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IZA DP No. 12007

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ABSTRACT

Real Estate Prices and Corporate Investment: Theory and Evidence of Heterogeneous Effects across Firms*

In this paper, we investigate the effect of real estate prices on productive investment. We build a simple theoretical framework of firms' investment with credit rationing and real estate collateral. We show that real estate prices affect firms' borrowing capacities through two channels. An increase in real estate prices raises the value of the firms' pledgeable assets and mitigates the agency problem characterizing the creditor-entrepreneur relationship. It simultaneously cuts the expected profit due to the increase in the cost of inputs. While the literature only focuses on the first channel, the identification of the second channel allows for heterogeneous effects of real estate prices on investment across firms. We test our theoretical predictions using a large French database. We do find heterogeneous effects of real estate prices on productive investment depending on the position of the firms in the sectoral distributions of real estate holdings. Our preferred estimates indicate that a 10% increase in real estate prices causes a 1% decrease in the investment rate of firms in the lowest decile of the distribution but a 6% increase in the investment rate of firms belonging to the highest decile.

JEL Classification: D22, G30, O52, R30

Keywords: firms' investment, real estate prices, collateral channel, financial contraints

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1 Introduction

This paper estimates the effect of real estate prices on productive investment (i.e., machines, equipment and intangible assets), focusing on potential heterogeneous impacts depending on the composition of the firms' assets.

From the late nineties to the financial crisis, real estate prices in many advanced countries have experienced a boom, unprecedented in size and duration. These booms led to significant capital misallocation across sectors and firms (Cette, Fernald, and Mojon, 2016).

While the literature has focused on the collateral channel of real estate prices, with monotonous effects on investment, we take into account both this collateral channel and a factor cost channel, which generates heterogeneous effects of real estate prices on productive investment of credit-constrained firms. These results are theoretically formalized and substantiated by empirical analyses performed on a large French firm-level database. We show that both the sign and the magnitude of their effect depend on the firms' real estate holdings.

In an imperfect credit market, collateral pledging enhances the firms' borrowing capacities. The ability of the lenders to seize pledged collateral increases the debt capacity of the borrowers as it mitigates the agency problem in this external financing relationship (Berger and Udell, 1990). The extent to which the borrowing constraint is relaxed by collateral pledging depends on the collateral liquidation value. Real estate assets often constitute the bulk of the firm's pledgeable assets since they are easily redeployable and have a long lifespan. Collecting data on the financing behaviour of 91 banks in 45 countries, Beck, Demirgüç-Kunt, and Martinez Peria (2008) find that more than three-quarters of banks require collateral to make business loans and that real estate is the most frequently accepted type of collateral for business lending, regardless of the firm's size. Through this mechanism, an increase in real estate prices is expected to relax the firm's borrowing constraints and to ease their funding.

The positive causal relationship between real estate prices and corporate investment, channeled by the collateral value, has been empirically examined by using firm-level data. Based on a large sample of publicly-listed firms in Japan, Gan (2007) finds a significant impact of the collateral value on corporate investment during the five-year period after the land price collapse which occurred in the early 1990s. Chaney, Sraer, and Thesmar (2012) (hereafter CST) study the sensitivity of investment to real estate collateral value by using data from a sample of US publicly-listed firms observed between 1993 and 2007. They find a substantial causal relationship between collateral value and business investment at the firm level. In a recent contribution focusing on labor market variables, Chaney, Sraer, and Thesmar (2013) document a significant real estate collateral channel by considering a large database of French firms observed over the period 1998-2007.

In these empirical studies, real estate prices are regarded as mere shifters of the pledgeable assets' value which determines the borrowing capacities of firms. This view relies on the credit rationing mechanism, put forward by Hart and Moore (1990) and built around the idea that, because loan agreement can be renegotiated and because the entrepreneur is required for the completion of the project, the borrowing capacity only depends on the anticipated liquidation value of the asset that the lender can seize. In this framework, asset prices have an unambiguous positive effect on the borrowing capacities of firms.

Yet, when as a result of the agency problem characterizing the creditor-entrepreneur relationship, the borrowing capacity is determined by the expected value of pledged assets along with the expected firms' profit (Tirole, 2010), real estate prices have an equivocal impact on borrowing capacities. Indeed, real estate prices draw the two components of this borrowing capacity in opposite directions: an increase in real estate prices raises the value of the pledgeable assets and mitigates the agency problem but it simultaneously lowers their profit due to the increase in the cost of inputs.

In order to formalize the link between real estate prices and productive investment, we propose a simple partial equilibrium model of investment subject to a credit rationing that results from moral hazard and where real estate assets are both pledged and used as an input in the production process. When investment is determined by the endogenous borrowing capacity, we show that the sign and the magnitude of the effect of real estate prices on investment are determined by the volume of real estate holdings of the firm. When prices increase, firms owning few real estate assets suffer from a negative profit channel without significantly benefiting from a positive collateral channel; conversely, firms owning more real estate assets face a less stringent profit channel and amply benefit from the collateral channel.

We use a large French firm database to confront these predictions with the data. France is a particularly relevant case to test these theoretical predictions as it experienced both a very steep, and yet uncorrected increase in real estate prices, while it registered growing signs of misallocations, in particular through increasing productivity dispersion across firms (Cette, Corde, and Lecat, 2017). When estimating the effect of real estate prices on productive investment, we face an identification issue resulting from the fact that real estate prices comove with the business cycle. More specifically, we know that the level of bank credits affect both investment and real estate prices (Mora, 2008, and Favara and Imbs, 2015). Thus, real estate prices are correlated with investment opportunities. Following Case, Quigley, and Shiller (2005) and *CST*, our identification strategy is twofold. First, we analyze the effect of real estate prices at the *département* level[1] on investment, which is not necessarily limited to the *département* boundaries. Large firms operating at the national level are expected to face similar economic conditions but their borrowing capacities follow different paths depending on the dynamics of local real estate prices, namely in the

[1] A *département* is an administrative zone. There are 95 *départements* in France. Each of them has approximately the same geographical size (6, 000 square kilometers), but different population sizes.

département where the firms' real estate assets are located. Second, within a *département* where firms face the same local economic conditions and thus similar investment opportunities, we can compare the impact of real estate prices on productive investment across firms with varying level of real estate holdings.

We contribute to the existing literature by providing an interpretation of the theoretical and empirical results that explicitly distinguishing the collateral and profit channels. In accordance with the results derived from a theoretical model with an endogenous borrowing constraint taking into account the firm's profit, the sign and the magnitude of the effect of real estate prices on productive investment are determined by real estate holdings. In particular, we show that real estate prices have heterogeneous effects on productive investment depending on the position of the firm in the 2-digit sectoral distribution of a normalized measure of real estate holdings. We find a negative impact of an increase in real estate prices on productive investment at the bottom of the distribution, while the effect is highly positive at the upper end of the distribution. Our preferred estimates indicate that a 10% increase in real estate prices causes a 1% decrease in the investment rate of firms in the lowest decile of the distribution but a 6% increase in the investment rate of firms belonging to the highest decile. Our empirical results also suggest that the impact of an increase in real estate prices on aggregate productive capital is positive. Nevertheless, the documented heterogeneous effects across the real estate holdings distribution could link real estate prices dynamics to misallocation of capital.

Our paper is organized as follows. Section 2 presents a tool model from which we derive our main testable predictions. Section 3 presents data sources and variables. Section 4 reports and comments our empirical findings. Section 5 concludes.

2 A simple theoretical framework

We develop a simple model of firms' productive investment with credit rationing and real estate collateral in the spirit of the one proposed by Chaney, Sraer, and Thesmar (2009). Nevertheless, we introduce two substantial changes that alter the effect of real estate prices on the productive investment of credit-constrained firms. First, we consider an alternative micro-founded borrowing constraint based on the moral hazard mechanism put forward by Tirole (2010). Second, we treat real estate assets as inputs in the firm's production process.

2.1 Model setup

In this model, we consider a risk-neutral representative Firm (the "Entrepreneur" or "Borrower") in a small open economy ; the risk free interest rate is $r > 0$. The Firm is assumed to have a finite horizon and the model has only two dates that correspond to the beginning and to the end of a period.

At the beginning of the period, the representative Firm is endowed with capital k_0, cash-flow c_0 (in units of capital), outstanding debt B_0 (in units of capital) owing to an external investor, and R_0 real estate units. The net debt is defined as the outstanding debt minus the cash-flow, hence $NB_0 = B_0 - c_0$.[2] The Firm can invest at the beginning of the period in a project that yields gross revenue $y(k, R, \theta)$ at the end of the period; k is the Firm's capital made of the initial capital and the investment, hence $k = k_0 + i$ where i is the investment at the beginning of the period; R is the amount of real estate units used by the Firm and θ is the Firm's productivity, with $\theta \in [\underline{\theta}, \bar{\theta}]$.[3] The revenue function is twice differentiable, increasing with k, R and θ, and concave with k, R and θ. Capital and real estate are also assumed to be partially substitutable and therefore $y_{kR} > 0$.

The Firm must choose at the beginning of the period the amount of real estate units used in its production process. To modulate the real estate facilities, the Firm has access to a perfectly competitive real estate market and contracts with an outside risk-neutral counterpart either to rent or to lend real estate units. We denote r^l the renting cost of one unit of real estate over the period; a simple no-arbitrage condition gives $r^l = rp$, where p is the market price of one real estate unit (in units of capital), with $p \in [\underline{p}, \bar{p}]$.[4] The function c_{re} denotes the Firm's real estate cost paid at the end of the period. Note that this real estate cost can also be seen as the user cost of real estate capital of a Firm that borrows at the risk free interest rate. From what precedes, we have $c_{re}(R) = rp(R - R_0)$.

At the end of the period, the Firm is liquidated. The liquidation value corresponds to the market value of the real estate assets since we assume that k has no outside value.

2.2 Credit rationing

The Firm may need external financing if the initial cash-flow is insufficient to finance investment. The Firm can contract with a deep-pocket, risk-neutral external Investor (or "the Lender"); the Lender behaves competitively in the sense that the loan, if any, makes no profit. A financing contract specifies two transfers $(b_0; b_1) \in \mathbb{R}^2$ from the Firm to the Investor; b_0 occurs at the beginning of the period and b_1 at the end of the period. They satisfy the condition $b_0 + \frac{b_1}{1+r} \geq B_0$.[5]

An essential feature of our model is that the Firm faces credit rationing. Some profitable

[2] We assume $k_0 \in [0, \bar{k_0}], c_0 \in [0, \bar{c_0}], B_0 \in [0, \bar{B_0}]$ and $R_0 \in [0, \bar{R_0}]$. Restrictions on the value of $\bar{B_0}$ are discussed below.

[3] We introduce the Firm's productivity in this model because the literature on agglomeration economies has documented the link between local spatial density and productivity (see Combes and Gobillon, 2014, for a recent survey). Introducing productivity in this model renders explicit that changes in productivity can partially offset the effects of prices on factors' demand when productivity and prices comove.

[4] An implicit hypothesis behind this renting rate is that there is no expected capital gain or loss. The hypothesis may be relaxed

[5] In order to discard any case of inevitable default, we assume that the net present value of the Firm is positive even if there is no initial investment. It implies an upper bound for B_0, i.e, $B_0 \leq c_0 + \frac{y(k_0,R,\theta)-c_{re}(R)+pR_0}{1+r}$ or equivalently, $NB_0 \leq \frac{y(k_0,R,\theta)-c_{re}(R)+pR_0}{1+r}$.

investments may not receive funding. This credit rationing is driven by the asymmetry of information between borrowers and lenders. The mechanism of credit rationing that we introduce is similar to the one set forth by Tirole (2010). The Lender faces an agency problem as the Firm (or "the Borrower") may mismanage the project. The Borrower can either "behave" or "misbehave". Behaving yields the above-described revenue y and no private benefit to the Firm. Misbehaving generates a private benefit $S > 0$ (measured in units of capital) to the Entrepreneur that can be interpreted as the disutility of effort saved by the Entrepreneur when shirking. This private benefit damages the profitability of the project and induces a fixed loss compared to the optimal revenue; the project yields $y - L$ when the Entrepreneur misbehaves. It is inefficient in the sense that the private benefit to the Firm is smaller than the foregone revenue (i.e., $S < L$) but, as this private benefit is not shared with the Investor conversely to the revenue, the Firm may prefer to misbehave. We assume that these values are known by both agents. Consequently, to ensure that the Firm will not shirk, the loan agreement between the Firm and the Investor (to be defined below) must secure a sufficient stake in the outcome of the project to the Firm. Thus, the project's income cannot be fully pledged to the outside Investor and a project may not receive financing even if the expected profit, when the Firm behaves, exceeds the required investment plus the interest expenses.

In order to enhance its borrowing capacity, the Firm pledges collateral. We focus our analysis on real estate collateral as we have set the outside value of used capital to 0. The value of collateralizable assets corresponds to the market value of the real estate assets, that is pR_0. The financing contract between the Firm and the Investor stipulates how the profit is shared as well as a contingent right for the Investor to seize the real estate collateral. A share φ of the profit goes to the Firm and a share $1 - \varphi$ goes to the Investor in order to pay back the loan and its interests. If the Firm defaults on the loan, that is to say if the Firm is not in a position to transfer an amount b_1 satisfying the above-mentioned condition, the investor seizes the collateral and the Firm losses the collateral pledged.[6]

We assume that L is large enough in comparison to S so that there is no profitable investment in case of a misbehaviour:

$$(y - c_{re} - L + S) - (1 + r)i < 0 \tag{1}$$

Making this assumption, we insure that the project is funded if and only if the incentive scheme is designed so that the Entrepreneur behaves. Indeed, equation (1) implies:

[6] Even if the default is contemplated because it affects the incentives of the borrower, it has to be noticed that the default never occurs in this model as the loan agreement is designed to discard it (see the conditions introduced below). In this context, a contract where the share φ would depend on the Firm's behaviour can overcome the agency problem; nonetheless we can easily think of information constraints (e.g., idiosyncratic income shocks) that would render such a contract unfeasible.

$$[(1-\varphi)(y-c_{re}-L)-(1+r)(i-c_0+B_0)]+[\varphi(y-c_{re}-L)+S-(1+r)c_0]<0 \quad (2)$$

In inequality (2), when the second term within square brackets - the profit to the Firm in case of a misbehavior minus the future value of initial cash - is positive, the first term within the square brackets - the profit to the Lender in case of a misbehavior minus the future value of outstanding debt - is negative. Shirking entails defaulting and thus no loan that gives an incentive to the Firm to misbehave will be granted.

