reflects the idea that relocations over farther distance are more likely to alter the local economic conditions and might require that the existing employees change their place of residence, inducing higher costs and new risks. All our subsequent results are robust to defining as local the relocations occurring within the local labor market area based on commuter flows from census data.

⁸In this control group made of static firms, we have excluded firms identified as having shifted towards a multi-establishment structure.

Table 1: Key summary statistics - relocating locally and static firms

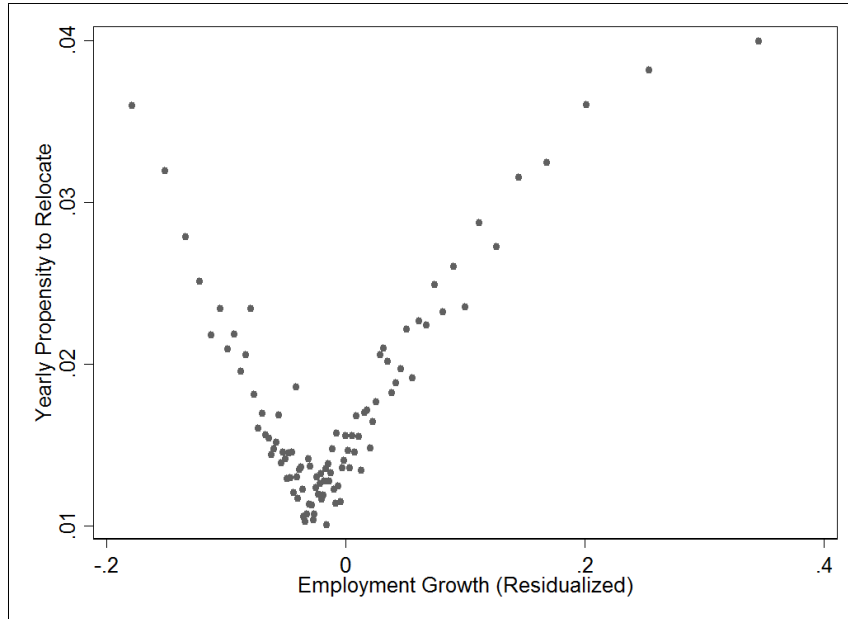
	Mean		Difference	
	Relocating locally	Static		
Employment	19.15	20.82	-1.67***	(0.20)
Sales	3.10	3.05	0.05***	(0.02)
BS size	1.92	2.02	-0.10	(0.18)
Profits	0.136	0.124	0.011***	(0.0013)
Age	12.1	14.2	-2.11***	(0.12)
Employment growth	5.2%	2.2%	2.9%***	(0.0013)
Real estate owner	28%	41%	14%***	(0.004)
Nb of obs.	17,830	94,298	-	

Notes: This table shows the mean of different key variables, in initial year of observation, for firms that locally relocate and for firms that neither relocate nor shift towards a multi-establishment structure over the observed period. Employment is given in full-time equivalent (FTE) number of workers as reported by the firm; Employment growth in the mean yearly percentage change in FTE over the observation period; Sales are in millions of euros; BS size is the net value of the assets reported in the balance sheet and is given in millions of euros; Profits is the Earning Before Interest and Tax margin (i.e., EBIT to Sales ratio); Age is the number of year since company's incorporation; Real estate owner is a dummy variable equal to 1 if the firm reports real estate holdings and 0 otherwise. Source: FiBEn, see Appendix A for more detail about the data. The latest column show the mean and standard deviation of the difference between the two coefficients and the Student t-stat on the nullity of this difference. ***, ** and * indicate that the null hypothesis of this test is rejected at the 1%, 5% and 10% level of significance.

Appendix B, we report the results of a similar analysis focusing on Paris (Figure B1), Lyon (Figure B2) and Marseille (Figure B3) areas which are the three largest cities in France. We also present the relationship between the propensity to relocate and employment growth in the whole country but excluding these three areas in Figure B4. We can see that the U-shaped relationship is robust to such stratifications and seems to be, as expected, stronger in the Paris area where on-site expansion is more constrained. Finally, Figures B5 and B6 report the results when focusing on service industries (Figures B5) and manufacturing firms (Figures B6). The link looks stronger in the service industries, where relocating costs are arguably lower and on-site expansion is more constrained.

In the following section, we develop a theoretical framework that relies on this link between factors' adjustment and relocations.

Figure 1: Propensity to relocate and employment growth



Notes: Employment growth is taken as the average employment growth over the period of observation and residualized on a set of sector-*département* dummies. The propensity to relocate is calculated as the number of observed local relocation divided by the number of year of observations. These two variables are averaged for each percentiles of the distribution of the residualized employment growth. The first and the last percentiles have been removed to focus to the core of the distribution. Period of observation: 1994-2013. Source: FiBEn, see Appendix A for more details about the data.

3 Model

In this section, we develop a standard model of monopolistic competition with heterogeneous firms in the spirit of Melitz (2003). Firms face a productivity shock and make the decision to adjust the size of its premises or not. Premises' size adjustment is associated with fixed relocation costs. This model sheds light upon the effect of the fixed adjustment costs of real estate on firms' behavior across the productivity distribution.

3.1 Model setup

3.1.1 Demand

There is a continuum of products $i \in [0, 1]$ and a final sector using all products i as inputs to produce Y with a CES technology:⁹

⁹Or equivalently, as explained in Dixit and Stiglitz (1977) and Melitz (2003), this is equivalent to considering a representative consumer with CES utility.

$$Y = \left[\int_0^1 y(i)^{1-\varepsilon} di \right]^{\frac{1}{1-\varepsilon}}. \quad (1)$$

The conditional demand function for $y(i)$ can be written as

$$y(i) = \left[\frac{P}{p(i)} \right]^{\frac{1}{\varepsilon}} Y, \quad (2)$$

where P is the final good price and $p(i)$ is the price of $y(i)$. From the zero profit condition of the final good producer:

$$P = \left[\int_0^1 p(i)^{\frac{\varepsilon-1}{\varepsilon}} di \right]^{\frac{\varepsilon}{\varepsilon-1}}. \quad (3)$$

3.1.2 Production

Each product i is produced by a monopolistic firm indexed by i with a Cobb-Douglas production function using labor and real estate as inputs.¹⁰ These firms differ by their parameters $\theta(i)$ such that:

$$y(i) = \theta(i) \left(\frac{l(i)}{\alpha} \right)^\alpha \left(\frac{r(i)}{1-\alpha} \right)^{1-\alpha}. \quad (4)$$

θ can be understood in many different ways, it can encompass a firm-specific demand shock, technology level or the quality of the intermediate input as in [Aghion and Howitt \(1992\)](#) or managerial ability as in [Garicano et al. \(2016\)](#), in what follows we will refer to it as the firm productivity. Labor and real estate are mobile across firms in the intermediate sector. The endogenous market wage, w , and the endogenous market price of one unit cost of real estate, u , that can be thought as either the user cost of real estate capital or its renting rate, are the same at each firm $i \in [0, 1]$. The firm i considers the demand function and takes into account the fact that prices $p(i)$ adjust to:

$$p(i) = \frac{Y^\varepsilon P}{\theta(i)^\varepsilon} \left(\frac{l(i)}{\alpha} \right)^{-\alpha\varepsilon} \left(\frac{r(i)}{1-\alpha} \right)^{-(1-\alpha)\varepsilon}, \quad (5)$$

hence, firm i 's revenue is given by:

$$p(i)y(i) = \Omega(i) \left(\frac{l(i)}{\alpha} \right)^{\alpha(1-\varepsilon)} \left(\frac{r(i)}{1-\alpha} \right)^{(1-\alpha)(1-\varepsilon)}, \quad (6)$$

where $\Omega(i) = \theta(i)^{1-\varepsilon} Y^\varepsilon P$ is the revenue productivity (see [Foster et al., 2008](#) and [Hsieh and Klenow, 2009](#)).

¹⁰Including productive capital stock as an input won't affect our theoretical prediction if we assume that adjustment costs in real estate are not affected by the level of capital stock. Hence, in this framework, l already encompasses the stock of capital.

3.1.3 Resource constraint

We consider a closed economy where a representative consumer owns the intermediate firms, real estate assets and provide labor. Aggregate labor and real estate are in fixed-supply and we set them to L_s and R_s , respectively. In equilibrium, aggregate demand for labor and real estate equal aggregate supply.

3.1.4 The problem of the firm

Each firm i faces an unanticipated productivity shock on $\theta(i)$. This shock is assumed to be idiosyncratic and uncorrelated with the observable characteristics of the firm. After observing its new level of productivity $\theta(i)$, the firm adjusts labor and can adjust real estate conditional on relocating. This condition relies upon the constrained on-site expansion and the constrained sublease of vacated premises hypotheses. We denote $z(i)$ the decision variable with $z(i) = 1$ if firm i relocates and $z(i) = 0$ otherwise. Relocating is associated with costs that we will specify below in order to relate them to actual costs faced by relocating firms. In this theoretical model, we model these costs as proportional to the size of the endowed premises. Formally, the costs are equal to $ar_0(i)$, where $r_0(i)$ is firm i 's initial premises volume and a is a non-negative real number.¹¹

Because of the fixed adjustment costs, a firm may decide to remain in its latest premises even it is hit by a non-zero productivity shock (see [Cooper et al., 1999](#) and [Cooper and Haltiwanger, 2006](#) for a thorough discussion on the implication of non-convex adjustment costs).

The price of both inputs are taken as given by the profit maximizing firms. In turn, firm i 's decision problem can be written:

$$\max_{z(i) \in \{0,1\}} \left[z(i) \max_{\substack{r(i) > 0 \\ l(i) > 0 \\ p(i) > 0}} [\pi(i, r(i)) - ar_0(i)] + (1 - z(i)) \max_{\substack{l(i) > 0 \\ p(i) > 0}} [\pi(i, r_0(i))] \right], \quad (7)$$

where $\pi(i, r(i))$ denotes the profit function of firm i defined as $p(i)y(i) - wl(i) - ur(i)$. In what follows, we shall call $\pi^{(1)}(i)$ the optimal profit in the case of a relocation and $\pi^{(0)}(i)$ in the case of no relocation.

¹¹The predictions of the model are unaltered if we introduce linear or/and convex adjustment costs in addition to those fixed costs. We focus on the consequences of changes in the value of parameter a , that is to say of the parameter governing the level of the fixed costs, because we observed firm level variation with respect to the fixed costs in the data.

3.2 Solving the model

3.2.1 Decentralized equilibrium

The equilibrium is defined by a vector of allocation $\{r(i), l(i), y(i), z(i), Y\}$ and a vector of prices $\{P, p(i), u, w\}$ such that:

- Given $y(i)$, u and w , $\{r(i), l(i), z(i), p(i)\}$ maximize firm i 's profit for every i as defined in equation (7) (and $r(i) = r_0(i)$ if $z(i) = 0$).
- Final good producing competitive firm chooses $y(i)$ for all i to produce Y by maximizing its profit taking $p(i)$ as given.
- Labor and real-estate market clear.
- The price of the final good is set to 1.

3.2.2 The frictionless case

In the simple case where $a = 0$, we show in Appendix C.1 that our model yields the following optimal allocation:

$$z(i) = 1 ; l(i) = \frac{\theta(i)^{\frac{1-\varepsilon}{\varepsilon}}}{\int_0^1 \theta(i)^{\frac{1-\varepsilon}{\varepsilon}} di} L_s \text{ and } r(i) = \frac{\theta(i)^{\frac{1-\varepsilon}{\varepsilon}}}{\int_0^1 \theta(i)^{\frac{1-\varepsilon}{\varepsilon}} di} R_s \quad \forall i \in [0, 1] \quad (8)$$

Normalizing P to 1, we show that prices are endogenously set as follows:

$$u = (1 - \varepsilon) \frac{1 - \alpha}{R_s} Y ; w = (1 - \varepsilon) \frac{\alpha}{L_s} Y \text{ and } p(i) = \frac{1}{\theta(i)} \left(\int_0^1 \theta(i)^{\frac{1-\varepsilon}{\varepsilon}} di \right)^{\frac{\varepsilon}{1-\varepsilon}} \quad (9)$$

and that aggregate production is equal to:

$$Y = \left(\int_0^1 \theta(i)^{\frac{1-\varepsilon}{\varepsilon}} di \right)^{\frac{\varepsilon}{1-\varepsilon}} \left(\frac{L_s}{\alpha} \right)^\alpha \left(\frac{R_s}{1 - \alpha} \right)^{1-\alpha} . \quad (10)$$

In particular, without friction, this model generates an optimal factor allocation in the sense that the allocation is uniquely determined by the level of the firms' productivity.

3.2.3 The case with frictions

To find the equilibrium allocation following productivity shocks in the case with frictions on real estate adjustment, we need to make an additional assumption on the distribution of $r_0(i)$. We consider that before the productivity shock, the allocation of production factors corresponds to the one derived in the frictionless case. This implies that $r_0(i)$ only depends on $\theta_0(i)$, the initial level of productivity. To simplify the interpretation of the results, we

consider that the productivity distribution is left unaltered by the productivity shocks that merely reshuffle firms in a stationary distribution. Labor adjustment being frictionless, $l(i)$ satisfies the first order conditions but this time, $r(i)$ only satisfies first-order conditions if $z(i) = 1$, otherwise $r(i) = r_0(i)$. If $z(i) = 1$, it is easy to show that firm i 's profit $\pi^{(1)}(i)$ is:

$$\pi^{(1)}(i) = \frac{u\varepsilon}{(1-\alpha)(1-\varepsilon)} r^*(i) - ar_0(i), \quad (11)$$

where $r^*(i)$ denotes the optimal volume of real estate conditional to relocating.

