Why do firms own and not lease corporate real estate?

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(A very preliminary draft)
Abstract

This paper examines the decision of real estate ownership of firms under uncertain productivity shock. It develops a theoretical model of production, in which firms do not substitute corporate real estate for other factors of production. Corporate real estate space is complement to other capital goods and labor, where a minimum proportion of real estate is required as in L-shaped isoquants to produce a fixed level of output. Unlike the Modigliani-Miler world, in our model, firms make the corporate real estate investment decision jointly with financing decision. Firms are free to choose owning and/or leasing options to procure real estate for the production needs. Real estate ownership “conserves liquidity, and it also reduces the distress risk of firms in the event of negative productivity shocks. Our model predicts that a separating equilibrium exists where low-risk and high-leveraged firms own \textit{ex-post} more real estate than high-risk and low-leveraged firms. Using data of listed US firms for the periods from 1984-2009, our empirical results support the prediction that corporate real estate ownership decreases with the distress risks of firms, after controlling for heterogeneity of firms. The investment in real estate is also related to productivity shocks and financing constrained of firms.

\textbf{Keywords:} Corporate real estate, financing decision, owning and leasing; productivity shocks; and distress risk
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1 Introduction

The relationship between investing in production capital and financing options (own versus lease) through which the capital can be acquired has been neglected by the finance and economic literature. The neo-classical economic literature studies the impact of irreversibility and convexity of adjustment costs of real capital investments on firms’ investment decisions under uncertainty (Pindyck, 1982; Abel 1983; Abel and Eberly, 1994; Leahy and Whited, 1996). The finance literature argues for tax advantages (Miler and Upton, 1976; Lewellen, Long and McConnell, 1976; Wolfson, 1985) and other non-tax incentives associated with leasing of capital goods by firms (Smith and Wakeman, 1985). In the frictionless financial environment of Modigliani and Miller (1958), firms’ choice of the optimal production function is assumed to be independent of the decisions on financing options. Similarly, the option to either own or lease real assets takes no consideration into the elasticity and substitutability of the factors of production.

Ang and Peterson (1984) first dispute the puzzle of substitutability between leases and secured debt, when they find empirical evidence of a positive relationship between debt and leasing. Eisfeldt and Rampini (2009) show that leasing increases debt capacity of constrained firms, and firms lease to “preserve liquidity.” Therefore, leasing is no longer just a financing tool, but it can be used by constrained firms to increase investment in input capital and expand production functions. Unlike lessees, owners of real assets, who retain the residual interest, take advantages of rises in collateralized asset values to increase investment in the production capacity. The liquidity of collateral assets is studied by the growing literature on the collateral effects (Benmelech, Garmaise and Moskowitz, 2005; Benmelech and Bergman, 2008 and 2009; Gan, 2007a; and Chaney, Sraer and Thesmar, 2010). The “redeployability” of liquid assets is not unique to the collateral assets, but liquidity can also be preserved in leased capital.
Real estate including both land and physical structure is the single largest fixed capital investment by some firms. It constitutes 85% of the lagged property, plant and equipment investment (PPE) by book value of average US listed firms, and a smaller average ratio of 44% was observed in real estate asset held by French listed firms (Chaney, Sraer and Thesman, 2010). In Japan, land accounts 67.7% of the replacement costs of average Japanese firms (Gan, 2007a and 2007b). Real estate holdings by firms create significant collateral effects\(^1\), which were estimated to be about 6% in the US, 11% in France (Chaney, Sraer and Thesman, 2010) and 8% in Japan (Gan, 2007a) on average. Chaney, Sraer and Thesman (2010) also show that the collateral effects are more significant for credit constrained firms.

The earlier studies did not address the issues of why some firms do not own, but instead lease corporate real estate. The collateral effects are not available to 42.8% of the US firms in Chaney, Sraer and Thesman’s (2010) samples that do not own real estate. Do these firms with leased assets face liquidity constraint in capital investments? We show from our samples of US listed firms collected from Compustat that real estate by book value accounts for around 10% on average of the total assets over the periods from 1984 to 2009. Not all the firms will chose to own corporate real estate. Neither is the investment decision (own versus lease) of firms a random process.

Corporate real estate has its own unique inherent features as a factor of production. Compared to other capital goods like equipment and plants, real estate are indivisible (non-substitutable), durable (low depreciation), and heterogeneity, which make the investment decisions in real estate a more complex problem. Unlike the putty-clay production model of Johansen (1959) and Gilchrist and Williams (2000), real estate is not perfectly substitutable in the firm’s production function. In our model, we assume that real estate factor is proportional to a combination of other input factors of production (capital and labor) at a given level of output.\(^2\) Conditional on the optimal real estate space

\(^1\) Collateral assets increase debt capacity of the firms. The sensitive of investments by firms to changes in collateral asset value is known as the “collateral effects.”

\(^2\) For example, if a machine requires a minimum operating space say 100 square meters, we cannot increase production output by simply adding one more machine, if the existing factory space is constrained for the new installation.
determined by the production technology, firms choose to either lease, or own, or use a combination of leasing and owning the real estate, to meet their expected production output requirement. In other words, the financing option (own versus lease) does not dictate the amount of real estate space needed in the production function, but the choice of the real estate right (right of use versus residual value) has significant impact on asset liquidity and productivity uncertainty of firms.

Second, real estate is highly durable with a slow depreciation rate (Fernández-Villaverde and Krueger, 2005, Glaeser and Gyourko, 2005). The Bureau of Economic Analysis (BEA) reports a depreciation rate ranging between 1.5% and 3% for non-residential real estate, compared to a range of 10% to 30% depreciation rate for equipment as surveyed by Fraumeni (1997). The feature makes the separation of user rights and residual value of corporate real estate via leasing a more favorable option (Smith and Wakeman, 1995; Brealey and Myers, 2005). The disincentive in maintenance and abuse in the use of assets commonly found in the leasing of non-durable and high depreciable goods can be effectively internalized in the corporate real estate leases.

Unlike equipment and plants, heterogeneous real estate space is created to meet different operational needs of firms. Demand for office space, factory and storage space vary by proportions and by firms in different industries. Variations in corporate real estate space requirements could still exist even for firms within the same industry. The leasing literature argues that an organization-specific asset that is highly specialized to a particular firm generates high agency costs during the lease contracts negotiation. For example, firms are more likely to lease office facilities with shorter leases on one hand, and firms, such as book publishers and bio-technologists, will minimize agency costs by not leasing production and research facilities that are highly sensitive and critical the firms’ production output (Smith and Wakeman, 1984).

When surveying the composition of corporate real estate of major corporations in US, Zeckhauser and Silverman (1983) find that the average firms’ real estate assets is about 25% of total assets. However, manufacturing firms own more real estate that constitutes about 40% of the total assets. Tuzel (2010) also find considerable heterogeneity in firms’
capital composition. By sorting firms on the share of buildings and capital leases in the
total physical capital (PPE), she find that the share of buildings and capital leases owned
by firms in the first quantile is 22% lower than the average firms in the industry. Firms in
the fifth quantile own 25% more buildings and capital leases than the average firms.
Agreeing with Tuzel’s (2010) findings, our results also report significant differences in
real estate asset ownership among different sample firms. The corporate real estate ratio,
defined by the ratio of real estate assets to total assets, of manufacture firms is about 5%
higher than that for service firms.

Real estate with its unique features offers a natural setting for us to study the importance
of the endogenous relationship between capital investment and choice of financing
options (own versus lease) by firms. It is not necessary for firms to purchase all real
estate to meet the production needs; leasing is an alternative way for firms to procure real
estate space for production. Owning and leasing real estate generate different shocks to
firm’s internal cash flows. The leasing literature argues that leasing contact is
synonymous to a “100% percent financing” that conserves cash for firms (Schallheim,
1994; Ang and Peterson, 1984; Brealey, et al., 2005; Eisfeldt and Rampini, 2009). Real
estate purchases though deplete internal cash flows of firms; and if financed externally,
increase debt ratios of firms; firms retaining the residual interest in real estate assets can
save cash outflows in the future, and also increase debt capacity through the ex-ante
collateral effects.³ Unlike in the Modigliani-Miller world, financing corporate real estate
generate cash flow shocks, which may cause significant productivity uncertainty of firms.