From the loan agreement's structure, we derive an incentive compatibility constraint stating that the share of the profit going to the Firm must insure that the entrepreneur is better off behaving:

$$\varphi y \geq \varphi(y-L)+S-pR_0 \quad (3)$$

This incentive constraint defines a lower limit for φ; we denote this limit $\underline{\varphi}=\frac{S-pR_0}{L}$. The private benefit being smaller than the foregone revenue, we have $\underline{\varphi}<1$. The sign of $\underline{\varphi}$, that is to say the sign of $S-pR_0$, is crucial as it determines whether or not credit rationing can arise. If $S-pR_0$ is negative, that is if the private benefit derived from shirking is lower than the market value of pledged collateral, the Borrower has no incentive to default, regardless of the share of the profit she can secure. The Investor is thus in a position to claim the entire profit for the reimbursement of the loan and its interests, and any profitable project is funded. Conversely, if $S-pR_0$ is positive, depending on the share of the profit that the Firm secures, the Entrepreneur may be better off defaulting and credit rationing can arise as the Lender cannot claim the entire profit to reimburse the loan and its interests.

We derive the borrowing constraint when $\underline{\varphi}\in(0,1)$. The Lender's rationality constraint implies that the share of the profit she secures through the loan agreement is higher than the amount of outstanding debt:

$$(1-\varphi)(y-c_{re})\geq(1+r)(B_0-b_0) \quad (4)$$

Incorporating the incentive compatibility constraint, equation (3), into the Lender's rationality constraint, equation (4) gives the following borrowing constraint:[7]

$$\frac{L-S+pR_0}{L}\left(y(k,R,\theta)-rp(R-R_0)\right)\geq(1+r)(B_0-b_0) \quad (5)$$

Real estate prices affect the credit limit through two channels potentially going in opposite directions. An upward change in the real estate prices increases the market value of

[7]Using this borrowing constraint and assuming that the amount of installed capital results from the Firm's history, we get another upper bound for the initial amount of the outstanding debt of constrained Firm, i.e., $B_0\leq\frac{L-S+pR_0}{(1+r)L}[y(k_0,R,\theta)-c_{re}(R)]$.

the collateral which raises the cost associated with a default and makes it possible for the Lender to secure a higher share of the profit. Simultaneously, if R is higher than R_0, real estate costs increase and cut back the profit.

2.3 Real estate prices and investment

The Firm makes a decision with respect to the investment, the amount of real estate units used for production and the debt contract in order to maximize the project's net present value. If the Firm is unconstrained, its program is the following:

$$\begin{aligned} & max_{(i,R,b_0,b_1)} && c_0 - b_0 - i + \frac{y(k,R,\theta) - c_{re}(R) + pR_0 - b_1}{1+r} \\ & s.t. && B_0 \leq b_0 + \frac{b_1}{1+r} \end{aligned} \tag{6}$$

By contrast, if the Firm is constrained, it is subject both to the borrowing constraint and to a liquidity constraint at the beginning of the period:

$$\begin{aligned} & max_{(i,R,b_0,b_1)} && c_0 - b_0 - i + \frac{y(k,R,\theta) - c_{re}(R) + pR_0 - b_1}{1+r} \\ & s.t. && B_0 \leq b_0 + \frac{b_1}{1+r} \\ & && (1+r)(B_0 - b_0) \leq \frac{L - S + pR_0}{L}\left(y(k,R,\theta) - c_{re}(R)\right) \\ & && i \leq c_0 - b_0 \end{aligned} \tag{7}$$

We are interested in highlighting the predicted impact of a modification in real estate prices on the Firm's investment decision in both cases. We first focus on the case where the Firm is not affected by the borrowing constraint, which is the case when $R_0 \geq \frac{S}{p}$, or alternatively when the borrowing constraint is not binding, which is the case if the initial cash-flow is big enough to finance the optimal level of investment. This optimal level of investment, as well as the optimal number of real estate units, are given by the first order conditions of the objective function in program (6) with respect to investment and real estate units:

$$\begin{aligned} y_k(k_0 + i^*, R, \theta) &= 1 + r \\ y_R(k_0 + i, R^*, \theta) &= rp \end{aligned} \tag{8}$$

where i^* and R^* denote the first best investment level and the first best real estate units level, respectively. Let us denote $k^* = k_0 + i^*$. We differentiate the system with respect to real estate prices to obtain:

$$\begin{aligned} \frac{\partial i^*}{\partial p} y_{kk}(k^*, R, \theta) &= -\frac{\partial R}{\partial p} y_{kR}(k^*, R, \theta) \\ \frac{\partial R^*}{\partial p} &= \frac{r}{y_{RR}(k, R^*, \theta)} - \frac{\partial i}{\partial p} \frac{y_{Rk}(k, R^*, \theta)}{y_{RR}(k, R^*, \theta)} \end{aligned} \tag{9}$$

Incorporating the second equation into the first when investment and real estate units are chosen optimally, we write:

$$\frac{\partial i^*}{\partial p}\left(\frac{y_{kR}(k^*,R^*,\theta)^2}{y_{RR}(k^*,R^*,\theta)}-y_{kk}(k^*,R^*,\theta)\right)=r\frac{y_{kR}(k^*,R^*,\theta)}{y_{RR}(k^*,R^*,\theta)} \tag{10}$$

Proposition 1 *The investment of the unconstrained Firm is negatively impacted by an exogenous increase in real estate prices.*

Proof. The term post-multiplying $\frac{\partial i^*}{\partial p}$ in the LHS of equation (10) is shown to be positive in Appendix A. The standard assumptions made on function y allow to deduce that $\frac{\partial i^*}{\partial p}<0$. ■

We can also show that, in the unconstrained case, investment is unaffected by the initial endowment in real estate units and in initial net debt, i.e., $\frac{\partial i^*}{\partial R_0}=\frac{\partial i^*}{\partial NB_0}=0$. The optimal investment increases with the productivity, i.e., $\frac{\partial i^*}{\partial \theta}>0$.

We now consider the case where the Firm is financially constrained. The constrained Firm invests less than the optimal investment i^*. The Firm is constrained when it is subject to a binding borrowing constraint. Investment and real estate units are then given by the liquidity constraint and the first order condition on real estate units, respectively:

$$\begin{aligned} i &= \frac{(L-S+pR_0)\left(y(k,R,\theta)-rp(R-R_0)\right)}{L(1+r)}-NB_0 \\ y_R(k,R,\theta) &= rp \end{aligned} \tag{11}$$

We are interested in finding the sign of the first derivative of the investment level with respect to real estate prices. From equation (11) we have:

$$\begin{aligned} \frac{\partial i}{\partial p} & \left((1+r)-\frac{L-S+pR_0}{L}y_k(k,R,\theta)\right)= \\ & \frac{L-S+pR_0}{L}\left(\frac{\partial R}{\partial p}[y_R(k,R,\theta)-rp]-r(R-R_0)\right) \\ & +\frac{R_0}{L}\left(y(k,R,\theta)-rp(R-R_0)\right) \end{aligned} \tag{12}$$

Incorporating the first order condition on real estate units, we can write:

$$\frac{\partial i}{\partial p}\left((1+r)-\frac{L-S+pR_0}{L}y_k(k,R,\theta)\right)=P(R_0) \tag{13}$$

where:

$$P(R_0)=\frac{1}{L}\left((2rp)R_0^2+(y(k,R,\theta)-2rpR+r(L-S))R_0-r(L-S)R\right) \tag{14}$$

Proposition 2 *The investment of the credit-constrained Firm is positively affected by an increase in real estate prices if and only if its initial endowment in real estate units is above a positive threshold $\bar{R}$.*

Proof. We show in the Appendix B that the sign of $\frac{\partial i}{\partial p}$ is given by the sign of the polynomial of degree two, $P(R_0)$, and that there exists a unique threshold $\bar{R}$ such that $\frac{\partial i}{\partial p} \geq 0$ if and only if $R_0 \geq \bar{R}$.[8] ∎

As noted above, an increase in real estate prices has two opposite effects on the constrained Firm. First it pushes up the liquidation value the collateral, which relaxes the borrowing constraint; second, it increases the cost of real estate which negatively affects the profit and tightens the borrowing constraint. Whether the first or the second effect dominates is determined by the initial endowment in real estate units.

We can also show that, in the constrained case, $\frac{\partial i}{\partial R_0} > 0$, $\frac{\partial i}{\partial NB_0} < 0$ and $\frac{\partial i}{\partial \theta} > 0$. A proof of these results is also provided in Appendix B.

2.4 Investment equation and predictions

We build this theoretical model in order to ease interpretation of the results derived from the reduced form approach adopted in the empirical part.

Denoting $h(k_0, NB_0, \theta, R_0, p)$ the policy function for i,[9] we can consider a first order linear approximation of this policy function around a firm with the median characteristics:

$$i = h(k_0, NB_0, \theta, R_0, p) \approx \gamma + \nabla h(\tilde{x})\tilde{x}' \tag{15}$$

where $\tilde{x} = (\tilde{k_0}, N\tilde{B}_0, \tilde{\theta}, \tilde{R_0}, \tilde{p})$ represents the state variables at their median level, γ is a constant, and $\nabla h(\tilde{x})$ is the gradient of the policy function evaluated at $\tilde{x}$. Hence:

$$i \approx \gamma + \frac{\partial h}{\partial k_0}(\tilde{x})k_0 + \frac{\partial h}{\partial NB_0}(\tilde{x})NB_0 + \frac{\partial h}{\partial \theta}(\tilde{x})\theta + \frac{\partial h}{\partial R_0}(\tilde{x})R_0 + \frac{\partial h}{\partial p}(\tilde{x})p \tag{16}$$

From our model, we can formulate the following predictions:

i) a positive estimate of the coefficient associated with the number of real estate units, or a negative estimate of the coefficient associated with the amount of net debt, imply a rejection of the null hypothesis that all firms are unconstrained;

ii) the sign of the estimated coefficient associated with real estate prices is expected to positively depend on the size of real estate holdings at the beginning of the period if

[8] The relative position of $\bar{R}$ with respect to $\frac{S}{p}$ depends on the parameters' values and on the functional form of y.

[9] Notice that in the maximization program we can substitute NB_0 to $B_0 - c_0$ and B_0 and c_0 disappears. The investment is thus a function of net debt.

the sample contains credit-constrained firms.

3 Data

We merge real estate prices at the *département* level with accounting data on French firms.

3.1 Real estate prices

Due to data limitation at the local level, we have to retain residential prices instead of commercial corporate real estate prices. It may be a source for concern because determinants of commercial corporate real estate prices and residential real estate are not necessarily the same. At the aggregate level, even if they follow similar trends, we observe some differences between the residential real estate indices and the corporate real estate indices (see Figure 3 in Appendix C). The impact of this approximation required by data availability issues is further discussed and tested in Section 4.4.[10] We hence use the *Notaires*-INSEE[11] apartment price indices built by Fougère and Poulhes (2012) which are based on the data collected by French *notaires* and the methodology developed by INSEE (i.e., the French statistical agency). 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; *département* is the smallest geographic entity for which those indices are available. We introduce geographic variability using 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 apartment transactions registered in a given year. The *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. 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 *départements* located in the Paris area (*Ile-de-France*) and the national housing price index (available from 1936 onwards) for the other *départements*. We report the trend of real estate prices in each *département* in Appendix C.

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

[10] *CST* has also shown, using US data, that commercial and residential prices lead to similar results in their study.

[11] Solicitor is the English equivalent for the French word *notaire*

Corsica.[12]

3.2 Accounting data

We exploit a large French firm-level database constructed by Banque de France called *FiBEn*. It is based on fiscal documents, including balance sheet and P&L statements, and it contains detailed information on flow and stock accounting variables. The database includes all French firms with annual sales exceeding 750,000 euros or with outstanding credit exceeding 380,000 euros. We exclude from our sample firms operating in finance, insurance, real estate, construction, mining industries as well as public administration and social services.

We build productive investment rates, as it is standard in the investment literature (Kaplan and Zingales, 1997, or Almeida, Campello, and Weisbach, 2004), by computing the ratio of productive investment to past year property, plant and equipment stock (hereafter PPE). Productive investment corresponds to capital expenditure net of real estate acquisitions, real estate acquisitions being approximated by positive variations of the gross value of real estate assets.[13] PPE are deflated as follows. We recover the mean age of fixed capital by computing the ratio of accumulated amortizations over gross book value and by making an assumption on the length of the amortization period.[14] Using the mean age we get the average year of acquisition. We then deflate the unamortized fixed capital by the aggregate deflator of the gross fixed capital formation of the average year of acquisition. We compute the net debt by subtracting the cash to the total financial debt. We also normalize the net debt by the PPE stock.

Using firms balance sheet information, we estimate total factor productivity (TFP) as the residual of a two-factor (fixed capital and labor) Cobb-Douglas production function.[15] TFP is estimated separately for each 2-digit sector using data over the period 1994-2013.[16] Our preferred measure uses the method proposed by Levinsohn and Petrin (2003).

We only 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. We 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. The median number of employees per firm is 16 and the median revenue is

[12] We also exclude firms headquartered in Aveyron, in Lot and in Mayenne as the housing price indices for those *départements* are based on too few observations at the beginning of the studied period.

[13] These variations may not exactly correspond to real estate asset acquisition as they may include some disposals.

[14] We retain an average amortization period of 10 years; this assumption reflects the fact that fixed capital is made of both equipments and buildings. Our results are not sensitive to this assumption.

[15] Total factor productivity is here the portion of output not explained by the amount of inputs used in production. As such, its level is determined by how efficiently and intensively the inputs are utilized in production.

[16] We use the NACE 2 classification of INSEE.