Whereas if $z(i) = 0$:

$$\pi^{(0)}(i) = \frac{u(1-\alpha(1-\varepsilon))}{(1-\alpha)(1-\varepsilon)} r^*(i)^{\frac{1-\varepsilon}{1-\alpha(1-\varepsilon)}} r_0(i)^{\frac{(1-\alpha)(1-\varepsilon)}{1-\alpha(1-\varepsilon)}} - ur_0(i). \quad (12)$$

The relocation condition, $\pi^{(1)}(i) > \pi^{(0)}(i)$, can be written as a simple condition on $\Delta_r(i) = \frac{r^*(i)}{r_0(i)} - 1$, the percentage change in size between optimal premises and endowed premises:

$$\frac{u}{(1-\alpha)(1-\varepsilon)} \left(\varepsilon(1 + \Delta_r(i)) - (1-\alpha(1-\varepsilon))(1 + \Delta_r(i))^{\frac{1-\varepsilon}{1-\alpha(1-\varepsilon)}} \right) + u - a > 0. \quad (13)$$

Because endowed premises' size $r_0(i)$ is proportional to $\theta_0(i)^{\frac{1-\varepsilon}{\varepsilon}}$ and optimal premises' size $r^*(i)$ is proportional to $\theta(i)^{\frac{1-\varepsilon}{\varepsilon}}$, there exist a direct relation between $\Delta_r(i)$ and the percentage change in productivity $\Delta_\theta(i)$. Formally, $1 + \Delta_r(i) = \lambda(1 + \Delta_\theta(i))^{\frac{1-\varepsilon}{\varepsilon}}$ where λ only depends on aggregate quantities.¹²

We show in Appendix C.2 that, as long as $a < u$, there exist threshold values $\Delta_r^- < 0$ and $\Delta_r^+ > 0$ such that if $\Delta_r(i)$ is included in $[\Delta_r^-; \Delta_r^+]$ it is optimal for firm i not to relocate. We label this interval the non-relocating interval. We show that the width of this non-relocating interval is increasing with the fixed costs. Notice that, because of the relationship linking $\Delta_r(i)$ and $\Delta_\theta(i)$, the non-relocating interval can be expressed in terms of $\Delta_\theta(i)$. Hence, a firm i does not relocate when $\Delta_\theta(i)$ belongs to the interval $[\Delta_\theta^-; \Delta_\theta^+]$ with $\Delta_\theta^- = \left(\frac{1+\Delta_r^-}{\lambda}\right)^{\frac{\varepsilon}{1-\varepsilon}} - 1$ and $\Delta_\theta^+ = \left(\frac{1+\Delta_r^+}{\lambda}\right)^{\frac{\varepsilon}{1-\varepsilon}} - 1$. The existence of such an interval of inaction is a classical result of the literature on lumpy and intermittent adjustments resulting from fixed lump-sum cost per adjustment decision (the (S,s) rules). This literature typically finds a range of inaction defined by two outer adjustment points between which the agent allows a state variable to diverge from its optimal value.¹³

¹²We indeed have $\lambda = (1-\alpha) \int_0^1 \theta(i)^{\frac{1-\varepsilon}{\varepsilon}} di Y P^{\frac{1}{\varepsilon}} (1-\varepsilon)^{\frac{1}{\varepsilon}} \frac{1}{R_s u^{\frac{1}{\varepsilon}}} \left(\frac{u}{u}\right)^{\frac{-\alpha}{1-\alpha(1-\varepsilon)}}$

¹³See Bertola and Caballero (1990) for a survey on discontinuous adjustment control policy and Grossman and Laroque (1990) model of consumer durable purchase for a example of such a range of inaction. Perhaps more closely related to our result, Gobillon and Le Blanc (2004) study residential mobility and find that the difference in terms of utility between the relocating household and the non-relocating household linearly depends on the square value of the difference between optimal housing stock and the previously occupied

The intuition for the existence of such an interval in our framework is straightforward. When a firm receives a positive productivity shocks, its profits can be optimized by using a larger amount of inputs. Because altering the level of inputs requires to pay a fixed cost, the positive productivity shock has to be large enough so that the difference between the profits when factors optimally adjust and when factors' adjustment is constrained covers these fixed costs. Similarly, when the firm receives a negative productivity shock, its profits can be improved by trimming down the amount of inputs. Reducing the amount of input is also associated with a fixed cost that is worth to be paid only if the profits saved by optimally adjusting the production factor are substantial enough. That is to say, if the negative productivity shock is large enough.

Using a local polynomial approximation of the difference between $\pi^{(1)}(i)$ and $\pi^{(0)}(i)$, we show analytically in Appendix C.2 that $|\Delta_r(i)^+| > |\Delta_r(i)^-|$. This result indicates that the difference between optimal premises' size and occupied premises' size that triggers relocation is higher in absolute value when the firm grows than when it declines. It implies that the minimum intensity of the productivity shock entailing firms relocation is stronger when this shock is positive than when it is negative. We hereafter refer to this property of the model as the asymmetrical effect of productivity shocks on firms' relocation behaviour. We show in the same appendix that this asymmetry is growing with the parameter a and declining with the parameter ε .

3.3 Results from simulations

To study general equilibrium effects in a model with non-zero adjustment costs, we run simulations of the model. We draw $N=100,000$ productivity levels from a normal distribution with mean μ and variance σ^2 and build the frictionless factors' endowment resulting from those draws. We then shock our economy by reshuffling the productivity draws between firms in order to study how factors subsequently adjust. Our function objective is to find values for Y , w and u built from the individual decisions of the 100,000 firms and satisfying all market clearing conditions. Based on this numerical resolution of the model, we explore the effect of the frictions on individual firms' behaviour and aggregate outcomes. Parameters value can be found in Table 2. The value of the intermediate output elasticity to real estate, $1 - \alpha$, is derived from the average ratio of the market value of structures and land over the aggregate value added of Non-Financial Corporations since 1979, based French aggregate series produced by the INSEE.

3.3.1 Adjustment costs and firm level behaviour

In the model with frictions, the non-relocating interval generates discontinuities, at the bounds of the interval, in the reaction of firms' labor demand to productivity shocks. Those

housing stock.

Table 2: Value of parameters used in the simulation procedure.

N	μ	σ	ϵ	α
100,000	1	0.1	0.2	0.925

discontinuities directly result from the complementarity between real estate and labor in the production function that conditioned optimal labor demand to the amount of real estate input. Crossing the productivity levels threshold that trigger relocation has a direct impact on the firm’s employment dynamics.

We illustrate this effect by simulating the firms’ labor demand, across the whole distribution of θ , for varying level of frictions a . Those experiments are presented in Figure 2.

Absent any adjustment costs (plain line ; $a = 0$), because real estate and employment jointly adjust for any productivity shocks, employment smoothly varies with changes in productivity and no discontinuity is observed as described in the frictionless model. When introducing adjustment costs, two regimes appear. Outside of the non-relocating interval, firms jointly adjust real estate and employment leading to similar dynamics as in the frictionless case.¹⁴ Within the non-relocating interval, employment adjusts to productivity shocks more sluggishly because of the pre-determined level of real estate. Comparing the dynamics associated with two levels of fixed-costs (dotted lines ; $a = 0.05$, dashed line $a = 0.1$), we observe that, as already noticed, the non-relocating interval widens with a , but also that the asymmetrical effect of the productivity shock grows with a .

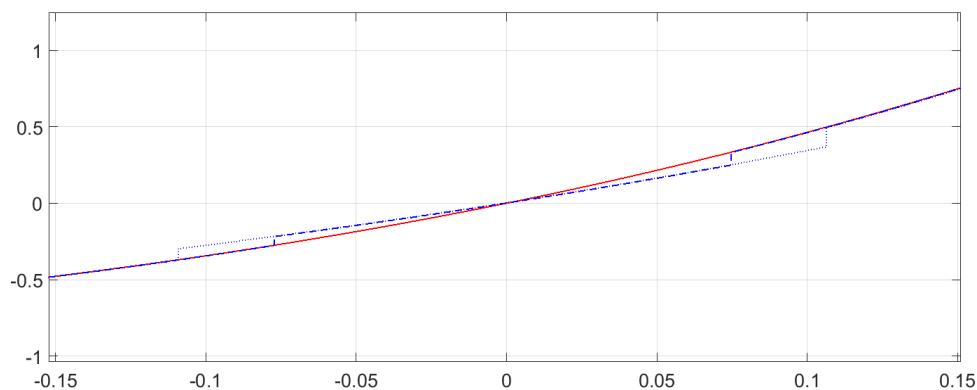


Figure 2: Employment growth as a function of productivity shocks for different values of a

Predictions: (i) relocating firms are characterized by larger employment growth; (ii) because of the asymmetrical effect of productivity shocks, the growth differential is larger

¹⁴The differences observed between the various curves outside the intervals of inaction result from changes in input prices that are discussed below

when the firms are growing.

3.3.2 Adjustment costs and aggregate relocating behaviour

We have analytically derived that the non-relocating interval widens with the level of the adjustment costs. We numerically solve the model for varying parameter values of a while keeping the productivity distribution constant. We report in Figure 3 the share of relocating firm as function of the parameter value a . Because of the increasing width of the non-relocating interval, we observe that this share strictly decreases from 1 to 0 as a increases.

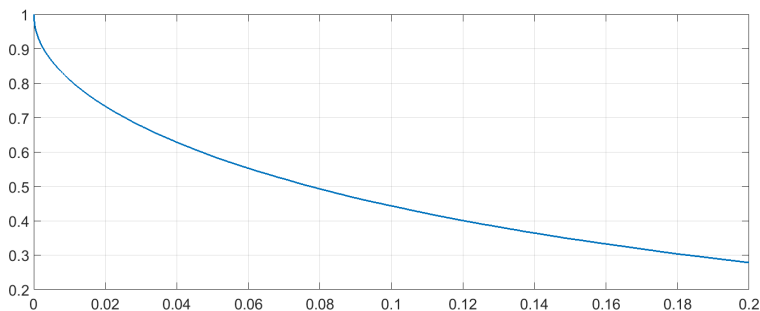


Figure 3: Share of relocating firms for different values of a

Prediction: for a given productivity distribution, the share of relocating firm is decreasing with the level of the adjustment costs.

3.3.3 Adjustment costs and workforce growth distribution

Ultimately, we are interested in deriving the effect of the adjustment costs on moments of the workforce growth distribution.

As the fixed costs associated with real estate adjustment rise, for a given distribution of the productivity shocks, a higher share of firms are located in the non-relocating interval. Within this interval, firms affected by positive shocks are stuck in under-sized premises that constrain employment growth whereas firms affected by negative shocks operates in over-sized premises that slow down job destruction. When studying how frictions affect the mean employment growth, we are capturing those two opposite effects.

Our simulations show that those two effects do not cancel out and that the negative effect of the frictions on the growing firms dominates. We indeed find that the mean employment growth decreases with the level of the adjustment costs (upper left panel of Figure 4). This is a direct consequence of the result stating that the asymmetrical effect of the productivity shock on relocation grows with the level of the frictions. In other words, when a rises, more growing firms than declining firms enter the non-relocating interval.

This result can be highlighted by studying the effect of the frictions on firms affected by positive and negative productivity shocks separately. We consider the employment growth

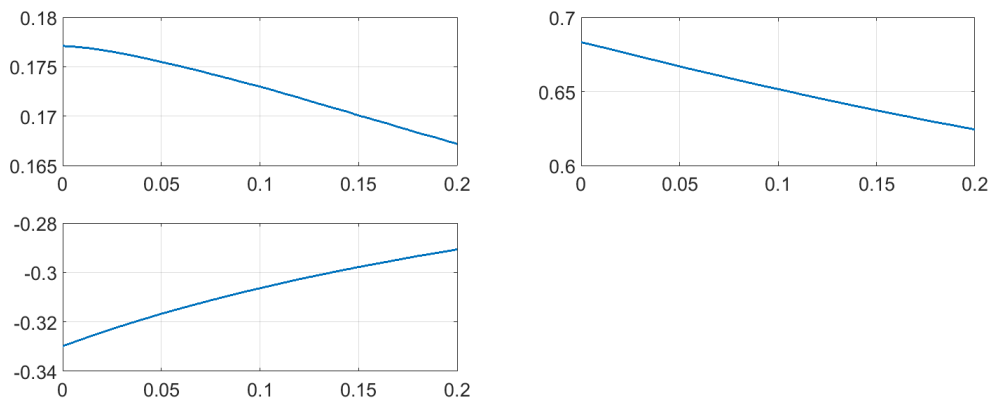


Figure 4: Mean employment growth as a function of a

distribution conditional on the sign of the productivity shock. We plot the mean employment growth as a function of a , conditional on positive and negative productivity shocks in the upper right panel and lower left panel of Figures 4, respectively. The mean employment growth of firms affected by a positive productivity shocks is sharply decreasing with a whereas a has a less marked positive impact on the employment decrease of firms stricken by negative productivity shocks.

