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Home Values and Firm Behavior[†]

By Saleem Bahaj, Angus Foulis, and Gabor Pinter*

The homes of firm owners are an important source of finance for ongoing businesses. We use UK microdata to show that a £1 increase in the value of the homes of a firm's directors increases the firm's investment by £0.03. This effect is concentrated among firms whose directors' homes are valuable relative to the firm's assets, that are financially constrained, and that have directors who are personally highly levered. An aggregation exercise shows that directors' homes are as important as corporate property for collateral driven fluctuations in aggregate investment demand.
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Economic mechanisms that generate a causal link between real estate prices and the macroeconomy have been a focus of attention in the recent literature. The extant literature pictures this link running through two main channels. First, households, particularly those that are financially constrained, use increases in real estate wealth to finance consumption (Mian and Sufi 2011, Berger et al. 2018). Second, credit constrained firms pledge the increased value of their commercial real estate to finance investment (Chaney, Sraer, and Thesmar 2012; Liu, Wang, and Zha 2013).

This paper explores a mechanism at the intersection of these two channels. The residential wealth owned by households is an important source of collateral to finance the corporate sector. It is common for the owners of small and medium sized enterprises (SMEs) to pledge their homes to finance their firms. The literature has yet to disentangle and quantify the aggregate consequences of this. The

*Bahaj: BoE and CfM (email: saleem.bahaj@bankofengland.co.uk); Foulis: BoE and CfM (email: angus.foulis@bankofengland.co.uk); Pinter: BoE and CfM (email: gabor.pinter@bankofengland.co.uk). Emi Nakamura was the coeditor for this article. Four anonymous referees made numerous comments that greatly improved the quality of this paper and we thank them for their input. We are also grateful to Andy Blake, Philippe Bracke, Thomas Chaney, Matthieu Chavaz, Giancarlo Corsetti, Wei Cui, Scott Frame, Kris Gerardi, Martin Griffiths, Wouter den Haan, Jonathan Haskel, Zhiguo He, Matteo Iacoviello, Koen Inghelbrecht, Sebnem Kalemli-Özcan, Nobu Kiyotaki, Peter Kondor, Fred Malherbe, John Moore, Christopher Palmer, Daniel Paravisini, José-Luis Peydró, Alexander Popov, Ricardo Reis, Jan Rouwendal, David Sraer, Adam Szeidl, Alan Taylor, Silvana Tenreyro, Neeltje Van Horen, Shengxing Zhang, Xin Zhang, and Eric Zwick for helpful comments. We also thank conference and seminar participants too numerous to list here. This paper contains the views of the authors and not necessarily those of the Bank of England, the MPC, the FPC, or the PRC. This article uses data compiled by Registers of Scotland. For further information, please contact data@ros.gov.uk. The authors declare that they have no relevant or material financial interests that relate to the research described in this paper.

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macroeconomic implications could be profound: the homes of those in charge of firms are worth 80 percent of GDP and four times more than owner occupied corporate real estate. And while this residential real estate largely (but not exclusively) supports the financing of smaller enterprises, such enterprises are responsible for a considerable share of economic activity and business cycle fluctuations.[1]

We address this issue by using a feature of firm-level data in the United Kingdom: the persons responsible for running a firm, known as *directors*, must declare their residential address to the public registrar.[2] By matching this information to transaction-level data on residential properties and administrative data on mortgages, we are able to obtain a time series of the value of each director's home and the equity contained within it. Our key microeconometric result is that a £1 increase in the value of the homes of a firm's directors leads the average firm in our sample to invest £0.03 more. The effects of an increase in the total home equity value of a firm's directors are the same.

Our dataset also allows us to observe corporate real estate holdings on the firm's own balance sheet. We can then run a horse race between these two types of real estate. We find that a £1 increase in corporate real estate values leads firms to increase investment by around £0.05. The magnitude of the investment response is similar to US evidence on listed firms (Chaney, Sraer, and Thesmar 2012).

We argue that the relevant mechanism driving our results is collateral constraints. The increase in the value of directors' homes has the largest impact on investment both when the firm exhibits signs of being financially constrained and when the directors have relatively less equity in their homes (as measured by the LTV ratio on their outstanding mortgages). We also show that our results seem only to apply to directors who are shareholders in the firm, who in turn have the greater incentive to pledge personal assets as collateral.