Motivated on the premise that production function and financing decisions (own or lease)
of firms are not independent, we develop a dynamic model for a typical firm to explain
the relationships between real estate financing decision (owning versus leasing) and
production outputs under random shocks. A firm uses real estate, \( H \), other capital goods,
\( K \), and labor, \( L \), in a fixed proportion as the factors of production in the objective function,
i.e. \( Y(f(K, L)) \), such that the input factors \( [H \alpha f(K, L)] \). Conditional on the output
objective, firms make decisions between owning and leasing real estate assets, the choice

³ Usually when firm purchase high quantity real estate assets, it will issue debt or equity to finance. For
debt, downpayment must come from internal cash flow. In future, this part of interest will be saved; for
equity, firm does not have the obligation of interest.
of which influences the distribution of the internal cash flows. Our model predicts that real estate ownership reduces in distress risk for firms. Corporate real estate ownership of high-risk firms increases with decreasing depreciation and increasing irreversibility (fire-sale) discounts of real estate. In the event of distress, low-risk firms can obtain higher marginal benefits from real estate when divested in fire-sales. Low-risk firms own more real estate assets than high risk firm keeping the marginal costs of real estate constant. In equilibrium, corporate real estate can be used as a signal to separate low-risk firms from high-risk firms. When the capital structure is considered, firms with higher leverage ratio will also reduce the distress risks through owning more real estate. Constrained firms will invest more real estate than unconstrained firms when positive productivity shocks occur. We test empirically our model’s predictions using data of US listed non real estate firms from 1984 to 2009, and our results support the negative relationships between corporate real estate and productivity risks of the sample firms. We also show that high leveraged and financially constrained firms own rather than lease more real estate leasing in periods of high productivity risks.

There are two strands of financial research that are closely related to our paper in examining corporate real estate owning decisions of firms. Tuzel (2010) develops a general equilibrium production economy with higher irreversibility costs for real estate, and she shows that firms will divests non-durable capital goods ahead of real estate in the events of productivity shocks. She finds empirical evidence to support a positive risk and real estate relationship using data of US listed firms. In Gan (2007a) and Chaney et. al.(2010) studies, real estate create positive collateral effects on investments by firms. Using real estate as collateral to finance new project, firms increase debt issuance when prices of real estate increase. Our research can be distinguished from the earlier studies in two aspects. First, real estate decisions (own versus lease) are not an exogenous process as in the earlier studies. The earlier studies ignore firms that lease rather than own real estate. However, in our model, real estate is not a not perfectly substitutable to other capital goods, and the financing and investment decisions on real estate are inseparable and dependent on the productivity risks in firms. We assume that firms real estate decision taking into consideration productivity risks of the firms ex-post. Second, the real estate risk in Tuzel’s paper is endogenous in real estate ownership of firms. In our paper,
the productivity risk is idiosyncratic risk, and owning real estate can help hedge productivity risks by firms.

The remainder of the paper is organized as follows. Section 2 develops a simple dynamic model of a typical firm under uncertain productivity shock. Section 3 presents the empirical evidence of the model’s prediction using empirical data of US listed firms for the periods from 1984 to 2009. The paper is concluded in section 4.

2 Theoretical Model of Financing Corporate Real Estate

In this section, we develop a dynamic model to predict the corporate real estate owning and leasing decisions of a firm under productivity uncertainty. In our model, corporate real estate ownership reduces the probability of distress for firms. Higher risk firms hold less corporate real estate based on the “marginal decision rule”. Both the external financing and productivity shock have influence on corporate real estate investment.

2.1 Model Set-up

In a discrete time production technology with infinite horizon, firms combine capital goods (equipments and machines) with labor to produce output at time $t$, $Y_t = F(K_t, L_t)$. The scale of production is represented by $\theta_t$, where $\theta > 0$ such that there is a positive return to scale for the production technology. The productivity uncertainty is added to the model through the random distribution of $\theta_t$, where the probability density function of $\theta_t$ is $\varphi(\theta)$, over the space $\theta \in (0, +\infty)$. The source of uncertainty influences dynamically the financing decisions on real estate space. At time $t$, the total output $Y_t$ is represented:

$$Y_t = \theta_t K_t^\alpha L_t^{1-\alpha}$$

where $\alpha$ is the capital share of the production input, and $1 - \alpha$ is the labor share of the production input.

We normalize the factors of firms’ production by the labor input, that is $[F(K_t, L_t) = f(K_t/L_t) L_t]$, and rewrite the normalized output function, $y_t$, in period $t$ as:
where \( k_t \) is the capital goods investment per unit labor.

In the above production technology, real estate has no direct influence on the production output, but it is an input that is not substitutable by other capital goods in the production function. We assume that real estate input in the production is a fixed proportion of the capital and labor in the production, that is \( H_t \alpha F(K_t, L_t) \), where \( F(K_t, L_t) \) denotes a combination of capital goods and labor, and \( H_t \) denotes real estate asset required for the production in period \( t \). Like the perfect “complement” assumption in the consumer theory, firms will require to procure a minimum real estate space, \( H_t \), to house the production inputs, that is \( \min(H_t, F(K_t, L_t)) \). Firms are free to finance real estate using different contract arrangements that are to either own real estate directly as denoted by a superscript “o”, or lease it as denoted by a superscript “l”. Assuming that the minimum real estate space per unit labor is equal to \( f(k_t) \) and firms own \( h_t^o \) amount of real estate, the balance of real estate space need will be met through leasing that is \( h_t^l = f(k_t) - h_t^o \). Here, \( f(k_t) \) satisfies \( f'(k_t) > 0 \) and \( f''(k_t) > 0 \).

The expenses on real estate lease and labor are flow variables, where firms incur a leasing fee of \( P^l \) and a fixed wage of \( W \) in each period \( t \). The internal cash flow in period \( t \) can be defined as \( c(k_t, h_t, \theta_t) \):

\[
c(k_t, h_t, \theta_t) = \theta_t k_t^\alpha - W - P^l [f(k_t) - h_t]
\]

(3)

Real estate and capital goods can be purchased by firms at one-off prices of \( P^h \) and \( P^k \) respectively. The real estate depreciates at slower rate of \( \mu \) compared to the depreciation rate of \( \delta \) for other capital goods, such that \( \mu < \delta \). At the end of the period, a firm can choose to increase or decrease the stock of real estate and capital goods by \( h'_t \) and \( k'_t \):

\[
h'_t = (1 - \mu)h_t
\]

(4)

\[
k'_t = (1 - \delta)k_t
\]

(5)
For a firm generating positive cash flows, \( c(k_t, h_t, \theta_t) \geq 0 \), it can increase the stocks of real estate or other capital goods by adding new investments in real estate by \( i_t^h \) and other capital goods by \( i_t^k \), which as a result, increase the stocks in the next period to:

\[
\begin{align*}
    h_{t+1} &= h_t' + \frac{i_t^h}{P^h} \\
    k_{t+1} &= k_t' + \frac{i_t^k}{P^k}
\end{align*}
\]

(6) (7)

However, in the case of distress where the end-of-period internal funds are insufficient to meet the obligations, \( (k_t, h_t, \theta_t) < 0 \), a fire-sale of fixed assets (including real estate and other capital goods) occurs.\(^4\) The stocks of real estate assets holding and other capital goods will be cut by \( h_t' \) and \( k_t' \) at the end of period \( t \). Firms will sell real estate and capital goods at distressed prices that are lower than the book values, which are captured in the “irreversibility discounts”, \( \psi_h < 1 \) for real estate assets, and \( \psi_k < 1 \) for other capital goods (Asquith, Gertner and Scharfstein, 1994, Gamba and Triantis, 2008, Hennessy and Whited, 2005) to cover for short-falls in operating cash flows in the period \( t \):

\[
\begin{align*}
    [(1 - \delta)k_t - k_t']P^k\psi^k + [(1 - \mu)h_t - h_t']P^h\psi^h &= -c(k_t, h_t, \theta_t)
\end{align*}
\]

(8)

At this juncture, we assume that firms are not constrained, and firms can choose to finance capital investments using either internal cash flows or external fund. The net capital required for the new asset acquisitions in period \( t \) is \( e(k_t, h_t, \theta_t, k_{t+1}, h_{t+1}) \), which can be written as:

\[
e(k_t, h_t, \theta_t, k_{t+1}, h_{t+1}) = \max[c(k_t, h_t, \theta_t), 0] - i_t^h - i_t^k
\]

(9)

where external financing is needed if \( e < 0 \). Firms could choose to retain the excess cash flows or distribute them back to investors as dividends, \( e > 0 \). The function \( e \) in equation (9) is continuous and strictly concave, except in the special case of fire sales, when

\(^4\) In Tuzel’s (2010) model of investment with convex adjustment costs, firms incur higher adjustment costs in disposing-off existing capital stock than the cost incurred in adding new capital stocks. In the event of negative productivity shocks, firms will first choose to reduce short-lived capital goods with high depreciation rates. Real estate will be the last to be divested. In our model, the asymmetric divestment is not considered.
$c(k_t, h_t, \theta_t) = 0$. The distressed firm’s $e$ is represented by a kink that causes the function to be discontinuous and non-differentiable in the states $(k_t, h_t, \theta_t)$.

If the excess cash flows are distributed to investors as dividends, the firm’s value can be determined following a discounted dividend model:

$$V_{t_0} = E_{t_0} \left\{ \sum_{t=t_0}^{\infty} \left( \frac{1}{1+r} \right)^{t-t_0} e_t \right\} \tag{10}$$

where the discount rate is $r \geq 0$.