Prediction: (i) overall average employment growth decreases with the level of adjustment costs; (ii) mean employment growth of growing firms markedly decrease with the level of adjustment costs whereas mean employment growth of declining firm slightly increases

3.3.4 Aggregate effects of the frictions

The adjustment costs hinder the optimal allocation of inputs. This results clearly appears when we observe the change in the covariance between inputs' allocation and firm level productivity as the level of the adjustment costs rise (Figure 5). We notice a very sharp decline in the covariance between $r(i)$ and $\theta(i)$ (left panel). We observe a similar pattern for the fall of the covariance between $l(i)$ and $\theta(i)$ but the magnitude of the fall is much less pronounced (right panel) because, even if firms are constrained by their premises' size, they are still able to adjust labor following the productivity shock.

The allocation of labor across firm primarily governs the dynamics of output. In this model where aggregate supplies of corporate real estate and labor are fixed, the effect of the frictions on aggregate output is exclusively channeled by the allocation of inputs across firms. Because the allocation of labor is only mildly impaired by the frictions, we obtained negative, but small, negative effect of the friction on the aggregate output (Figure 6).

Our general equilibrium model settles input prices so that the real estate and the labor markets both clear. Figures 7 present the dynamics of the equilibrium inputs' prices when a rises. While the negative impact of the adjustment costs on the weighted average

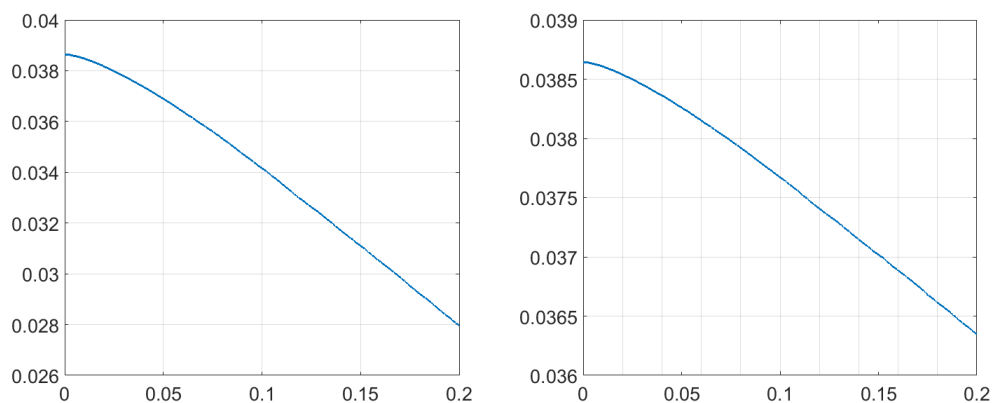


Figure 5: Covariance between $r(i)$ and $\theta(i)$ as a function of a

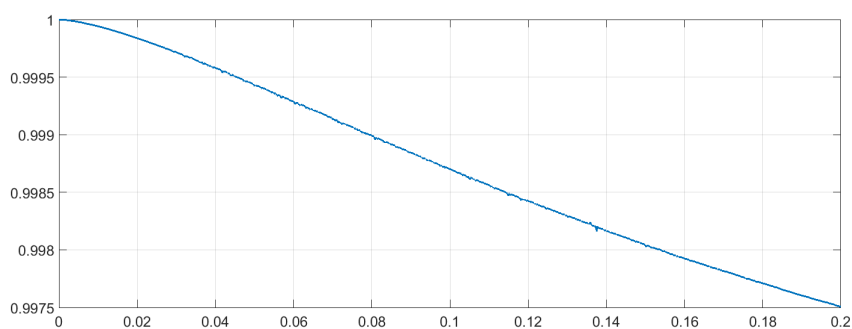


Figure 6: Aggregate output as a function of a (no friction = 1)

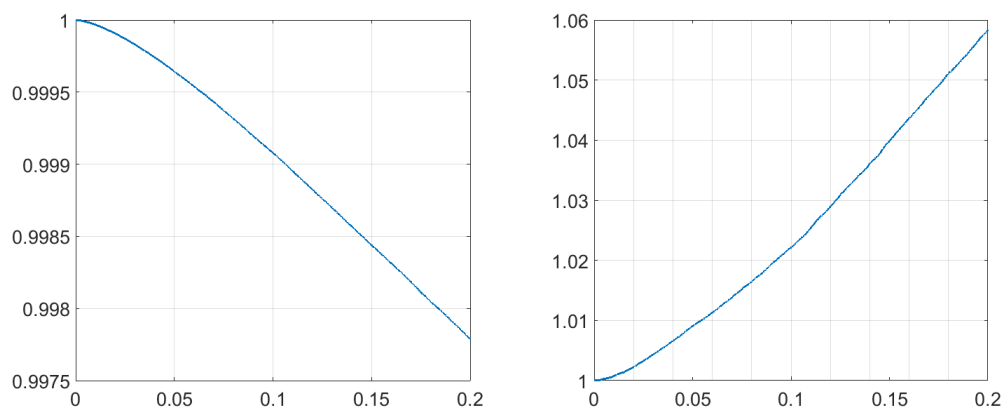


Figure 7: Equilibrium inputs' price as a function of a (no friction = 1)

productivity of labor puts downward pressures of the wages (left panel),¹⁵ the distortion induced by the real estate adjustment costs increases the equilibrium price of real estate (right panel). The reason for this result is the following. A rise in a implies that more firms are locked in their premises. It turns out that the supply cut induced by this additional non-relocating firms is larger than the counter-factual optimal real estate size that would be used by those non-relocating firms. As a result, a rise in a has a larger negative impact on aggregate supply than on aggregate demand and causes a sharp increase in u .

4 Empirical evidence

In this section, we use the firm-level dataset described in section 2 to test the predictions of the model. In particular, we show that firms that relocate experience a higher growth rate in their workforce (in absolute value) and that relocations and workforce adjustments are contemporaneous. We find evidence of an asymmetric impact of relocation on the number of employees between growing and declining firms, a fact that is also predicted by the model. We show that relocation costs and notably the latent capital gains is negatively correlated with the occurrence of a premises adjustments. We then explore the direct effect of those adjustment costs on the workforce growth distribution.

4.1 Effect of a local relocation on employment dynamics

Our first set of regressions aims at confirming the predictions of our model regarding the interaction between relocation and employment growth:

- (i) Among growing (resp. declining) firms, the ones that relocate are characterised by higher (resp. lower) employment growth rates than the ones that do not.
- (ii) Employment growth gap between relocating and non-relocating firms should be larger for growing firms than for declining firms, resulting in an overall positive effect of relocation on employment.

Cross-Section results

For a firm i , in sector s and *département* d , we denote Δl_i the average growth of employment over the period of observation and we first consider the following model:

$$\Delta l_i = \beta_1 z_i + X_i \beta_2 + \varepsilon_{i,s,d}, \quad (14)$$

where z_i is a binary variable that takes the value 1 if the firm has relocated (locally) during the observed period and 0 otherwise and X_i is a vector of firm specific characteristics

¹⁵In their model, [Garicano et al. \(2016\)](#) also find a negative effect of the regulation on wage.

taken at the initial year of observation (age, size...). $\varepsilon_{i,s,t}$ includes fixed effects at the sector times *département* level (s, d) plus an idiosyncratic error. We allow for correlation of this error terms within *département*.

Table 3: Relocation and employment dynamics - Cross section results

Dependent variable: Yearly average employment growth (in %)			
	All (1)	Growing (2)	Declining (3)
Relocate	2.341*** (0.147)	2.391*** (0.300)	-0.353*** (0.054)
Age	-0.082*** (0.004)	-0.085*** (0.007)	-0.003*** (0.001)
Size	-0.003** (0.001)	-0.005*** (0.002)	0.003*** (0.000)
Observations	109,381	52,717	43,965
R ²	0.032	0.063	0.307

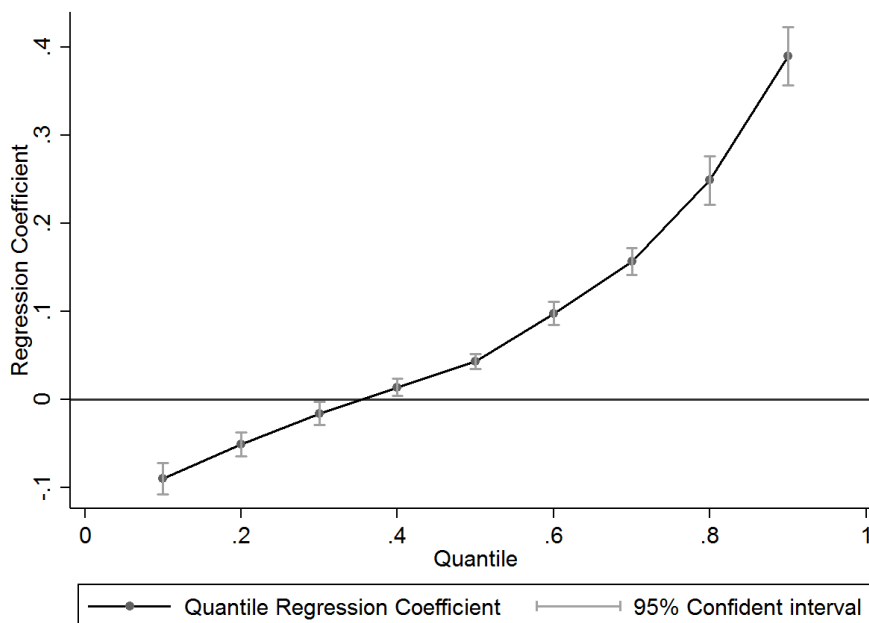
Notes: The dependent variable, average employment growth, is measured as the mean of yearly employment growth over the period of observation and given in %. Variables definitions are given in Table A3. Age and Size are taken in the first year the firm appears in the database. Column 1 uses all firms, column 2 (resp. 3) restricts to firms with positive (resp. negative) employment growth. Relocate is a binary variable equal to 1 if the firm has locally relocated (with a distance below 15km) at least once from 1994 to 2013. Regressions include the number of years of observation for each firm and a sector times *département* fixed effect. Cross section OLS regression with robust standard errors clustered at the *département* level reported in parenthesis. ***, ** and * respectively indicate 0.01, 0.05 and 0.1 levels of significance.

Coefficients of equation (14) are estimated using ordinary least square on different samples: first for all firms, then for firms with a positive average employment growth rate and finally for firms with a negative average employment growth rate. Results are respectively presented in columns 1, 2 and 3 of Table 3. Overall, the occurrence of a local relocation is positively associated with employment growth (column 1). The effect is positive for growing firms and negative for declining firms, as predicted by the model. For the former, results suggest that firms that have relocated at least once from 1994 to 2013 observe an average growth rate of employment that is 2.4 percentage point higher than their static peers. Consistently with the model, relocating seems to allow the firm to adjust its workforce either upward or downward. However, as suggested by the positive coefficient in column 1, the overall effect on employment growth is positive. Our results are robust to considering

smaller time periods, such as 1994-2000, 2000-2006 or 2006-2012 to give more relevance to the initial year conditions, and to select sample based on value added or sales instead of employment.

To gain further insight on the heterogeneous effect of a relocation across the distribution of employment growth, we estimate equation (14) using quantile regression model focusing on each of the different deciles. We plot the coefficient on variable z_i along with confident intervals in Figure 8. Results confirm the those of Table 3, namely that relocating is associated with a different effect for firm regarding their position in the distribution of average employment growth. This effect changes sign around the 40th percentile, which corresponds to an average employment growth of 0.

Figure 8: Relocation and employment dynamics - Quantile regression results



Notes: This graph plots the coefficients on the dummy indicating local move during the observed period from a cross-section quantile regression with employment growth as a dependent variable (equation (14)) residualized on a *département*-sector fixed effect. We plot the coefficient obtained for each of the quantile: 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8 and 0.9 along with the 95% confidence interval. Regression also includes our usual control variables: Age, Size (both taken in the first year of observation) and the number of years of observation. Confidence intervals at the 95% level have been estimated with a variance-covariance matrix built with 40 bootstrap replications.

One may worry that our regression capture agglomeration effects. As documented by [Delgado et al. \(2014\)](#) and [Combes et al. \(2012\)](#), regional clusters can result in an increasing growth rate of nearby firms that benefit from spillover, even if competition is stiffer. Firms are likely to be attracted by such clusters and subsequent employment growth may be affected by the new site. However, comparing the characteristics between the municipality

of departure and the municipality of settlement for growing relocating firms and declining relocating firms does show support for this alternative mechanism, at least for local relocations. Indeed, agglomeration effect would predict that growing firms relocate to larger or more dense cities, or to cities where the industry in which they operate is more represented while declining firms would act conversely. Yet, in the data, we observe that both growing and declining firms tend to relocate to smaller and less dense municipalities where the level of concentration in the industry as well as its overall size are smaller. This rather corroborates the results on the urban sprawling, documented in the Paris area by [Delisle and Laine \(1998\)](#).¹⁶ We do not observe any significant asymmetrical behaviour between growing and declining firms in that respect.¹⁷

Panel Fixed-Effect

Next, we take advantage of the time dimension of our sample to control for unobserved firm characteristics using fixed-effects panel regressions. We consider the following model:

$$\Delta l_{i,t} = \sum_{l=1}^k \gamma_{1,l} z_{i,t-l} + X_{i,t} \gamma_2 + \epsilon_{i,t,s}, \quad (15)$$

where this time, $\Delta l_{i,t}$ denotes employment growth between $t - 1$ and t and control variables vector X is taken at t . $\epsilon_{i,t,s,d}$ includes fixed effects at the sector times year level (s, t) a firm fixed effect and an idiosyncratic error. We allow for correlation of this error terms within firm.