The effect is concentrated only at firms where directors' homes represent a meaningful source of collateral: once the directors' residential real estate is worth less than 15 percent of the firm's assets, investment becomes insensitive to home values. We find this to be more important than firm size in governing the response: some larger firms with directors' home values above this 15 percent threshold still react to increases in residential real estate values (and in much the same way that they react to increases in corporate real estate values). We complement this finding with new survey evidence indicating that some larger firms do pledge their directors' assets as collateral. This result suggests that what is relevant is the liquidation value of the house to the creditor. The corporate finance literature (surveyed in Coco 2000) has argued that pledging housing may have additional incentive or signaling effects

[1] In the United Kingdom, where we focus our study, SMEs (using the UK definition of firms with less than 250 employees) were responsible for 42 percent of investment and 52 percent of employment in 2014. They also account for a large share of aggregate fluctuations. For example, during the Great Recession (from 2008 to 2009) 43 percent of the fall in employment was due to SMEs, whilst they were responsible for 66 percent of the increase in employment from 2010–2014. They were also responsible for 57 percent of the increase in investment over this latter period. Sources: Investment, *Annual Business Survey*; Employment, *SME Statistics*, *Business Population Estimates*. The importance of SMEs is not confined to the United Kingdom: across the OECD SMEs account for 60 percent of employment and 50–60 percent of value added on average (OECD 2017).

[2] A director does not just refer to a member of the board of a large firm. These are the individuals legally responsible for running a firm and who have a duty to promote its success. Every firm, no matter how small, must have at least one director. There were 2.8 million active firm directors in the United Kingdom in 2014.

due to the directors valuing their homes more than lender; however, we do not find conclusive evidence of this.

We then consider consequences for aggregate investment demand arising from an increase in real estate prices. At the level of an individual firm a £1 increase in corporate real estate values has a 70 percent larger effect on investment than residential real estate. However, as mentioned, we estimate that the total value of residential real estate held by firm directors is around four times greater than the total value of owner-occupied corporate real estate. The shock to aggregate investment demand from a 1 percent change in real estate prices should therefore be at least as strong via residential real estate. Our microeconometric estimates suggest that a 1 percent rise in real estate prices leads to a 0.28 percent increase in firm investment demand due to director real estate, and a 0.11 percent increase due to firm real estate.

Our microeconometric estimates rely on two primary sources of variation. First, directors live in homes of differing initial values (and loan-to-value). This implies that a given percentage change in real estate prices translates into differential changes in home values (equity) measured in £ terms. Second, around 66 percent of directors live in a different region from their firm. This generates regional heterogeneity in the real estate price dynamics that an individual director faces depending on where he or she is located.

A number of different sources of endogeneity may bias our estimates. First, a director's property purchase is an endogenous choice that may be related to firm performance. We address this concern by holding the properties of directors constant by firm at the start of our sample, and rely solely on changes in regional real estate prices. Second, our regressions could be detecting the impact of local economic conditions. In addition to including region-time fixed effects we also show that (i) firms operating in the tradable goods sector, and therefore less sensitive to the local economy (Mian and Sufi 2014), respond equally to our residential real estate measure; (ii) our results are unaffected by matching the firm to its creditor bank and including bank-time fixed effects to control for shocks to bank credit supply; (iii) the results are similar if we focus only on directors that live in a different region (or sufficiently far) from their firm, or, even, rely solely on variation in real estate prices in the director's region unexplained by developments in the firm region; and (iv) we obtain the same result when instrumenting local house prices with the interaction of aggregate mortgage interest rates and regional supply constraints (similar to, for example, Chetty, Sándor, and Szeidl 2017).

A third concern is that unobserved heterogeneity may confound our estimates. Time-invariant director heterogeneity is absorbed by fixed effects. However, director-level heterogeneity could lead to differing sensitivities to real estate price fluctuations at the firm level. We address this by saturating our model with a large number of director characteristics (age, gender, experience, income, etc.) and interact them with real estate prices. Crucially, we can proxy for director skill by assessing the performance of *other* companies that the director is part of. We also show that director home values are no longer relevant for investment once the director has left the firm.