Table 1: Descriptive statistics of the main variables

	N	Mean	S. D.	Min	Q1	p50	Q3	Max
Sales	1,534,721	10,959	166,779	0	1,275	2,198	4,987	34,608,167
Numbers of employees	1,534,721	56.67	701.75	1	9	16	34	152,586
Productive investment ratio	1,497,095	0.62	1.39	0.00	0.08	0.23	0.58	19.65
NREH	1,532,139	0.47	0.96	0.00	0.00	0.00	0.55	8.88
Net debt	1,487,184	0.60	6.46	-44.69	-0.57	0.34	1.24	80.93
TFP	1,525,543	4.79	0.56	1.76	4.43	4.74	5.11	8.97

Notes: The sales are in thousands of euros. The number of employees is measured in full time equivalent. The $NREH$, in m^2 per thousands of euros, is defined below (see equation 18) as the Normalized Real-Estate Holdings. The net debt is normalized by the PPE stock. The TFP is estimated separately for each 2- digit sector using the method proposed by Levinsohn and Petrin (2003). Sources: FiBEn, *Banque de France*.

2.2 million euros. Further descriptive statistics are provided in Table 1.

3.3 Real estate units at the firm level

A key issue in our study is to recover the real estate units held by a firm every year. We thereafter define a real estate unit as an apartment's square meter equivalent. Real estate assets reported in the balance sheet are not mark-to-market. Hence, depending on the purchase date of real estate assets, the gross value reported in the firm's balance sheet corresponds to different amounts of real estate units.

Firms' balance sheets provide information on gross value of land and buildings and accumulated amortizations of buildings.[17] The mean age of real estate assets is computed thanks to the ratio of the accumulated amortizations of buildings over the gross book value of buildings:

$$Age_{it} = \frac{AccuAm_{it}}{grossBV_{it}} NormAm \tag{17}$$

where Age_{it} is the mean age of real estate assets held by firm i in year t, $AccuAm_{it}$ is the accumulated amortization of buildings, $GrossBV_{it}$ is the gross book value of buildings and $NormAm$ is the normative amortization period. Assuming that buildings are linearly

[17]The gross value of land and buildings corresponds to their historical value adjusted by accounting reevaluations. We are interested in historical value as we use this historical value combined with the mean age of real estate assets to recover the number of real estate units held by the firms. We can keep trace of accounting reevaluations because these operations are offset by dedicated accounts on the liability side - “reevaluation surplus” for non-depreciable assets and “regulated reserves” for depreciable assets. From these accounts we compute the total amount of historical reevaluations. Unfortunately, we do not know which assets have been reevaluated. We thus reallocate the total amount of reevaluations to land and buildings based on the share of land in the gross non-depreciable assets and on the share of gross buildings in the gross depreciable assets. This assumption is coherent with the compulsory accounting reevaluations which occurred in 1976 in France. Overall, these reevaluations have a limited impact on the value of land and buildings as reevaluations allocated to real estate assets through this method account for less than 1% of the gross value of real estate assets.

amortized over 25 years,[18] we can deduce for each firm×year observation the mean age of the real estate assets. For example, if the ratio of amortizations over the gross book value equals one fifth, we deduce that the mean age of the real estate assets is five years. When a firm holds both land and buildings, the mean age of land is assumed to be the same as the buildings' one. The mean age of the buildings in our sample is around 13.7 years. Notice that implementing this methodology requires observing price indices from 1969 onwards in each *département*.[19]

We do not have precise information on the location of the firms real estate assets. We use the *département* where the firms are headquartered as a proxy for the location of real estate assets. The validity of this approximation is supported by the fact that, given the size of the median firm in our database, establishments tend to be clustered in the headquarters' *département*, and that the headquarters are likely to account for an important share of the real estate holdings value. Nevertheless, we perform robustness checks by restricting our analysis to single-establishment firms, that is to say firms for which the assumption on the real estate assets' location is undoubtedly trustworthy.

In order to compute the amount of real estate units held by the firms, we divide the historical value of real estate holdings by the real estate prices in the headquarters' *département* at the date when, on average, real estate assets were purchased. We eventually obtain, for each firm×year observation, the number of real estate units held by the firm. We normalize this value by PPE in order to have a synthetic indicator of real estate ownership which is comparable across firms. We can think of this variable as the number of square meters per thousand euros of physical capital. It is hereafter called the Normalized Real-Estate Holdings ($NREH$):

$$NREH_{it}^{d} = \frac{AcqRE_{it}^{d}}{Price_{AcqYear_{it}}^{d}} \frac{1}{PPE_{it-1}} \tag{18}$$

where $NREH_{it}^{d}$ is the normalized real estate holdings for firm i in year t and *département* d, $AcqRE_{it}^{d}$ is the acquisition value of real estate assets, $Price_{AcqYear_{it}}^{d}$ is the price index in *département* d in the mean acquisition year[20] and PPE_{it-1} is the PPE stock of firm i in year $t-1$.

The validity of our measurement of $NREH$ strongly relies on the accuracy of the hypothesis made on the length of the amortization period of buildings. The choice of this parameter can be questioned since the amortization rates depend on the nature of the buildings. In our baseline analysis we retain 25 years, which corresponds to the rate com-

[18] The accounting standard for the length of the amortization period depends on the nature of the buildings. Following Chaney, Sraer, and Thesmar (2013), we retain an average length of 25 years.

[19] This is the reason why we have extended the series of the *Notaires*-INSEE indices.

[20] The acquisition year is recovered by subtracting the integer value of the computed age of real estate assets to the current year. Thus, the acquisition year is defined as $AcqYear_{it} = t - \llcorner Age_{it} \lrcorner$.

monly applied for office buildings[21] and to the rate used by Chaney, Sraer, and Thesmar (2013) in their study on French data. As a robustness check, we estimate our model using $NREH$ series computed with alternative amortization rates (specifically, 3% and 5% instead of 4%).

Main summary statistics are reported in Table 1.

3.4 The distribution of normalized real estate holdings

A key result derived from our theoretical approach is that the investment of credit-constrained firms react differently to real estate price shocks according to the size of their real estate holdings. We hence examine whether the impact of real estate prices on investment depends on the position of the firms in the distribution of the $NREH$ defined in equation (18).

Parameters of the production function may vary over time and across sectors. Indeed, the median $NREH$ widely differs across sectors (see, e.g., Figure 1). The ratio of the highest sectoral median (manufacture of leather and leather products) to the lowest sectoral one (water transport services) is equal to 9.[22] We hence consider sectoral distributions. Besides, we focus on the distribution of real estate holdings for firms that own real estate assets. We sort firms holding real estate in the decile corresponding to the position of their $NREH$ in the 2-digit sectoral distributions in a given year.[23] Figure 1 represents the $NREH$ distribution in the land transportation industry and in the wholesale trade industry.

Alternatively, we may consider distances to sectoral benchmarks.[24] This alternative method does not affect the results reported below.

3.5 The non-real-estate-holding firms

In our sample, for 52 percent of the firm×year observations, no real estate assets are reported in the balance sheet. It might be the case that some real estate assets actually held by firms are not identified in our database. Indeed, our firm-level data provide information on social financial statements but we have no information on consolidated accounts at the group level. Consequently, we do not observe real estate assets held by partially or fully owned real estate subsidiaries. It may be a source for concern because the practice of gathering real estate assets into dedicated legal structures is common in France since the beginning of the eighties. The number of real estate partnerships (*Sociétés Civiles Immobilières*, hereafter

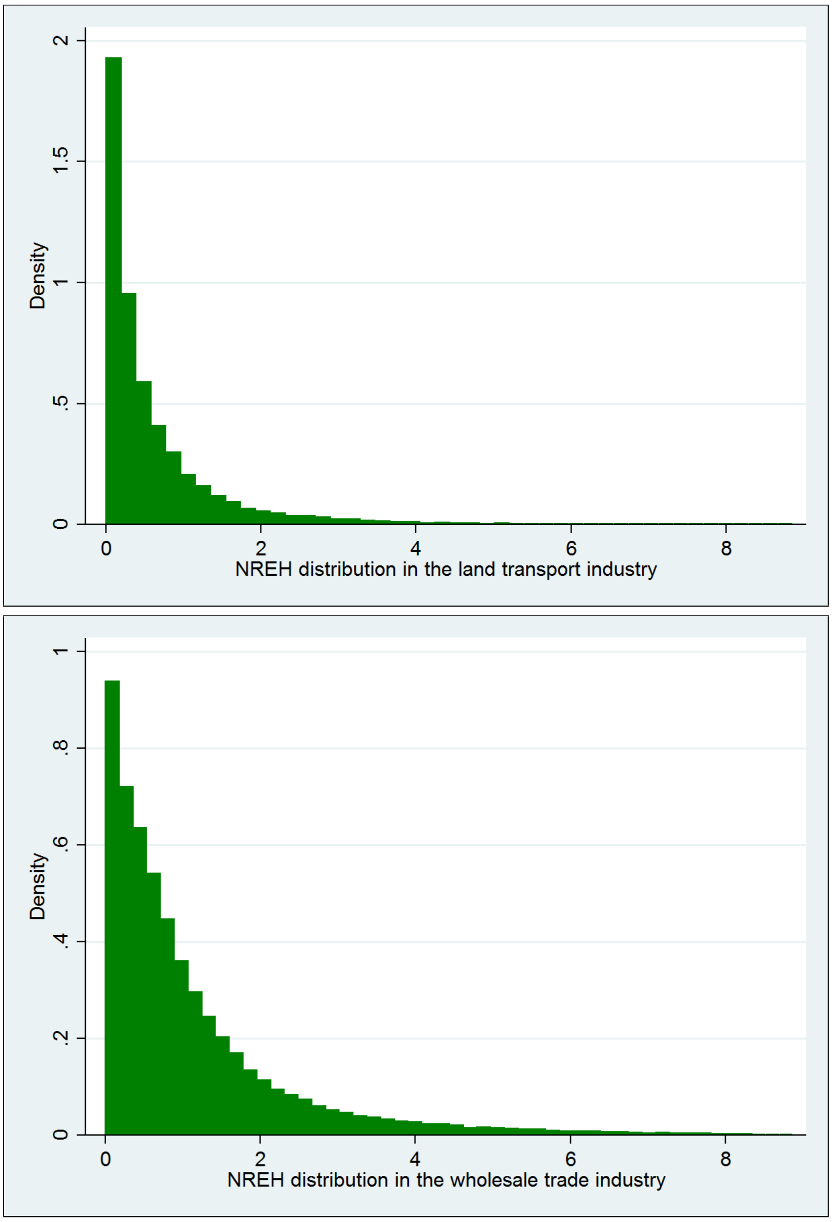
[21]See the ruling by the *Conseil d'État* dated 12 January 1983, number 32728.

[22]These statistics correspond to the sample restricted to firms owning real estate assets.

[23]This approach requires that we accept to discard the few sectors for which we do not have enough observations for some years.

[24]We recover the median value of the $NREH$ for each 2-digit sector in a given year. This median can be viewed as an annual reference level for real estate holdings in each industry. We compute the distance between each firm×year $NREH$ observation and the relevant sectoral benchmark. We then assign to each firm×year observation the decile corresponding to the rank of the above-described distance within the distribution of all computed distances. Using this method, we assume that there exists a unique real estate market.

Figure 1: $NREH$ sectoral distributions - Two examples



Notes: These figures plot the $NREH$ distributions for all firm×year observations in the land transportation industry (division 49 in the NACE 2 classification of INSEE)- top panel - and in the wholesale trade industry (division 46 in the NACE 2 classification of INSEE) - bottom panel. To choose those sectors we have ranked sectors according to their $NREH$ sectoral median. Among the 25% lowest and the 25% highest values of those medians, we have selected the sector with the highest number of observations. Sources: FiBEn, *Banque de France*.

SCI) registered in France has soared from c.11,000 in 1978 to c.1.3 million in 2014.[25] This measurement issue is more likely to affect $NREH$ at the extensive margin (owning real estate or not) than at the intensive margin.

4 The effects of real estate prices

We analyze the effect of real estate prices on corporate investment at the firm level. Our empirical analysis is based on our theoretical model.

4.1 Estimating the investment equation

We first estimate the reduced-form equation (16) presented in section 2.4. More specifically, the estimated investment equation in year t for a firm i headquartered in *département* d is:

$$Inv_{it} = \alpha_i + \gamma_t + \beta_1 NREH^d_{it-1} + \beta_2 lnPrice^d_t + \beta_3 NetDebt_{it-1} + \beta_4 TFP_{it-1} + \epsilon_{it} \quad (19)$$

where:

- Inv_{it} is firm's i capital expenditure net of real estate acquisitions normalized by the PPE stock in period $t-1$;
- $NREH^d_{it-1}$ is the number of real estate units held by firm i at the end of year $t-1$, normalized by the PPE stock in period $t-1$ as defined in equation (18);
- $lnPrice^d_t$ is the logarithm of the real estate transaction price per square meter in *département* d in year t;
- $NetDebt_{it-1}$ is firm's i total financial debt minus cash holdings of firm i at the end of year $t-1$ normalized by the PPE stock in period $t-1$;
- TFP_{it-1} is the total factor productivity of firm i in period $t-1$ estimated by the method introduced by Levinsohn and Petrin (2003).

As suggested by our theoretical framework, we aggregate financial debt and cash holdings.[26] We include firm fixed-effects (hereafter, FE), which are assumed to control for all

[25] In French civil law, a real estate company (SCI) is a partnership, which has a real estate object. It is sometimes also called a real estate management company. The use of an SCI allows the holding of a property by several persons and can facilitate the transfer of the property. This form of partnership requires a minimum of two partners at the time of incorporation. In the course of its existence, an SCI may however be held by a single associate, but this situation can only be transitory according to article 1844-5 of the Civil Code.

