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Corporate Real Estate Holding and Stock Returns: Testing Alternative Theories with International Listed Firms

Joe Cho Yiu Ng[1] · **Charles Ka Yui Leung**[2] · **Suikang Chen**[2]

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Abstract

This study examines the relationship between corporate real estate (CRE) holdings and stock returns before and after the Global Financial Crisis (GFC). We find that (1) the United States and the United Kingdom show a *negative* relationship before the GFC and *positive* after the GFC. (2) Firms that pay positive tax or have positive R&D investments are *not* systematically different from the full sample. This finding cannot support the "scarce capital" theory or the tax incentive explanation, but it is consistent with the "empire building" theory. After the GFC, financial constraints tightened, and both CRE holding and stock returns dropped. (3) European (excluding the United Kingdom) sample shows a *positive* relationship in the pre-crisis period. This finding is compatible with the "illiquidity premium" theory. However, the association becomes inconclusive in the post-crisis period. (3) The Japanese sample shows a *negative* association between CRE and stock returns in the pre-crisis period, like the United States and the United Kingdom. However, the relationship becomes statistically insignificant in the post-crisis period, consistent with the theory of financial constraint tightening after the GFC.

Keywords Global Financial Crisis · Corporate real estate holding · Collateral constraint · Illiquidity premium · Panel regression

JEL Classification E44 · G10 · G30

✉ Joe Cho Yiu Ng
joeng@hsu.edu.hk

✉ Charles Ka Yui Leung
kycleung@cityu.edu.hk

[1] Department of Economics and Finance, Hang Seng University of Hong Kong, New Territories, Hong Kong

[2] Department of Economics and Finance, City University of Hong Kong, Kowloon Tong, Hong Kong

Introduction

This paper investigates the relationship between corporate real estate (CRE) holdings and stock returns. CRE refers to the real estate such as buildings and lands owned or leased by firms not primarily engaged in real estate business (Dresdow & Tryce, 1988; Johnson & Keasler, 1993). Many non-real estate firms around the world hold a considerable amount of CRE. Table 1 shows that the percentage of CRE as a share of total corporate assets ranges from 10% to more than 40%, depending on the country and sampling period.[1] For such sizable CRE holding, a variety of explanations have been proposed by different groups of economists. Thus, following the spirit of Eberly et al. (2012), we include both micro and macro-based explanations.[2] As Table 2 provides a summary, and the appendix provides a detailed literature review, we briefly discuss these theories. Casual observation may suggest that firms hold CRE for production needs. For instance, manufacturing firms tend to have more CRE than service firms.[3] Brounen and Eichholtz (2005) find that industrial differences rather than regional differences drive the differences in CRE ownership. Since CRE is a value-enhancing tool, the share of CRE in the total corporate asset would be positively correlated with the stock return.

The asset pricing literature suggests another reason for a positive nexus. For instance, Tuzel (2010) proposes that firms with a relatively high real estate level are riskier due to the slow adjustment to adverse productivity shocks. Hence, they are expected to have a higher return. Therefore, a "risk premium" or "illiquidity premium" could be associated with CRE, and there could be a positive relationship between the CRE holding and the stock returns. Moreover, the macroeconomics literature proposes an additional reason for a positive relationship between CRE holding and stock return. Firms may hold CRE as collateral for loans (Bernanke & Gertler, 1989, 1990; Chaney et al., 2012; Gan, 2007a, 2007b; Jin et al., 2012; Kiyotaki & Moore, 1997). Due to an aggregate negative shock, the value of CRE suddenly drops, some firms may sell CRE to repay the debts. Thus, firms decrease their CRE holdings, causing their productivity and even investment drop, which bring them lower returns. Therefore, a positive nexus also exists after a negative shock hits the firms.

[1] For instance, in the United States, Zeckhauser and Silverman (1983) report that at least 25% of the total assets of corporations in the U.S. were corporate properties in the 1980s. From 1984 to 2011, Zhao and Sing (2016) report that the average CRE controlled by listed firms in the U.S. was about 10% of the total assets. In Europe, a report conducted by DTZ (2003) shows that the full value of the CRE in Germany, France, and the U.K. was 1 trillion, 0.7 trillion, and 0.71 trillion euros, respectively, in 2002. In Asia, Liow (1999) reports that over 1987-1996, CRE held by a sample of Singapore non-real estate firms was about S$ 35.9 billion and comprised about 29% of the firms' total tangible assets. Brounen and Eichholtz (2005) study an international sample of nine countries whose CRE as a percentage of total assets ranges from 17% in Germany to 41% in Canada in 2000. See also Riddiough (2022).

[2] Several papers compare competing theories on housing and commercial real estate, such as Kwan et al. (2015), Leung et al. (2002), Leung and Feng (2005), among others.

[3] For example, in 2000, the average CRE ratio for the sample countries was 0.13 for the business service industry and 0.63 for mining companies.

Table 1 CRE held by firms around the world reported in previous literature

Region	Literature	CRE holdings
North America and Australia	Zeckhauser and Silverman (1983)	At least 25% of the total assets of corporations in the US are corporate properties in the 1980s
	Roulac (2003)	The inflation-adjusted book value of the corporate-owned real estate was approximately $8.6 trillion in 2000
	Brounen and Eichholtz (2005)	CRE as a percentage of total assets in 2000: 26% in the U.S; 35% in Australia
	Zhao and Sing (2016)	The average CRE controlled by listed firms in the U.S. was about 10% of the total asset from 1984 to 2011
Europe	DTZ (2003)	The 2002 total value of the CRE in Germany, France, and the United Kingdom was 1 trillion, 0.7 trillion, and 0.71 trillion euros, respectively
	Brounen and Eichholtz (2005)	CRE as a percentage of total assets in 2000: 18% in France; 17% in Germany; 22% in the Netherlands; 29% in the United Kingdom
	Krumm and Linneman (2001)	The book value of CRE held by Dutch corporations was approximately 0.22 trillion euros in 1995
Asia	Liow (1999)	Over 1987–1996, CRE held by a sample of Singapore non-real estate firms was about S$35.9 billion and comprises about 29% of the firms' total tangible assets
	Brounen and Eichholtz (2005)	CRE as a percentage of total assets in 2000: 30% in Hong Kong; 31% in Japan

Table 2 Theoretical predictions on the relationship between CRE holdings and stock returns