Related Literature.—There is a growing body of theoretical work in the macroeconomics literature on the aggregate consequences of credit constrained

households borrowing against their homes for consumption (Iacoviello 2005; Justiniano, Primiceri, and Tambalotti 2015; Guerrieri and Lorenzoni 2017; Favilukis, Ludvigson, and Nieuwerburgh 2017). A related empirical literature shows how real estate prices affect consumer demand through the behavior of homeowners. Typical estimates based on microdata put the marginal propensity to consume out of housing wealth at 5–7 cents on the dollar (Mian, Rao, and Sufi 2013; Kaplan, Mitman, and Violante forthcoming; Berger et al. 2018; and Stroebel and Vavra 2019).[3] In a similar vein, the works of Gan (2007); Chaney, Sraer, and Thesmar (2012); Kleiner (2013); and Cvijanović (2014) provide microeconometric evidence on the various aspects of the links between real estate prices, collateral, firm activity, and capital structure. The typical estimate of a firm's marginal propensity to invest out of corporate real estate holdings is 6 cents on the dollar (Chaney, Sraer, and Thesmar 2012). We corroborate this figure. More importantly, we complement these literatures by documenting that the marginal propensity of firms to invest out of their directors' housing collateral is 3 pence on the pound.

Liu, Wang, and Zha (2013) and Liu, Miao, and Zha (2016) use quantitative models to show that credit constrained firms who borrow against their real estate amplify the macroeconomic consequences of disturbances in the housing market. In a companion paper (Bahaj, Foulis, and Pinter 2019) we show that accounting for the ability of firms to borrow against their owner's housing can add substantial further amplification. More generally, our findings have implications for how asset price fluctuations interfere with the economic stabilization objective of policymakers. We document that house prices directly influence the availability of credit to firms and hence the supply side of the economy. This may alter the conclusions of research that considers optimal stabilization policy in the presence of a housing sector (Adam and Woodford 2018).

The link between house prices and start-up rates has been explored in the entrepreneurship literature. Some authors found that rising house prices do enable collateral constrained, fledgling entrepreneurs to start new firms (Corradin and Popov 2015; Schmalz, Sraer, and Thesmar 2017). Others argued that the link between house prices and entry reflect other mechanisms (local demand, wealth effects) and that residential real estate is not key to unlocking entrepreneurship (Hurst and Lusardi 2004; Kerr, Kerr, and Nanda 2015).[4] Even those finding a link at the micro level conclude that aggregate consequences are limited.[5] Our analysis differs in that we look at how residential real estate values affect existing enterprises on an ongoing basis. Moreover, we find that our mechanism is just as relevant for mature firms, and the effects are strong enough to influence macroeconomic dynamics.[6]

[3] See DeFusco (2018) for a comprehensive list of recent empirical studies in this area. Agarwal and Qian (2014) discusses related estimates of consumption responses to income shocks.

[4] Bracke, Hilber, and Silva (2018) shows theoretically that housing wealth has an ambiguous impact on entrepreneurship.

[5] Schmalz, Sraer, and Thesmar (2017) finds that a 19 percent increase in house prices raises employment by 0.16 percent via new firm creation.

[6] Adelino, Schoar, and Severino (2015) is an exception. They use regional data to argue that residential real estate prices have an aggregate effect through the behavior of small firms and start-ups via collateral constraints. However, Davis and Haltiwanger (2017) argues that a number of other mechanisms could explain this comovement at the regional level including, inter alia, the response of local credit supply to housing shocks through bank behavior, and the effect of housing wealth on risk tolerance and the attractiveness of entrepreneurship. Importantly, we

The empirical corporate finance literature has long recognized the importance of housing as a source of collateral in the business loan market (Berger and Udell 1995; Avery, Bostic, and Samolyk 1998; Jiménez and Saurina 2004; Berkowitz and White 2004; Brick and Palia 2007; Davydenko and Franks 2008; Ono and Uesugi 2009). An accompanying theoretical literature finds that pledging collateral that is more valuable to the borrower than the lender has a powerful role in aligning incentives or signaling quality in credit markets (see Bester 1985, 1987; Boot and Thakor 1994, among others). The attention has focused on when and why such collateral is used. Our contribution is to quantify how changes in the value of residential real estate affect firm activity and consequently the aggregate economy. We also shed light on the heterogeneity in firm-level responses and the implications it has for the theory.

I. Home Values and Corporate Financing

This section summarizes the institutional framework regarding the use of residential real estate to fund a firm. This is based on relevant laws and precedents, the corporate finance literature, and conversations with bank supervisors who deal with this type of credit at the UK Prudential Regulatory Authority. We also discuss evidence from surveys on the prevalence of this type of borrowing, and provide theoretical motivation for their use.

Legal Framework.—There are two ways in which residential real estate can be used to fund a firm: (i) directors can extract home equity via a personal mortgage and give the funds to the firm; and (ii) directors can use housing wealth to personally *guarantee* the firm's borrowing. In the former case, the loan sits on the director's balance sheet, manifesting on the liability side of the *firm's* balance sheet as increased issued equity (or a directors loan). In the latter case, the debt sits directly on the liability side of the firm's balance sheet, but the guarantee means the director's exposure to the firm goes beyond her equity stake. However, the net worth of a single owner-director is the same either way.