[26] Besides, this specification allows to take into account the fact that firms may contract loans to finance investment in the accounting period preceding the investment. In that case, an increase in the financial debt will be positively correlated with investment in the subsequent period. It may hide the fact that higher

the time invariant unobserved firm's characteristics, and year dummies which control for economic conditions at the aggregate level. We allow for possible correlations between the shocks ϵ_{it} at the *département*×year level.[27]

To validate empirically the theoretical prediction regarding the effect of real estate prices on corporate investment, we allow real estate prices to have differentiated effects depending on the firms' position in the $NREH$ distribution. For that purpose, we introduce interaction terms between real estate prices and $NREH$ deciles. We estimate the following equation:

$$\begin{aligned} Inv_{it} &= \alpha_i + \gamma_t + \beta_1 NREH^d_{it-1} + \textstyle\sum_{j=1}^{10} \beta_2^j D^j_{it-1} lnPrice^d_t + \sum_{j=1}^{10} \lambda_j D^j_{it-1} \\ &+ \beta_3 NetDebt_{it-1} + \beta_4 TFP_{it-1} + \epsilon_{it} \end{aligned} \tag{20}$$

where D^j_{it-1} for $j = 1, ..., 10$, is a dummy variable indicating if firm's i $NREH$ belongs to the j-th decile of the distribution.

We report in Table 2 parameter estimates of equation (19). Column 1 corresponds to the OLS estimation of equation (19). The parameter estimate associated with the $NREH$ is found to be positive. The baseline coefficient is 0.12, meaning that one additional square meter increases, on average, yearly investment by 120 euros. The estimated coefficient associated with net debt is negative: each additional euro of net debt decreases yearly investment by 0.6 per cent. The coefficient associated with productivity is positive. These coefficients are all statistically significant at the 1 percent level. The estimated coefficient associated with real estate prices is positive but not significant. Those estimates are consistent with the predictions derived from our theoretical framework. Column 2 corresponds to the same estimation with year dummies. Introducing year dummies affects the coefficient associated with real estate prices which now becomes statistically significant at the 5% level. On average, a 10% increase in real estate price translates into a 0.35 percentage point increase in the investment ratio; that corresponds to 1.5% of the median investment ratio. Other coefficients remain largely unaffected. Column 3 corresponds to the same estimation with year×sector dummies. Sectoral dynamics at the aggregate level may affect the path of corporate investment; these sectoral shocks are captured by the year×sector dummies. The coefficients remain unchanged. Column 4 reports parameter estimates of equation (19) for single-establishment firms. The assumption made on the location of real estate assets

leverages lessen firms' capacity to finance investment. Aggregating financial debt and cash holdings is an easy way to overcome this issue. Indeed, if proceeds from the loans are not used to finance investment in the contemporaneous accounting period, they will inflate cash holdings and have no impact on the net debt (computed as the financial debt minus the cash).

[27]Interpretations of β_1, β_2, β_3 and β_4 are derived from the model. The coefficient β_1 is expected to be positive if the sample contains constrained firms. It reflects the fact that constrained firms can relax their borrowing constraint through real estate assets pledging. As shown in section 2, the coefficient β_2 is expected to be negative for unconstrained firms and to depend on the amount of real estate units held by the constrained firms. The coefficient β_3 is also expected to be negative if the sample contains constrained firms. The coefficient β_4 is expected to be positive.

Table 2: Real estate holdings, prices and investment behavior - All firms

	(1)	(2)	(3)	(4)	(5)	(6)
NREH	.12***	.12***	.12***	.12***	.16***	.10***
	(.003)	(.004)	(.004)	(.004)	(.008)	(.005)
Real-Estate prices	.01	.035**	.029**	.034*	-.017	.087***
	(.006)	(.015)	(.014)	(.018)	(.029)	(.020)
Net debt	-.006***	-.006***	-.006***	-.005***	-.006***	-.002*
	(.001)	(.001)	(.001)	(.001)	(.002)	(.001)
TFP	.039***	.038***	.033***	.042***	.073***	.009
	(.005)	(.005)	(.005)	(.005)	(.012)	(.008)
Fixed effects:						
Firm fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes
Year dummies	No	Yes	No	Yes	Yes	Yes
Year×sector dummies	No	No	Yes	No	No	No
Observations	1,447,299	1,447,299	1,447,299	1,177,846	315,768	410,210
Adjusted R^2	.16	.16	.16	.14	.13	.20

Notes: $***$ when $pvalue < 0.01$, $**$ when $pvalue < 0.05$, $*$ when $pvalue < 0.10$.
Robust standard errors in brackets.

Notes: The dependent variable is capital expenditure net of real estate acquisition normalized by the PPE stock in year $t-1$. Column 1 is an OLS estimation of equation (19) without year dummies. Column 2 corresponds to the same equation but with year dummies. Column 3 introduces also year×sector dummies. Column 4 reports estimated parameters of equation (19) for single-establishment firms. Columns 5 and 6 present estimated parameters of equation (19) for "small" and "large" firms, respectively. Sources: FiBEn, *Banque de France*.

(the *département* where the firms are headquartered) is strong. Nevertheless, it is unquestionably true for firms operating only in one establishment. Splitting the sample between multiple and single-establishment firms allows to appraise the importance of this assumption. Estimates of the coefficients are largely unaffected when we restrict the sample to single-establishment firms. Columns 5 and 6 present parameter estimates of equation (19) for small and large firms, respectively.[28] The estimated coefficient associated with $NREH$ is higher for small firms than for large firms, and statistically significant at the 1 percent level in both samples. The effects of real estate prices hence appear to be heterogeneous. A comparison with the results found in the existing literature can be found in the appendix D.

As mentioned above, the group composed of non-real estate-holding firms includes also firms that might own some real estate assets through subsidiaries. Heterogeneity among this group may bias our estimates. We hence present in Table 3 the same estimates for the subsample of firms holding real estate assets.

[28] Small firms are defined as firms reporting, in the initial observation year, a revenue below the 25th percentile of revenues in the corresponding year, and large firms are the ones reporting an initial revenue above the 75th percentile.

Table 3: Real estate holdings, prices and investment behavior - Firms holding some real estate

	(1)	(2)	(3)	(4)	(5)	(6)
NREH	.17***	.17***	.17***	.17***	.22***	.14***
	(.003)	(.004)	(.004)	(.004)	(.008)	(.005)
Real estate prices	.027***	.057***	.051***	.057***	-.013	.075***
	(.006)	(.015)	(.014)	(.019)	(.038)	(.019)
Net debt	-.006***	-.006***	-.006***	-.006***	-.012***	.001
	(.001)	(.001)	(.001)	(.001)	(.002)	(.002)
TFP	.034***	.032***	.029***	.042***	.064***	.011
	(.005)	(.005)	(.005)	(.005)	(.014)	(.008)
Fixed effects:						
Firm fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes
Year dummies	No	Yes	Yes	Yes	Yes	Yes
Year×sector dummies	No	No	Yes	No	No	No
Observations	696,889	696,889	696,889	565,848	124,394	260,317
Adjusted R^2	.18	.18	.18	.16	.15	.20

Notes: $***$ when $pvalue < 0.01$, $**$ when $pvalue < 0.05$, $*$ when $pvalue < 0.10$.
Robust standard errors in brackets.

Notes: The dependent variable is capital expenditure net of real estate acquisition normalized by the PPE stock in year $t-1$. Column 1 is an OLS estimation of equation (19) without year dummies. Column 2 corresponds to the same equation but with year dummies. Column 3 introduces also year×sector dummies. Column 4 reports estimated parameters of equation (19) for single-establishment firms. Columns 5 and 6 present estimated parameters of equation (19) for "small" and "large" firms, respectively. Sources: Fiben, *Banque de France*.

To elaborate on heterogeneous effects of prices on corporate investment, we estimate equation (20) and report results in Table 4.

Column 1 reports OLS parameter estimates of equation (20) without year fixed effects. The coefficients associated with interactions between real estate prices and deciles of the sectoral $NREH$ distribution exhibit a pattern which is very much in line with our theoretical results. We observe a monotonic increase in the estimated values, going from negative values for the lowest decile to high positive values for the highest ones. While the investment of firms that have few real estate holdings compared to their sectoral peers is slightly negatively affected by an increase in real estate prices, the investment of those firms holding more real estate, relatively to their peers, is very significantly and positively impacted by increasing real estate prices. Estimated values of the coefficient associated with the other regressors remain largely unaffected by the introduction of interactions between real estate prices and $NREH$ deciles into the list of regressors. Column 2 corresponds to the same model but with year fixed effects. In column 3, we add year×sector fixed effects. Parameter estimates are similar for these three specifications. Results from our preferred estimation (column 2) imply that a 10% increase in real estate prices causes a 0.48 percentage point decrease in the investment rate of firms belonging to the lowest decile of the $NREH$ distribution, that is to say approximately 1% of the mean investment rate in the first $NREH$ decile, but a 3.1 percentage point increase in the investment rate of firms belonging to the highest decile, that is to say approximately 6% of the mean investment rate in the top $NREH$ decile. In column 4, we present estimated parameters of equation (20) for single-establishment firms only. Estimates are similar to those obtained for the whole sample (column 2, Table 4) except for the estimated parameter associated with the interaction terms between real estate prices and the lowest $NREH$ deciles. These results echo estimates reported in columns 5 and 6 which present estimates of the same equation for small and large firms, respectively. The negative effect of real estate price increases on the investment rate of firms located in the lowest deciles of the $NREH$ distribution is much higher for small firms than for large firms. This could result from differences in the intensity of the borrowing constraint between small and large firms. Moreover, there may be concern that the increase in the estimated coefficients associated with the interaction terms could result from the variability of firms' size across deciles. This point is further explored in section 4.2.

One can wonder whether the documented effect of real estate prices is identical when prices raise and fall. Overall, during the period studied in this paper (1994-2013), real estate prices have sharply increased in France. Unlike in many countries where, as in France, prices skyrocketed during the 2000s, the French real estate market didn't burst in the aftermath of the financial crisis. During the trough which occurred in 2009 $Q2$, prices (at the aggregate level) were only 9.2% below their peak level observed in 2008. This peak level was overtaken as soon as 2010. The studied period is not well suited to analyze the effect of falling prices. Nevertheless, we estimated our baseline equation over a ten-year sub-period,

Table 4: Real estate holdings, prices and investment behavior - Heterogeneous effects by decile of the distribution of real estate holdings

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
NREH	.11***	.11***	.11***	.11***	.13***	.10***	.15***	.11***	
	(.005)	(.005)	(.005)	(.005)	(.012)	(.007)	(.008)	(.009)	
NREH (instrumented prices)									.073***
									(.010)
Real estate prices	-.14***	-.048***	-.052***	-.073***	-.13***	-.013	.082**	-.019	-.52***
	(.015)	(.018)	(.018)	(.022)	(.046)	(.028)	(.034)	(.072)	(.091)
Real estate prices×dec2	.043***	.046***	.046***	.059***	.081**	.032	.003	-.011	.13**
	(.016)	(.016)	(.016)	(.016)	(.035)	(.030)	(.023)	(.048)	(.070)
Real estate prices×dec3	.035**	.04**	.041**	.051***	.048	.032	-.010	-.006	.12**
	(.018)	(.018)	(.018)	(.017)	(.035)	(.030)	(.022)	(.053)	(.072)
Real estate prices×dec4	.056***	.063***	.063***	.089***	.10**	.053*	.034	-.007	.16**
	(.018)	(.018)	(.018)	(.018)	(.040)	(.030)	(.025)	(.062)	(.075)
Real estate prices×dec5	.094***	.10***	.10***	.11***	.090**	.091***	.077***	.009	.20***
	(.019)	(.019)	(.019)	(.018)	(.036)	(.030)	(.025)	(.068)	(.073)
Real estate prices×dec6	.12***	.13***	.13***	.14***	.14***	.096***	.095***	.017	.28***
	(.019)	(.018)	(.018)	(.018)	(.036)	(.028)	(.026)	(.072)	(.070)
Real estate prices×dec7	.16***	.17***	.17***	.18***	.17***	.14***	.13***	.032	.36***
	(.020)	(.020)	(.020)	(.019)	(.037)	(.028)	(.025)	(.076)	(.075)
Real estate prices×dec8	.19***	.21***	.20***	.22***	.25***	.15***	.18***	.09	.47***
	(.021)	(.021)	(.021)	(.02)	(.039)	(.029)	(.026)	(.078)	(.079)
Real estate prices×dec9	.25***	.27***	.27***	.27***	.31***	.23***	.23***	.10	.57***
	(.020)	(.020)	(.020)	(.020)	(.043)	(.029)	(.028)	(.091)	(.081)
Real estate prices×dec10	.35***	.36***	.36***	.37***	.38***	.31***	.32***	.095	.78***
	(.023)	(.023)	(.023)	(.023)	(.051)	(.033)	(.036)	(.11)	(.099)
Net debt	-.006***	-.006***	-.006***	-.006***	-.012***	.001	-.009***	.005	-.007***
	(.001)	(.001)	(.001)	(.001)	(.003)	(.002)	(.002)	(.005)	(.002)
TFP	.032***	.034***	.032***	.043***	.063***	.014*	.031***	.035***	.045***
	(.005)	(.005)	(.005)	(.005)	(.014)	(.008)	(.008)	(.011)	(.009)
Fixed effects:									
Decile dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year dummies	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year×sector dummies	No	No	Yes	No	No	No	No	No	No
Observations	696,599	696,599	696,599	565,612	124,344	260,218	346,384	140,150	634,475
Adjusted R^2	.18	.18	.18	.17	.16	.20	.20	.23	.18

Notes: $***$ when $pvalue < 0.01$, $**$ when $pvalue < 0.05$, $*$ when $pvalue < 0.10$.
Robust standard errors in brackets from columns 1 to 8.
In column 9, we report in brackets standard errors bootstrapped within *département*-year clusters.

Notes: The dependent variable is capital expenditure net of real estate acquisition normalized by the PPE stock in year $t-1$. Column 1 is an OLS estimation of equation (20) without year dummies. Column 2 corresponds to the same equation with year dummies. Column 3 introduces also year×sector dummies. Column 4 reports estimated parameters of equation (20) for single-establishment firms. Columns 5 and 6 present estimated parameters of equation (20) for "small" and "large" firms, respectively. Columns 7 and 8 present estimated parameters of equation (20) for sub-periods 1999-2008 and 1994-1998, respectively. Column 9 reports IV estimates when real estate prices are instrumented by the interaction between real housing loan rate and the local elasticity of land supply estimated by Chappelle and Eyméoud, 2017. The first-stage regression is reported in Table 5. Sources: FiBEn, *Banque de France*.