For the manager of the firm, the objective to maximize the firm’s value as defined by the Bellman equation:

$$V(k_t, h_t, \theta_t) = \max_{k_{t+1}, h_{t+1}} \left\{ e(k_t, h_t, \theta_t, k_{t+1}, h_{t+1}) + \frac{1}{1+r} \int_{0}^{\infty} \varphi(\theta) V(k_{t+1}, h_{t+1}, \theta) d\theta \right\} \tag{11}$$

2.2 Optimal Real Estate Strategies

The optimal investment strategies in real estate and other capital goods can be derived from equations (1)-(11). Using the marginal approach that equates the marginal costs to the marginal benefits with respects to the use of real estate and capital goods, we derive the optimal holdings of the two assets in the following first order conditions:

$$P^h(1 + r) = \int_{\tilde{\theta}_{t+1}}^{+\infty} \varphi(\theta) \left[ P^h(1 + \mu) \right] d\theta$$

$$+ \int_{0}^{\tilde{\theta}_{t+1}} \varphi(\theta) \left( 1 + \frac{\psi^h}{\psi^h} \right) \left[ \frac{\rho^l}{\psi^h} + P^h(1 + \mu) \right] d\theta \tag{12}$$

$$P^k(1 + r) = \int_{\tilde{\theta}_{t+1}}^{+\infty} \varphi(\theta) \left[ \theta k_{t+1}^{a-1} - P^l f'(k_{t+1}^*) + P^k(1 + \delta) \right] d\theta$$

$$+ \int_{0}^{\tilde{\theta}_{t+1}} \varphi(\theta) \left( 1 + \frac{\psi^k}{\psi^h} \right) \left[ \frac{\rho^l}{\psi^h} \theta k_{t+1}^{a-1} - P^l f'(k_{t+1}^*) \right] d\theta \tag{13}$$

where the term $\int_{0}^{\tilde{\theta}_{t+1}} \varphi(\theta) d\theta$ represents the distress probability of the firm with an upper limit of the integral, $\tilde{\theta}_{t+1}$, defined as a function $\tilde{\theta}_{t+1}(k_{t+1}^*, h_{t+1}^*)$ that satisfies
The left-hand-sides of the Equations (12) and (13) represent the marginal costs and the right-hand-side of the Equations represent the marginal benefits associated with the use of the real estate and capital goods respectively. The detailed derivations are shown in Appendix A.1.

We rearrange Equations (12) and (13) as follows:

\[
\begin{align*}
c(k_{t+1}^*, h_{t+1}^*, \bar{\theta}_{t+1}) &= \bar{\theta}_{t+1} k_{t+1}^* \alpha - W - P^l[f(k_{t+1}^*) - h_{t+1}^*] = 0 \quad (14)
\end{align*}
\]

In Equations (15) and (16), we can determine the optimal holdings of corporate real estate (own and/or lease) and other capital goods by “smooth-pasting” the marginal costs of assets in operation to the marginal discounted values of divested assets when firms are distressed. The left-hand side of Equation (15) represents the gross marginal cost of real estate, which include the marginal cost of owning real estate, \(P^h r + P^h \mu \) and the marginal leasing cost for real estate, \(P^l\). The marginal cost is equated to the gross marginal fire-sale values of real estate when firms are in distress as in the right-hand side of the equation. Similarly, for other capital good in Equation (16), the marginal cost of other capital goods, \(P^k r + P^k \delta\), for a healthy firm is equated to the marginal values of the goods that are sold when the firm is in distress, \(\int_0^{\theta_{t+1}} \varphi(\theta) \theta k_{t+1}^{* \alpha - 1} - P^l f'(k_{t+1}^*) d\theta\). The marginal values of real estate assets and other capital goods in the two equations are defined as functions of the probability of distress \(\int_0^{\theta_{t+1}} \varphi(\theta, u_t, \sigma^2) d\theta\), depreciation rates (\(\delta\) and \(\mu\)), and irreversibility discounts in fire sale (\(\psi^h\) and \(\psi^k\)).
**Proposition 1:** Owning corporate real estate can reduce the distress risk, $\frac{\partial \theta}{\partial h^i} < 0$.

**Proof.** See Appendix A.2

Firms are free to choose owning and/or leasing options in procuring real estate for the production needs of the firms. The two financing options on real estate impact the cash flows of firms in different ways. For corporate real estate owning, firms incur a large capital outlay upfront at the time of purchase, but small interim cash outflows for maintenance and depreciation during the production process. In real estate leasing contracts, however, firms avoid the one-off lump-sum payment at the beginning by smoothing out the cash flows through periodic payments at market lease rates over the lease terms. For firms owning real estate, depreciation and amortization, if debt financing is used in the purchase, are recorded in the income statements of the firms. Under the Chapter 11 bankruptcy code of US, firms owning real estate are protected against foreclosure by lenders in the event of financial distress; and such protection is not available to lessees in negative shocks (Eisfeldt and Rampini, 2009). Firms may lose the control of leased real estate assets, if they failed to make the lease payments, and suffer losses due to forced shutdown of the production line.

2.3 Numerical Analysis

There is no analytical solution to the optimal corporate real estate ownership in Equations (15) and (16), and we will simulate the relationship between real estate holdings and distress risks of firms based on a set of input parameters. For the production inputs, we set the prices of real estate and other capital goods at $P^h = P^k = 1$, labor wage at $W = 2$, and leasing rate at $P^l = 0.12$, which is less than $P^h r + P^h \mu$. The capital share of the aggregate input is fixed at $\alpha = 0.45$, such that the corresponding labor share is $1 - \alpha = 0.55$ in the production function. The productivity shocks are represented by the log-normal distribution of the random variable, $\theta_t$, which has a constant mean $\mu_t=3$ and a standard deviation $\sigma$, where $\sigma$ is a proxy of the firms’ productivity risks. Other capital goods depreciate at a rate $\delta = 0.20$. The fire-sale price of other capital goods is determined by the irreversibility discounts to the replacement cost that is $\psi^k = 0.70$. The
discount ratio is set at $r = 0.10$. The proportion of real estate to other capital goods per unit of labor is assumed at $f(k_t) = \beta k_t$, where $\beta = 1$. The relative weight of real estate owned by firms to other capital goods is measured by $h/k$.

With the input parameters defined above, we run simulation on $h/k$ over a range of productivity shocks, $\sigma$. Our results support the prediction of Proposition 1 that real estate ownership reduces the distress risks of a firm. In the event when firms are in financial distress, real estate is sold in fire sale at marginal discounted prices. As the probability of distress is lower for low-risk firms, marginal value for each unit real estate discounting for irreversibility costs is higher for low-risk firms relatively to high-risk firms. If the marginal cost of owning each unit of real estate is constant, low-risk firms own more real estate than high-risk firms as shown by the downward sloping curve in Figures 1 and 2.

In Figure 1, we simulate the $h/k$ and productivity risk relationships with three different rates of depreciation for real estate, $[\mu = (0.05, 0.10, 0.15)]$. The downward sloping curves showing declining $h/k$ ratios over productive risks for all three real estate assets persist in the three depreciation scenarios. The relative elasticity of $h/k$ to changes in productivity risks for firms owning real estate with the lowest rate of depreciation, $\mu = 0.05$ as shown by the darken line is the smaller compared to the other two lines represented by real estate with higher depreciation rates. For high-risk firms, the marginal costs of owning real estate are more sensitive to the depreciation rate of real estate. The high-risk firms hold a smaller fraction of real estate if the depreciation rate of the real estate is high. For low-risk firms, however, owning more real estate is in-line with the output maximizing objectives and it is not intended for risk hedging purposes; they increase holdings in real estate when depreciation rates increase, though the elasticity of the $h/k$ is marginal.

[Insert Figure 1 about Here]

In Figure 2, the relationships between corporate real estate ownership and distress risk are simulated by varying the irreversibility discounts of real estate in the case of fire sale, $\psi^k$. For high-risk firms, the proportion of real estate holdings over other capital goods increases in irreversibility discounts. However, the irreversibility discounts have limited
impact on the h/k ratio of low-risk firms. High-risk firms are more sensitive to changes in the fire-sale discounts. At an irreversibility discount, \( \psi^k = 0.9 \), where firms can sell capital goods in fire sales at prices close to replacement costs, high-risk firms own more real estate. The converse is observed in low-risk firms that will own a smaller proportion of real estate, at a high irreversibility discount. The use of real estate for risk-hedging motive by low-risk is relatively weak as they are less sensitive to changes to the irreversibility discounts.

[Insert Figure 2 about Here]

2.4 Debt Policy and Corporate Real Estate Ownership

The earlier production model of firms does not consider the capital structure of firms. In real life, firms use extensively external financing either through equity issuance or debt issuance to supplement the internal cash flows in the acquisitions of new capital and real estate. Unlike equity capital, debt issuance imposes upon firms to a more restrictive covenant on prioritizing cash flows, and subjects them to more stringent external monitoring during their production. They must make interest payments and partial principal amortization out of the free-cash flows to firms generated in the production process. Firms having high leverage are also exposed to high bankruptcy risks, which in turn influence corporate real estate ownership decision.