In practice, guarantees have many advantages. In the United Kingdom, the director can benefit from the firm's tax shield when guaranteeing a loan, as interest on residential mortgages is not tax deductible. Having the firm borrow has other contractual benefits. First, guarantees can be "conditional," forcing creditors to liquidate firm assets before seizing the director's personal wealth.[7] Second, in firms with several directors (as is the norm), clauses in guarantees can enable cross-pledging, without affecting the firm's ownership structure. Third, guarantees can be used to support lines of credit, which may be more convenient for the firm in managing its liquidity needs. We discuss evidence on the choice between personal mortgages and guarantees in more detail in online Appendix Section A.7.

Guarantees can be explicitly secured on directors' assets and often on property, exactly like a collateralized loan. However, the security is often implicit. The director commits to cover the loan if the firm defaults, without specifying a particular

conduct our analysis at the firm (and director) level rather than the regional level. This means we can disentangle these various channels.

[7] See *National Westminster Bank PLC v. Alfano and Others,* 2012.

asset as security (an unsecured guarantee). Lenders then request a "statement of means" from the director, summarizing her net worth including the home and any debts outstanding. Creditors then judge the guarantee's value, aware that they can obtain a court order to seize the assets should the director fail to meet her commitment.[8] Avery, Bostic, and Samolyk (1998) finds that these two types of guarantee contracts are close substitutes. We abstract from the difference as our data offer no means to distinguish between them.

There are further noteworthy points regarding the process through which creditors value and call on a guarantee. First, the minimum due diligence from lenders, when a home is pledged as security or listed on a statement of means, is (i) a check of public information to value the property, and (ii) a credit check to value existing mortgages on the property.[9] Second, assuming the director has sufficient net worth, creditors do not have to force the liquidation of personal assets if the firm defaults. The creditor can transfer the loan from a failed firm to the directors, e.g., by insisting that the director remortgage her property (Field Fisher Waterhouse 2012). Third, guarantees are typically joint and several (Riches and Allen 2009, p. 84). Lenders can seize the assets of any and all directors to recoup the amount owed. This motivates our regression specification, which uses the total housing value across all directors.[10] This structure allows for cross-pledging, mentioned above: if the wealth of one director falls, creditors may go after the assets of a more fortunate director. However, directors can manage their liability using caps agreed ex ante in the loan contract. Fourth, if the lender does force liquidation, existing mortgages on real estate are senior (Field Fisher Waterhouse 2012).

Prevalence.—To illustrate the prevalence of residential real estate and personal guarantees as security for corporate loans in the United Kingdom, we present evidence from two surveys.[11] First, from the borrowers' perspective, the 2004 and 2008 waves of the UK Survey of SME Finance, covering 2,500 enterprises (with $<$250 employees) asks "What security was used to get this loan/mortgage?" Our second source, from the lenders' perspective, is the Bank of England's 2015 survey of UK SME and Mid-Corporate Lending. This survey covers outstanding loans at major banks to businesses (with annual revenue $<$ £500 million) borrowing at least £250,000. The survey asks "Does your bank hold any of the following as collateral?" In both surveys multiple answers can be given.

Table 1 presents the results. Loans are commonly secured on property, occurring in 71–72 percent of cases. Personal assets are also frequently used as collateral: in the borrowers' survey, 41 percent of SMEs use residential property or personal

[8] How secured and unsecured guarantees differ depends on the contract. If directors explicitly pledge their homes, creditors will likely have the right to prevent the sale of the home without further security being pledged and face lower legal hurdles to seizing the asset. However, unsecured guarantees can also contain clauses limiting how directors use their wealth.

[9] Online Appendix Section B.3 provides survey evidence that the vast majority of banks value property collateral professionally, and revalue the property when their total credit exposure to the firm increases.

[10] In the United Kingdom, banks face legal barriers to seizing the share of a family home owned by a spouse not part of the business (*Royal Bank of Scotland PLC v. Etridge* (*No 2*), 2011). Hence, while we sum twice over the same home for directors who are husband and wife, this is appropriate as twice as much of any equity is available to be pledged.

[11] See online Appendix Section B.2 for international evidence.