	Justification	Examples
Theories suggest a positive relationship between CRE holding and stock returns	Production-based perspective: Technological constraint	Brounen and Eichholtz (2005); Gort et al. (1999); Kan et al. (2004)
	Asset Pricing perspective: Illiquidity Premium	Tuzel (2010)
	Macroeconomic perspective: Collateral Constraint	Bernanke and Gertler (1989, 1990); Chaney et al. (2012); Chen and Leung (2008); Chen and Wang (2007), Gan (2007a, 2007b); Jin et al. (2012); Kiyotaki and Moore (1997)
Theories suggest a negative relationship between CRE holding and stock returns	Basic trade-off: Scarcity of Capital	Brown et al. (2009); Chan et al. (1990); Eberhart et al. (2004); Gu (2016); Li (2011); Sundaram et al. (1996)
	Corporate Finance perspective: Weak governance leads to "empire-building" or over-expansion	Coles et al. (2006); Dong et al. (2012); Du et al. (2014); Sing and Sirmans (2008); Sirmans (1999)

However, if firms hold too much CRE or CRE outside their core business, this may reduce their capital to support other investments, like R&D (Linneman, 1998). Many studies find that firms gain higher returns after more R&D expenses (Brown et al., 2009; Chan et al., 1990; Eberhart et al., 2004; Gu, 2016; Li, 2011; Sundaram et al., 1996). Since capital for investment is limited ("scarce capital" argument), more capital allocated to CRE means less for R&D.[4] Hence, a positive relationship between R&D and returns would negatively affect CRE holdings and returns. The corporate finance perspective provides an additional justification why a large amount of CRE holding may not be return-enhancing (Coles et al., 2006; Du et al., 2014; Sing & Sirmans, 2008; Sirmans, 1999). For instance, Du et al. (2014) show that less financially constrained, weakly governed U.S. listed firms are more likely to over-expand (the so-called "empire building" problem). Therefore, the "empire building" and "scarce capital" arguments suggest a negative relationship between CRE holdings and returns.

To summarize, while some theories predict a positive relationship between the CRE holding and stock returns, some conjectures predict a negative one. Hence, clarifying the correlation between the CRE holding and stock returns would help us focus on the fact-consistent views and progress in economics (Cooley, 1995; Friedman, 1953).

Here are our key contributions to the literature. First, most of the existing literature focuses on U.S. firms. We study the U.S. sample, the European sample, and the Japanese sample. Since institutions and market conditions differ across countries, comparing geographical subsamples would help us establish robust results.[5] Second, we use the Global Financial Crisis (GFC) as a natural experiment to test these competing theories on the relationship between CRE holdings and stock returns. This investigation is motivated by several considerations. As we explained earlier, the macro-based theory would suggest that the relationship between CRE holding and stock returns be positive after a tremendous negative shock such as GFC, which is exogenous to firms and brings a tightening of financial conditions. On the other hand, a positive relationship between CRE holdings and stock returns can hold both before and after a crisis if the illiquid premium is the dominant reason for firms to own CRE. Thus, the GFC may shed light on the driving force of the CRE holdings. Moreover, recent research suggests a "structural change" in the housing market after the GFC.[6] Therefore, it is interesting to see if a similar change occurs in the commercial real estate sector.

More specifically, this study addresses the following questions: (1) Does CRE holdings affect stock returns? If so, how? (2) Did the GFC bring any changes to the relationship between CRE holdings and stock returns? If so, is the change in

[4] The appendix presents a simple model of corporate investment, where the trade-off between investing in CRE and R&D depends on the probability of success in R&D, which may vary across firms.

[5] Some authors also argue that the U.S. dollar has an "exorbitant privilege" (Eichengreen, 2011). Some investors are willing to accept a lower return for U.S. assets (Forbes, 2010). Therefore, it is beneficial to verify whether the "stylized facts" in the U.S. market also hold in other markets.

[6] Among others, see Chang and Leung (2022), Green (2022), Leung and Ng (2019), Ng (2022), Van Eyden et al. (2022).

that relationship consistent with the theories we discussed? (3) Is the relationship between CRE holdings and stock returns in the U.S. also observed in other major stock markets? To address these questions, we employ panel regressions with the system GMM estimator to study the relationship between CRE holdings and stock returns after controlling for firm characteristics that may also affect stock returns. Relative to the earlier literature, this paper examines whether the GFC affects the relationship between CRE holdings and stock returns. Therefore, we divide our sample into pre-crisis and post-crisis. We then compare whether there is a change in the nexus. In addition to the U.S., we study samples of European economies and Japan.[7]

The remainder of this paper is organized as follows. Section 2 describes the data, and Section 3 presents the results for the U.S. sample. Data and results for the European and the Japanese sample are shown in Section 4. The last section concludes.

Data for the U.S. Sample

Following the standard practice, we employ annual data from all listed non-financial and non-real estate firms (excluding firms with four-digit SIC codes between 6000 and 6999) from 2001 to 2015 for the U.S. sample.[8] All the accounting variables are collected from the Compustat. In our study, CRE is measured by the ratio of net property, placement, and equipment (PPE) and a firm's total assets in each fiscal year.[9]

$$\mathrm{CRE}_{i,t} = \frac{PPE_{i,t}}{Total\ Asset_{i,t}} = \frac{FATB_{i,t} + FATC_{i,t} + FATP_{i,t} + FATL_{i,t}}{AT_{i,t}}$$

where *FATB*, *FATC*, *FATP* and *FATL* stands for buildings (cost), construction in progress (cost), land and improvements (cost) and leases (cost), respectively.

The Compustat Industry Annual provides a breakdown of PPE into buildings, capitalized leases, machinery and equipment, natural resources, land and improvements, and construction in progress, both in gross and net value for each fiscal year-end. Following Tuzel (2010), machinery, equipment, and natural resources are excluded from net PPE as these items do not satisfy the definition of corporate real estate. Following the corporate finance and real estate finance literature, our dataset includes other accounting variables. Table 3 defines each variable. To make firms of a different size comparable, we use the R&D ratio

[7] We also conduct the same analysis for an Asia pacific sample (excluding Japan). Unfortunately, the results do not pass the specification tests (the Arellano-Bond and the Hansen test).

[8] Notice that some financial firms can take deposits or premiums from customers, and hence their cost of capital will be very different from non-financial firms. Some financial firms are also subject to various regulations than non-financial firms. In addition, real estate firms may need real estate as input, and thus, their motives for CRE holding may differ from non-real estate firms.

We compare the pre-crisis and post-crisis periods, and we employ data starting from 2001 to balance the pre-crisis (2001–2006) and post-crisis (2010–2015) samples.

[9] Different measures of CRE employed in the previous literature are provided in the appendix.

(R&D expenses / total sales) rather than the R&D expenses. These accounting variables will be used as control variables in the panel regression analysis, except for "Taxrate," which is used for dividing a sub-sample with firms who pay positive tax on average. We will discuss this in the next section.