Estimation results of equation (15) for various values of k can be found in Table 4. The sample used in columns 1 and 3 is the same as in column 2 of Table 3 whereas the sample used in columns 2 and 4 is the same as in column 3 of Table 3. From these regressions, we see that firms experience a statistically significant modification in the size of their workforce contemporaneously with their relocation. In columns 3 and 4, we look at the effect of a relocation for different time lags from 0 to 3. We obtain a statistically significant negative effect of the relocation on declining firms. We also find that the relocation has a persistent effect in time, although decreasing, for growing firms while we do not observe such persistence for declining firms.

¹⁶In fact, those results are altered when we exclude the *Île-de-France* (Paris area) to compute those statistics and the differences in population and density are much lower in that case.

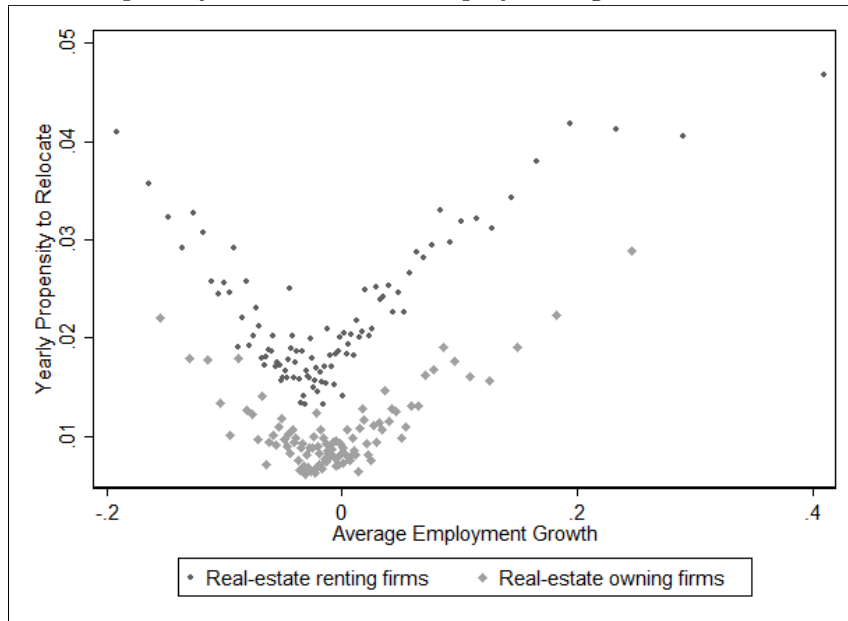
¹⁷Of course, other external factors may explain both a higher propensity to relocate and employment dynamics. For example, the displacement effect of publicly funded place-based programs documented by [Givord et al. \(2013\)](#); [Mayer et al. \(2015\)](#) and [Overman and Einio \(2012\)](#) can offer a potential alternative story to explain our results. A famous example in France, documented by [Mayer et al. \(2015\)](#) in the case of *Zone France Urbaine (ZFU)*. Our results are however only marginally altered when we remove all firms located less than 15km away from a ZFU. There exist other differences in the level of local taxes that can also alter location choices ([Devereux and Griffith, 2003](#); [Rathelot and Sillard, 2008](#) and [Duranton et al., 2011](#)). Unfortunately, we do not have access to precise information on the local indirect taxes at the level of the municipality over the observation period that would allow us to take them into account.

Table 4: Relocation and employment dynamics - Panel Fixed-Effect results

Dependent variable: Employment growth at t (in %)				
	Growing (1)	Declining (2)	Growing (3)	Declining (4)
Relocate $_t$	4.078*** (0.869)	-1.825*** (0.417)	4.445*** (1.152)	-2.029*** (0.500)
Relocate $_{t-1}$			3.000*** (0.762)	-0.579 (0.466)
Relocate $_{t-2}$			1.169 (0.787)	0.508 (0.422)
Relocate $_{t-3}$			-0.619 (0.483)	-0.019 (0.428)
Age	-0.542*** (0.202)	-0.470*** (0.124)	-0.165 (0.141)	-0.515*** (0.131)
Size	-0.208*** (0.050)	-0.029*** (0.011)	-0.283*** (0.077)	-0.052*** (0.019)
Observations	429,436	335,500	329,402	251,745
R ²	0.164	0.120	0.158	0.161

Notes: Variables definitions are given in Table A3. Columns 1 and 3 (resp. 2 and 4) restrict to firms with positive (resp. negative) average employment growth over the period 1994-2012. Relocate $_t$ is a binary variable equal to 1 if the firm has locally relocated (with a distance below 15km) during year t . The regressions include a firm fixed effect and a sector times year fixed effect. Panel fixed effect OLS regression with robust standard errors clustered at the *département* level reported in parenthesis. ***, ** and * respectively indicate 0.01, 0.05 and 0.1 levels of significance.

Figure 9: Propensity to relocate and employment growth: owners vs renters



Notes: See Figure 1. Owners and renters have been selected on the first year they appear in the dataset based on their reported volume of real estate. Period of observation: 1994-2013. Source: FiBEn, see Appendix A for more details about the data.

4.2 Effects of adjustment costs on employment dynamics

Our second step is to identify the effect of real estate adjustment costs on employment growth. We need to find an observable measure of relocation costs that is heterogeneous across firms. One first natural candidate is the tenure status (whether the firm owns or rents its premises). Relocating is indeed less costly for renting firms than for real estate owning firms. For example, owners pay legal fees associated with real estate transactions and taxes triggered by the sales of their previous real estate assets. Besides, searching costs are likely to be higher for this type of firms. We therefore expect different relocation behaviour between real estate owner firms and renting firms. This intuition is confirmed by Figure 9 where we replicate Figure 1 but separating for owners and renters. It clearly appears that not only renting firms relocate on average more than others, they also exhibit smaller changes in their workforce for a given propensity to relocate as compared to owners.

However, the choice of the tenure status is not exogenous and is likely to depend on unobservable growth prospects. One can for example imagine that a firm expecting significant increases in its workforce would prefer to rent its premises in order to be more flexible. This would cause a reverse causality issue preventing us from associating a difference in the relocating behaviour or the employment dynamics to higher relocation costs. We therefore turn to another measure of the relocation costs: the tax on capital gains that the firm would have to pay upon relocating. If this tax is paid by real estate owning firms only when they

sell their assets, we can proxy its latent level at a yearly frequency at the firm level thanks to the local real estate price dynamics. The base for this latent tax is determined by the interaction between the acquisition date, the local dynamic of real estate prices since this acquisition and the volume of the premises (see appendix A for more detail). For the sake of comparison across firms, we normalize the amount of the latent tax on capital gains by dividing it by the market value of real estate assets in order to obtain the share of the proceeds from the sale that would be paid under the heading of “tax on capital gains” in the event of the sale of real estate assets. The firm level variation for this quantity is driven by the interaction of the timing of the acquisition of the premises and the local price dynamism since this acquisition, the latter being mostly driven by household and larger firms that we are not considering in our analysis. In addition, because the latent tax level varies with the interaction of these two factors, the impact of each of these factor considered individually can be controlled for in our analysis. The variable that we shall denote Tax can theoretically takes values between 0 and the marginal corporate income tax which has been equal to 33% in France over the studied period. We observe large variation across firms, with a little less than half of the real-estate owners being unaffected by the tax on capital gain ($Tax = 0$), notably because the tax scheme takes into account the holding period and allows to diminish the tax base by 10% each year after a five-year holding period, and an overall average value of 3.9% that reaches 7.7% conditional on being non null with a standard deviation of 4.6%.

We proceed in two steps. In the first step, we run various cross-section regressions to show that higher relocation costs, as proxied by the tenure status or, for owning firms, by the latent capital gains, are indeed associated with a lower propensity to relocate. More precisely, we run the following specification for firm i 's decision to relocate:

$$z_i = \mu_1 T_i + X_i \mu_2 + \varepsilon_{i,s,d}, \quad (16)$$

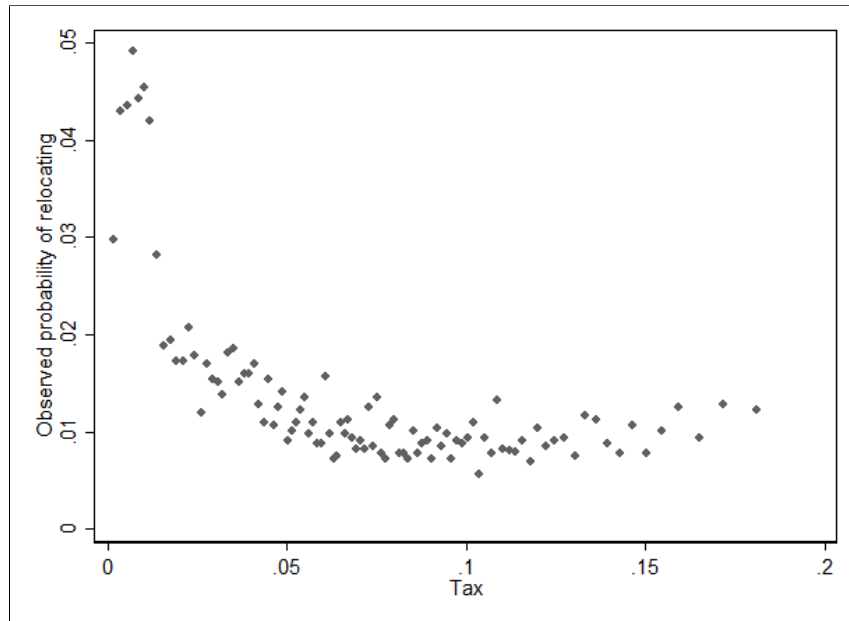
where T_i is our dummy equal to 1 if the firm reports real estate holdings in initial year of observation. We also consider:

$$z_i = \beta_1 Tax_i + X_i \beta_2 + \varepsilon_{i,s,d}, \quad (17)$$

where Tax_i is the share of the proceeds from the real estate asset sales that would be paid under the heading of the “tax on capital gains” if the real estate assets were to be sold by the firm in the initial year of observation. This regression is close to the theoretical results shown in Figure 3. In Figure 10 we plot the observe probability to relocate and the average value of the variable Tax for each percentile of the distribution of Tax . We find a downward curve that shows the same shape as the one in Figure 3.

The estimation results can be found in Table 5: column 1 corresponds to the model presented in equation (16) while columns 2 to 4 correspond to model defined by equation

Figure 10: Propensity to relocate and relocation costs as measured by the latent tax on capital gains



Notes: *Tax* denotes the share of the proceeds from a potential real estate sale that must be paid as a tax on capital gains. We separate each observations into 100 percentiles of *Tax* and plot the within percentile share of relocating firms. Period of observation: 1994-2013. Source: FiBEn, see Appendix A for more details about the data.

(17). As previously, we control for the age and the size of the firm and add the length of the observation period in the four regressions. In columns 3 and 4, we also add covariates capturing the age and the volume of the premises owned by the firm, both of which having direct influence on the propensity to relocate. Finally, a *département*-sector fixed effect is added in each specification. From column 1, we see that a real estate firm has a lower propensity to relocate that an otherwise similar renting firm by 5 percentage points.

In columns 2 to 4, the main coefficient of interest is the one associated with the share of the proceeds from the real estate asset sales that would be paid under the heading of the "tax on capital gains". This share results from a marginal tax rate, identical across firms, and a tax base, the capital gains on real estate assets, that varies across firms and across time. The variability of the tax base across firms and across time results from varying acquisition dates and varying dynamics of local prices since the acquisition. Results suggest that a one standard deviation increase in this fiscal share is associated with a 0.8 to 0.9 percentage point reduction in the propensity to relocate among real estate owning firms.

One may be concerned that the level of the latent tax on capital gains is correlated with unobservable growth prospects and that the distributions of changes in productivity is affected by the level of these latent capital gains. However, because the latent capital gains are growing with the positive change in local real estate prices, we are expecting that the higher the latent capital gains, the better the local economic conditions and the more likely

Table 5: Relocation cost and relocation choice - Cross section OLS

Dependent variable: Dummy for having relocated				
	All (1)	Owners (2)	Owners (3)	Owners (4)
Real estate Owner	-0.050*** (0.004)			
Tax		-0.159*** (0.033)	-0.173*** (0.034)	-0.187*** (0.042)
Age	-0.002*** (0.000)	-0.001*** (0.000)	-0.001*** (0.000)	-0.001*** (0.000)
Size	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)
Real estate Volume			-0.001*** (0.000)	-0.001*** (0.000)
Real Estate Age				-0.001*** (0.000)
Observations	109,381	42,791	42,791	42,067
R ²	0.080	0.078	0.078	0.078

Notes: Variables definitions are given in Table A3. Column 1 uses all firms while columns 2 to 4 restrict to real estate owners. The dependent variable is a binary variable equal to 1 if the firm has locally relocated (with a distance below 15km) from 1994 to 2012. Other variables are taken in the first year of observation. Regressions include the number of year of observations for each firm and a sector times *département* fixed effect. Cross section OLS regression with robust standard errors clustered at the *département* level reported in parenthesis. ***, ** and * respectively indicate 0.01, 0.05 and 0.1 levels of significance.

the firms are to relocate. We hence argue that any correlation between the latent capital gains and unobservable growth prospects upward bias our coefficient of interest and that the negative effect of the latent tax on the propensity to relocate is an upper bound. Another potential concern is that the latent tax on capital gains is in fact capturing many different features, and namely the fact that it mechanically decreases with age (see Appendix A for details about its construction). One first response is that when relocating from column 2 to column 4 of Table 5, the coefficient on the latent tax variable is stronger (in absolute value) as we add more control variables on the nature of the real estate. A second potential response is that restricting to firms owning their real estate for less than 5 years does not affect our result. For these firms, the only impact of the age of the premises on variable Tax_i is through real estate price dynamics. In addition to this, we run panel fixed effects regressions in order to control for firm specific characteristics. Results are presented in Table 6 and are consistent with what was found in the OLS estimation of the cross-section model.