1999-2008, when prices have steadily increased and have been multiplied by 2.5 times in real terms as well as over a five-year sub-period, 1994-1998, during which aggregate prices have slightly decreased. The result are presented in columns 7 and 8, Table 4, respectively. The heterogeneous effect across deciles is observed in both periods, but the effects of prices are not precisely estimated when prices stagnate and the magnitude of the estimates is also lower. The negative effect of real estate prices on the investment of firms in the first decile is not found in the booming period, potentially because of difficulties to disentangle investment opportunities and prices dynamics in that specific period.

As noted in the introduction of the paper, real estate prices may be correlated with the investment opportunities of real-estate-holding firms. Following Himmelberg, Mayer, and Sinai, 2005, CST, 2012, and Cvijanović, 2014, we try to address this source of endogeneity by instrumenting local real estate prices by the interaction between housing loan interest rates and local supply elasticity. This strategy relies on the idea that when housing loan interest rates decrease, the demand for real estate increases. If the local supply of land is very elastic, the increased aggregate demand will translate mostly into more construction rather than higher real estate prices. Conversely, if the supply of land is very inelastic, the increased demand will translate mostly into higher prices. We thus expect that in a *département* where land supply is more elastic, a drop in housing loan interest rate should have a larger impact on real estate prices (see our first-stage regression). For *département* d, in year t, we estimate the following equation for predicting real estate prices:

$$lnPrice_t^d = \gamma SupplyElasticity^d \times ir_t + \varepsilon_{it} \tag{21}$$

where $SupplyElasticity^d$ is the estimated supply elasticity at the *département* level and ir_t is the real interest rate at which banks lend to households at the aggregate level. ε_{it} are error terms clustered at the *département* level.

We use the local land supply elasticity estimated by Chappelle and Eyméoud, 2017, in a recent contribution. These authors replicate the method introduced by Saiz, 2010, for estimating the inverse supply elasticity at the urban area level. More precisely, they use a long difference in residential real estate prices and in population between 1999 and 2012. With the help of their estimates, we build the supply elasticity at the *département* level by weighting each urban area supply elasticity by its 2012 population share in the *département*. The housing loan rates at the aggregate level are provided by the *Banque de France*.

We then conduct an instrumental variable (IV) strategy where real estate prices are instrumented by the interaction between interest rates and supply elasticity. Estimated parameters of the first stage regression are presented in Table 5. We notice that a high supply elasticity is negatively associated with real estate prices. The estimated value of the coefficient γ is negative and statistically significant at the 1% level.

In the second-stage equation, we simply use predicted prices $ln\tilde{Price}_t^d$ obtained from the

Table 5: First-stage regression: supply elasticity, demand shock and real estate prices

	(1)
$SupplyElasticity^d \times IR_t$	-.11***
	(.009)
Observations	4,048
Adjusted R^2	.18

Notes: $***$ when $pvalue < 0.01$, $**$ when $pvalue < 0.05$, $*$ when $pvalue < 0.10$. Robust standard errors in brackets.

Notes: The dependent variable is the log of real estate prices in *département* d in year t. We use here the local supply elasticity estimated by Chappelle and Eyméoud, 2017, who replicate for France regressions proposed by Saiz, 2010. Sources: INSEE, and Chappelle and Eyméoud, 2017.

estimation of equation (21) and use them as an explanatory variable in equation (20). The real estate volume called *NREH(instrumented prices)* is computed with the instrumented price level at the date of acquisition. In column 9 of Table 4, we report second-stage estimated parameters. Because we construct our set of predicted prices with a different sample than the sample used for estimating our investment regression, we adjust standard errors to account for this issue. In Table 4, we thus report bootstrapped t-stats.[29] We obtain 2SLS estimates associated with prices whose absolute values are larger than those obtained with the OLS procedure, notably with respect to the negative effect of prices on investment for firms holding few real estate assets. One possible explanation for those differences may be that the 2SLS procedure allows to appropriately treat confounding factors that concomitantly affect prices and investment opportunities and may generate an upward bias in the negative effect of price increases.

Let us examine now the effect of real estate prices on the productive investment of firms holding no real estate (let us call them 'non-real estate-holding firms').

We first estimate equation (19) on the sub-sample of firm×year observations for which no real estate asset is reported (see column 1, Table 6). Real estate prices are found to be slightly positively correlated with corporate investment but the estimate is not statistically significant. Estimated coefficients associated with net debt and total factor productivity are similar to the ones found for the whole sample and both statistically significant at the

[29] Following CST, 2012, the bootstrap has been done as follows: we first draw a random sample with replacement within the sample of *département*×years; we run the first-stage regression with this sample; we then draw another random sample with replacement within the sample of firm×years; to correct for the correlation structure within this sample (*département*×year), this random draw is made at the *département*×year level, and not at the firm×year level. We randomly draw with replacement a *département*×year and then select all the firms within this *département*×year. We finally run our second-stage regression with this sample. We repeat this procedure 500 times, and the standard error we report corresponds to the empirical standard error of the 500 estimated coefficients.

Table 6: Real estate prices and investment behavior - Firms with no real estate

	(1)	(2)	(3)	(4)	(5)
Real estate prices	.012	.031	.001	-.18*	-.54*
	(.023)	(.025)	(.09)	(.11)	(.31)
Net debt	-.006***	-.006***	-.013***	-.010**	-.021***
	(.001)	(.001)	(.003)	(.004)	(.008)
TFP	.067***	.064***	.094***	.053*	.17***
	(.008)	(.008)	(.035)	(.029)	(.064)
Fixed effects:					
Firm fixed-effects	Yes	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes	Yes
Observations	750,410	634,765	37,160	73,259	37,351
Adjusted R^2	.15	.14	.18	.20	.18

Notes: $***$ when $pvalue < 0.01$, $**$ when $pvalue < 0.05$, $*$ when $pvalue < 0.10$.
Robust standard errors in brackets.

Notes: The dependent variable is capital expenditure net of real estate acquisition normalized by the PPE stock in year $t-1$. Column 1 reports estimates from the sample made of firm×year observations for which no real estate assets are reported. Column 2 corresponds to the same estimation on the sub-sample made of firms that have never held real estate. Columns 3 and 4 correspond to firms that report no real estate assets in the contemporaneous period but that have reported real estate before (column 3) or after (column 4). In column 5, we restrict the analysis to the 3 years preceding the acquisition. Sources: FiBEn, *Banque de France*.

1 percent level. We study further the effect of real estate prices on non-real estate-holding firms by splitting the firm×year observations into three categories:

- firms that have never reported real estate assets over the observation period (82,599 firms and 634,765 firm×year observations),
- firms that do not report real estate assets in the current period but had reported real estate assets before (6,637 firms and 37,160 firm×year observations),
- firms that do not report real estate assets in the current period but will acquire real estate assets afterward (15,598 firms and 73,259 firm×year observations).

Results are presented in columns 2, 3 and 4 of Table 6, respectively. We observe that real estate prices do not significantly affect productive investment of the first two categories but have a negative impact, statistically significant at the 10 percent level, on the last category. This negative effect of real estate prices on firms' investment is more pronounced if we restrict the analysis to the three years preceding real estate acquisition (column 5, Table 6). These results tend to show that non-real estate-holding firms are rather immune from real estate prices when they are not considering real estate acquisitions. The negative effect of an increase in real estate prices on capital investment could result from a crowding-out effect of planned real estate investment on current productive investments. These results can be alternatively explained by the above-mentioned measurement issue. More precisely, firms that initially report no real estate holdings and that, at some point in time, start reporting real estate assets in their balance sheet are unlikely to be involved in the legal separation of real estate holdings prior to the acquisition. Hence, even if the legal separation of real estate holdings blurs the effects of real estate prices for seemingly non-real estate-holding firms, we nevertheless expect that real estate prices have a negative impact on the investment of firms that report no real estate assets in the current period but acquire some later.

4.2 Complementary robustness checks

We have found that effects of real estate prices on corporate investment depend on the position of the firm in the $NREH$ sectoral distribution. However, this result could be biased if real estate holdings were correlated with the sensitivity of investment to local real estate prices. For example, we would overestimate the effect of real estate prices on investment for real estate-rich firm if those firms were more sensitive to the local economic condition. This issue of the sensitivity to local economic condition is partly addressed by the consideration of sectoral distributions for the variable $NREH$. Nevertheless, we can refine our analysis by introducing interaction terms between real estate prices and age, size or profit margin of the firm in equation (20). Indeed, if age, size or profitability are correlated with firms' real estate holdings as well as with firms' sensitivity to local economic conditions, the introduction of those interaction terms is required to properly identify the impact of real estate prices. The estimation results corresponding to this specification are presented in column 2 in Table 8 whereas column 1 reports our baseline estimates presented in column 2 in Table 4. Our results are largely unaffected by the introduction of these interactions terms.

A closely related issue is that firms in the same decile may have similar characteristics that could alternatively drive the results. We first produce descriptive statistics on firms' characteristics across the deciles. The median age of firms steadily increases with the level of real estate holdings. The age of the median non-real estate-holding firm is 13 years while the median firm that reports the highest level of real estate holdings is 28-year old (see Table 7). There is an inverted U-shaped relationship between the size of the firm (measured as the size of the balance sheet or the headcount) and the amount of real estate holdings. For real estate-holding firms, we observe a decreasing relationship between profitability (measured as the EBIT[30] margin) and the position in the $NREH$ distribution. However, the median profitability of no real estate firms is below the median profitability of the whole sample. The relationship between labor productivity and the position in the $NREH$ distribution presents similar patterns. Interestingly enough, the median labor productivity is lower in the two top deciles of the $NREH$ distribution, precisely the ones for which we find a sizable positive effect of real estate prices on investment.

Based on these findings on the determinants of real estate holdings, we then run additional robustness tests that aim at convincing the reader that the heterogeneous effects of prices are not driven by other observable characteristics that are correlated with real estate holdings. We first regress the firm level $NREH$ on a set of observable characteristics (age, size, profit) and year$\times$ *département*$\times$sector fixed effects.[31] We then calculate the estimated residuals, that is to say the component of the real estate in the firm's balance sheet that is uncorrelated with these regressors. We run our baseline regression by interacting real estate prices with the inclusion in deciles of the overall distribution of estimated residuals. Results are presented in column 3 in Table 8. They show that the unexplained real estate holdings determine the impact of real estate prices on corporate investments.

Another possible cause of concern could be that firms invest in real estate asset prior to invest in productive assets, which entails a spurious correlation, possibly varying with the level of real estate prices, between real estate holdings and subsequent productive investment. In order to ensure that this mechanism doesn't affect our results, we estimate equation (20) with lagged values of real estate holdings (3 and 4 years, respectively) in columns 4 and 5 of Table 8. These alternative specifications tend to alter the precision of estimates associated with interactions between prices and deciles of the distribution of estimated residuals even if we still obtain the same upward trend.

[30]Earning Before Interest and Tax.

[31]Estimates obtained in the first stage are unreported but are available upon request

Table 7: Descriptive statistics per $NREH$ decile

	Age	Size of BS	Headcount	EBIT marg.	Labor prod.
No real estate	13	0.9	13	.051	51.7
Decile 1	13	1.5	22	.060	49.2
Decile 2	14	1.4	20	.058	49.4
Decile 3	15	1.5	20	.058	49.8
Decile 4	16	1.6	20	.059	50.2
Decile 5	17	1.6	21	.059	49.6
Decile 6	18	1.7	22	.059	49.4
Decile 7	20	1.7	22	.057	49
Decile 8	22	1.6	22	.055	48.5
Decile 9	24	1.6	21	.051	47.7
Decile 10	28	1.4	19	.043	45.8
Overall	16	1.1	16	.053	50.2

Notes: The median age is expressed in year and the median size of the balance sheet in millions of euros. The headcount is the number of full time equivalent jobs at the end of the year. The EBIT margin is the ratio of the Earning Before Interest and Tax on Sales. The (apparent) labor productivity is the wage bill in thousands of euros divided by the headcount. Sources: FiBEn, *Banque de France*.

As mentioned above, real estate prices are likely to be correlated with local investment opportunities. Our empirical strategy relies on the comparison of the investment of firms facing the same local economic conditions but varying exposition to real estate prices because of different real estate holdings. The efficiency of this difference-in-differences strategy for differentiating the effects of real estate prices on investment from the impact of local economic impetus can be assessed by stratifying firms belonging to tradable and non-tradable sectors. Indeed, firms operating in tradable sectors are likely to be less affected by local economic condition while they are similarly affected by real estate prices' fluctuations through the profit and the collateral channels. Estimated parameters of equation (20) for firms operating in tradable sectors are presented in column 6 of Table 8, results for firms operating in non-tradable sectors are presented in column 7. The sign and the magnitude of the estimates associated with prices are similar in the two sub-samples. We also would like to account for other local economic variables that are likely to affect corporate investment and to be correlated with real estate prices. Local unemployment rate at the *département* level is provided by INSEE (Paris) for the whole observation period. We then estimate equation (20) when adding a variable corresponding to the local unemployment rate in the *département* where the firm i is headquartered in year t. Results are reported in column 8 of Table 8. We obtain an expected negative and statistically significant estimate for the coefficient associated with the local unemployment rate. Other estimates are not altered by the introduction of this covariate.[32]

We do not tackle the issue of attrition because we do not have precise information on the reasons why firms enter or exit the sample. Nevertheless, to ensure that the moves in and out of the sample do not affect our results, we estimate our preferred equation (column 1, Table 9), on a balanced panel in which firms are observed each year from 1994 onwards. Results are reported in column 2, Table 9. Our findings concerning the impact of prices are robust to this restriction. In columns 3 and 4 of Table 9, we present estimated parameters of our baseline estimation conducted on two subperiods of equal length, 1994-2003 and 2004-2013, respectively. The estimated coefficient associated with the $NREH$ variable increases during the second half of the observation period, which suggests that firms may have faced fiercer credit constraint during this subperiod. Columns 5 and 6 report estimated parameters obtained when the amortization rate used to build $NREH$ series is 3% and 5% per year, respectively, instead of 4% per year in our baseline estimation. The estimates are unaffected, except for the coefficient associated with the $NREH$ variable. This coefficient mechanically increases with the depreciation rate as, in the context of an overall sharp increase in real estate prices, the older the acquisition date the higher the proxied real estate volume. Column 7 corresponds to the subsample without firms headquartered in *Ile-de-France* (Paris region) which appears to be an outlier with respect to real estate prices evolution (see Figure 2 in Appendix C). Column 8 shows that considering an alternative measure of TFP, that is to say residuals from simple OLS regression at 2-digit level, has no impact on our results. We have also run unreported regressions (that are available upon request) where we use an alternative construction of the $NREH$ deciles, namely by considering the overall distribution instead of the sectoral ones. We found no difference with our baseline estimates.