We extend our earlier model by allowing firms to choose either debt or equity to a new source external financing in acquisitions of new capitals. Firm can borrow money \( d_t \) at an interest rate \( p \) in each period, when \( \max[c(k_t, h_t, \theta_t), 0] - i_t^h - i_t^k < 0 \):

\[
d_t < -\{\max[c(k_t, h_t, \theta_t), 0] - i_t^h - i_t^k\}
\]  
(17)

The debt principal together interests will be fully repaid in the consecutive period. Here \( c(k_t, h_t, \theta_t) \) given a fixed debt originated in the previous period, t-1, will be re-writes as \( c(k_t, h_t, d_{t-1}, \theta_t) \):

\[
c(k_t, h_t, d_{t-1}, \theta_t) = \theta_t k_t^\alpha - W - p_t [f(k_t) - h_t] - d_{t-1}(1 + p)
\]  
(18)
The net cash flow in period $t$ will be

\[ e(k_t, h_t, d_{t-1}, \theta_t, k_{t+1}, h_{t+1}, d_t) = \max[c(k_t, h_t, d_{t-1}, \theta_t), 0] - i^h - i^k + d_t \]  

(19)

Substituting Equation (19) into the Bellman Equation (11), we derive the optimal mix of real estate ownership and other capital goods, and the optimal debt level. The optimal proportion of real estate ownership over other capital goods still satisfies the conditions defined in Equations (15) and (16).  

**Proposition 2:** If $r > p + \int_0^{\beta_{t+1}} \phi(\theta)(1 + p) \left( \frac{1}{\psi^k} + \frac{1}{\psi^n} - 1 \right) d\theta$, debt issuance will increase in firm’s value.

**Proof. See Appendix A.3**

The discount rate in this model, $r$, determines the expected return of firms, whereas $p$ is the interest rate for using the debt financing. The effects of debt financing on the marginal value of a firm when it is in distress are reflected in $\int_0^{\beta_{t+1}} \phi(\theta)(1 + p) \left( \frac{1}{\psi^k} + 1/\psi^n - 1 \right) d\theta$. If the marginal distress value including the costs of debt is lower than the expected return, the firm will issue debt to finance new real estate acquisitions, which in turn enhance the firm’s value.

**Proposition 3:** Firms issuing more debt also own more real estate under the same productivity uncertainty, $\frac{\partial h^*_t}{\partial d_t} > 0$.

**Proof. See Appendix A.4**

The positive relationship between corporate real estate holding and debt is consistent with the propositions of the literature on collateral effect (Chaney, et al., 2010, Gan, 2007a). Using real estate as collateral pledging, firms can enhance the effective financing capacity. However, the motivation of debt financing in our model differs from the

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5 The proof is similar with appendix A.1
collateral effects story. In our model, the real estate holdings (Proposition 1) and the debt issuance both have positive effects on the financial distress of firms. In Equation (15), the optimal value strategy is attained when $\theta_t$ is a constant, while other exogenous variables are also held constant. In equilibrium, the results imply that firms with higher debt own more real estate to reduce the risk of distress.

2.5 Firms with External Financing Constraint

In the previous section, we assume that firms could freely obtain without constraints external financing either equity or debt in funding new capital and real estate acquisitions. However, some firms choose to use only internal cash flows to fund new investments under the following condition:

$$\max[c(k_t, h_t, \theta_t), 0] - i_t^h - i_t^k \geq 0$$

(20)

Two types of firms will meet the above financing conditions: an unconstrained firm that has excess internal cash flows in funding new investments without using external financing; and a constrained firm with no access to external financing invests only up to the limit imposed by Equation (20), that is $e(k_t, h_t, \theta_t) = 0$, and $d_{t-1} = 0$.

**Proposition 4:** If a firm is constrained in accessing to external financing, the net investment on real estate is positively related to productivity shocks in the same period.

**Proof.** See Appendix A.5

The net investment on real estate is defined by the changes in real estate ownership between two consecutive periods, $h_t - h_{t-1}(1 - \mu)$. For firms in financial distress, a negative net real estate investment is expected as they are forced to divest some real estate through fire sales. The scale of divestment by distressed firms increases inversely in productivity shocks, which implies that a large net decrease in real estate is observed in periods of low productivity shocks. Even if firms are not in financial distress, constrained firms with no access to new debt and/or equity capital will only invest in new real estate conditional on the availability of internal cash flows. The net real estate investment of the constrained firms increases in productivity shocks.
3 Empirical Evidence

This section presents empirical evidence using data of US listed firms for the periods from 1984 to 2009. We start with a discussion on the data sources and variable derivations. Descriptive statistics showing real estate weight as a percentage of the total assets of firms are analyzed by industry and over time. We run two sets of regressions to test the empirical relationships of how corporate real estate ownership in levels and in differences change with idiosyncratic risks of firms. Data on real estate leases are not reported by our sample firms. On the premise that firms have only a mutually exhaustive option to either own or lease real estate conditional on the minimum real estate input in the production function, the amount of real estate owned may reflect inversely the level of real estate leasing activities by the sample firms in our tests.

3.1 Data Analysis and Model Design

We collect data of real estate ownership and financial statistics of our sample firms from the Compustat. The Compustat Industrial Annual breaks down Property, Plant, and Equipment (PPE) into buildings, capitalized leases, machinery and equipment, natural resources, land and improvements, and construction in progress. Following Chaney et al. (2010), building, land and improvement, and construction in progress are used to proxy real estate holdings of sample firms in our model. “Building” is the replacement cost of buildings in the PPP account of sample firms; “Land and improvement” includes acquisition costs and other expenses on the land; “Construction in process" refers to uncompleted real estate development projects reported in the books of sample firms. Tuzel (2010) and others include "Capitalizes leases" as real estate for two reasons. First, capitalized leases for real estate are significantly higher than the capitalized leases for equipment (Eisfeldt and Rampini, 2009). Second, capitalized leases transfer a substantial portion of benefits and risks incident to the ownership of property to the lessee\(^6\). In our empirical model, however, the emphasis is on different cash flows generated in owning

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\(^6\) The Financial Accounting Standards Board (FASB) classified leases as either capitalized leases or operating leases. The details can be found in the Statement of Financial Accounting Standards No. 13.
and leasing real estate. As the cash flows in capitalized leases are difficult to be separated from those in operating leases, we exclude them from real estate definition in our tests.

The breakdown of PPE for U.S. listed firms is only available in the Compustat database after 1984. We truncate our samples in the left-tails such that the sample periods start from 1984 to 2009. The Compustat reports the PPE in both “net” and “historical cost” terms only after 1993. The PPE data before 1993 were recorded as the “historical cost”, which represents the book value of real estate. As real estate depreciates slowly, the use “historical cost” to represent real estate holdings in our empirical tests is not unreasonable. We also use the year-on-year differences in “historical cost” to measure net investment in real estate. We compute the corporate real estate ratio (CRER) by dividing real estate owned by sample firms that includes building cost (#FATB), land and improvement (#FATP), and costs of construction in progress (#FATC) by the total asset (#AT) in book value of sample firms for each year in the sample periods.

We need the cash flows from operation as the proxy for the outputs of our sample firms. The total cash flow (CASH) is the sum of the two cash flow items in the Compustat database that are Income before Extraordinary Items (#IB) and the Depreciation and Amortization (#DP). The total cash flow is normalized by the lagged total asset to derive at the cash flow ratio (CASHR), which measures the productivity (outputs) of firms. On the assumption that the productivity of firm follows a lognormal distribution, \( LN(\theta_t) = N(\mu_t, \sigma^2) \), where \( \mu_t \) is the expected CASHR and \( \sigma \) is the standard deviation of CASHR in its natural-logarithm term.

We derive two empirical idiosyncratic productivity risk measures using annual time-series of \( Ln(CASHR) \) for the sample firms. The first risk measure, RISK1, is computed as the standard deviation of \( Ln(CASHR) \). The second risk measure, RISK2, captures the time variations of \( u_t \) in an auto-regressive \( AR(1) \) process. We run an AR(1) regression of \( Ln(CASHR) \) on its own lagged term for each sample firm, and derive RISK2 as the standard residual errors of the regression. In the two time-series risk measures, sample

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\(^7 \# \) represents the variable’s name in Compustat.
firms with less than five time-series points are dropped to keep consistency in the model prediction.

The production function of the sample firms that defines the total output of the firms, \( \pi(x_t, \theta_t) \), as a function of a vector of input factors, \( x_t \), and a productivity shock, \( \theta_t \), can be represented in a linear approximation by the following empirical specification:

\[
\pi(x_t, \theta_t) = \rho + \frac{\partial \pi}{\partial x_t}(\bar{x}_t, \bar{\theta}_t)x_t + \frac{\partial \pi}{\partial \theta_t}(\bar{x}_t, \bar{\theta}_t)\theta_t
\]

where \((\bar{x}_t, \bar{\theta}_t)\) represents the state variables at the median level, and \(\rho\) is constant, such that \(\rho = \pi(\bar{x}_t, \bar{\theta}_t) - \frac{\partial \pi}{\partial x_t}(\bar{x}_t, \bar{\theta}_t)x_t + \frac{\partial \pi}{\partial \theta_t}(\bar{x}_t, \bar{\theta}_t)\theta_t\). The component \(\rho + \frac{\partial \pi}{\partial x_t}(\bar{x}_t, \bar{\theta}_t)x_t\) is not linked to productivity shocks in the expected cash flow; whereas the transitory cash flow, \(\frac{\partial \pi}{\partial \theta_t}(\bar{x}_t, \bar{\theta}_t)\theta_t\), is dependent on the productivity shocks. Based on the linear approximation form, we run regressions of the cash flow ratio (CASHR), that proxy the total output of product function, against the input factors consisting of firm size (SIZE) and PPE ratio (PPER) in the last period. Based on the predicted models, we estimate the expected cash flow and the transitory cash flow variables for each sample firm. We also control for firm characteristics in the model using two other variables that are market-to-book ratio (MB) and leverage ratio (LEVERAGE).