We conduct the usual "winsorizing," which eliminates firm-year observations for which no CRE holding is reported and those with financial variables in the top and bottom 1% percentiles. After this data screening process, firms in the agriculture (SIC = 0) and public administration (SIC = 9) industry are all excluded from our samples. As a result, our sample has more than 18,000 firm-year observations. To control for the industry effect and to construct a measure that is comparable across different industries, we employ the RCRE (or relative CRE) ratio, which is defined as

$$\mathrm{RCRE}_{i,j,t} = \mathrm{CRE}_{i,j,t} - \frac{1}{N_{j,t}} \sum_{i=1}^{N_{j,t}} \mathrm{CRE}_{i,j,t},$$

where $N_{j,t}$ is the number of firms in industry j in fiscal year t. Thus, the RCRE of a firm i in industry j in fiscal year t is the difference between the CRE ratio of that firm and the industry equal-weighted average.

The stock return data in monthly frequency are obtained from the CRSP. We eliminate firms with less than 36 months of consecutive returns. Following Fama and French (1992, 1993) and Tuzel (2010), we match the annual accounting information in the fiscal year ending in year t-1 with the stock return data from July of year t to June of year t + 1, allowing for a minimum of a six-month gap.

To calculate the "excess return" (Alpha), we employ firm-to-industry-excess return (FIER) rather than the conventional firm-level excess return (FLER). While FLER only compares the stock performance over the risk-free rate to the market return, FIER compares the firm excess return relative to its corresponding industry. This distinction may be potentially valuable. For example, due to the difference in production mode, some industries have higher CRE holding than others. Since CRE holding could affect the potential risk, some industries may offer higher returns than others. Thus, it may be instructive to use FIER, considering the possible differences in risk and return across sectors. The monthly FLER for each firm i would be the return over the month m over the risk-free monthly rate of return:

$$R_{i,m} = r_{i,m} - rf_m$$

Then we can compute the value-weighted average return of the industry over the same period for each industry j:

$$R_{j,m} = \sum\nolimits_{i=1}^{n} w_i R_{im}{}_{i \in j}, w_i = \frac{MV_{i,m}}{\sum_1^n MV_{i,m}}$$

Once we have the industry weighted-average return, we can compute the firm-to-industry-excess return (FIER), which is simply:

Table 3 Definition of accounting variables

Variable	Definition	Measurement
AT	Total asset	Total asset (AT)
CAPX	Capital expenditure	Capital expenditure (CAPX)
Leverage	Long term debt/Total asset	Long term debt (DLTT) / Total asset (AT)
MV	Market value	Common shares outstanding (CSHO) * Price close annual – fiscal (PRCC_F)
RD	R&D expenses/ Total sales	R&D expenses (XRD) / Total sales (SALE)
Taxrate	Income tax rate	Income tax total (XTX) / Earnings before interest and tax (EBIT)
TQ	Tobin's Q	Market value (MV) / (Total asset (AT) – Common equity (CEQ) – Deferred tax (TXDB))

$$RI_{i,m} = R_{i,m} - R_{j,m}.$$

Then, we adopt the Fama–French three factors and the momentum factor introduced by Carhart (1997) to calculate Alpha. All these series come from Kenneth R. French's Data Library. Alpha is extracted from the standard four-factor model:

$$r_{i,m,t} = \alpha_{i,t} + \beta_{1i,t}MKT_{m,t} + \beta_{2i,t}SMB_{m,t} + \beta_{3i,t}HML_{m,t} + \beta_{4i,t}MOM_{m,t} + \varepsilon_{i,m,t}$$

where $r_{i,m,t}$ represents the FIER of firm i at month m over the period t.[10]

Result for the U.S. Sample

Panel Regression with System GMM Estimator

This section employs the panel regression model to study the relationship between alpha and CRE holdings. We control for firm characteristics and unobservable factors. We include individual firm-fixed effects to control for unobservable variations across firms. We also have time-fixed effects for unobservable variations across different periods. Our simple regression model takes the following form:

$$\begin{aligned} alpha_{i,t} = \theta_0 + \theta_1 RCRE_{i,t-1} + \theta_2 RD_{i,t-1} + \theta_3 lnMV_{i,t-1} + \theta_4 lnAT_{i,t-1} \\ + \theta_5 CAPX_{i,t-1} + \theta_6 leverage_{i,t-1} + \theta_7 TQ_{i,t-1} + \gamma_i + \delta_t + \varepsilon_{i,t} \end{aligned}$$

$alpha_{i,t}$ is the annual alpha of firm i. *RCRE* is the RCRE ratio described in the previous section. Control variables include *lnMV, lnAT, CAPX, leverage* and *TQ*. Their definitions are presented at Table 3. γ_i and δ_t account for the individual and time-fixed effects, respectively.

Our regression model offers protection against bias arising from reverse causality by employing lagged regressors. However, the strict exogeneity assumption might still be violated since the fixed effect model is used. For example, under the within-groups transformation, the unbiased estimates require $\mathrm{E}\left(RCRE_{i,t-1} - RCRE_{i,-1}, \varepsilon_{i,t} - \varepsilon_i\right) = 0$ where $RCRE_{i,-1}$ is the average of $RCRE_{i,t}$ over the periods 0,…,T-1 and ε_i is the average of $\varepsilon_{i,t}$. However, it still violates the strict exogeneity assumption since $RCRE_{i,-1}$ and ε_i contain *RCRE* and ε from every period. Therefore, we employ the system GMM estimator (Arellano & Bover, 1995; Blundell & Bond, 1998). The system GMM estimator augments the difference GMM by assuming that the first differences of instruments are uncorrelated with the fixed effects. It simultaneously estimates a differenced equation and a level equation,

[10] Note that period t covers the 12-month from July in year t to June in year $t+1$. The Fama-French three factors are calculated at a monthly frequency. MKT represents the market excess return, SMB represents the return of the portfolio that is long in small firms and short in big firms, and HML stands for the return of the portfolio that is long in high B/M firms and short in low B/M firms. Finally, Carhart (1997) momentum factor (MOM) is constructed at a monthly frequency. It captures the return of the trading strategy that is long in short-term winners and short in short-term losers. $${\alpha }_{i,t}$$ absorbs all the abnormal returns that are not captured by the four factors.

where lagged variables in levels instrument the differenced equation, lagged differences instrument levels. It is a general estimator designed for situations with independent variables that are not strictly exogenous; they correlate with past and possibly current error realizations (Roodman, 2009b).[11]

We employ a two-step system GMM estimator and Windmeijer's (2005) finite-sample adjustment to correct the downward bias in the computed standard errors in two-step results. We also employ the "forward orthogonal deviations" transformation (Arellano & Bover, 1995). To avoid over-fitting the endogenous variables, we collapse the instruments and use lag 2 to 4 for instruments. We report the p-values of the Arellano-Bond test for AR(2) and the Hansen test for each regression. An AR(1) process is expected in first differences, because $\varepsilon_{i,t} - \varepsilon_{i,t-1}$ should correlate with $\varepsilon_{i,t-1} - \varepsilon_{i,t-2}$ since both share the $\varepsilon_{i,t-1}$ term. But the absence of an AR(2) process in the first differences should not be rejected. The null hypothesis of the Hansen test is that the instruments as a group are exogenous. Since omitting important explanatory variables could make the error term correlated with the instruments, the Hensen test can also be viewed as a test of structural specification (Roodman, 2009a). Failing to reject the null implies there is no specification problem.