4.3 The effect of real estate prices on arguably unconstrained firms

The prediction of the theoretical model regarding the differentiated impact of real estate prices on financially constrained or unconstrained firms has not been empirically explored so far. Even if the empirical counterpart of a financially constrained firm as defined in the theoretical model is not straightforward, we try to tackle this issue by finding a relevant way to stratify our sample by distinguishing constrained and unconstrained firms.

To do so, we rely on the "*cotation*" of the *Banque de France*. The "*cotation*" is a rating that classifies companies according to their financial strength and capacity to meet their financial commitments. There are eight possible grades that can be given to a firm. The closer the firm is to category 1, the healthier it is as judged by the *Banque de France*. This rating is mainly updated by experts; it is calculated by using a balance sheet based formula

[32] In unreported regressions, we find that, when we interact the local unemployment with the $NREH$ deciles, none of the coefficients associated with the interacted terms is statistically significant.

Table 8: Real estate holdings, prices and investment behavior - Robustness checks (1)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
NREH	.11***	.11***	.14***	.028***	.012**	.09***	.12***	.11***
	(.005)	(.005)	(.0044)	(.004)	(.005)	(.005)	(.006)	(.005)
Real estate prices	-.048***	-.14***	.0052	-.026	-.016	-.054**	-.035	-.056***
	(.018)	(.019)	(.019)	(.020)	(.023)	(.026)	(.025)	(.019)
Real estate prices×dec2	.046***	.041***	-.019	.007	-.006	.051**	.037*	.046***
	(.016)	(.008)	(.014)	(.016)	(.017)	(.023)	(.019)	(.016)
Real estate prices×dec3	.04**	.031*	-.053***	.009	.013	.037	.034	.039**
	(.018)	(.018)	(.015)	(.016)	(.017)	(.023)	(.022)	(.018)
Real estate prices×dec4	.063***	.050***	-.022	.020	.015	.039*	.065***	.063***
	(.018)	(.018)	(.017)	(.015)	(.018)	(.023)	(.024)	(.018)
Real estate prices×dec5	.10***	.086***	-.022	.052***	.030*	.067***	.11***	.10***
	(.019)	(.019)	(.014)	(.017)	(.017)	(.023)	(.026)	(.019)
Real estate prices×dec6	.13***	.11***	.0039	.081***	.049***	.099***	.13***	.13***
	(.018)	(.019)	(.015)	(.018)	(.018)	(.021)	(.025)	(.018)
Real estate prices×dec7	.17***	.15***	.028*	.085***	.089***	.15***	.17***	.17***
	(.020)	(.020)	(.015)	(.017)	(.017)	(.022)	(.028)	(.020)
Real estate prices×dec8	.21***	.18***	.07***	.12***	.10***	.18***	.20***	.21***
	(.021)	(.021)	(.014)	(.018)	(.018)	(.022)	(.029)	(.021)
Real estate prices×dec9	.27***	.24***	.16***	.19***	.13***	.22***	.27***	.27***
	(.020)	(.020)	(.017)	(.019)	(.019)	(.024)	(.027)	(.020)
Real estate prices×dec10	.36***	.33***	.27***	.21***	.15***	.28***	.37***	.36***
	(.023)	(.024)	(.020)	(.020)	(.023)	(.029)	(.030)	(.023)
Net debt	-.006***	-.006***	-.0057***	-.007***	-.010***	-.005**	-.006***	-.006***
	(.001)	(.001)	(.0013)	(.001)	(.001)	(.002)	(.001)	(.001)
TFP	.034***	.036***	.033***	.043***	.036***	.10***	.001	.034***
	(.005)	(.005)	(.0051)	(.006)	(.008)	(.008)	(.007)	(.005)
Unemployment rate								-.0077***
								(.0027)
Real estate prices×age		.0038***						
		(.0002)						
Real estate prices×size		-.000056						
		(000044)						
Real estate prices×profit		.0078						
		(.0063)						
Fixed effects:								
Decile dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	696,599	693,734	694,436	567,189	499,283	253,635	442,964	696,599
Adjusted R^2	.18	.18	.18	.17	.17	.15	.19	.18

Notes: $***$ when $pvalue < 0.01$, $**$ when $pvalue < 0.05$, $*$ when $pvalue < 0.10$.
Robust standard errors in brackets.

Notes: The dependent variable is capital expenditure net of real estate acquisition normalized by the PPE stock in year $t-1$. Column 1 is our benchmark result; that is to say column 2 in Table 4. Column 2 is an OLS estimation of equation (20) where we add interaction terms between real estate prices and the firm's age, the size of the balance sheet and the profit margin. In column 3, deciles correspond to the position of the firm in the distribution of the residuals estimated from a first-stage equation where the firm level $NREH$ is regressed on a set of observable characteristics (age, size, profit) and year × *département* × sector fixed effects. Columns 4 and 5 present estimated parameters of equation (20) with lagged values for real estate holdings (3 and 4 years, respectively). Column 6 reports estimated parameters of equation (20) for firms operating in tradable sectors (manufacturing sectors) whereas column 7 reports results for firms operating in non-tradable sectors (non-manufacturing sectors). Column 8 presents estimated parameters of equation (20) when we control for the unemployment rate at the *département*'s level. Sources: FiBEn, *Banque de France*.

Table 9: Real estate holdings, prices and investment behavior - Robustness checks (2)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
NREH	.11***	.11***	.10***	.18***	.057***	.16***	.11***	.11***
	(.005)	(.008)	(.008)	(.008)	(.003)	(.006)	(.005)	(.005)
Real estate prices	-.048***	-.052*	-.002	-.11***	-.050***	-.044***	-.094***	-.047***
	(.018)	(.028)	(.035)	(.035)	(.018)	(.019)	(.022)	(.016)
Real estate prices×dec2	.046***	.019	.024	.047*	.041***	.048***	.028	.046***
	(.016)	(.026)	(.032)	(.028)	(.015)	(.017)	(.018)	(.016)
Real estate prices×dec3	.04**	.015	.011	.051	.032**	.041**	.021	.04**
	(.018)	(.028)	(.037)	(.035)	(.016)	(.017)	(.019)	(.018)
Real estate prices×dec4	.063***	.011	.059*	.093**	.057***	.073***	.031	.062***
	(.018)	(.025)	(.035)	(.036)	(.018)	(.018)	(.020)	(.018)
Real estate prices×dec5	.10***	.058**	.078**	.17***	.093***	.089***	.059***	.10***
	(.019)	(.024)	(.036)	(.038)	(.018)	(.018)	(.019)	(.019)
Real estate prices×dec6	.13***	.039*	.13**	.15***	.11***	.14***	.11***	.13***
	(.018)	(.022)	(.038)	(.040)	(.020)	(.018)	(.020)	(.018)
Real estate prices×dec7	.17***	.10***	.18***	.22***	.16***	.17***	.14***	.17***
	(.020)	(.023)	(.041)	(.042)	(.019)	(.020)	(.019)	(.020)
Real estate prices×dec8	.21***	.11***	.23***	.25***	.19***	.21***	.18***	.21***
	(.021)	(.024)	(.043)	(.048)	(.020)	(.023)	(.020)	(.021)
Real estate prices×dec9	.27***	.18***	.29***	.28***	.26***	.26***	.26***	.27***
	(.020)	(.023)	(.045)	(.076)	(.020)	(.020)	(.021)	(.020)
Real estate prices×dec10	.36***	.29***	.34***	.37***	.36***	.35***	.36***	.36***
	(.023)	(.029)	(.052)	(.051)	(.022)	(.024)	(.025)	(.023)
Net Debt	-.006***	-.010***	-.002	-.011***	-.006***	-.006***	-.006***	-.005***
	(.001)	(.002)	(.003)	(.002)	(.001)	(.001)	(.001)	(.001)
TFP	.034***	.054***	.026***	.025***	.035***	.034***	.038***	.15***
	(.005)	(.009)	(.007)	(.008)	(.005)	(.005)	(.005)	(.005)
Fixed effects:								
Decile dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	696,599	207,692	300,284	396,315	697,243	696,599	586,863	696,599
Adjusted R^2	.18	.14	.19	.21	.18	.18	.17	.18

Notes: $***$ when $pvalue < 0.01$, $**$ when $pvalue < 0.05$, $*$ when $pvalue < 0.10$.
Robust standard errors in brackets.

Notes: The dependent variable is capital expenditure net of real estate acquisition normalized by the PPE stock in year $t-1$. Column 1 is our benchmark result; that is the column 2 in Table 4. Column 2 reports estimated parameters of equation (20) with a balanced panel where all the firms are observed from the year 1994 onwards. Columns 3 and 4 present estimated parameters of the same equation over two sub-periods, 1994-2003 and 2004-2013, respectively. Columns 5 and 6 report estimated parameters obtained when the amortization rate used to build the $NREH$ variable is 3% and 5% per year, respectively, vs 4% in the baseline regression. Column 7 corresponds to a sample where the firms headquartered in the Paris area are not included. Column 8 uses an alternative measure of the TFP, namely the estimated residual of a simple OLS regression at the 2-digit level. Sources: FiBEn, *Banque de France*.

and through on-site visits and interviews. On average, it is updated every 14 months, but it can be updated more frequently in some cases. All private banks can have access to this rating; they use it when deciding to grant a credit. Evidence shows that this rating is a good indicator of a firm's default risk. It is hence a relevant candidate to detect the level of the credit constraint faced by a firm.

In our sample, the best credit rating category corresponds to 13.6% of the observations. We build a sample exclusively composed of firms characterized by a top credit rating in order to isolate firms that are arguably the less credit constrained ones. We then run our baseline regressions on these two distinct samples, one made of top credit rating firms and one made of the other firms. Results are presented in the first and the second columns of Table 10.

Notice that, broadly in accordance with our theoretical predictions, the effect of prices on arguably unconstrained firms is less affected by real estate holdings.

4.4 The impact of using residential real estate prices

As already mentioned, due to data limitations at the local level, we use residential prices and not commercial corporate real estate prices that would have been better suited to empirically validate our theoretical model.

To assess whether this approximation affects our results, we run our baseline specification on a sub-sample made of small and medium firms in the service industry. We argue that the corporate real estate used and held by this sub-group of firms shares similarities with the residential real estate, as their real estate lies on the same premises and shares the same technical characteristics (as opposed to factories for example). Results are reported in column 3 of Table 10. The statistical significance of some estimates is affected by the reduction of the sample size but the pattern of the estimated coefficients associated with real estate prices in each decile is unaltered.

Besides comovements between residential real estate prices and corporate real estate prices, our analysis rests on a constant price-to-rent ratio over time, all other controls included in the regression being equal. We indeed posit in the theoretical framework that a change in real estate prices affects renters because of the concomitant and proportional change in the renting rate of real estate. At the aggregate level, prices and rents may diverge, but part of this divergence is captured in our model through our controls; in particular, interest rates fluctuations, which explain part of the divergence between rents and prices, are captured through year dummies. We do not have precise data on rents at the local level. We nevertheless try to build rent indices at the regional level based on Enquète Logement, a survey conducted every 4 or 5 years by INSEE (Paris) that covers more that 50,000 dwellings. Those rent indices are not fully satisfactory because the survey is not necessarily representative at the regional level. We notably have to exclude some regions because they correspond to a small number of observations. Doing this, we lose two thirds of our observations when merging the data sets. As a robustness check, we add to our baseline regression interaction terms between local rents[33] and the $NREH$ deciles. We present estimated results in column 4 of Table 10. The effects of local rents are not precisely estimated but we notice that the pattern of the interaction terms between real estate prices and the deciles is not affected.

4.5 The borrowing capacity channel and other real effects of real estate prices

In our model, the effect of real estate prices on productive investment of constrained firms is channeled through changes in the firms' borrowing capacity. For unconstrained firms, real estate prices may also affect (negatively) the level of debt if investment is not internally financed. Hence, we should observe similar results with regards to the impact of the different explanatory variables on investment and on new bank loans. Unfortunately, the balance sheet data do not provide information on the new bank loans. We only observe the amount of outstanding bank loans in each period. The variation in this amount results from new loans as well as debt repayments. As we can not disentangle those two components, we consider the positive variation in the amount of outstanding loan as a proxy for new loans. We estimate the following equation:

$$\begin{aligned} \Delta Debt_{it} &= \alpha_i + \gamma_t + \beta_1 NREH^d_{it-1} + \textstyle\sum_{j=1}^{10} \beta_2^j D^j_{it-1} lnPrice^d_t + \sum_{j=1}^{10} \lambda_j D^j_{it-1} \\ &+\beta_3 NetDebt_{it-1} + \beta_4 TFP_{it-1} + \epsilon_{it} \end{aligned} \tag{22}$$

where $\Delta Debt_{it}$ is the difference between the outstanding bank loans in period t and the outstanding bank loans in period $t-1$ if this difference is positive, 0 otherwise. This difference is normalized by the PPE stock in period $t-1$.

We report estimated parameters of equation (22) in the fifth column of Table 10. Estimates of the coefficients associated with interacted real estate prices present a pattern similar to the one obtained for the investment equation, even though the effects in the highest deciles are slightly lower. With the exceptions of coefficients associated with the net debt and the TFP, which are not statistically significant, the signs of the estimates are in line with the theory and with those obtained for the investment equation. This result tends to validate the idea that real estate prices affect investment through their effect on firms's borrowing capacity.