The firm size (SIZE) is defined as the nature log of total book asset (#AT). For the market-to-book ratio (MB), the numerator is the market value of equity, which is computed by multiplying the number of common stocks (#CSHO) by the end-of-year closing price of common shares (#PRCC_F); and the denominator that is the book value of debt and quasi equity is computed as book value of assets (#AT) minus common equity (#CET) and deferred taxes (#TXDB). The PPE ratio is calculated by dividing the total PPE value (#PPEGT) by the total asset value. The PPE includes real estate and other capital goods such as plant and equipment. The ratio of PPE excluding CRE (PPEOR) is also computed by dividing the total PPE (#PPEGT) net off the CRE component by the

\[8\] The prediction model is \(\text{CASHR}_t = \alpha + \beta_1\text{SIZE}_{t-1} + \beta_2\text{PPER}_{t-1}\)

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total asset. The leverage ratio is the sum of short term liabilities (#DLC) and long term
debt (#DLTT) divided by the total asset.

In our model that assumes that real estate is an input factor that is not substitutable by
other capital goods, the investment decisions on real estate and other capital goods are
not exogenous. Therefore, there is a need to control for the effects of investment on other
capital goods excluding real estate in our model. We calculate other capital goods
investment (CGI) as the capital expenditure (#CAPX) minus investment in real estate,
and then normalize it by the lagged period total PPE.

The heterogeneity of real estate ownership by firms in different industries are controlled
by the first two digits of the standard industry classification (#SIC) code. Sample firms in
three industries, that are mining, financial service, and real estate firms, are excluded
from the tests because the real estate ownership decision is more complex than that
described in our model. Firms with the first digit SIC code of 1 and 6 are excluded in our
tests.

The house price index (HPI)\textsuperscript{9} published by the Federal Housing Financial Agency\textsuperscript{10}
(FHFA) is included in our model to control for the broad time trends in the US housing
price movements. The HPI date is available at the state level starting from 1975, and it
tracks mainly the residential real estate price movements, but the changes in prices are
expected to reflect price sensitivity in commercial real estate. We match the state level
HPI with our accounting data using the state identifier (#STATE) from the Compustat. In
regression, we take the natural-log of HPI in order to smooth-out the price trends.

For the purposes of quality controls on the statistical robustness of the empirical
estimation and to minimize biases in data, we drop observations with corporate real estate
ratio (CRER) and leverage ratio (LEVERAGE) that are either more than 1 or less than 0.
Firms with negative cash flow (CASH) are also dropped from our samples.

\textsuperscript{9} It has two types of house price index, purchase only index and all transactions index. For purchase only
index, the hedonic model is estimated using sales price data; all transaction index use both sales price data
and appraisal data. HPI in this paper is all transactions index.

\textsuperscript{10} See http://www.fhfa.gov/
3.2 Corporate Real Estate Ownership by Industry

Real estate that includes building, land and improvement, and construction in progress accounts for approximately 20% of the PPE, and 10% of the total asset of average sample firms over the periods 1984-2009. Table 1 shows the descriptive statistics of corporate real estate ratio (CRER) for the sample firms over three periods: 1980s, 1990s and 2000s. The statistics show that corporate real estate ratios decline significantly during the periods from 1984 to 2009. The pre-1989 average CRER of 15% decreases to less than 10% in the 2000s periods. The decreases in real estate may be coincided with the progression in production technology that requires less real estate space.

Table 1 also summarizes average corporate real estate ownership of sample firms in four different industries based on the first digit of the SIC code; they are light manufacture industry (SIC=2), heavy manufacture industry (SIC=3), wholesale and retail (SIC=5), and services (SIC=7). Like Tuzel (2010), we find significant heterogeneity in CRER of our sample firms in different SIC sector. Firms in the service industry own less real estate than firms in other industries. The median values of CRER for the service industry firms are zero in 1990s and 2000s, which indicate that the service sector firms rely extensively and exclusively on real estate leases to meet the business operation needs. The highest CRER firms are in the wholesale and retail industry. Heavy manufacturing firms may trade off real estate for more intensive investments in other capital goods compared with light manufacturing firms.

3.3 Corporate Real Estate Ownership and Productivity Risks

Table 2 reports the descriptive statistic of relative CRER of sample firms sorted using RISK1 and RISK2 variables into five quantiles. The relative CRER is defined as the mean quantile CRER in excess of industry average. Based on the cash flow risk measure, RISK1, we sort relative CRER of the sample firms into five risk-based quantiles controlling for heterogeneity of firms by industry (Panel A). We also treat the risk-based
relative CRER quantiles of firms by the leverage of firms (Panel B). We also use the second risk measure, RISK2, to sort the industry-adjusted CRER (Panel C).

[Insert Table 2 about Here]

For the full sample of 5584 firms as reported in Panel A, the results show that the relative CRER decreases in the cash flow (productivity) risks of firms, RISK1. The relative CRER ratio for the sample firms in the first risk-based quantile is 2.4% higher than the industry average CRER, whereas for the high-risk firms in the fifth quantile, the CRER is 1.52% lower than the industry average. The relative CRER of firms in the lowest-risk quantile is 4% higher than that of firms in the highest-risk quantile. The negative CRER and risk relationship is consistent with the prediction in theoretical model. In Panel A, we also analyze the relative CRER and risk relationships for firms in different industries. Decreases in relative CRERs from the low risk quantiles to high risk quantiles are observed for firms in all industries.

In Panel B, we further treat the sample risk-based quantiles into a high leverage group and a low leverage group. Based on the firms’ average leverage during the sample period, we determine the relative leverage of firms in excess of the industry average, and then sort the firms based on the relative leverage in an ascending order. The top 30% firms by the relative leverage as the high-leveraged firms and the bottom 30% of the sample firms as the low-leveraged firms. High-leveraged firms will need to set aside more internal cash flows to meet the payment obligations for the loan principals and interests. The firms will thus face higher risks of distress compared to low-leveraged firms. Panel B compares the relative CRER between firms with low and high leverage, and the results show that firms in the high leverage group own more real estate than firms in the low leverage group for each risk quantile. The difference in CRER between firms in high- and low-leverage groups is about 4% on average. The difference in relative CRER is widened for the sample firms in the highest-risk quantile, which works out to be around 6% on average.

As robustness tests, we replace RISK1 by RISK2, which is the standard deviation of $\text{Ln}(\text{CASHR})$ obtained in the AR1 process, as our indicator to sort the sample into five risk-based quantiles in Panel C. The results of the relative CRER in Panel C show that the
relative CRER and leverage relationships remain unchanged. The results are independent of the risk-based treatments either by RISK1 or RISK2. The results are not different from those observed in Panel B, where we find that high-risk and high-leveraged firms own relatively more CRER than low-risk and low-leveraged firms.

3.4 Optimal Real Estate Investment Strategies

The descriptive statistics in the earlier sections show some preliminary evidence on the relationships between corporate real estate ownership, risk and leverage ratio. We next use a reduced form approach to empirically estimate the sensitivities of CRER to changes in productivity risk and leverage controlling for other exogenous variables, such as housing price, firm size, PPE excluding real estate to total asset ratio, expected cash flow, year and industry fixed effects. In our theoretical model, we assume that real estate is complement to other capital goods per unit labour in the production function, such that firms will optimize the two inputs along the L-shaped isoquants, that is $\min(h_t, f(k_t),...)$, given the constraints in budget. The PPE excluding CRE to the total asset ratio (PPEOR) and expected cash flow ratio are used to control for investment in other goods and also budget constraints in the models. We also adjust for possible endogeneity in the relationships between corporate real estate and leverage as predicted by the collateral channel literature by using market to book value, time and industry effects as instrument variables in the alternate Models 2, 4 and 6 as shown in Table 3.

Table 3 reports the empirical estimates modeling corporate real estate ownership decision. The corporate real estate ratio (CRER) is the dependent variable, and the two risk measures RISK1 and RISK2 that represent standard deviations of cash flow ratio, are the key determinants in the models. The results of Model (1) that excludes other capital goods ratio and expected cash flow ratios, show that the coefficients for all the explanatory variables are highly significant at less than 1% level controlling for time and industry effects in the model. The RISK1 coefficient is significant and negative in explaining the variations in CRER, which did not reject the theoretical prediction of our model. The leverage ratio is significantly and positively related to real estate ownership
of the firms. The real estate price index is also significant, but is negatively related to the real estate ownership, which may imply the adoption of market timing rules by firms in the purchase of real estate. The firm size is positive and significant, which indicates that large firms own more corporate real estate.