To study the impact of the GFC, we divide the sample into pre-crisis and post-crisis sub-samples and compare the relationship of CRE holding and stock return in each sub-sample. In addition, we study sub-samples of firms with positive R&D expenses and positive tax payments. These subsample analyses are motivated by the theories we discussed earlier. If R&D matters for firms' return, then we expect that the effect of CRE holdings on returns will be different in the sub-samples of firms with positive R&D expenses and the entire sample with all firms. The reason for studying firms with actual tax payments is as follows. The current U.S. corporate tax code allows for the loss-offset provision, which means that firms can write off operation losses against both past and future profit and reduce their tax obligations (Kaymak & Schott, 2019). Therefore, firms may purchase an "excessive amount" of CRE to immediately reduces the pretax profit, and hence the tax obligation, at the year of purchase. Also, should there be a capital loss when the CRE is sold, the loss-offset provision would allow the firms to pay lower taxes or no tax. Thus, those tax-paying firms are less likely to be "overloaded" with CRE. Hence, the relationship between CRE holdings and returns among firms might be "weaker'' than the whole sample.

Table 4 shows the panel regression results for the U.S. Sample. First, Arellano-Bond tests for AR(2) are not rejected, meaning that the error term in levels is serially uncorrelated. Also, the Hansen test of over-identification indicates that the instruments as a group appear exogenous. Second, there is a negative relationship between the RCRE ratio and the Alpha in the pre-crisis sample. The point estimate of the coefficient on RCRE among positive R&D firms seems to be more negative

[11] Furthermore, the endogeneity problem caused by selection bias is a common concern (e.g., see Dang et al. (2015) and the reference therein). In the current context, the entry and exit of firms could potentially create a selection bias (Guo and Leung, 2021; Hopenhayn, 1992; Jovanovic, 1982). Fortunately, through analyzing the dynamic panel data models with sample selection, Al-Sadoon et al. (2019) recently found that the inconsistency of the System GMM estimator is tiny and hardly induces bias in the estimator, even and especially in small samples.

Table 4 Panel regressions: United States sample

Dependent variable: Alpha	(1)	(2)	(3)	(4)	(5)	(6)
	All firms	Positive RD	Positive tax	All firms	Positive RD	Positive tax
	Pre-crisis sample: 2001–2006			Post-crisis sample: 2010–2015		
$RCRE_{i,t-1}$	-0.129*	-0.153*	-0.121	0.222**	0.502**	0.252**
	(0.077)	(0.093)	(0.083)	(0.112)	(0.255)	(0.123)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Arellano-Bond test for AR(2)	0.326	0.631	0.683	0.583	0.331	0.601
Hansen test of overidentification	0.432	0.361	0.362	0.774	0.765	0.521
Observations	10,831	7297	8650	7437	4770	6100
Number of instruments	33	33	33	33	33	33
F statistic: compared to the coefficient in column (1)		0.040	0.005		1.01	0.033
F statistic: difference between pre- and post-crisis	All firms: 6.67***		Positive RD: 5.82**		Positive tax: 6.32**	

Robust standard errors are given in parentheses. *, ** and *** indicate 10%, 5% and 1% level of significance. P-values are reported for the Arellano-Bond and Hansen test

than that of the whole sample. It indicates that if the positive R&D firms allocate funds more to purchasing CRE, their average returns will drop more than the counterpart of the entire sample. However, the F test shows that the difference between the two coefficients is insignificant. Thus, we do not have direct statistical evidence to support the "scare capital" theory. Third, the F test also indicates that the positive tax firms' sample has no (statistical) difference compared to the whole sample, suggesting that CRE holding tax incentives may not be substantial.

Forth, the negative relationship in the pre-crisis sample indicates that while the "empire building" theory may hold before the crisis, it is then challenged after the GFC, as the relationship between RCRE and the stock return becomes positive. The F test also confirms that the difference between pre-crisis and post-crisis samples is significant. The finding is consistent with the macroeconomic theory, which proposes that in the post-crisis period, with declining productivities, tightening financial constraints force the firms to sell CRE, perhaps to repay the debts.

We also adopt a more direct approach to test the "empire building" theory by including firm-level corporate governance-related variables into the regression. Unfortunately, corporate governance variables that are commonly agreed upon for all countries are unavailable. Therefore, we restrict our attention to the U.S. sample. We employ the firm-level corporate governance index constructed by Gompers et al. (2003). This index is only available for a sub-sample of U.S. firms in 1990, 1993, 1995, 1998, 2000, 2002, 2004, and 2006. Thus, we are unable to compare the regressions before and after the GFC. The results are shown in the appendix. The coefficient on RCRE is insignificant in this sub-sample of U.S. firms even before adding the corporate governance index. And the coefficient continues to be negligible after introducing the corporate governance variable. A small and discontinuous sample could cause the estimation result, and hence it may be premature to reject the empire-building theory on this basis.[12] We would instead conclude that we have not found any direct support for that class of theory.

The European and Japanese Sample

Thus far, we have focused on U.S. firms. How about the firms in other countries? Economic intuitions suggest that explanations on the relationship between CRE holdings and stock returns should also hold across countries. Also, GFC affects not only U.S. firms but all firms globally. On the other hand, institutional factors might also affect the CRE holdings. Hence, examining the relationship between CRE holdings and stock returns would ensure that the economic explanations provided in this paper indeed hold in general.[13]

[12] Moreover, firm-level variables such as leverage may be influenced by corporate governance variables. For more discussion, see Morellec et al. (2012) and the reference therein, among others,

[13] We receive an additional suggestion during the GFC, capital flow to the USA for flight-to-liquidity (FTL) or flight-to-safety (FTS) considerations. Hence, the results that hold in the U.S. do not necessarily hold internationally. Considering the impact of international capital flows on CRE holding would be beyond the scope of this paper. The literature on FTL and FTS is also abundant. See Baele et al. (2019), Beber et al. (2008), Longstaff (2004), and the references therein, among others.

Data

Therefore, we would repeat the analysis with our European and Japanese samples. Based on Compustat, the European sample covers seven economies, in alphabet order, Denmark, France, Germany, Italy, Netherlands, Russia, and the United Kingdom. We employ the same econometric model and the same set of variables and "winsorizing" as the U.S. sample. The Fama–French three factors and the momentum factor are obtained from Kenneth R. French's Data Library and Gregory et al. (2013).