The available data also allows to explore the impact of real estate prices on real estate investment and on employment. We estimate equation (22) by successively replacing the dependant variable $\Delta Debt_{it}$ by the real estate investment $REinv_{it}$, that we proxy by the

[33] We recover local rents from the survey by computing local yearly means of new contracts.

positive variation in the gross value of real estate assets, and the employment variation ΔEmp_{it}, that is the percentage change in the FTE workforce in period t. Results are reported in the sixth and the seventh columns of Table 10. Estimates obtained when real estate investment is the dependent variable markedly differ from the ones obtained with productive investment. Although estimated coefficients associated with the $NREH$ variable, the net debt and the TFP have the same signs, the last two estimates are not statistically significant. Estimates associated with interacted real estate prices present a U-shaped pattern. The positive impact of prices on real estate investment in the lowest and the two highest deciles is not statistically significant, but the negative impact is statistically significant between the third decile and the seventh decile. This result suggests that the demand for real estate assets of firms holding few real estate assets is less price sensitive.

Results concerning employment growth are in line with the ones obtained for productive investment. We find that the employment growth of firms located in the lowest decile of the $NREH$ distribution is reduced by 0.16 percentage point when real estate prices increase by 10%, whereas this growth rate is increased by 0.08 percentage point for firms located in the highest decile. It is noticeable that the negative impact of a price increase on employment growth is observed over a larger share of the $NREH$ distribution (up to the eighth decile) than when the dependent variable is investment.

4.6 Discussion on aggregate effects of real estate prices

It is widely known that real estate assets can be used to enhance corporate financing. This generates a channel through which real estate prices affect corporate investment. We have shown that real estate prices might also affect investment through a profit channel. These collateral and profit channels pull investment in opposite directions. Using our simple theoretical model, we have shown that the dominant channel depends on the structure of the firm's assets. Our empirical findings support this theoretical prediction. We find that a rise in real estate prices negatively affects the investment of firms holding few real estate assets in comparison to their sectoral peers, while a similar rise has a significant positive impact on the investment of firms reporting more real estate assets than their sectoral peers. We have highlighted that the reaction of employment to changes in real estate prices present a similar pattern as that of investment. These heterogeneous effects of real estate prices may distort the allocation of investment and employment growth across firms and affect aggregate investment, aggregate production and aggregate TFP. To tackle these issues, we first provide a quick quantification exercise. This exercise, based on reduced form estimates, is performed to give a sense of the magnitude of the economic effects, it is not intended to constitute a precise evaluation.

The impact of an exogenous shock on prices, affecting all firms, on aggregate investment can be obtained by summing individual impacts across firms. Let's denote I the aggregate

Table 10: Robustness checks - Heterogeneous financial constraints, real estate prices and other real effects

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
NREH	.11***	.22***	.18***	.12***	.063***	.024***	.0024***
	(.0048)	(.027)	(.01)	(.011)	(.005)	(.003)	(.0007)
Real estate prices	-.039**	-.16	-.072	-.073*	-.041***	.013	-.016***
	(.019)	(.15)	(.085)	(.039)	(.015)	(.011)	(.005)
Real estate prices×decile 2	.042***	.08	.082	.071**	.013	-.017	.0006
	(.016)	(.11)	(.062)	(.028)	(.015)	(.009)	(.003)
Real estate prices×decile 3	.035*	.17	.064	.054*	.003	-.036***	.005
	(.019)	(.11)	(.065)	(.032)	(.017)	(.010)	(.004)
Real estate prices×decile 4	.059***	.29**	.078	.082**	.012	-.045***	.002
	(.019)	(.13)	(.075)	(.032)	(.017)	(.012)	(.04)
Real estate prices×decile 5	.097***	.38***	.147**	.14***	.038**	-.039***	.006*
	(.02)	(.13)	(.072)	(.033)	(.017)	(.011)	(.004)
Real estate prices×decile 6	.12***	.43***	.156**	.13***	.057***	-.031***	.007*
	(.019)	(.16)	(.066)	(.034)	(.017)	(.011)	(.004)
Real estate prices×decile 7	.16***	.37**	.183**	.19***	.071***	-.023**	.011***
	(.021)	(.15)	(.077)	(.036)	(.017)	(.011)	(.004)
Real estate prices×decile 8	.2***	.38***	.194**	.24***	.10***	-.013	.014***
	(.021)	(.14)	(.078)	(.039)	(.019)	(.011)	(.004)
Real estate prices×decile 9	.26***	.37**	.301***	.29***	.12***	.009	.017***
	(.021)	(.15)	(.084)	(.038)	(.023)	(.020)	(.006)
Real estate prices×decile 10	.35***	.38**	.383***	.39***	.18***	.021	.025***
	(.024)	(.16)	(.091)	(.046)	(.028)	(.014)	(.004)
Rents				YES			
Rents×deciles				YES			
Net debt	-.0035***	-.036***	-.007**	-.005**	.0004	-.0006	-.0002
	(.0013)	(.0056)	(.003)	(.002)	(.002)	(.001)	(.0001)
TFP	.036***	-.042	.114***	.033***	-.0005	.003	.063***
	(.0053)	(.028)	(.026)	(.01)	(.005)	(.004)	(.005)
Fixed effects:							
Decile dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	639198	57401	66,105	235,009	711,325	711,325	711,325
Adjusted R^2	.18	.28	.28	.30	.16	.02	.03

Notes: $***$ when $pvalue < 0.01$, $**$ when $pvalue < 0.05$, $*$ when $pvalue < 0.10$.
Robust standard errors in brackets.

Notes: In columns 1 to 4, the dependent variable is capital expenditure net of real estate acquisition normalized by the PPE stock in year $t-1$. Column 1 contains all firms except those receiving a top credit rating in the *Banque de France* classification; they are deemed credit constrained in this analysis. Column 2 includes firms with the top credit rating; they are deemed to be financially unconstrained. Column 3 uses a sample only made of small and medium firms operating in the service industry. Column 4 introduces local rents interacted with the deciles of the $NREH$ distribution. In column 5, the dependent variable is the difference between the outstanding bank loans in period t and the outstanding bank loans in period $t-1$ normalized by the PPE stock in period $t-1$. In column 6, it is the difference between the the gross value of real estate assets in period t and the the gross value of real estate assets in period $t-1$ normalized by the PPE stock in period $t-1$. In column 7, it is the percentage change in the FTE workforce in period t.. Sources: FiBEn, *Banque de France*.

investment defined as $I = \sum_i i_{i,j}$, where $i_{i,j}$ is the investment of firm i ranged in the j-th decile of the $NREH$ sectoral distribution. We hence have $\frac{\partial I}{\partial lnPrice} = \sum_i \frac{\partial i_{i,j}}{\partial lnPrice} = \sum_i \beta_2^j k_{i,j}$, where β_2^j is the estimated coefficient associated with real estate prices in equation (20). This coefficient is reported in column 2 of Table 4, for a firm located in the j-th decile of the $NREH$ distribution; $k_{i,j}$ is the PPE stock of firm i. Normalizing by I, we obtain the elasticity of aggregate investment with respect to real estate prices. From our data, we obtain an elasticity of 0.14, which implies that a 10% increase in real estate prices entails a jump by 1.4% in investment. This increase translates into a short term elasticity of aggregate capital whith respect to real estate prices which is equal to 0.056.[34]

We now turn to the impact of price shocks on aggregate production. For the sake of simplicity, we consider a Cobb-Douglas technology that only uses fixed assets and labor as inputs, that is to say $y_{i,j,s} = \theta_{i,j,s} k_{i,j,s}^{\alpha_s} l_{i,j,s}^{\beta_s}$, where indices i, j, s correspond to the firm i operating in sector s and pertaining to the j-th decile of the $NREH$ sectoral distribution. Parameters of the production function are estimated separately for each 2-digit sector. We denote Y the aggregate production defined as $Y = \sum_i y_{i,j,s}$. The aggregate effect of prices on production can be recovered by summing the impact across firms. It can be shown that $\frac{\partial Y}{\partial lnPrice} = \sum_i (\alpha_s \frac{\partial k_{i,j,s}/k_{i,j,s}}{\partial lnPrice} + \beta_s \frac{\partial l_{i,j,s}/l_{i,j,s}}{\partial lnPrice})\, y_{i,j,s} = \sum_i (\alpha_s \beta_{2,inv}^j + \beta_s \beta_{2,emp}^j)\, y_{i,j,s}$, where $\beta_{2,inv}^j$ and $\beta_{2,emp}^j$ are the estimated coefficients associated with real estate prices, respectively reported in column 2 of Table 4 and in column 7 of Table 10, for a firm pertaining to the j-th decile of the $NREH$ distribution. Normalizing by Y, we find an elasticity of aggregate production to real estate prices equal to .003. This very low elasticity results from the employment contraction following a price increase for a large share of firms.[35] The negative impact of real estate prices on aggregate employment, along with a positive impact on aggregate investment, cannot easily be accounted for by a model without labor and housing markets because, in a simple optimal investment model, the link between real estate prices and employment can only be channeled through complementarities between fixed capital and labor. Housing prices and wages being intertwined, an increase in real estate prices is likely to be associated with an increase in labor costs that has a direct negative effect on labor demand. Precisely assessing the magnitude of this direct effect is beyond the scope of this paper.

Finally, we compute the effect of a price increase on the aggregate TFP. As mentioned above, because of its interaction with the credit friction, a price increase may affect allocation of inputs across firms in a way that damage aggregate productivity. Let us define the share-weighted aggregate TFP as $\Theta = \sum_i \frac{y_{i,j,s}}{Y} \theta_{i,j,s}$. We have $\frac{\partial \Theta}{\partial lnprice} = \sum_i \frac{1}{Y^2} \theta_{i,j,s} (\frac{\partial y_{i,j,s}}{\partial lnprice} Y - \frac{\partial Y}{\partial lnprice} y_{i,j,s})$. We can compute $\frac{\partial \Theta}{\partial lnprice}$ by using our estimates and our database. We find an elasticity equal to $-.004$.

[34]Computations are made with a sample composed of all real estate holding firms over the whole period.

[35]In a similar way, we can compute the elasticity of aggregate employment with respect to real estate prices; it is found to be equal to -0.009.

It is important to notice that this simple analysis doesn't take into account the effect of prices on business creation. A related literature has highlighted that real estate prices may affect small business creations and self-employment. Adelino, Schoar, and Severino (2015) find that the increase in real estate prices has enhanced growth in employment by easing small business starts in the US between 2002 and 2007. Schmalz, Sraer, and Thesmar (2013) combine local housing prices with micro-level data on home ownership by entrepreneurs. They find that differences in the size of businesses created by homeowners and renters and the propensity to start a business are larger in regions where housing prices have significantly increased. We do not address this question in this study, even though such mechanisms could matter.

5 Conclusion

The present paper has investigated the effect of real estate prices on productive investment through a theoretical framework and an empirical validation with a large French firm-level database.

Our theoretical framework models firms' investment with credit rationing and with real estate assets that can be used as collateral but also as inputs in the production process. Real estate prices operate through two channels with opposite effects on borrowing capacities of credit-constrained firms. Through the first channel, an increase in real estate prices raises the market value of firms' pledgeable assets and facilitates their access to credit. Through the second channel, this increase raises the cost of structures, decreasing expected profit and damaging borrowing capacities. As a result, the impact of an increase in real estate prices on credit-constrained firms depends on firms' characteristics, the level of real estate holdings being the main determinant.

Our empirical analysis has validated our main theoretical predictions. The impact of real estate prices on productive investment is globally positive, although modest and weakly robust. Considering firms' heterogeneity, we do find a negative impact for firms in the lower part of the sectoral distribution of real estate ownership, and a positive impact in the upper part. These results suggest that French firms have faced binding borrowing constraints over the studied period.

Hence, real estate price fluctuations affect resources allocation. Future research could hence focus on the impact of real estate changes on productivity dynamics, specifically through entry/exit processes.

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6 Appendix

6.1 Appendix A: Proof of proposition 1

We know that $i^*$and R^* maximize the objective function. Let the function $V(i,R)$ denote the value of the objective function associated with an investment i and a number of real estate units R. By definition, $\forall (g,h) \in \mathbb{R}^2$, $V(i^*+g, R^*+h) - V(i^*, R^*) \leq 0$. A second-order Taylor approximation of the function V around (i^*, R^*) gives:

$$\begin{aligned} V(i^* + g, R^* + h) - V(i^*, R^*) \approx \; & \frac{y_{kk}(k^*, R^*, \theta)}{1+r} g^2 \\ & + 2\frac{y_{kR}(k^*, R^*, \theta)}{1+r} gh + \frac{y_{RR}(k^*, R^*, \theta)}{1+R} h^2 \end{aligned} \tag{23}$$

Dividing by h^2 we get:

$$\begin{aligned} \frac{V(i^* + g, R^* + h) - V(i^*, R^*)}{h^2} \approx \; & \frac{y_{kk}(k^*, R^*, \theta)}{1+r} \frac{g^2}{h^2} \\ & + 2\frac{y_{kR}(k^*, R^*, \theta)}{1+r} \frac{g}{h} + \frac{y_{RR}(k^*, R^*, \theta)}{1+R} \end{aligned} \tag{24}$$

We know that, $\forall g \in \mathbb{R}, \forall h \in \mathbb{R}^*$:

$$\frac{V(i^* + g, R^* + h) - V(i^*, R^*)}{h^2} < 0 \tag{25}$$

Hence we can write:

$$\left(2\frac{y_{kR}(k^*, R^*, \theta)}{1+r}\right)^2 - 4\frac{y_{kk}(k^*, R^*, \theta)}{1+r} \frac{y_{RR}(k^*, R^*, \theta)}{1+r} < 0 \tag{26}$$

and eventually:

$$\frac{y_{kR}(k^*, R^*, \theta)^2}{y_{RR}(k^*, R^*, \theta)} - y_{kk}(k^*, R^*, \theta) > 0 \tag{27}$$

6.2 Appendix B: Proof of proposition 2

Let F be a function of i, with $i \in [0, i^*]$ such that:

$$F(i) = (1+r) + \frac{L - S + pR_0}{L} \left(y(k_0 + i, R, \theta) - rp(R - R_0)\right) - (1+r)i - (1+r)B_0 \tag{28}$$

We get:

$$\frac{\partial F}{\partial i}(i) = \frac{L - S + pR_0}{L} y_k(k_0 + i, R, \theta) - (1+r) \tag{29}$$

and:

$$\frac{\partial^2 F}{\partial i \partial i}(i) = \frac{L - S + pR_0}{L} y_{kk}(k_0 + i, R, \theta) \tag{30}$$

From the properties of the function y, we deduce that $\forall i \in [0, i^*]$, $\frac{\partial^2 F(i)}{\partial i \partial i} < 0$. We know that, in the constrained case, $\frac{L-S+pR_0}{L} \in [0,1]$. From the first equation in system (6), we know that $\frac{\partial F}{\partial i}(i^*) < 0$.