We add the PPE excluding CRE ratio and the expected cash flow in Model (3) to control for the effects of investments in other capital goods and also cash flows constraints, the results, however, remain unchanged. The risk measure is still significant and negative in affecting the corporate real estate of the sample firms.

We then adjust for possible endogeneity between corporate real estate and leverage in Models (2) and (4) using the instrumental variable approach. The coefficients of leverage is still significantly positive, but the values of the coefficients are larger compared to the same estimates in the OLS estimates in Models (1) and (3). The estimates and the signs of the coefficients for other variables are the same as in the two OLS Models. The negative relationships between real estate ownership and the risk and the real estate price remain significant at a less than 1% level.

In Models (5) and (6), we replace the RISK1 variable in Models (3) and (4) by the alternative risk variable, RISK2, derived from the AR(1) process. However, the results show no changes in the relationships between corporate real estate and risk in production of firms. We could not reject the hypothesis that high-risk firms will reduce distress risk by owning less real estate compared to low-risk firms. The high-risk firms may use leasing contract to procure necessary real estate space for the production needs.

3.5 Marginal Optimal Investments in Corporate Real Estate

In this section, we test the impact of productivity shocks on decision to invest in new real estate. The dependent variable is the net changes in corporate real estate, which is computed as the natural-log of the difference of corporate real estate in two continuous years plus one. The transitory cash flow variable, which is the residual term of the predicted model: \( CASHR_t = \alpha + \beta_1 SIZE_{t-1} + \beta_2 PPE_{t-1} \), is estimated to proxy productivity shocks. For other exogenous variables, we have the housing price index to
proxy the market timing strategy, the capital expenditure excluding CRE to proxy other investment goods, the leverage ratio, market to book ratio, firm size, the lagged ratios for PPE and CRE, and the year and industry fixed effects. Two CRE change models are estimated, where in Model (2), one additional expected cash flow change variable\(^{11}\) is added to capture for changes in productivity shocks.

The regression results are summarized in Table 4, which show that the transitory cash flow variable has significant and positive impact on the net investment in real estate in both Models (1) and (2). Firms facing external financing constraints, increase the real estate stocks in productivity shocks increase. In periods with high (positive) productivity shocks, firms are expected to generate more internal cash flows, which can then be used to increase real estate holdings. Firms with residual cash flows will invest incremental in real estate to hedge against the risks of financial distress in the event of negative productive shocks. Therefore, the results support our model’s prediction that the net change in corporate real estate of firms is dependent on the productivity shocks.

[Insert Table 4 about Here]

The results of other estimates in our regressions in Table 4 show that investment in capital goods, CGI, is negatively related to the net investment in real estate. Firms with higher real estate stock in the previous period, CRER(-1), are also more likely to increase real estate in periods of positive productivity shock. Firms with high PPE ratio need more real estate. The coefficients for the lagged leverage ratio and the housing price index are significant, but negative in the models. The coefficients for the market to book ratio and the firm size are significant and positive in explaining the sensitivity in changes in real estate. In model 2, the expected increases in cash flow will motivate firms to invest more in real estate.

Financially constrained firms rely on external capital to finance investments in both real estate and other input goods for the production function. In the previous regressions, the transitory cash flows capture only the productivity shocks on internal source of funds

\(^{11}\) Expected cash flow change is the difference of expected cash flow in natural-log term between two consecutive years plus one.
Productivity shocks will have more impact on corporate real estate investment decision of firms, which are subjected to external financing constrained. It is difficult in practice to determine the external financing constraints faced by firms. We treat the sample firms based on ex-post strategies on dividend payout and debt issuance. In term of dividend payout policy, dividend payouts reduce the available internal cash flows to make new investments in real estate. Therefore, firms that make dividend payouts in a particular year are assumed to face externally financing constraints. Other firms with no dividend payouts in a particular year are not constrained in obtaining external financing. For the debt issuance policy, firms issuing debts in a particular year are unconstrained in external financing, whereas other firms with no debt issuance are treated as constrained firms.

We rerun the regression models in Table 4 for the constrained and unconstrained sub-sample of firms, and the results are summarized in Table 5. The results do not vary significantly from those estimated in Table 4. The signs of the key coefficients remain unchanged. The elasticity of CRE increase to changes in the transitory cash flows for constrained firms is higher than that for unconstrained firms. The results imply that investment of firms with external financing constrained are more sensitive for the productivity shock.

[Insert Table 5 about Here]

4 Conclusion

This paper develops a dynamic model to predict the real estate ownership and leasing decisions of firms under different productivity shocks. In the earlier literature on the collateral effects (Gan, 2007; Chaney, Sraer and Thesmar, 2010) and also the irreversibility of real estate of Tuzel (2010), real estate decisions are made ex-post. Changes in real estate prices that are exogenous will affect ex-ante the real estate investment and divestment decisions of firms. In our models, real estate decision is not exogenous; firms make real estate decisions to complement to other capital goods in the production function. Productivity shocks that create uncertainty in firms’ internal cash
flows will affect the investment decisions on corporate real estate. Based on the “marginal rule” of investing in corporate real estate, we predict that low-risk firms own more real estate assets to reduce distress risks. Therefore, corporate real estate holdings of firms can be used as a separating signal to sort firms into high-risk and low-risk groups. High-risk firms that are more prone to distress risks will lease more real estate, and have a relatively smaller fraction of real estate in PPE compared to low-risk firms. Our model also shows that constrained firms with high-leverage ratio own more real estate to hedge this risk when there are positive shocks to productivity.

In our empirical tests of the real estate ownership of firms under productivity shocks using listed US firms from 1984 to 2009, our results show that corporate real estate ownership is significantly and negatively related to distress risks of firms, which is measured as the standard deviations of cash flows from operation, after controlling for other factors. We also find that high-leveraged firms own more real estate than low-leverage firms. The results support the predictions of the theoretical model, which argues that firms’ real estate invest decisions (own versus lease) are not exogenous; firms that are more prone to productivity shocks will choose to lease more rather than own real estate. We also show that firms facing externally financing constraints will invest more corporate real estate when positive productive shocks occur.
Reference


Appendix A. Proofs

A.1 Derivations of the Optimal Policy First Best Condition

The optimal first best condition is derived from the Bellman Equation (9). Because $e(k_t, h_t, \theta_t, k_{t+1}, h_{t+1})$ is continuous and differentiable for $k_t, h_t$ except states $(k_t, h_t, \theta_t)$, such that

$$c(k_t, h_t, \theta_t) = 0$$

So except these points, we have

$$V_i(k_t, h_t, \theta_t) = e_i(k_t, h_t, \theta_t, k_{t+1}, h_{t+1})$$

For $i = 1$ or 2. Next, we define $\bar{\theta}_{t+1}$ satisfies

$$c(k_{t+1}^*, h_{t+1}^*, \bar{\theta}_{t+1}) = \bar{\theta}_{t+1} k_{t+1}^{*\alpha} - W - P^l [f(k_{t+1}^*) - h_{t+1}^*] = 0$$

We differential $V(k_{t+1}, h_{t+1}, \theta)$ around $k_{t+1}^*$ and $h_{t+1}^*$, when $\theta > \bar{\theta}_{t+1}$, $c(k_{t+1}^*, h_{t+1}^*, \theta) > 0$, and from equation (1) to (9)

$$V_1(k_{t+1}, h_{t+1}, \theta) = \theta k_{t+1}^{a-1} - P^l f'(k_{t+1}^*) + P^k (1 - \delta)$$

$$V_2(k_{t+1}, h_{t+1}, \theta) = P^l + P^h (1 - \mu)$$

when $\theta < \bar{\theta}_{t+1}$, and $c(k_{t+1}^*, h_{t+1}^*, \theta) < 0$

$$V_1(k_{t+1}, h_{t+1}, \theta) = \left(1 + \frac{\psi^k}{\psi^h}\right) \left[\frac{\theta k_{t+1}^{a-1} - P^l f'(k_{t+1}^*)}{\psi^k} + P^k (1 - \delta)\right]$$

$$V_2(k_{t+1}, h_{t+1}, \theta) = \left(1 + \frac{\psi^h}{\psi^k}\right) \left[\frac{P^l}{\psi^k} + P^h (1 - \mu)\right]$$

For $k_{t+1}, h_{t+1}, e(k_t, h_t, \theta_t, k_{t+1}, h_{t+1})$ is continuous and differentiable with any given $k_t, h_t, \theta_t$, and,
If we sum them together, we can derive equation (10) and (11).