Panel Regression Results

Table 5 shows the results for the European sample.[14] The coefficients on RCRE are negative but insignificant in both pre-crisis and post-crisis samples. The F test shows that the pre- and the post-crisis difference is statistically insignificant. However, when we conduct the leave-one-out-cross-validation as a robustness check (Table 6), we find that after dropping the United Kingdom, the coefficients on RCRE become positive and significant in the pre-crisis sample.

Therefore, we exclude the United Kingdom and re-run the panel regressions. Table 7 shows the results for Europe, excluding the U.K. sample. The relationship between the RCRE ratio and the Alpha is positive in the pre-crisis period, consistent with the production-based explanation and the "illiquidity premium" theory. However, the relationship becomes insignificant in the post-crisis period. One possibility is the illiquidity of CRE does not concern investors anymore. Alternatively, it might be that the illiquidity concern (which would drive the CRE-return correlation to positive) is offset by other forces, such as the financial constraints (which would cause the CRE-return correlation to negative). We leave this to future research for further clarification.

Table 8 shows that, like the U.S. case, the RCRE ratio and the stock return relationship in the United Kingdom is negative before the GFC and positive after. The F test also confirms that the pre-crisis and post-crisis difference is significant. Again, factors such as the "empire building" may be driving the relationship before the crisis. In the post-crisis period, these factors are overwhelmed by tightening financial constraints or CRE illiquidity, making the CRE-return relationship positive.

Table 9 displays the results for Japan. In the pre-crisis sample, similar to the U.S. and the U.K. sample, the coefficients on RCRE are negative and significant. In the post-crisis period, the relationship between CRE holding and stock return is mainly weakened and insignificant. The F test shows that the pre-crisis and post-crisis difference is significant. The finding may also suggest that tighter financial constraint matters after the financial crisis since it potentially turns the negative relationship into a positive one or weaken the negative correlation. To facilitate a comparison of results, Table 10 provides a summary.

[14] Although corporate tax policies vary among different economies, to be consistent, we compare the subsample of tax-paying firms with the entire sample in each region.

Table 5 Panel regressions: European sample

Dependent variable: Alpha	(1)	(2)	(3)	(4)	(5)	(6)
	All firms	Positive RD	Positive tax	All firms	Positive RD	Positive tax
	Pre-crisis sample: 2001–2006			Post-crisis sample: 2010–2015		
$RCRE_{i,t-1}$	-0.098	-1.433	-0.102	-0.338	-0.162	-0.384
	(1.418)	(3.105)	(1.782)	(0.449)	(0.793)	(0.457)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Arellano-Bond test for AR(2)	0.366	0.231	0.528	0.832	0.934	0.562
Hansen test of overidentification	0.473	0.562	0.489	0.69	0.744	0.703
Observations	5500	3148	4819	4549	2785	3988
Number of instruments	33	33	33	33	33	33
F statistic: compared to the coefficient in column (1)		0.153	0		0.037	0.005
F statistic: difference between pre- and post-crisis	All firms: 0.026		Positive RD: 0.157		Positive tax: 0.023	

Robust standard errors are given in parentheses. *, ** and *** indicate 10%, 5% and 1% level of significance. P-values are reported for the Arellano-Bond and Hansen test

Table 6 Leave-one-out test: coefficient on $RCRE_{i,t-1}$, European sample

Excluding:	(1) All firms	(2) Positive RD	(3) Positive tax	(4) All firms	(5) Positive RD	(6) Positive tax
	Pre-crisis sample: 2001–2006			Post-crisis sample: 2010–2015		
Denmark	0.005	-1.528	0.114	-0.356	-0.047	-0.412
	(2.395)	(4.129)	(3.173)	(0.503)	(1.034)	(0.645)
France	-1.005	-2.456	-1.10	0.451	-0.429	-0.499
	(2.866)	(4.806)	(4.246)	(0.686)	(1.435)	(0.778)
Germany	-0.224	-0.906	-0.206	0.075	0.442	0.102
	(2.749)	(5.323)	(3.751)	(0.701)	(1.452)	(0.871)
Italy	-0.054	-1.437	-0.227	-0.490	-0.558	-0.475
	(2.430)	(3.778)	(3.353)	(0.548)	(1.102)	(0.707)
Netherlands	-0.045	-1.994	-0.843	-0.324	-0.233	-0.355
	(2.787)	(3.989)	(3.512)	(0.536)	(1.044)	(0.662)
Russia	-0.470	-2.359	-0.846	0.021	-0.105	-0.107
	(2.169)	(4.136)	(2.879)	(0.549)	(1.032)	(.604)
United Kingdom	**0.950****	**1.447***	**1.390****	0.098	0.128	0.190
	(0.467)	**(0.759)**	**(0.563)**	(0.473)	(0.524)	(0.558)

Bold values: Robust standard errors are given in parentheses. *, ** and *** indicate 10%, 5% and 1% level of significance

Concluding Remarks

By definition, CRE holdings refer to real estate ownership by firms that do not primarily engage in real estate business. Why would firms commit resources on that when capital is scarce? Researchers from different backgrounds provide different answers. Some authors argue that a relatively high level of CRE holdings reflects a relatively low level of corporate governance. As a result, over-expansion, or the so-called "empire building" problem, is more likely to occur. Therefore, a higher level of CRE holding will be associated with a lower level of stock returns. Some other authors propose that firms with a relatively high CRE holding are riskier due to the illiquidity and slow adjustment nature of CRE. Hence, such firms are expected to provide higher returns to compensate for the risk. Besides, some authors consider that CRE serves as collateral and enhances borrowing capacity. If the value of CRE suddenly drops due to a negative shock, financially constrained firms may face forfeiture of collateral, and some of them may sell CRE to repay the debts. Since firms' returns are likely to be lower in that scenario, a positive relationship between CRE holding and stock returns has resulted.