All these results speak to the intuitive idea that relocation costs dampen the firms' propensity to relocate. By highlighting the role of the latent tax on capital gains, they provide empirical evidence to support our model. They also echo those of the existing literature that emphasized the “lock-in” effect of the tax on capital gains (see for example Yitzhaki, 1979; Feldstein et al., 1980 or Kanemoto, 1996).

We now turn to our second step where we explore the effect of the relocation costs on employment dynamics though its direct negative effect on the propensity to relocate. Our model predicts that the relationship between relocation costs and employment growth differ across the distribution of productivity shocks.

As in Table 3, we run cross-section *OLS* and quantile regressions where the dependent variable is the average employment growth over the observed time period. As in Table 5, we focus on the two distinct sources of heterogeneity with regard to relocation costs. Specifically, we estimate the following equation:

$$\Delta l_i = \beta_1 T_i + X_i \beta_2 + \varepsilon_{i,s,d}, \quad (18)$$

where T is, as previously, a binary variable equal to 1 if the firm owns its real estate and $\varepsilon_{i,s,d}$ contains an idiosyncratic error term and a *département*-sector fixed effect. Restricting our sample to owning firms, we also estimate:

$$\Delta l_i = \beta_1 Tax_i + X_i \beta_2 + \varepsilon_{i,s,d}. \quad (19)$$

Results can be found in Table 7. Columns 1 and 2 report estimates of equation (18) and restrict attention to declining and growing firms. We include our usual set of control variables considered in the first year the firm appears in the sample. For growing firms, we find that holding real estate assets is associated with a mean employment growth lower by

Table 6: Relocation cost and relocation choice - Panel Fixed-Effect results

Dependent variable: Dummy for having relocated at t				
	Owners (1)	Owners (2)	Owners (3)	Owners (4)
Tax _{t}	-0.234*** (0.008)			-0.176*** (0.011)
Tax _{$t-1$}		-0.183*** (0.007)		-0.085*** (0.010)
Tax _{$t-2$}			-0.117*** (0.006)	-0.015** (0.006)
Age	0.001* (0.000)	0.001* (0.000)	-0.000 (0.001)	0.000 (0.001)
Size	-0.000 (0.000)	-0.000 (0.000)	-0.000* (0.000)	-0.000 (0.000)
Real Estate Age	-0.003*** (0.000)	-0.003*** (0.000)	-0.002*** (0.000)	-0.003*** (0.000)
Real Estate Volume	0.000*** (0.000)	0.000*** (0.000)	0.000*** (0.000)	0.000*** (0.000)
Observations	481,708	436,844	391,162	391,162
R ²	0.174	0.179	0.186	0.191

Notes: Variables definitions are given in Table A3. The dependent variable is a binary variable equal to 1 if the firm has locally relocated (with a distance below 15km) between t and $t + 1$. Regression includes a firm fixed effect and a sector times year fixed effect. Panel fixed effect OLS regression with robust standard errors clustered at the *département* level reported in parenthesis. ***, ** and * respectively indicate 0.01, 0.05 and 0.1 levels of significance.

1.2 percentage point as compared to similar renting firms. For declining firm, the estimate is negative but close to 0 and non-significant. Of course in this model, the fact that owning and renting firms can be different even after controlling by observable characteristics. We therefore turn to the model presented in equation (19) using the latent tax on capital gains. Results are presented in columns 3 and 4, where we have also added covariates to control for the age and volume of owned real estate assets. We observe that the latent tax on capital gains has a negative effect for growing firms. A one percentage point reduction in the (latent) share of the proceeds from the premises' sales that would be paid as a tax on capital gains is associated with a decrease of 0.25 percentage point in yearly employment growth for growing firms (this corresponds to 1 additional job creation every 20 jobs in these firms).

Overall, relocation costs have a negative effect on employment as predicted by the model. We can show this by taking advantage of our panel and we run the following model for various value of k :

$$\Delta l_{i,t} = \beta_1 Tax_{i,t-k} + X_{i,t}\beta_2 + \varepsilon_{i,s,d,t}. \quad (20)$$

Just like previously, $\varepsilon_{i,t,s,d}$ includes fixed effects at the sector times year level (s, t) a firm fixed effect and an idiosyncratic error. We allow for correlation of this error terms within firm. Results are shown in Table 8 and confirm our previous findings even after controlling for any firm specific unobserved time-invariant characteristics.

4.3 Implication in terms of misallocation

Our results suggest that frictions in the real-estate market generate a suboptimal allocation of premises volume and in turns of workforce due to the complementarity between the two inputs. To illustrate this, we construct a measure of misallocation based on [Olley and Pakes \(1996\)](#) and following [Duranton et al. \(2015\)](#) by calculating the covariance between the market share of a firm and its labor productivity level. We should expect that areas in which the real-estate market is more constrained have a higher misallocation of inputs. In Figure 11, we have plotted the misallocation index against the share of firms that are real-estate owners for each *département*. The correlation between the two is clearly positive as expected.¹⁸ As in [Hsieh and Klenow \(2009\)](#), misallocation induced by the distortion of the real-estate market account for a reduction in aggregate productivity and consequently of aggregate output.

¹⁸In Figure 11, we show results for the year 1994 but using another year or pooling all years together show similar upward sloping fitting line.

Figure 11: Relocation frictions and misallocation



Notes: This graph plots the measure of misallocation presented in subsection 4.3 against the share of real-estate owning firms in each *département* in 1994. *Département* codes are explained in Table A1. Source: FiBEn, see Appendix A for more details about the data.

Table 7: Relocation costs and employment dynamics - Cross section results

Dependent variable: Yearly average employment growth (in %)				
	Declining	Growing	Declining Owners	Growing Owners
	(1)	(2)	(3)	(4)
Real Estate Owner	-0.005 (0.036)	-1.205*** (0.179)		
Tax			0.222 (0.617)	-5.414** (2.408)
Age	-0.003** (0.001)	-0.080*** (0.008)	-0.006*** (0.002)	-0.036*** (0.009)
Size	0.003*** (0.000)	-0.005*** (0.002)	0.006*** (0.002)	-0.006 (0.003)
Real estate Age			0.003 (0.005)	-0.095*** (0.030)
Real Estate Volume			-0.015 (0.013)	0.130* (0.068)
Observations	43,965	52,717	18,863	19,082
R ²	0.307	0.062	0.334	0.100

Notes: The dependent variable, average employment growth, is measured as the mean of yearly employment growth over the period of observation and given in %. Variables definitions are given in Table A3. All covariates are taken in the first year the firm appears in the database. Columns 1 and 3 (resp. 2 and 4) restrict to firms with positive (resp. negative) employment growth over the period of observation. Columns 3 and 4 in addition restrict to real estate owning firms. Regressions include the number of years of observation for each firm and a sector times *département* fixed effect. Cross section OLS regression with robust standard errors clustered at the *département* level reported in parenthesis. ***, ** and * respectively indicate 0.01, 0.05 and 0.1 levels of significance.

Table 8: Relocation costs and employment dynamics - Cross section results

Dependent variable: employment growth at t (in %)				
	Owners (1)	Owners (2)	Owners (3)	Owners (4)
Tax $_{t-1}$	-13.732*** (1.717)			-6.522*** (2.384)
Tax $_{t-2}$		-11.709*** (1.316)		-5.811** (2.434)
Tax $_{t-3}$			-8.192*** (1.517)	-2.199 (2.146)
Age	-0.220** (0.096)	-0.121 (0.110)	-0.275** (0.110)	-0.268** (0.110)
Size	-0.112*** (0.025)	-0.115*** (0.025)	-0.135*** (0.030)	-0.133*** (0.030)
Real Estate Age	-0.247*** (0.022)	-0.192*** (0.017)	-0.152*** (0.018)	-0.184*** (0.021)
Real Estate Volume	0.142*** (0.036)	0.107*** (0.026)	0.100*** (0.025)	0.099*** (0.025)
Observations	424,912	381,535	338,238	338,238
R ²	0.155	0.167	0.171	0.171

Notes: Variables definitions are given in Table A3. Regression includes a firm fixed effect and a sector times year fixed effect. Panel fixed effect OLS regression with robust standard errors clustered at the *département* level reported in parenthesis. ***, ** and * respectively indicate 0.01, 0.05 and 0.1 levels of significance.

5 Conclusion

This paper derives the theoretical implications of adjustment costs of real estate assets on firm level factors' demand and explores the empirical relevance of the derived theoretical prediction.

First, we build a general equilibrium model in which firms make decisions on inputs' adjustment following productivity shocks against a background of fixed adjustment costs of real estate induced by relocation. The model predicts that a relocation is associated with a concomitant adjustment of employment level. The magnitude of those adjustments may differ whether the firm is growing or slackening; the relocation of a growing firms being typically associated with larger change in the workforce. Our model also predicts that relocation costs reduce the propensity to relocate and distort the employment growth distribution with a particularly marked negative impact on firms facing positive productivity shocks.

Second, we confront these predictions to the data using a large dataset on French firms over the period 1994-2013 and taking advantage of the firm-level heterogeneity in the real estate adjustment costs entailed by the latent tax on real estate capital gains. All the results derived from the theoretical framework are confirmed. Relocating is associated with significant adjustment in the workforce numbers and the level of the adjustment costs reduces the propensity to relocate, and constrains jobs creation of the growing firms.

This paper documents an example of costs that prevent the optimal adjustment of inputs across firms following productivity shocks and provides evidence of their effect on misallocation of inputs across firms. Arguably, our results also have implications for policy makers. Since the tax on realized capital gain on real-estate transaction is a burden to growing firms' employment dynamic, a less distortive tax should be contemplated.

References

- Aghion, Philippe and Peter Howitt**, “A Model of Growth through Creative Destruction,” *Econometrica*, March 1992, 60 (2), 323–351.
- Asker, John, Allan Collard-Wexler, and Jan De Loecker**, “Dynamic Inputs and Resource (Mis)Allocation,” *Journal of Political Economy*, 2014, 122 (5), 1013 – 1063.
- Bertola, Giuseppe and Ricardo Caballero**, “Kinked adjustment costs and aggregate dynamics,” in “NBER Macroeconomics Annual 1990, Volume 5,” MIT Press, 1990, pp. 237–296.
- Best, Michael Carlos and Henrik Jacobsen Kleven**, “Housing market responses to transaction taxes: Evidence from notches and stimulus in the UK,” 2013. Mimeo, London School of Economics.
- Brouwer, Aleid E., Ilaria Mariotti, and Jos N. van Ommeren**, “The firm relocation decision: An empirical investigation,” *The Annals of Regional Science*, 06 2004, 38 (2), 335–347.
- Chaney, Thomas, David Sraer, and David Thesmar**, “Real Estate Collateral and Labor Demand,” 2013. Mimeo, Toulouse School of Economics.
- Combes, Pierre-Philippe, Gilles Duranton, Laurent Gobillon, Diego Puga, and Sebastien Roux**, “The productivity advantages of large cities: Distinguishing agglomeration from firm selection,” *Econometrica*, 2012, 80 (6), 2543–2594.
- Cooper, R. and J. Haltiwanger**, “On the nature of capital adjustment costs,” *The Review of Economic Studies*, 2006, 73 (3), 611–633.
- , – , and **L. Power**, “Machine Replacement and the Business Cycle: Lumps and Bumps,” *American Economic Review*, 1999, 89 (4), 921–946.
- Dachis, Benjamin, Gilles Duranton, and Matthew Turner**, “The effects of land transfer taxes on real estate markets: evidence from a natural experiment in Toronto,” *Journal of Economic Geography*, 2012, 12 (2), 327–354.
- Delgado, Mercedes, Michael E. Porter, and Scott Stern**, “Clusters, convergence, and economic performance,” *Research Policy*, 2014, 43 (10), 1785–1799.
- Delisle, Jean-Pierre and Frédéric Laine**, “Les transferts d’établissements contribuent au desserrement urbain,” *Économie et Statistique*, 1998, 311 (1), 91–106.
- Devereux, Michael P. and Rachel Griffith**, “Evaluating tax policy for location decisions,” *International Tax and Public Finance*, 2003, 10 (2), 107–126.