A.2 Proof of Proposition 1

We differential equation (12) w.r.t. \( h_{t+1}^* \),

\[
k_t^* \alpha \frac{\partial \tilde{h}_{t+1}}{\partial h_{t+1}^*} = -p^t < 0
\]

So \( \frac{\partial \tilde{h}_{t+1}}{\partial h_{t+1}^*} < 0 \). In each period, we have \( \frac{\partial \theta}{\partial h_t^*} < 0 \).

A.3 Proof of Proposition 2

Similar with the proof in Appendix A.1, \( e(k_t, h_t, d_{t-1}, \theta_t, k_{t+1}, h_{t+1}, d_t) \) is is continuous and differentiable for \( d_{t-1} \) except for states \( (k_t, h_t, d_{t-1}, \theta_t) \), such \( c(k_t, h_t, d_{t-1}, \theta_t) = 0 \). We differential \( d_t \) around \( (k_{t+1}^*, h_{t+1}^*, d_t^*) \), and \( c(k_{t+1}^*, h_{t+1}^*, d_t^*, \tilde{\theta}_{t+1}) = 0 \). When \( \theta > \tilde{\theta}_{t+1} \), from equation (2)-(6), (15) and (16),

\[
V_3(k_{t+1}, h_{t+1}, d_t, \theta) = 1 + p
\]

Similarly, when \( \theta < \tilde{\theta}_{t+1} \),

\[
V_3(k_{t+1}, h_{t+1}, d_t, \theta) = (1 + p) \left( \frac{1}{\psi^k} + \frac{1}{\psi^h} \right)
\]

And the marginal benefit of debt is defined as the increase of firm’s value per unit debt,

\[
\frac{\partial e(k_t, h_t, d_{t-1}, \theta_t, k_{t+1}, h_{t+1}, d_t)}{\partial d_t} = 1
\]

and the expected marginal cost is the sum of \( V_3 \) in different productivity shock

\[
\int_{\tilde{\theta}_{t+1}}^{+\infty} \varphi(\theta, u_t, \sigma^2)(1 + p) + \int_0^{\tilde{\theta}_{t+1}} \varphi(\theta, u_t, \sigma^2)(1 + p) \left( \frac{1}{\psi^k} + \frac{1}{\psi^h} \right)
\]

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Only the marginal benefit of debt is bigger than marginal cost, the firm’s value can increase.

A.4 Proof of Proposition 3

The optimal real estate ownership and optimal other capital goods is decided by equation (13) and (14). When other factors are given, $\bar{\theta}_{t+1}$ is constant. And the debt issuance will not influence other capital decision, from proposition 2. And $\bar{\theta}_{t+1}k^*_{t+1}a - W - p^l[f(k^*_{t+1}) - h^*_{t+1}] - d_t(1 + p) = 0$. We differential this equation w.r.t. $d_t$,

$$p^l \frac{\partial h^*_{t+1}}{\partial d_t} = (1 + p) > 0$$

So $\frac{\partial h^*_{t+1}}{\partial d_t} > 0$.

A.5 Proof of Proposition 4

We proof it from two aspects. Firstly, $c(k_t, h_t, \theta_t) < 0$. In order to satisfy equation (17), $i^h_t \leq 0, i^k_t \leq 0$. Then the net investment on real estate $h_t - h_{t-1}(1 - \mu) = h'_{t-1} - h_{t-1}(1 - \mu) + i^h_t$. From equation (2), we have $\frac{\partial h'_{t-1} - h_{t-1}(1-\mu)}{\partial \theta_{t-1}} > 0$.

In other side, if $c(k_t, h_t, \theta_t) > 0$ and the optimal points of firm is constrained by external financing, the Lagrange factor of equation (17) is bigger than zero, and $h_t - h_{t-1}(1 - \mu) = i^h_{t-1}$. From equation (17), we have $\frac{\partial i^h_{t-1}}{\partial \theta_{t-1}} > 0$. 
Table 1. The descriptive statistic of corporate real estate ownership

<table>
<thead>
<tr>
<th></th>
<th>1980s</th>
<th>1990s</th>
<th>2000s</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Corporate Real Estate</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>0.1568</td>
<td>0.1101</td>
<td>0.0846</td>
<td>0.1063</td>
</tr>
<tr>
<td>Median</td>
<td>0.1301</td>
<td>0.0354</td>
<td>0.0069</td>
<td>0.0309</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>0.1704</td>
<td>0.1620</td>
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<tr>
<td>Observations</td>
<td>18449</td>
<td>50918</td>
<td>51793</td>
<td>121160</td>
</tr>
<tr>
<td><strong>SIC=2</strong></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Mean</td>
<td>0.1723</td>
<td>0.1260</td>
<td>0.0965</td>
<td>0.1204</td>
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<tr>
<td>Median</td>
<td>0.1680</td>
<td>0.1068</td>
<td>0.0369</td>
<td>0.0937</td>
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<tr>
<td>Std. Dev.</td>
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<td>0.1387</td>
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<td>Observations</td>
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<td>9335</td>
<td>10201</td>
<td>23239</td>
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<td><strong>SIC=3</strong></td>
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<tr>
<td>Mean</td>
<td>0.1467</td>
<td>0.1037</td>
<td>0.0802</td>
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<td>Median</td>
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<td>0.0699</td>
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<td>0.1086</td>
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<td>17445</td>
<td>42410</td>
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<td>Mean</td>
<td>0.1725</td>
<td>0.1434</td>
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<td>0.0591</td>
<td>0.0432</td>
<td>0.0613</td>
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<td>0.1941</td>
<td>0.2038</td>
<td>0.1965</td>
</tr>
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<td>2782</td>
<td>7162</td>
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<td>15805</td>
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<tr>
<td><strong>SIC=7</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
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<td>0.0819</td>
<td>0.0574</td>
<td>0.0777</td>
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<td>Std. Dev.</td>
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<td>0.1979</td>
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<td>9167</td>
<td>10488</td>
<td>21779</td>
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</table>

Notes: (1) The corporate real estate is measured by the sum of Building at cost, Land and improvement at cost and Construction in progress at cost under the breakdown of PPE, and normalized by total book value. (2) “SIC=2” means the first digital of SIC code is “2” and the rest is the same manner. Separately, they are light manufacture industry (SIC=2), heavy manufacture industry (SIC=3), wholesale and retail (SIC=5), and service (SIC=7).
Table 2. The descriptive statistic of corporate real estate ownership by risk level

<table>
<thead>
<tr>
<th>Risk</th>
<th>Low</th>
<th>2</th>
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<th>4</th>
<th>High</th>
<th>Total</th>
<th>Observation</th>
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<td>0.0072</td>
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<td>-0.0276</td>
<td>-0.0276</td>
<td>-0.0235</td>
</tr>
<tr>
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<td>0.1276</td>
<td>0.1241</td>
<td>0.1155</td>
<td>0.1206</td>
<td>0.1207</td>
<td>0.1226</td>
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<tr>
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<td>0.0032</td>
<td>0.0014</td>
<td>0.0000</td>
<td>-0.0173</td>
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<tr>
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<td>Median</td>
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<td>0.0013</td>
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<td>-0.0142</td>
<td>-0.0397</td>
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<td>Mean</td>
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<td>-0.0284</td>
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<td>-0.0410</td>
<td>-0.0399</td>
<td>-0.0296</td>
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<td>Total</td>
<td>Observation</td>
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<td><strong>Panel B</strong></td>
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</tr>
<tr>
<td>Low Leverage</td>
<td>Mean</td>
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<td>0.0189</td>
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<td>-0.0105</td>
<td>-0.0132</td>
<td>-0.0209</td>
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<td>0.1322</td>
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<td><strong>Panel C</strong></td>
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<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Corporate Real Estate</td>
<td>Mean</td>
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<td>0.0115</td>
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<td>-0.0093</td>
<td>-0.0105</td>
<td>0.0000</td>
</tr>
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<td>0.1298</td>
<td>0.1149</td>
<td>0.1147</td>
<td>0.1316</td>
<td>0.3228</td>
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<td>Low Leverage</td>
<td>Mean</td>
<td>0.0078</td>
<td>0.0023</td>
<td>-0.0198</td>
<td>-0.0337</td>
<td>-0.0534</td>
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<td>-0.0226</td>
<td>-0.0327</td>
<td>-0.0411</td>
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<td>-0.0264</td>
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<td>0.1390</td>
<td>0.1145</td>
<td>0.1244</td>
<td>0.1370</td>
<td>0.1291</td>
</tr>
</tbody>
</table>

Notes: (1) The measurements of risk, corporate real estate ratio, and leverage ratio in this table are all industry adjusted; they represent relative positions with other same industry type firms based on the first two digitals of SIC code. (2) The observations are all sorted by five different risk quintiles from low to high. (3) "SIC=2" in panel A means the first digital of SIC code is "2"; and the rest is the same manner. (4) Panel A and B use the Std. Dev. of cash flow ratio after taken nature log (RISK1) as risk measurement; panel C uses the Std. Dev. of Ln(CASHR) after eliminated.
historical influence (RISK2) as risk measurement. (5) The low and high leverage groups indicate the bottom and top 30% firms sort by relative leverage ratio.
Table 3. Decision of corporate real estate ownership