This study has no ambition to settle this debate in one research paper. It merely provides some robust stylized facts that hopefully inspire future theoretical modeling (Abad & Khalifa, 2015; Cochrane, 2011; Cooley, 1995; Leung & Tse, 2017). More specifically, it uses the Global Financial Crisis (GFC) as a natural experiment to test these competing theories on the relationship between CRE holdings and stock

Table 7 Panel regressions: European excluding United Kingdom sample

Dependent variable: Alpha	(1)	(2)	(3)	(4)	(5)	(6)
	All firms	Positive RD	Positive tax	All firms	Positive RD	Positive tax
	Pre-crisis sample: 2001–2006			Post-crisis sample: 2010–2015		
$RCRE_{i,t-1}$	0.950**	1.447*	1.390**	0.098	0.128	0.190
	(0.467)	(0.759)	(0.563)	(0.473)	(0.524)	(0.558)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Arellano-Bond test for AR(2)	0.889	0.981	0.730	0.599	0.776	0.706
Hansen test of overidentification	0.735	0.895	0.738	0.756	0.913	0.875
Observations	3138	1789	2792	3041	1831	2715
Number of instruments	33	33	33	33	33	33
F statistic: compared to the coefficient in column (1)		0.311	0.362		0.002	0.016
F statistic: difference between pre- and post-crisis	All firms: 1.64		Positive RD: 2.05		Positive tax: 2.29	

Robust standard errors are given in parentheses. *, ** and *** indicate 10%, 5% and 1% level of significance. P-values are reported for the Arellano-Bond and Hansen test

Table 8 Panel regressions: United Kingdom sample

Dependent variable: Alpha	(1)	(2)	(3)	(4)	(5)	(6)
	All firms	Positive RD	Positive tax	All firms	Positive RD	Positive tax
	Pre-crisis sample: 2001–2006			Post-crisis sample: 2010–2015		
$RCRE_{i,t-1}$	-1.751**	-2.1*	-1.25*	1.251**	0.579*	0.756*
	(0.861)	(1.085)	(0.701)	(0.523)	(0.308)	(0.436)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Arellano-Bond test for AR(2)	0.751	0.254	0.412	0.699	0.591	0.948
Hansen test of overidentification	0.511	0.894	0.882	0.833	0.86	0.823
Observations	2362	1359	2027	1508	954	1273
Number of instruments	33	33	33	33	33	33
F statistic: compared to the coefficient in column (1)		0.063	0.204		1.226	0.528
F statistic: difference between pre- and post-crisis	All firms: 8.88***		Positive RD: 5.64**		Positive tax: 5.1**	

Robust standard errors are given in parentheses. *, ** and *** indicate 10%, 5% and 1% level of significance. P-values are reported for the Arellano-Bond and Hansen test

Table 9 Panel regressions: Japanese sample

Dependent variable: Alpha	(1)	(2)	(3)	(4)	(5)	(6)
	All firms	Positive RD	Positive tax	All firms	Positive RD	Positive tax
	Pre-crisis sample: 2001–2006			Post-crisis sample: 2010–2015		
$RCRE_{i,t-1}$	-0.170***	-0.159**	-0.157***	0.010	0.044	-0.045
	(0.057)	(0.075)	(0.052)	(0.071)	(0.065)	(0.029)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Arellano-Bond test for AR(2)	0.555	0.544	0.489	0.130	0.320	0.276
Hansen test of overidentification	0.110	0.139	0.185	0.515	0.528	0.581
Observations	5604	4131	5448	4789	3383	4653
Number of instruments	33	33	33	33	33	33
F statistic: compared to the coefficient in column (1)		0.014	0.028		0.125	0.514
F statistic: difference between pre- and post-crisis	All firms: 3.91**		Positive RD: 4.18**		Positive tax: 3.54*	

Robust standard errors are given in parentheses. *, ** and *** indicate 10%, 5% and 1% level of significance. P-values are reported for the Arellano-Bond and Hansen test

Table 10 A summary of results: Relationship between CRE holding and stock return

Sample	Pre-Crisis Period (2001–2006)	Post-Crisis Period (2010–2015)
The United States	Negative	Positive
Europe (excluding the United Kingdom)	Positive	Insignificant
The United Kingdom	Negative	Positive
Japan	Negative	Insignificant

returns. We find that (1) the United States and the United Kingdom show a similar pattern on the relationship between CRE holding and stock return in both pre-crisis (negative correlation) and the post-crisis period (positive correlation). This finding suggests the "empire building" theory might be valid before the GFC. A tightening of financial constraints after the crisis dominates the relationship between CRE holding and stock return. (2) We also compare the sample of all firms with the subsample that pay positive tax or have positive R&D investment and find no systematic difference. Hence, we cannot provide direct evidence to support the "scarce capital" theory. (3) European, excluding the United Kingdom sample, shows a positive relationship in the pre-crisis period. This finding suggests that the "illiquidity premium" argument holds before the crisis. However, the link between CRE holding and stock return becomes negligible in the post-crisis period. (4) The Japanese sample shows a negative relationship in the pre-crisis period, similar to the United States and the United Kingdom. However, the association is primarily weakened and becomes insignificant in the post-crisis period. This finding may also suggest that tighter financial constraint matters after the GFC.

Putting all these together, we conclude that tightening financial constraints after the GFC matter for firms in the United States, the United Kingdom, and Japan. It turns a negative relationship into a positive or insignificant one. The results of the European sample (excluding the United Kingdom) are admittedly counter-intuitive. One possibility is that after the GFC and the later EURO crisis in 2011, there was a wave of government interventions, including the Outright Monetary Transactions (OMT) program conducted by the European Central Bank (ECB). Those interventions lead banks to make “zombie loans” to firms that would otherwise declare bankruptcy (Acharya et al., 2019a, 2019b; Andrews & Petroulakis, 2019; McGowan et al., 2018; Schmidt et al., 2020).[15] With the support of such loans, firms may not need to unload their CRE. Hence, the CRE-stock return relationship may be changed artificially. We leave it to future research for further explorations.

We believe that the critical question is whether the CRE holding boost or diminish the firm value. For listed firms, stock returns are arguably a less controversial measure. On the other hand, non-listed firms also have a substantial amount of commercial real estate. Thus, future research should also study how CRE holding would impact those firms.

[15] There are different definitions of “zombie firms” used in the literature. However, a prevalent practice is to include firms which “were not able to cover their interest expenses out of their pretax earnings.” See Acharya et al., (2019a, b), among others, for more details.

Appendix A

This appendix mainly discusses two strands of the literature: the motives to own CRE and the relationship between CRE holdings and firm performance.

Motives to Own CRE

In the main text, we indicate that there are different motives to own CRE beyond production needs. Each purpose could result in another nexus between CRE holdings and returns. The first motivation for CRE holding is "empire building." Due to weak corporate governance, firms may over-invest in CRE and make less investment, and R & D. It leads to a negative correlation in CRE holding and stock return. Based on Real Estate Investment Trusts (REITs) data in the U.S., Sirmans (1999) hypothesizes that specific sets of corporate governance mechanisms are needed for firms with substantial real estate holding. Sing and Sirmans (2008) employ a sample of 228 stocks listed in Singapore and formally reject the hypothesis that corporate governance mechanisms are independent of a firm's real estate ownership. Thus, the result is consistent with Sirmans (1999). Coles et al. (2006) show a strong causal relationship between management incentives and firms' behavior on investment policy, debt policy, and risk-taking. Employing a sample of U.S. listed corporations, Du et al. (2014) find no evidence for a return-enhancing role for CRE holdings, suggesting that CRE holdings are a form of managerial "empire building." In firms with weak governance, over-investment in the CRE is more likely to occur, and higher CRE holdings are associated with lower returns to shareholders. Dong et al. (2012) employ the Listed Chinese firms and find that corporate governance, state ownership, and preferential tax policy explain the CRE holding.