- Dixit, Avinash K and Joseph E Stiglitz**, “Monopolistic Competition and Optimum Product Diversity,” *American Economic Review*, June 1977, 67 (3), 297–308.
- Duranton, Gilles., Laurent Gobillon, and Henry G. Overman**, “Assessing the effects of local taxation using microgeographic data,” *The economic journal*, 2011, 121 (555), 1017–1046.
- Duranton, Gilles, Syed Ejaz Ghani, Arti Grover Goswami, and William Robert Kerr**, “The misallocation of land and other factors of production in India,” March 2015.
- Feldstein, Martin, Joel Slemrod, and Shlomo Yitzhaki**, “The Effects of Taxation on the Selling of Corporate Stock and the Realization of Capital Gains,” *The Quarterly Journal of Economics*, 1980, 94 (4), 777–791.
- Foster, Lucia, John Haltiwanger, and Chad Syverson**, “Reallocation, Firm Turnover, and Efficiency: Selection on Productivity or Profitability?,” *American Economic Review*, March 2008, 98 (1), 394–425.
- Fougère, Denis and Mathilde Poulhes**, “The Effect of Housing on Portfolio Choice: A Reappraisal Using French Data,” *CEPR Discussion Paper*, 2012, (9213).
- Friggit, Jacques**, “Le prix des logements sur longue période,” *Informations sociales*, 2009, 155 (5), 26–33.
- Garicano, L., C. Lelarge, and J. Van Reenen**, “Firm Size Distortions and the Productivity Distribution: Evidence from France,” *American Economic Review*, November 2016, 106 (11), 3439–79.
- Givord, P., R. Rathelot, and P. Sillard**, “Place-based tax exemptions and displacement effects: An evaluation of the Zones Franches Urbaines program,” *Regional Science and Urban Economics*, 2013, 43 (1), 151–163.
- Gobillon, L. and D. Le Blanc**, “L’impact des contraintes d’emprunt sur la mobilité résidentielle et les choix entre location et propriété,” *Annales d’Économie et de Statistique*, 2004, pp. 15–45.
- Grossman, S. and G. Laroque**, “Asset Pricing and Optimal Portfolio Choice in the Presence of Illiquid Durable Consumption Goods,” *Econometrica*, 1990, 58 (1), 25–51.
- Hamermesh, D. and G. Pfann**, “Adjustment Costs in Factor Demand,” *Journal of Economic Literature*, 1996, 34 (3), 1264–1292.
- Hilber, C. and T. Lyytikäinen**, “Housing transfer taxes and household mobility: Distortion on the housing or labour market?,” 2013. Government Institute for Economic Research VATT Working Papers 47/2013.

- Hsieh, C. and P. Klenow**, “Misallocation and Manufacturing TFP in China and India,” *The Quarterly Journal of Economics*, 2009, pp. 1403–1448.
- Kanemoto, Y.**, “On the “Lock-In” Effects of Capital Gains Taxation,” *Journal of Urban Economics*, 1996, 40 (3), 303–315.
- Knoben, J., L. Oerlemans, and R. Rutten**, “The effects of spatial mobility on the performance of firms,” *Economic Geography*, 2008, 84 (2), 157–183.
- Mayer, T., F. Mayneris, and L. Py**, “The impact of Urban Enterprise Zones on establishment location decisions and labor market outcomes: evidence from France,” *Journal of Economic Geography*, 2015, p. lbv035.
- Melitz, Marc J.**, “The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity,” *Econometrica*, November 2003, 71 (6), 1695–1725.
- Olley, G. and A. Pakes**, “The Dynamics of productivity in the telecommunication equipment industry,” *Econometrica*, 1996, 64 (6), 1263–1297.
- Overman, Henry G. and Elias Einio**, “The Effects of Spatially Targeted Enterprise Initiatives: Evidence from UK LEGI,” 2012. ERSA conference papers No. 12p164.
- Pellenbarg, P., L. Van Wissen, and J. Van Dijk**, *Firm relocation: state of the art and research prospects*, University of Groningen, Research Institute SOM, 2002.
- Pen, C. and P. Pellenbarg**, “Firm migration and central government policy; An overview,” in “Paper from the Regional Science Association conference, Groningen” 1998.
- Rathelot, Roland. and Patrick. Sillard**, “The importance of local corporate taxes in business location decisions: Evidence from French micro data,” *The Economic Journal*, 2008, 118 (527), 499–514.
- Schmenner, Roger W.**, “Choosing New Industrial Capacity: On-Site Expansion, Branching, and Relocation,” *The Quarterly Journal of Economics*, 1980, 95 (1), 103–119.
- Weltevreden, J., F. Van Oort, J. Van Vliet, P. Pellenbarg, H. Van Amsterdam, and M. Traa**, “Firm relocation and regional employment development in the Netherlands (1999-2006),” *European Regional Science Association*, 2007.
- Yitzhaki, S.**, “An empirical test of the lock-in-effect of the capital gains tax,” *The Review of Economics and Statistics*, 1979, pp. 626–629.

A Data description

A.1 Data sources

We use French firm-level data merged with real estate prices at the *département* level.¹⁹

A.1.1 firm-level information

We exploit a large French firm-level database constructed by the Banque de France: FiBEn. It is based on fiscal documents, including balance sheet and P&L statements, and contains detailed information on flow and stock accounting variables as well as information on firms' activities, location and workforce size.

The database includes French firms with annual sales exceeding 750,000 euros or with outstanding credit exceeding 380,000 euros. It has a large coverage of French medium and large firms. Using a dummy variable indicating if firms operate in more than one establishment, we only retain single establishment firms and we restrict our sample to firms with total headcount below 250 to ensure the validity of this information. We also exclude from our sample firms operating in the retail industry and the hotel and catering industry. Those sectors are indeed characterized by small catchment areas than can be affected by short-distance relocations.²⁰ We keep firms that declare data over at least three consecutive years. Our panel is unbalanced as firms may enter and exit the sample between 1994 and 2013.²¹ The median length of the observation period is 9.75 years.

A.1.2 Real estate prices

We need real estate prices to compute capital gains on real estate assets as well as real estate volume. Commercial real estate local prices being not available in France, we use residential prices. More precisely, we use the *Notaires*-INSEE²² apartment price indices built by Fougère and Poulhes (2012) which are based on the data collected by French *notaires* and the methodology developed by the INSEE.²³ These indices take into account changes in the quality of apartments since hedonic characteristics of the flats are used to build the indices. The indices in each *département* are standardized to be equal to 100 in 2000. In addition, we have apartment per square meter prices in each *département* in 2013. Apartment per square meter prices at the *département* level are collected by the *Chambre des Notaires*. They correspond to the average price per square meter of all

¹⁹There are 94 *départements* in mainland France, a complete list can be found in Table A1. Because of the lack of reliable data on real estate, we excluded departments 12 (Aveyron), 46 (Lot) and 53 (Mayenne).

²⁰Note that keeping those sectors in the database has no effects on the results

²¹We cannot conclude that a firm exiting the sample has gone bankrupt as it may have merely crossed the above-mentioned declaration thresholds; alternatively it may have been bought by another firm.

²²Solicitor is the English equivalent for the French word *notaire*

²³The National Institute of Statistics and Economic Studies, the French National Statistical Bureau.

apartment transactions registered in a given year.²⁴ We retropolate apartment prices using the apartment price index to build apartment prices per square meter at the *département* level from 1994 onwards. Prior to 1994, housing price indices used to retropolate the series are taken from Friggit (2009). We use the Paris housing price index (available from 1840 onwards) for *département* located in the Paris area (*Île-de-France*) and the national housing price index (available from 1936 onwards) for the other *département*. We report the trend of real estate prices given in thousand of 2013 euros in each *Département* in Table A2.

Real estate prices at the *département* level being less precise before 1994, we start our analysis in 1994. We also restrict our study to the firms headquartered in so-called “*départements de France métropolitaine*” (mainland France), excluding overseas territories and Corsica.

A.2 Variable construction and further descriptive statistics

A.2.1 Firms mobility

We derive information on firms relocation behaviour thanks to the reported location of headquarters. FiBEn provides, at annual frequencies, the municipality where the headquarters are located at the end of the year. We identify the occurrence of a relocation when we observe a change in the municipality of the headquarters. Hence, we only identify relocations across municipalities and clearly underestimate the number of relocations.

Besides, in order to insure that the headquarters’ relocation coincides with the relocation of the whole firm’s activities, we restrict our analysis to single establishment firms. Single establishment firms account for around 80% of the firms registered in FiBEn.

We find that, over an average observation period of 10 years, around 20% of the firms relocate their activities in another municipality. Among those relocating firms, 17.5% relocate once and 2.4% relocate twice and the rest relocate more than twice. Overall, we observe more than 35,000 relocations. We mentioned in the introduction that a concurrent strategy to local relocation might consist in opening new establishments (branching). We find that 2% of the firms initially identify as single-establishment turn to multi-establishment structures. When compared to the 15.3% of firms relocating locally, this finding shows that local relocation is a much more common event than branching.

For each relocation observed we compute the “as-the-crow-flies” distance between the municipality of departure and the municipality of arrival using the latitude and the longitude of the center of the municipality from the National Geographic Institute (IGN). The distance is below 7.5km for 50% of the relocations; it is below 16km for 75 percent of the relocating

²⁴The *Chambre des Notaires de Paris* has registered apartment prices in the database *Bien* from 1992 onwards and the *Notaires de France* started to register those prices for the rest of mainland France in the database *Perval* in 1994.

Table A1: French *Départements* in 2013

<i>Département</i> name	<i>Département</i> code	Population	<i>Département</i> name	<i>Département</i> code	Population
Ain	01	634 173	Lozère	48	76 204
Aisne	02	538 743	Maine-et-Loire	49	809 505
Allier	03	343 680	Manche	50	500 019
Alpes-de-Haute-Provence	04	162 924	Marne	51	572 968
Hautes-Alpes	05	140 706	Haute-Marne	52	179 638
Alpes-Maritimes	06	1 081 821	Mayenne	53	307 831
Ardèche	07	323 543	Meurthe-et-Moselle	54	729 664
Ardennes	08	278 970	Meuse	55	190 550
Ariège	09	153 011	Morbihan	56	747 458
Aube	10	308 085	Moselle	57	1 047 013
Aude	11	370 056	Nièvre	58	212 111
Aveyron	12	278 062	Nord	59	2 607 174
Bouches-du-Rhône	13	2 007 684	Oise	60	822 858
Calvados	14	693 277	Orne	61	286 256
Cantal	15	146 299	Pas-de-Calais	62	1 466 483
Charente	16	354 586	Puy-de-Dôme	63	646 537
Charente-Maritime	17	639 596	Pyrénées-Atlantiques	64	670 434
Cher	18	311 768	Hautes-Pyrénées	65	228 304
Corrèze	19	238 713	Pyrénées-Orientales	66	472 033
Corse-du-Sud	2A	152 720	Bas-Rhin	67	1 118 009
Haute-Corse	2B	174 178	Haut-Rhin	68	763 716
Côte-d'Or	21	533 023	Rhône	69	1 816 373
Côtes-d'Armor	22	599 438	Haute-Saône	70	238 181
Creuse	23	119 381	Saône-et-Loire	71	555 840
Dordogne	24	418 219	Sarthe	72	572 135
Doubs	25	536 474	Savoie	73	429 253
Drôme	26	501 154	Haute-Savoie	74	791 094
Eure	27	599 518	Paris	75	2 218 536
Eure-et-Loir	28	435 171	Seine-Maritime	76	1 255 587
Finistère	29	907 423	Seine-et-Marne	77	1 391 429
Gard	30	748 509	Yvelines	78	1 424 411
Haute-Garonne	31	1 335 366	Deux-Sèvres	79	372 586
Gers	32	191 639	Somme	80	571 595
Gironde	33	1 542 964	Tarn	81	386 004
Hérault	34	1 123 990	Tarn-et-Garonne	82	255 666
Ille-et-Vilaine	35	1 039 983	Var	83	1 041 681
Indre	36	225 590	Vauchuse	84	554 619
Indre-et-Loire	37	606 164	Vendée	85	667 970
Isère	38	1 253 614	Vienne	86	433 682
Jura	39	259 455	Haute-Vienne	87	375 363
Landes	40	405 213	Vosges	88	371 792
Loir-et-Cher	41	332 775	Yonne	89	340 884
Loire	42	761 357	Territoire de Belfort	90	145 074
Haute-Loire	43	227 509	Essonne	91	1 279 864
Loire-Atlantique	44	1 358 627	Hauts-de-Seine	92	1 603 379
Loiret	45	670 906	Seine-Saint-Denis	93	1 573 959
Lot	46	173 021	Val-de-Marne	94	1 372 018
Lot-et-Garonne	47	334 106	Val-d'Oise	95	1 210 318

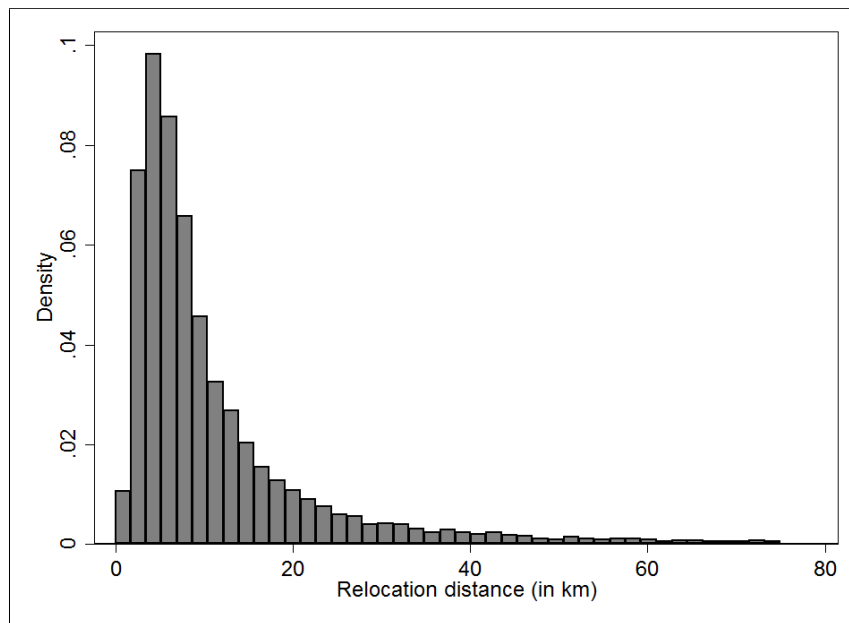
Notes: List of French *département* in 2013 and population. The codes presented in this table are consistent from 1994 to 2013. Source: INSEE.