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<tr>
<th>VARIABLES</th>
<th>CRER</th>
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<td>(1)</td>
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<tr>
<td></td>
<td>OLS</td>
</tr>
<tr>
<td>RISK1</td>
<td>-0.0223***</td>
</tr>
<tr>
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<td>(0.00141)</td>
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<tr>
<td>RISK2</td>
<td>-0.0274***</td>
</tr>
<tr>
<td></td>
<td>(0.00212)</td>
</tr>
<tr>
<td>Leverage</td>
<td>0.0526***</td>
</tr>
<tr>
<td></td>
<td>(0.00260)</td>
</tr>
<tr>
<td>Housing Price Index (HPI)</td>
<td>-0.0420***</td>
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<tr>
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<td>(0.00419)</td>
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<tr>
<td>Size</td>
<td>0.00733***</td>
</tr>
<tr>
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<td>(0.000277)</td>
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<td>PPE excluding CRE Ratio (PPEOR)</td>
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<tr>
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<td>(0.00217)</td>
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<td>Expected Cash Flow</td>
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<tr>
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<td>(0.000276)</td>
</tr>
<tr>
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<td>Industry Fixed Effect</td>
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<td>Observations</td>
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</tr>
<tr>
<td>R-squared</td>
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</table>

Notes: (1) Standard errors in parentheses. (2) ***, **, * indicates significance at the 1%, 5%, and 10% level respectively. (3) Column (1), (3) and (5) are general OLS regression; column (2), (4) and (6) are two-stage regression by instrumenting leverage by market to book ratio and controlling year effects and industry effects. (4) Industry effects are controlled based on the first two digits of SIC.
Table 4. Decision of corporate real estate investment

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<tr>
<th>VARIABLES</th>
<th>(1)</th>
<th>(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transitory Cash Flow</td>
<td>0.297***</td>
<td>0.699***</td>
</tr>
<tr>
<td></td>
<td>(0.0577)</td>
<td>(0.0886)</td>
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<tr>
<td>Expected Cash Flow Change</td>
<td></td>
<td>0.724***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.0944)</td>
</tr>
<tr>
<td>Housing Price Index (HPI)</td>
<td>-0.661***</td>
<td>-0.641***</td>
</tr>
<tr>
<td></td>
<td>(0.0458)</td>
<td>(0.0464)</td>
</tr>
<tr>
<td>Capital Expenditure excluding CRE (CGI)</td>
<td>-0.0121***</td>
<td>-0.0113***</td>
</tr>
<tr>
<td></td>
<td>(0.00189)</td>
<td>(0.00189)</td>
</tr>
<tr>
<td>CRE Ratio (CRER) (-1)</td>
<td>2.727***</td>
<td>2.944***</td>
</tr>
<tr>
<td></td>
<td>(0.0455)</td>
<td>(0.0473)</td>
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<tr>
<td>PPE ratio (PPER) (-1)</td>
<td>0.0480**</td>
<td>-0.0357</td>
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<td>(0.0209)</td>
<td>(0.0221)</td>
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<tr>
<td>Leverage (-1)</td>
<td>-0.247***</td>
<td>-0.102***</td>
</tr>
<tr>
<td></td>
<td>(0.0323)</td>
<td>(0.0346)</td>
</tr>
<tr>
<td>Cash Flow Ratio (CASHR) (-1)</td>
<td>0.0117***</td>
<td>1.400***</td>
</tr>
<tr>
<td></td>
<td>(0.00252)</td>
<td>(0.0704)</td>
</tr>
<tr>
<td>Market to Book Ratio (MB)</td>
<td>0.0236***</td>
<td>-0.000342</td>
</tr>
<tr>
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<td>(0.00298)</td>
<td>(0.00323)</td>
</tr>
<tr>
<td>Size</td>
<td>0.571***</td>
<td>0.585***</td>
</tr>
<tr>
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<td>(0.00327)</td>
</tr>
<tr>
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<td>Yes</td>
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<tr>
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<tr>
<td>Observations</td>
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<td>35577</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.591</td>
<td>0.601</td>
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</table>

Notes: (1) Standard errors in parentheses. (2)***, **, * indicates significance at the 1%, 5%, and 10% level respectively. (3) The CRE change is measured by the difference of total corporate real estate in two continuous years plus one after taken nature log; transitory cash flow is the residual of cash flow ratio prediction model; expected cash flow change is the difference of expected cash flow in two continuous years plus one after taken nature log. (4) Industry effects are controlled based on the first two digits of SIC.
Table 5. The corporate real estate investment for constrained and unconstrained firms

<table>
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<tr>
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<td>Constrained</td>
<td>Unconstrained</td>
<td>Constrained</td>
<td>Unconstrained</td>
</tr>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
</tr>
<tr>
<td>Transitory Cash Flow</td>
<td>0.638***</td>
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<td>0.467***</td>
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</tr>
<tr>
<td></td>
<td>(0.109)</td>
<td>(0.0681)</td>
<td>(0.116)</td>
<td>(0.0669)</td>
</tr>
<tr>
<td>Housing Price Index (HPI)</td>
<td>-0.615***</td>
<td>-0.643***</td>
<td>-0.352***</td>
<td>-0.755***</td>
</tr>
<tr>
<td></td>
<td>(0.0658)</td>
<td>(0.0646)</td>
<td>(0.0658)</td>
<td>(0.0637)</td>
</tr>
<tr>
<td>Capital Expenditure excluding CRE (CGI)</td>
<td>-0.00881***</td>
<td>-0.157***</td>
<td>-0.177***</td>
<td>-0.0101***</td>
</tr>
<tr>
<td></td>
<td>(0.00197)</td>
<td>(0.0125)</td>
<td>(0.0180)</td>
<td>(0.00198)</td>
</tr>
<tr>
<td>CRE Ratio (CRER) (-1)</td>
<td>3.034***</td>
<td>2.509***</td>
<td>2.139***</td>
<td>3.076***</td>
</tr>
<tr>
<td></td>
<td>(0.0712)</td>
<td>(0.0587)</td>
<td>(0.0667)</td>
<td>(0.0599)</td>
</tr>
<tr>
<td>PPE ratio (PPER) (-1)</td>
<td>-0.0413</td>
<td>0.0473*</td>
<td>0.0838***</td>
<td>-0.0587**</td>
</tr>
<tr>
<td></td>
<td>(0.0327)</td>
<td>(0.0267)</td>
<td>(0.0274)</td>
<td>(0.0297)</td>
</tr>
<tr>
<td>Leverage (-1)</td>
<td>-0.352***</td>
<td>-0.193***</td>
<td>-0.155***</td>
<td>-0.520***</td>
</tr>
<tr>
<td></td>
<td>(0.0539)</td>
<td>(0.0400)</td>
<td>(0.0487)</td>
<td>(0.0449)</td>
</tr>
<tr>
<td>Cash Flow Ratio (CASHR) (-1)</td>
<td>0.0644***</td>
<td>0.00850***</td>
<td>0.256***</td>
<td>0.0106***</td>
</tr>
<tr>
<td></td>
<td>(0.0110)</td>
<td>(0.00249)</td>
<td>(0.0346)</td>
<td>(0.00272)</td>
</tr>
<tr>
<td>Market to Book Ratio (MB)</td>
<td>0.0184***</td>
<td>0.0338***</td>
<td>0.0311***</td>
<td>0.0276***</td>
</tr>
<tr>
<td></td>
<td>(0.00421)</td>
<td>(0.00414)</td>
<td>(0.00382)</td>
<td>(0.00449)</td>
</tr>
<tr>
<td>Size</td>
<td>0.679***</td>
<td>0.459***</td>
<td>0.420***</td>
<td>0.632***</td>
</tr>
<tr>
<td></td>
<td>(0.00488)</td>
<td>(0.00456)</td>
<td>(0.00471)</td>
<td>(0.00429)</td>
</tr>
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Test "Constrained=Unconstrained"

<table>
<thead>
<tr>
<th>T-test Value</th>
<th>428.538***</th>
<th>226.433***</th>
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</thead>
<tbody>
<tr>
<td>Year Fixed Effect</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Industry Fixed Effect</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Observations</td>
<td>16990</td>
<td>20915</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.639</td>
<td>0.479</td>
</tr>
</tbody>
</table>

Notes: (1)Standard errors in parentheses. (2)***,**,* indicates significance at the 1%, 5%, and 10% level respectively. (3)The CRE change is measured by the difference of total corporate real estate in two continuous years plus one after taken nature log; transitory cash flow is the residual of cash flow ratio prediction model. (4) Column (1) includes observations with dividend payment; column (2) includes observations without dividend payment; column (3) includes observations with long debt issuance; column (4) includes observations without long term debt issuance. (5) Industry effects are controlled based on the first two digital of SIC.
Figure 1. The real estate ownership weight by risk with different depreciation rate

\[
\delta = 0.20 \quad h = 0.90 \quad k = 0.70
\]
Figure 2. The real estate ownership weight by risk with different discount rate

$\delta=0.20 \ \mu=0.05 \ \psi^k=0.70$