The second motive is related to CRE's collateral channel effect, which will lead to a positive nexus between CRE holdings and returns. Firms use CRE as inputs of production and collaterals to raise debt for investment, and firms could benefit from the appreciation of CRE holdings (Bernanke & Gertler, 1989, 1990; Chaney et al., 2012; Gan, 2007a, 2007b; Kiyotaki & Moore, 1997). For instance, Ogawa et al. (1996) and Ogawa and Suzuki (1998) find that the land price fluctuations in Japan would affect corporate investment behaviors. Gan (2007a) finds that, during the early 1990s, the investment rate of an average firm in Japan drops by 0.8 percentage points resulting from a 10% drop in land value. Chaney et al. (2012) also find that firms' investments in the U.S. are substantially affected by the shocks to the value of real estate holdings. For example, during 1993–1997, a $1 increase in collateral value leads the representative U.S. corporation to raise its investment by $0.06.

Relationship between CRE Holdings and Firm Performance

After discussing the motives to own CRE, we review the literature on the relationship between CRE holdings and firm performance. The first strand of research employs the idiosyncratic return (Alpha) and systematic risk component (Beta) to measure firm performance. Table 11 provides a summary of their main findings. For example, in the case

of the United States, Deng and Gyourko (1999) employ firm-level data for 717 companies from 57 different non-real estate industries in the U.S. in 1984–1993 and find that firms with high degrees of real estate concentration and high Beta experience lower returns. However, employing a similar sample period (1985–1994), Seiler et al. (2001) find no relationship between CRE holdings and systematic risk and excess return.

On the other hand, Tuzel (2010) finds that CRE holdings positively affect abnormal returns in non-real estate firms in the U.S. from 1963 to 2003. In the case of other economies, Brounen and Eichholtz (2005) explores international CRE effects using samples from 18 industries and nine countries in the year 1992, 1995, 1998, and 2000, and find a significantly negative relationship between CRE holdings and systematic risk, while no association between CRE holdings and idiosyncratic risk. Finally, Cheong and Kim (1997) find that a listed manufacturing firm's CRE holdings had no significant effect upon the return-on-investment in its stocks from 1987 to 1991 in Korea.

On the other hand, Liow and Ooi (2004) use entirely different measures of firm performance. They evaluate stock return by two value-based metrics: economic value added (EVA), and market value added (MVA). Based on the data of listed non-real estate firms in Singapore from 1997 to 2001, the authors find that CRE hurts non-real estate firms' EVA and MVA. Based on the data of listed non-real estate firms in Singapore from 1997 to 2001, the authors find that CRE hurts non-real estate firms' EVA and MVA.

Another strand of literature explores the impact of CRE holding on other aspects of a firm's operation. For instance, Zhao and Sing (2016) empirically test the relationship between CRE holdings and the production risk of firms, which is measured by the volatility of the output per unit of capital. The publicly listed U.S. firms' data from 1984 to 2011 prove that CRE holding is significantly and negatively correlated with a firm's productivity risks. As a result, firms with high productivity risk (more volatile firms) hold a relatively lower level of the CRE.

Appendix B

This section presents a simple model of a firm, which can engage in R&D investment and corporate real estate (CRE) investment.

There are two periods, $t = 0, 1$. At time 0, a risk-neutral firm endowed with an amount of initial capital K and a linear technology to produce can choose to invest in R&D investment, which would boost productivity and invest in CRE, whose valuation in time 1 can be different. For simplicity, we assume that all these investment decisions are discrete. More specifically, the firm which invests D units of capital, $0 < D < K$ has a probability p to be successful, $p \in [0, 1]$, and its productivity would increase from A to Ag, $A > 0, g > 1$. If the firm fails, the productivity remains to be A. On the other hand, the firm can also acquire 1 unit of CRE, which costs P_h units of capital in period 0, $P_h > 0$. In period 1, the valuation of the CRE would become $P_h\varepsilon$, where ε represents an idiosyncratic valuation shock. The shock has finite and positive support, $\varepsilon \in [\varepsilon_L, \varepsilon_H], 0 < \varepsilon_L < \varepsilon_H < \infty$. We assume that the first moment is also finite, $0 < E(\varepsilon) < \infty$. We assume that the valuation shock is independent of the risk involved in the R&D if R&D efforts are ever be made.

Table 11 Previous literature on the relationship between CRE holdings and returns

Literature	Sample	Sample Period	Relationship		
			Systematic risk (Beta)	Abnormal return (Alpha)	Stock return
Deng and Gyourko (1999)	717 companies from 57 different non-real estate industries in the U.S	1984–1993		Negative (for the high beta firm)	
Seiler et al. (2001)	Firms from four industries (SIC = 20/35/36/37) in the U.S	1985–1994	Insignificant	Insignificant	
Tuzel (2010)	Non-real estate firms in the U.S	1963–2003	Mixed	Positive	
Cheong and Kim (1997)	Listed manufacturing firms in Korea	1987–1991			Insignificant
Brounen and Eichholtz (2005)	Samples from 18 industries and 9 countries	1992, 1995, 1998 and 2000	Negative	Insignificant	

Alternatively, the firm may rent CRE from the market at a rate R_h, $0 < R_h < P_h$.[16] And to produce in period 1, the firm needs to pre-install capital in period 0. To simplify the analysis, we assume that $K - D - P_h > 0$. We introduce two indicator functions to represent the firm's R&D and CRE investment decisions. Formally,

$$I^R = \left\{ \begin{matrix} 1 & \textit{firm invests in R\&D} \\ 0 & \textit{otherwise} \end{matrix} \right\},$$

$$I^H = \left\{ \begin{matrix} 1 & \textit{firm invests in CRE} \\ 0 & \textit{otherwise} \end{matrix} \right\}.$$

Thus, the firm which maximizes the expected value of the profit is

$$max.E(\pi)$$

where $E[\pi(I^R, I^H)] = \{[pAg + (1-p)A]I^R + (1-I^R)A\} * [K - I^R D - I^H P_h - (1-I^H)R_h] + I^H P_h \varepsilon$. This formula looks more complicated than it is. For instance, the profit for a firm engaging in both R&D and CRE investment is simply

$$E[\pi(1,1)] = \{[pAg + (1-p)A]\} * [K - D - P_h] + P_h E(\varepsilon).$$

Similarly, the profit for a firm engaging in R&D but not CRE investment is simply

$$E[\pi(1,0)] = \{[pAg + (1-p)A]\} * [K - D - R_h].$$

The profit for a firm engaging in CRE but not R&D investment is simply

$$E[\pi(0,1)] = A * [K - P_h] + P_h E(\varepsilon).$$

The profit for a firm engaging in neither R&D nor CRE investment is simply

$$E[\pi(0,0)] = A * [K - R_h].$$

Since the investment decisions are discrete, we simply compare different options pairwise.