Table A2: Real estate prices and propensity to relocation across *départements*

<i>Département</i>	(1)	(2)	(3)	(4)	<i>Département</i>	(1)	(2)	(3)	(4)	<i>Département</i>	(1)	(2)	(3)	(4)
1	1 101	0.76	1.89	1.19%	33	2 032	0.81	2.6	1.78%	66	559	0.91	2	0.97%
2	657	0.83	1.36	0.87%	34	1 212	1.5	2.75	1.52%	67	1 831	1.25	2.15	1.36%
3	399	0.43	1.05	1.13%	35	1 593	1.32	2.28	1.14%	68	1 236	0.59	1.52	1.28%
4	183	0.81	1.87	1.03%	36	305	0.47	1.06	0.75%	69	3 396	1.74	2.77	2.51%
5	217	0.71	2.15	0.77%	37	902	0.97	2.02	1.65%	70	357	0.5	1.03	0.73%
6	1 452	1.96	3.75	1.31%	38	2 230	1.24	2.16	1.45%	71	987	0.73	1.14	0.95%
7	426	0.68	1.4	1.06%	39	541	0.54	1.33	0.69%	72	687	0.66	1.39	1.05%
8	431	0.57	1.13	1.14%	40	473	1.01	2.3	0.79%	73	894	1.36	2.61	1.50%
9	196	0.97	1.72	0.86%	41	513	0.7	1.47	0.70%	74	1 571	1.38	3.26	1.44%
10	532	0.49	1.28	1.20%	42	1 511	0.66	1.14	1.17%	75	4 990	2.89	8.14	3.40%
11	396	0.93	2.11	0.49%	43	401	0.41	1.12	0.82%	76	1 672	0.98	1.93	1.71%
13	2 932	1.07	2.54	1.43%	44	1 738	1.13	2.52	1.32%	77	2 005	1.16	2.69	1.56%
14	888	1.66	2.37	1.59%	45	925	1.05	1.8	1.16%	78	1 746	1.65	3.78	2.12%
15	199	0.52	1.3	0.68%	47	528	0.4	1.15	1.00%	79	591	0.6	1.19	0.90%
16	535	0.42	1.02	1.07%	48	110	0.68	1.49	0.37%	80	672	1.02	2.08	0.86%
17	827	1.7	2.97	0.83%	49	1 400	0.96	1.7	1.10%	81	656	0.81	1.45	0.70%
18	438	0.72	1.26	0.87%	50	637	0.77	1.51	1.09%	82	344	0.51	1.39	0.48%
19	331	0.52	1.18	0.68%	51	1 044	1.15	1.93	0.96%	83	1 123	1.3	3.08	1.34%
21	846	0.97	2	1.45%	52	275	0.7	1.1	0.51%	84	882	0.92	1.91	0.93%
22	905	0.92	1.6	0.93%	54	801	0.73	1.62	1.60%	85	1 240	1.35	2.33	0.68%
23	139	0.47	0.94	0.42%	55	209	0.48	1.13	0.75%	86	640	1.18	1.59	0.98%
24	601	0.64	1.35	1.03%	56	1 020	1.15	2.08	1.01%	87	515	0.71	1.22	0.86%
25	892	0.77	1.64	1.14%	57	1 068	0.8	1.59	1.41%	88	629	0.57	1.11	0.77%
26	1 015	0.63	1.46	1.05%	58	243	0.47	0.95	0.86%	89	486	0.86	1.4	0.96%
27	716	0.9	1.67	1.27%	59	3 185	1.08	2.39	1.79%	90	169	0.67	1.21	1.53%
28	625	1.11	2.01	1.09%	60	1 006	1.45	2.35	1.50%	91	1 819	1.28	2.69	2.30%
29	1 191	0.45	1.37	0.85%	61	404	0.47	1	0.94%	92	2 511	2.27	5.26	3.51%
30	853	0.88	1.92	1.08%	62	1 625	1.25	2.02	1.33%	93	1 943	1.48	3.2	2.71%
31	1 830	1.04	2.39	1.60%	63	954	0.6	1.68	1.18%	94	1 888	1.87	4.19	2.47%
32	261	0.51	1.44	0.25%	64	1 127	0.99	2.36	1.32%	95	1 330	1.17	2.76	2.08%
33	2 032	0.81	2.6	1.78%	65	272	0.62	1.54	1.10%					

Notes: This table presents some descriptive statistics across *départements*. Column 1 gives the number of mono-establishments firms observed across the time period 1994-2013, column 2 gives the level of real estate prices in 1994 in thousands euros of 2010 per square meters, column 3 gives the level of real estate prices in 2013 in thousands euros of 2010 per square meters and column 4 gives the percentage of firms that have relocated, on average, each year over the period 1994-2013. *Départements* names are given in Table A1. Source: FiBEn, INSEE

Figure A1: Histogram of the distances between the place of departure and the place of settlement



Notes: This Figure plots the distribution of the as-the-crow-flies distances between the place of departure and the place of settlement of a relocating firm. For the sake of readability, we restrict our analysis to relocations characterized by a distance inferior to 50km ; the percentile 90 in the distances distribution is 60km and the percentile 99 is around 600km. Period of observation: 1994-2013. Source: authors calculations based on FiBEn.

firms. We report in Figure A1 the histogram of the distances between the place of departure and the place of settlement.

A.2.2 Real estate assets and capital gains

Real estate assets reported in the balance sheet are not mark-to-market. The market value of firms real estate holdings is important in our analysis because it determines the capital gains on which a tax is levied in the event of a sale.

Nevertheless, firm's balance sheets provide information on gross value of land and buildings and on accumulated amortizations of buildings. The gross value of land and buildings corresponds to their historical value adjusted by accounting reevaluations. A proxy for the mean age of real estate assets can be recover thanks to the ratio of the accumulated amortizations of buildings over the gross book value of buildings when we assume that buildings are linearly amortized.²⁵

²⁵The accounting standard for the length of the amortization period depends on the nature of the buildings. We retain an average length of 25 years following Chaney et al. (2013).

We do not have precise information on the location of the firm’s real estate assets. Consequently, we use the *département* where the firm is headquartered as a proxy for the location of real estate assets.²⁶ In order to recover the market value of real estate units held by the firm, we multiply the historical value of real estate holdings by the accrued changes in the real estate prices in the headquarters’s *département* since the average acquisition date. We eventually obtain, for each firm×year observation, the market-value of real estate holdings.

With the market-value, we can compute the capital gains on real estate assets by subtracting the historical value to the market-value. The amount of realised capital gains does not necessarily constitute the fiscal base. Indeed, the tax scheme takes into account the holding period. After a five-year holding period the gains retained in the tax base are diminished by 10% each year; so that after a fifteen-year holding period the firm is not anymore subject to the tax.

For each firm×year observations, we build a variable indicating the share of the proceeds that would be paid by the firm under the heading of tax on capital gains in the event of a sale of the real estate assets. This variable varies with:

- (i) The marginal tax rate: constant across firms and equal to the corporate tax rate as capital gains are added to the net income of the firm.
- (ii) The dynamics of real estate prices since the acquisition date: varying with the *département*.
- (iii) The length of time since acquisition: varying with the acquisition date and the year in which the firm is observed.

A.2.3 Variable description

Variable description and construction is summarized in Table A3.

²⁶As we restrict our analysis to single-establishment firms, this is a mild assumption.

Table A3: Variable descriptions

Variable	Description
Employment	Full-time equivalent (FTE) number of workers as reported by the firm.
RE owner	Dummy variable equal to one if the firm reports real estate assets in its balance-sheet.
Relocation	Dummy variable equal to one if the firm have relocated its activities over the observed period.
Age	Number of years since company's incorporation.
Size	Net value of the assets reported in the balance sheet in constant million of euros of 2010.
Profit	EBIT margin (i.e., EBIT to Sales ratio).
Age of RE	Average age, in years, of real estate assets held by the firm.
Tax on cap. gains	Share, in %, of the proceeds from the real estate asset sales that would be paid under the heading of the tax on capital gains if the real estate assets were to be sold by the firm in a given year.
Volume of RE	Numbers of square meters normalised the net value of the balance sheet.
Population	Population of the current municipality in thousands inhabitants
Density	Population of the current municipality in thousands inhabitants per square kilometer.
Herfindahl index	Sum of the square of the market share, in % of all firms in a give 2-digit sector and in the municipality during the year.
Sectoral size	Sum of the sales at the 2-digit sector \times municipality \times year level in constant million of euros of 2010.

Notes: This table gives the definition of the variables used in the empirical analysis. For a detailed description of these variables construction, see appendix [A](#).

B Additional figures

Figure B1: Propensity to relocate at different percentiles of employment growth - within *Île-de-France* (Paris area)

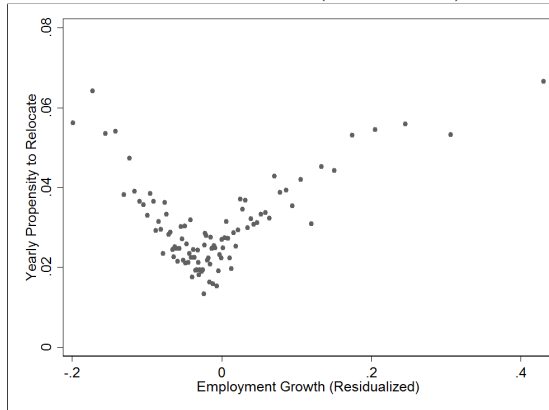
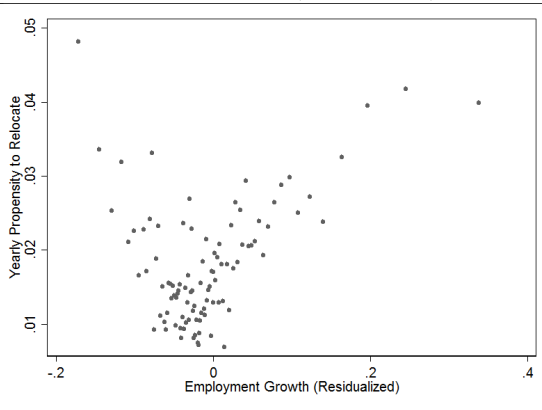


Figure B2: Propensity to relocate at different percentiles of employment growth - within *Rhône-Alpes* (Lyon area)



Notes: see Figure 1. Period of observation: 1994-2013. Right-hand side figure only includes observations from Lyon Area (Region *Rhone-Alpes*, D'epartements 01, 07, 26, 38, 42, 69, 73, 74) while left-hand side figure only includes observations from Paris Area (Region *Ile de France*, D'epartements 75, 77, 78, 91, 92 ,93 ,94 ,95). Source: FiBEn.

Figure B3: Propensity to relocate at different percentiles of employment growth - (Marseille area)

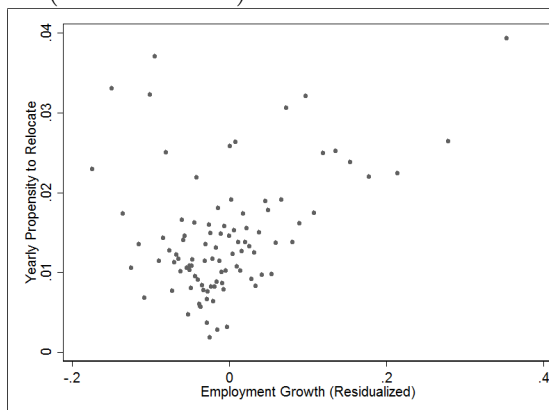
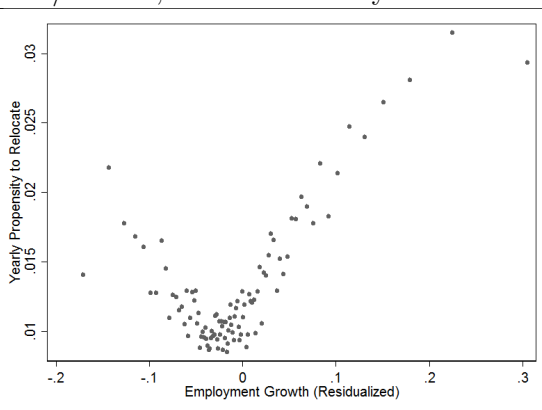


Figure B4: Propensity to relocate at different percentiles of employment growth - w/o Paris, Marseille and Lyon areas



Notes: see Figure 1. Period of observation: 1994-2013. Right-hand side figure excludes all observations from Paris, Lyon and Marseille areas while left-hand side figure only includes observations from Marseille Area (Region *Provence-Alpes-Cote-d'Azur*, D'epartements 04, 05, 06, 13, 83, 84) Source: FiBEn.