We distinguish two cases:

- If $\frac{\partial F}{\partial i}(0) < 0$, we conclude that, $\forall i \in [0, i^*]$:

$$(1 + r) - \frac{L - S + pR_0}{L} y_k(k_0 + i, R, \theta) > 0 \tag{31}$$

- If $\frac{\partial F}{\partial i}(0) \geq 0$, we know that there exists a unique threshold $\tilde{i} \in [0, i^*)$ such that $\frac{\partial F}{\partial i}(i) < 0$ if and only if $i > \tilde{i}$. The function F is increasing on the interval $[0, \tilde{i}]$ and decreasing on the interval $[\tilde{i}, i^*]$. The constraint concerning the initial amount of debt, i.e., $\frac{L-S+pR_0}{L}(y(k_0, R, \theta) - c_{re}(R)) \geq (1 + r)B_0$, insures that $F(0) > 0$ and we deduce from the variation of F that the value i satisfying $F(i) = 0$ belongs to the interval $(\tilde{i}, i^*]$. Thus, when i denotes the investment in the constrained case, we also have:

$$(1 + r) - \frac{L - S + pR_0}{L} y_k(k_0 + i, R, \theta) > 0 \tag{32}$$

We conclude that the sign of $\frac{\partial i}{\partial p}$ is determined by the sign of $P(R_0)$.

The discriminant of the polynomial P is strictly positive and $P(0) < 0$. We know that P has a unique positive real root $\bar{R}$. So we conclude that $\frac{\partial i}{\partial p} \geq 0$ if and only if $R_0 \geq \bar{R}$, with:

$$\bar{R} = \frac{2prR - y(k, R, \theta) - r(L - S) + \sqrt{[y(k, R, \theta) - 2rpR + r(L - S)]^2 + 8r^2 p(L - S)R}}{4rp} \tag{33}$$

Note that the relative position of $\bar{R}$ with respect to $\frac{S}{p}$ depends on the parameters value and the functional form of y.

The sign of $\frac{\partial i}{\partial R_0}$, $\frac{\partial i}{\partial c_0}$, $\frac{\partial i}{\partial B_0}$ and $\frac{\partial i}{\partial \theta}$ can be obtained thanks to the result derived above. We have:

$$\frac{\partial i}{\partial R_0} = \frac{\frac{L-S+pR_0}{L} rp + \frac{p}{L}[y(k, R, \theta) - rp(R - R_0)]}{(1 + r) - \frac{L-S+pR_0}{L} y_k(k, R, \theta)} > 0 \tag{34}$$

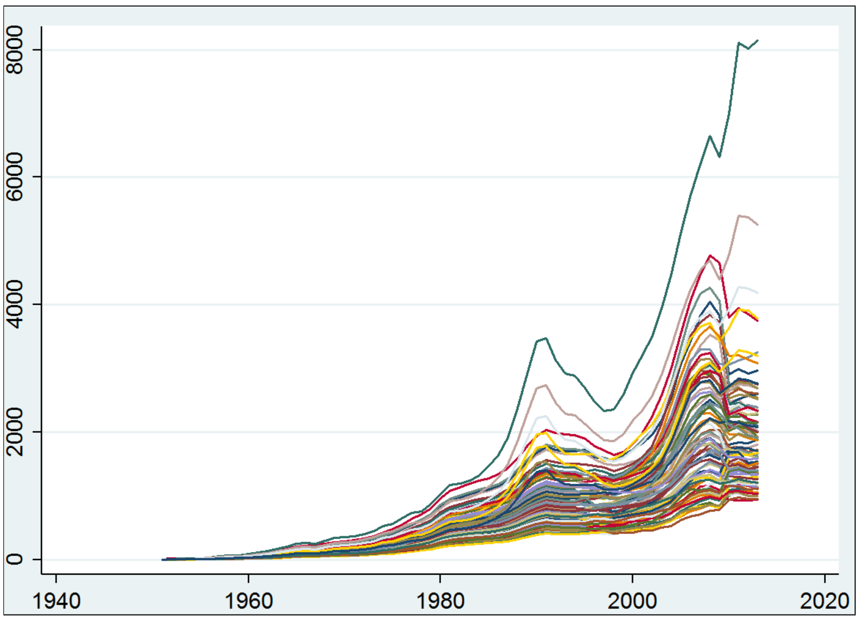
$$\frac{\partial i}{\partial c_0} = \frac{1}{(1 + r) - \frac{L-S+pR_0}{L} y_k(k, R, \theta)} > 0 \tag{35}$$

$$\frac{\partial i}{\partial B_0} = \frac{-1}{(1+r) - \frac{L-S+pR_0}{L} y_k(k,R,\theta)} < 0 \tag{36}$$

$$\frac{\partial i}{\partial \theta} = \frac{\frac{L-S+pR_0}{L} y_\theta(k,R,\theta)}{(1+r) - \frac{L-S+pR_0}{L} y_k(k,R,\theta)} > 0 \tag{37}$$

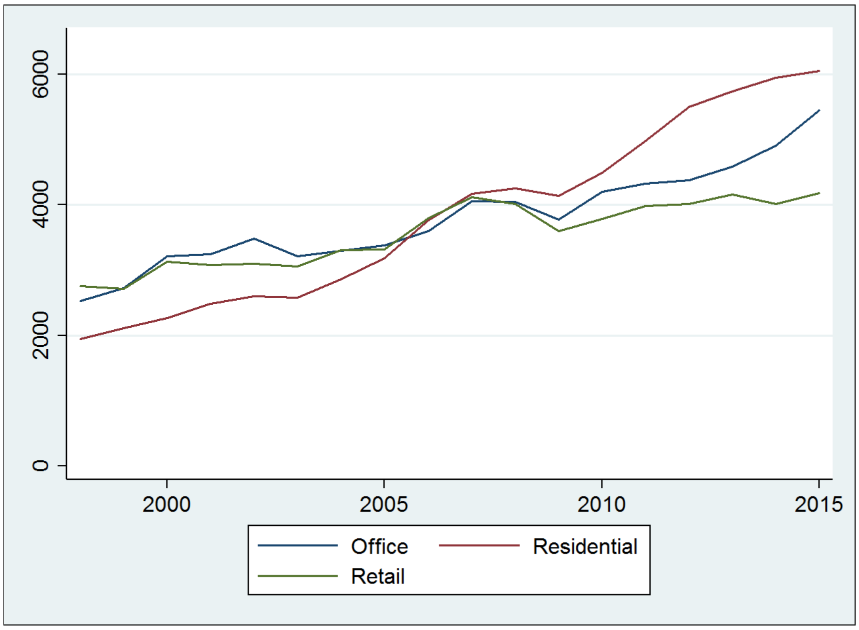
6.3 Appendix C: Further details on real estate price indices

Figure 2: Real estate prices at the *département* level: 1952-2013



Notes:This graph plots real estate prices in euros (2013) per square meter in each mainland French *département*. The series are built with the *Notaires*-INSEE apartment price indices built by Fougère and Poulhes (2012). Sources: French Notaires, Fougère and Poulhes (2012), Friggit (2009).

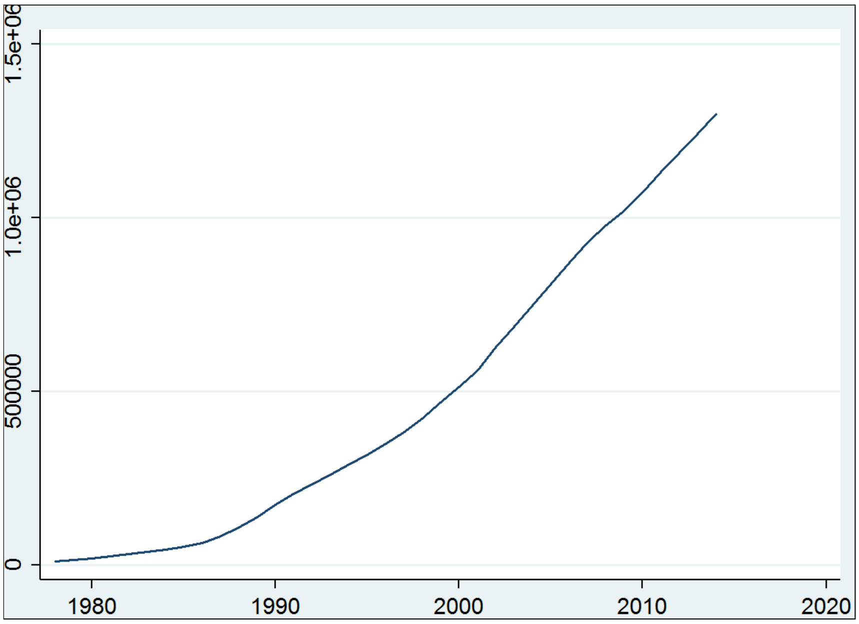
Figure 3: Real estate prices in France by market segment: 1998-2015



Notes: This graph plots real estate prices in euros per square meter in three market segments: office, residential and retail. Sources: HCSF report (MSCI).

6.4 Appendix D: Further details on real estate partnerships

Figure 4: The number of real estate partnerships (*Sociétés Civiles Immobilières*) incorporated in France: 1978-2013



Notes: This graph plots the evolution of the number of *Sociétés Civiles Immobilières* incorporated in France since 1978. Source: Infogreffe.

6.5 Appendix D: Comparison with the existing literature

The existing empirical literature on the real estate collateral channel has highlighted the amount of additional investment resulting from a 1 euro increase in the value of real estate holdings. This parameter cannot be easily recovered from the above-presented parameter estimates because our estimation strategy aims at disentangling the collateral channel from the profit channel. Following the identification strategy of CST, 2012, we can estimate this parameter by replacing $NREH^d_{it-1}$ by $REvalue^d_{it-1}$ in equation (19) where $REvalue^d_{it-1}$ is the value of real estate holdings held by firm i at the end of year $t-1$, normalized by the PPE stock in period $t-1$. Results are reported in Table 11. The estimated parameter associated with $REvalue$ indicates that firms invest 0.065 euro out of each 1 euro of real estate collateral. This result is very similar to the one obtained by CST, 2012, who find a baseline parameter value of 0.06 for US firms observed over the period 1993-2007. We also notice that, in these regressions, the effect of the local real estate price on productive investment varies across sub-samples.

Another legitimate question relates to the magnitude of the negative effect associated with an increase in real estate prices for firms that hold few or no real estate asset. Estimates

Table 11: Collateral value and investment behavior

	(1)	(2)	(3)	(4)	(5)	(6)
RE value	.065***	.066***	.066***	.065***	.081***	.058***
	(.002)	(.002)	(.004)	(.002)	(.005)	(.003)
Real estate prices	-.041 ***	-.021	-.030**	-.022	-.071**	.023
	(.007)	(.015)	(.014)	(.018)	(.029)	(.020)
Net debt	-.006***	-.006***	-.005***	-.005***	-.006***	-.002**
	(.001)	(.001)	(.001)	(.001)	(.001)	(.001)
TFP	.041***	.039***	.036***	.044***	.074***	.012
	(.005)	(.005)	(.005)	(.005)	(.012)	(.008)
Fixed effects:						
Firm fixed-effects	Yes	Yes	Yes	Yes	Yes	Yes
Year dummies	No	Yes	No	Yes	Yes	Yes
Year×sector dummies	No	No	Yes	No	No	No
Observations	1,447,299	1,447,299	1,447,299	1,177,846	315,768	410,210
Adjusted R^2	.16	.16	.16	.15	.13	.20

Notes: $***$ when $pvalue < 0.01$, $**$ when $pvalue < 0.05$, $*$ when $pvalue < 0.10$.
Robust standard errors in brackets.

Notes: The dependent variable is capital expenditure net of real estate acquisition normalized by the PPE stock in year $t-1$. Column 1 is an OLS estimation of equation (19), where $NREH^d_{it-1}$ is replaced by $REvalue^d_{it-1}$, without year dummies. Column 2 corresponds to the same equation but with year dummies. Column 3 introduces also year×sector dummies. Column 4 reports estimated parameters for single-establishment firms. Columns 5 and 6 present the same estimates for "small" and "large" firms, respectively. Sources: FiBEn, *Banque de France*.

presented in Table 4 suggest that the median firm located in the lowest decile of the $NREH$ distribution lowers its investment level by 1.8% following a 10% increase in real estate prices. For acquiring firms which didn't hold prior real estate, the estimated parameter suggests a 4.7% decrease in investment for the same increase in real estate prices. We propose to analyse these figures with the help of an oversimplified static model where the Entrepreneur adopts a Cobb-Douglas decreasing returns-to-scale technology that uses real estate assets, productive assets and labor as inputs. The elasticity of productive assets used in the production process with respect to real estate prices is given by $\xi = \frac{\iota}{\nu+\iota-1}$, where ι is the output elasticity with respect to real estate assets and ν is the sum of the output elasticity with respect to productive assets and the output elasticity with respect to labor. If we retain the hypothesis that ν is equal to 0.8, which is a plausible value for the sum of these two output elasticities, then ξ is equal -0.18 when ι equals 0.03, which happens to be the calibrated value of this parameter in Iacoviello (2005).[36] The parameter ξ reaches -0.47 if ι equals 0.064, which is still a plausible value for ι if we consider the average ratio of corporate real estate holdings over the annual output between 1993 and 2013.[37] Even if this simple framework does not properly consider the law of motion of capital, it allows to show that the magnitude of the negative effects of real estate prices on investment that we find is in line with what we could expect given the share of real estate expenditures in the firms' output.

[36] This paper is calibrated using US data.

[37] In our sample, the ratio of the total market value of corporate real estate holdings over total annual value-added is, on average over the 20 years, equal to 2.17. In the national accounts produced by INSEE (Paris), this average ratio is 2.07.