Lemma 1. If $\frac{1}{g-1} * \left[\frac{E(\varepsilon)}{A\left(1 - \frac{R_h}{P_h}\right)} - 1 \right] > 0, E[\pi(1,0)] > E[\pi(1,1)]$ if and only if p is sufficiently large.

Proof. The proof is straightforward. Observe that

$$\begin{aligned} &E[\pi(1,0)] - E[\pi(1,1)] \\ &= \{[pAg + (1-p)A]\} * [K - D - R_h] - \{[pAg + (1-p)A]\} * [K - D - P_h] - P_h E(\varepsilon) \\ &= \{[pAg + (1-p)A]\} * (P_h - R_h) - P_h E(\varepsilon) \end{aligned}$$

[16] To further simplify the analysis, we can assume that the rental rate for the CRE, i.e. R_h is pre-determined in period 0.

>0 if and only if $p > p_1^*$, where $p_1^* = \frac{1}{g-1} * \left[\frac{E(\varepsilon)}{A\left(1-\frac{R_h}{P_h}\right)} - 1\right]$. Since $\frac{1}{g-1} * \left[\frac{E(\varepsilon)}{A\left(1-\frac{R_h}{P_h}\right)} - 1\right] > 0$, $p_1^* > 0$.

Notice further that in practice, $\frac{R_h}{P_h}$ is very small. Hence, if $(\varepsilon) > A$, then it is likely that $\frac{1}{g-1} * \left[\frac{E(\varepsilon)}{A\left(1-\frac{R_h}{P_h}\right)} - 1\right] > 0$.

Notice further that if our condition is violated, for instance, $E(\varepsilon) < A\left(1 - \frac{R_h}{P_h}\right)$. In that case, it means that every firm which satisfies the stated assumption would find it better to invest in R&D only, rather than both R&D and CRE investment.

Lemma 2. If $\left[\frac{A[D+R_h]-P_h(A-E(\varepsilon))}{A(K-D-R_h)}\right] > 0$, $E[\pi(1,0)] > E[\pi(0,1)]$ if and only if p is sufficiently large.

Proof. The proof is again straightforward. Observe that

$$
\begin{aligned}
&E[\pi(1,0)] - E[\pi(0,1)] = \{[pAg + (1-p)A]\} * [K - D - R_h] - \{A * [K - P_h] + P_h E(\varepsilon)\} \\
&= p(g-1)AK - \{[pAg + (1-p)A]\} * [D + R_h] + P_h(A - E(\varepsilon)) \\
&= p(g-1)A[K - D - R_h] - A[D + R_h] + P_h(A - E(\varepsilon))
\end{aligned}
$$

> 0 if and only if $p > p_2^*$, where $p_2^* = \frac{1}{(g-1)} * \left[\frac{A[D+R_h]-P_h(A-E(\varepsilon))}{A(K-D-R_h)}\right]$. Since $\left[\frac{A[D+R_h]-P_h(A-E(\varepsilon))}{A(K-D-R_h)}\right] > 0$, $p_2^* > 0$.

First, notice that $A(K - D - R_h) > 0$, and $(g-1) > 0$ by assumption. Hence, it suffices to study the term $A[D + R_h] - P_h(A - E(\varepsilon))$. And $A[D + R_h] - P_h(A - E(\varepsilon)) > 0$ iff $P_h E(\varepsilon) < AP_h - AR_h - AD$. Notice also that

$P_h E(\varepsilon)$	return from investing in CRE.
AP_h	addition return from investing in R&D only.
AR_h	loss from investing in R&D only.
AD	return from investing in R&D.

Thus, the RHS $AP_h - AR_h - AD$ is the *net return* from R&D only, while the LHS $P_h E(\varepsilon)$ is *net return* from investing in CRE. If LHS < RHS, then the firm will invest in R&D only when the probability of success in R&D is sufficiently high.

Lemma 3. $E[\pi(1,0)] > E[\pi(0,0)]$ if and only if p is sufficiently large.

Proof. The proof is again straightforward. Observe that

$$
\begin{aligned}
&E[\pi(1,0)] - E[\pi(0,0)] = \{[pAg + (1-p)A]\} * [K - D - R_h] - A * [K - R_h] \\
&= p(g-1)A[K - R_h] - \{[pAg + (1-p)A]\}D \\
&= p(g-1)A[K - D - R_h] - AD
\end{aligned}
$$

> 0 if and only if $p > p_3^*$, where $p_3^* = \frac{1}{(g-1)} * \left[\frac{D}{(K-D-R_h)}\right]$. Notice that $p_3^* > 0$. It means that some firms would find it optimal not to make any investment, should they inherit a probability of success low enough.

Based on the three lemmas, we can define a new quantity $p_1^{**} = max\{p_1^*, p_2^*, p_3^*\}$. And for $p > p_1^{**}$, it is necessary that $E[\pi(1,0)] = argmax\{E[\pi(I^R, I^H)]\}$. In other words, it means that investing in R&D but not in CRE is the best strategy if the probability of success in R&D is sufficiently high.

Appendix C

Table 12 Different measures of CRE in the previous literature

Literature	Data Source	CRE measurement
Deng and Gyourko (1999)	Compustat	Real Estate Concentration (RC) RC = (building at cost + land and improvements)/ Total Asset
Seiler et al. (2001)	Compustat	Real Asset (RA) RA = PPE/ Total Asset
Liow and Ooi (2004)	Compustat	Real Estate Asset Intensity (PPTY) PPTY = Tangible Asset/ Total Asset
Brounen and Eichholtz (2005)	Compustat	Corporate Real Estate Ratio (CRER) CRER = PPE/ Total Asset
Tuzel (2010)	Compustat	Real Estate Raio (RER) RER = (buildings + capitalized leases)/ Total Asset
Zhao and Sing (2016)	Compustat	Ratio of CRE ownership to total asset (CRE_A) CRE_A = (building cost + land and improvements + construction in progress)/ Total Asset

Table 13 Panel regression with the corporate governance index

Dependent variable: Alpha	(1)	(2)
$RCRE_{i,t-1}$	-0.017	-0.042
	(0.082)	(0.094)
$cooperate\ governance_{i,t-1}$		0.009
		(0.007)
Controls	Yes	Yes
Year fixed effect	Yes	Yes
Arellano-Bond test for AR(2)	0.640	0.751
Hansen test of overidentification	0.627	0.596
Observations	1686	1686
Number of instruments	37	37

All firms are from the U.S. sample. We do not distinguish between the pre-crisis and the post-crisis periods. The corporate governance index here is from Gompers et al. (2003)

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