Figure B5: Propensity to relocate at different percentiles of employment growth - service industries

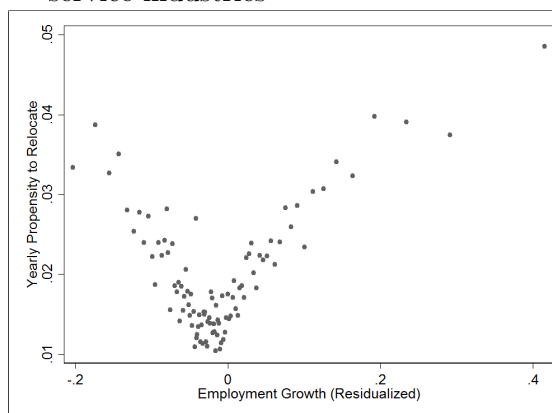
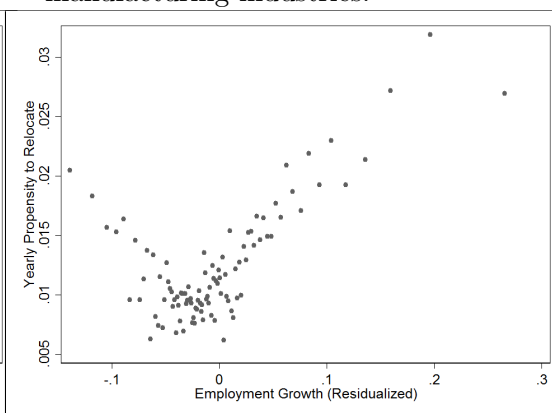


Figure B6: Propensity to relocate at different percentiles of employment growth - manufacturing industries.



Notes: see Figure 1. Period of observation: 1994-2013. Right-hand side figure only includes observations from manufacturing industry while left-hand side figure only includes observations from the service industry. Source: FiBEn.

C Theory appendix

C.1 Model without friction

In a model without friction, each intermediate firm maximizes its revenue by choosing $r(i)$ and $l(i)$. First order conditions yields:

$$l(i) = \alpha \left[\frac{\Omega(i)(1-\varepsilon)}{w} \right]^{\frac{1}{\varepsilon}} \left(\frac{w}{u} \right)^{\frac{(1-\alpha)(1-\varepsilon)}{\varepsilon}} \quad (21)$$

$$r(i) = (1-\alpha) \left[\frac{\Omega(i)(1-\varepsilon)}{u} \right]^{\frac{1}{\varepsilon}} \left(\frac{w}{u} \right)^{\frac{-\alpha(1-\varepsilon)}{\varepsilon}} \quad (22)$$

which implies that firm i 's output price is a fixed markup over its marginal costs:

$$p(i) = \frac{1}{1-\varepsilon} \frac{w^\alpha u^{1-\alpha}}{\theta(i)} \quad (23)$$

and hence:

$$P = \frac{1}{1-\varepsilon} (w^\alpha u^{1-\alpha}) \left(\int_0^1 \theta(i)^{\frac{1-\varepsilon}{\varepsilon}} di \right)^{\frac{\varepsilon}{\varepsilon-1}} \quad (24)$$

We can then write:

$$y(i) = \theta(i) [\Omega(i)(1-\varepsilon)]^{\frac{1}{\varepsilon}} (w^\alpha u^{1-\alpha})^{\frac{-1}{\varepsilon}} = \theta(i)^{\frac{1}{\varepsilon}} (1-\varepsilon)^{\frac{1}{\varepsilon}} Y P^{\frac{1}{\varepsilon}} (w^\alpha u^{1-\alpha})^{\frac{-1}{\varepsilon}} \quad (25)$$

using the value of P yields:

$$y(i) = \theta(i)^{\frac{1}{\varepsilon}} \left(\int_0^1 \theta(i)^{\frac{1-\varepsilon}{\varepsilon}} di \right)^{\frac{1}{\varepsilon-1}} Y \quad (26)$$

from the FOCs, note that

$$wl(i) + ur(i) = \theta(i)^{\frac{1-\varepsilon}{\varepsilon}} w^\alpha u^{1-\alpha} \left(\int_0^1 \theta(i)^{\frac{1-\varepsilon}{\varepsilon}} di \right)^{\frac{1}{\varepsilon-1}} Y \quad (27)$$

on the other hand:

$$p(i)y(i) = \frac{w_t^\alpha u^{1-\alpha}}{1-\varepsilon} \theta(i)^{\frac{1-\varepsilon}{\varepsilon}} \left(\int_0^1 \theta(i)^{\frac{1-\varepsilon}{\varepsilon}} di \right)^{\frac{1}{\varepsilon-1}} Y \quad (28)$$

We then show that the profit is equal to the production up to a markup

$$\pi(i) = \frac{\varepsilon}{1-\varepsilon} (w^\alpha u^{1-\alpha}) \theta(i)^{\frac{1-\varepsilon}{\varepsilon}} \left(\int_0^1 \theta(i)^{\frac{1-\varepsilon}{\varepsilon}} di \right)^{\frac{1}{\varepsilon-1}} Y \quad (29)$$

and

$$\int_0^1 \pi(i) di = \frac{\varepsilon}{1-\varepsilon} (w^\alpha u^{1-\alpha}) \left(\int_0^1 \theta(i)^{\frac{1-\varepsilon}{\varepsilon}} di \right)^{\frac{\varepsilon}{\varepsilon-1}} Y \quad (30)$$

From market clearing condition

$$\begin{aligned} L_s &= \int_0^1 l(i) di \\ R_s &= \int_0^1 r(i) di \\ PY &= \int_0^1 p(i)y(i) di, \end{aligned} \quad (31)$$

we can show that in equilibrium:²⁷

$$Y = \left(\frac{L_s}{\alpha} \right)^\alpha \left(\frac{R_s}{1-\alpha} \right)^{1-\alpha} \left(\int_0^1 \theta(i)^{\frac{1-\varepsilon}{\varepsilon}} di \right)^{\frac{\varepsilon}{1-\varepsilon}} \quad (32)$$

plugging into $\Omega(i)$ yields:

$$(1-\varepsilon)\Omega(i) = \theta(i)^{1-\varepsilon} \left(\frac{L_s}{\alpha} \right)^{\varepsilon\alpha} \left(\frac{R_s}{1-\alpha} \right)^{\varepsilon(1-\alpha)} \left(\int_0^1 \theta(i)^{\frac{1-\varepsilon}{\varepsilon}} di \right)^\varepsilon (w^\alpha u^{1-\alpha}). \quad (33)$$

we can rewrite:

$$l_t(i) = \theta_t(i)^{\frac{1-\varepsilon}{\varepsilon}} \left(\frac{L_s}{\alpha} \right)^\alpha \left(\frac{R_s}{1-\alpha} \right)^{(1-\alpha)} \left(\int_0^1 \theta(i)^{\frac{1-\varepsilon}{\varepsilon}} di \right)^{-1} \left(\frac{u}{w} \right)^{1-\alpha} \quad (34)$$

We know that $\frac{r(i)}{l(i)} = \frac{R_s}{L_s} = \frac{(1-\alpha)w}{\alpha u}$, hence:

$$l(i) = \theta(i)^{\frac{1-\varepsilon}{\varepsilon}} \left(\frac{L_s}{\alpha} \right)^\alpha \left(\frac{R_s}{1-\alpha} \right)^{(1-\alpha)} \left(\int_0^1 \theta(i)^{\frac{1-\varepsilon}{\varepsilon}} di \right)^{-1} \left(\frac{L_s}{\alpha} \right)^{1-\alpha} \left(\frac{R_s}{1-\alpha} \right)^{\alpha-1} \quad (35)$$

Finally:

$$l(i) = \frac{\theta(i)^{\frac{1-\varepsilon}{\varepsilon}}}{\int_0^1 \theta(i)^{\frac{1-\varepsilon}{\varepsilon}} di} L_s \text{ and } r(i) = \frac{\theta(i)^{\frac{1-\varepsilon}{\varepsilon}}}{\int_0^1 \theta(i)^{\frac{1-\varepsilon}{\varepsilon}} di} R_s \quad (36)$$

Normalizing P to 1 ; we obtain:

$$u = (1-\varepsilon) \frac{1-\alpha}{R_s} Y \quad (37)$$

and

²⁷This result comes from the fact that the market clearing condition implies: $YP = \int_0^1 p(i)y(i)di$ and that $\frac{L_s}{R_s} = \frac{l(i)}{r(i)}$.

$$w = (1 - \varepsilon) \frac{\alpha}{L_s} Y \quad (38)$$

and

$$p(i) = \frac{1}{\theta(i)} \left(\int_0^1 \theta(i)^{\frac{1-\varepsilon}{\varepsilon}} di \right)^{\frac{\varepsilon}{1-\varepsilon}} \quad (39)$$

C.2 Existence of an interval of inaction

The relocating condition $d = \pi^1 - \pi^0 > 0$ is a function of Δ_r and we have:

$$d(\Delta_r) = \frac{u(1+b)}{(1-\alpha)(1-\varepsilon)} \left(\varepsilon(1+\Delta_r) - (1-\alpha(1-\varepsilon))(1+\Delta_r)^{\frac{\varepsilon}{1-\alpha(1-\varepsilon)}} \right) + u - a. \quad (40)$$

The function d is differentiable and continuous in Δ_r . It is straightforward to show that d is decreasing with Δ_r when $\Delta_r < 0$ and increasing with Δ_r when $\Delta_r > 0$. The function d takes the value $u - a$ when Δ_r equals -1 , $-(a+b)$ when Δ_r equals 0 and tends to the infinity when Δ_r tends to infinity. Hence, if $u > a$, there exist only two values of Δ_r , one being negative and the other positive, such that $d = 0$. We denote them Δ_r^- and Δ_r^+ , respectively. The function d is negative when Δ_r is between Δ_r^- and Δ_r^+ and positive otherwise. Then, Δ_r^- and Δ_r^+ are the bounds of the non-relocating interval. We can easily show that $|\Delta_r^-|$ and $|\Delta_r^+|$ are increasing in a .

We explore further the properties of the bounds of the non-relocating interval when Δ_r is close to 0 using a third-order local approximation of the function d around 0.

$$d(\Delta_r) = 0 \Leftrightarrow \frac{2((1-\alpha)(1-\varepsilon)) + \varepsilon}{3(1-\alpha(1-\varepsilon))} \Delta_r^3 - \Delta_r^2 + \frac{2(a+ub)(1-\alpha(1-\varepsilon))}{u\varepsilon(1+b)} \approx 0 \quad (41)$$

Let us denote P the above-derived polynomial of degree 3. We can easily show that P' is negative when Δ_r is between 0 and $\frac{2(1-\alpha(1-\varepsilon))}{2(1-\varepsilon)(1-\alpha)+\varepsilon}$ and positive otherwise. P tends to $-\infty$ in $-\infty$ and $+\infty$ in $+\infty$. We can also show $P(0) > 0$ and $P\left(\frac{2(1-\alpha(1-\varepsilon))}{2(1-\varepsilon)(1-\alpha)+\varepsilon}\right) < 0$ when $u \gg a$. Then, P has three real roots, λ_1 , λ_2 and λ_3 with $\lambda_1 < 0 < \lambda_2 < \lambda_3$. The two roots that are solutions to our problem $\pi^1 - \pi^0 = 0$ are λ_1 and λ_2 because linear approximation is only valid around 0. We know from usual properties of polynomials on degree 3 that:

$$\begin{aligned} \lambda_1 + \lambda_2 + \lambda_3 &= \frac{3(1-\alpha(1-\varepsilon))}{2((1-\alpha)(1-\varepsilon))+\varepsilon} \\ \lambda_1\lambda_2 + \lambda_1\lambda_3 + \lambda_2\lambda_3 &= 0 \\ \lambda_1\lambda_2\lambda_3 &= \frac{-6(a+ub)(1-\alpha(1-\varepsilon))^2}{u\varepsilon(1+b)(2((1-\alpha)(1-\varepsilon))+\varepsilon)} \end{aligned} \quad (42)$$

We obtain:

$$\lambda_1 + \lambda_2 = (\lambda_1 \lambda_2)^2 \frac{u\varepsilon(1+b)(2((1-\alpha)(1-\varepsilon)) + \varepsilon)}{6(a+ub)(1-\alpha(1-\varepsilon))^2} > 0 \quad (43)$$

which implies $|\Delta_r^+| > |\Delta_r^-|$.

We also have:

$$\sqrt{\lambda_1 + \lambda_2}^3 = \sqrt{\lambda_1 + \lambda_2} \frac{2((1-\alpha)(1-\varepsilon)) + \varepsilon}{3(1-\alpha(1-\varepsilon))} + \sqrt{\frac{6(a+ub)(1-\alpha(1-\varepsilon))^2}{u\varepsilon(1+b)(2((1-\alpha)(1-\varepsilon)) + \varepsilon)}} \quad (44)$$

From which we deduce that $\sqrt{\lambda_1 + \lambda_2}$ is increasing in a and decreasing in ε .