TABLE 1—SURVEY EVIDENCE ON SECURITY USED WHEN OBTAINING A BUSINESS LOAN

	Secured on any property (1)	Secured by guarantee or res. property (2)	Secured by corp. property (3)
Panel A. Results from surveys of borrowers (%)			
Employment			
0–49 employees	72	42	44
50–249 employees	65	27	58
Assets			
£5 million or less	72	41	45
More than £5 million	56	34	56
All firms	71	41	46

	Secured on any property			Secured by guarantee		
	All firms (1)	House value/assets >15% (2)	House value/assets <15% (3)	All firms (4)	House value/assets >15% (5)	House value/assets <15% (6)
Panel B. Results from surveys of lenders (%)						
Employment						
0–49 employees	74	76	64	53	57	24
50–249 employees	66	63	75	38	39	33
250+ employees	70	75	62	39	42	33
Total assets						
<£2.5m	75	75	75	65	66	49
£2.5m–£10m	70	72	64	38	41	24
£10m+	59	55	64	29	31	26
All firms	72	73	68	48	52	29

Notes: In panel A, the values are calculated based on the answers to the question: "What security was used to get this (business) loan?" in the UK Survey of SME Finances (2004 and 2008 waves). Only firms that have a commercial loan outstanding (46%) answer this question. In the survey there are 13 responses for the types of security, we focus on answers (d) business property; (e) personal property (e.g., house); (f) mixed property (e.g., flat above shop); and (i) directors or personal guarantee. Column 1 shows the share of firms that answer (d)–(f) and hence secure their loan against property of any type. Column 2 shows the share of firms that report using non-business property (e)–(f) or a personal guarantee (i) to secure a loan. Both columns report the of firms that respond they did use the particular form of security, by firm size (using the questions "How many people, including you, work in this business?" and "What is the total amount of assets held by your business?" The latter is top-coded at £5 million). Responses weighted using the survey sampling weights. We exclude firms that operate in the real estate and construction (no firms operating in the financial or mining sectors are included in the survey) and only include for-profit limited liability companies. The survey excludes firms with more than 250 employees. In panel B, results are from the Bank of England's 2015 survey of UK SME and Mid-Corporate Lending. This survey covered loans from the five major UK banks to businesses borrowing at least £250,000 with annual revenue less than £500 million. We reweight the sample to correct for some oversampling of certain loan types by the BoE that was done for regulatory purposes. We exclude lending to firms operating in mining and quarrying, construction, financial and insurance activities, and commercial real estate sectors or in Northern Ireland and focus on limited liability companies that are not subsidiaries. The survey is merged with the data from BvD. Our values are calculated from responses to the question: "Does your bank hold any of the following as collateral?" The bank can give 5 potential answers: (a) property; (b) debenture including charges over plant, equipment, and vehicles; (c) cash or cash equivalent; (d) other tangible collateral/security; (e) personal guarantee. Column 1 shows the fraction of bank-business lending relationships (weighted by number) where the response was (a), broken down by the size of business. Columns 2 and 3 repeat this for firms where the total value of director real estate to the firm's *Total Assets* is at least 15 percent and less than 15 percent. Columns 4–6 repeat this for the fraction of bank-business lending relationships (weighted by number) that were secured by a personal guarantee, response (e).

guarantees (panel A); in the lenders' survey, 48 percent use personal guarantees (panel B).[12]

[12] In the lenders' survey we cannot distinguish loans secured directly on residential property from those secured on other property (e.g., the firm's buildings).

Personal assets are pledged less frequently at larger firms, who tend to have other sources of collateral, e.g., corporate property. Larger firms typically also have more directors, and a greater distance between ownership and control, making the pledging of personal assets a more complex endeavor (Ang, Lin, and Tyler 1995). In the lenders' survey, personal guarantees are used by 53 percent (39 percent) of small (large) firms measured by employment (with a slightly greater difference when size is measured using assets). Larger firms may have funding needs much larger than the value of their directors' homes. To explore this, we merge the lenders' survey with data on directors' home values (described in Section II), and split firms into two groups: those where the combined value of director real estate is worth at least 15 percent of the firm's balance sheet, and those where it is not. The use of personal guarantees falls dramatically across the two groups, from 52 percent to 29 percent. This difference still holds within firm size groups, with a marked difference for the smallest firms by employment (57 percent versus 24 percent). Still, around 30 percent of large firms, whose directors also have relatively less valuable houses, use personal guarantees. This suggests there may be other considerations beyond the liquidation value of the house when determining the use of guarantees.[13]

Online Appendix Section B.1 explores the lenders' survey in other dimensions beyond size and shows that the use of guarantees is relatively evenly distributed across different industries; but is more concentrated in firms that appear to be financially constrained. Last, note that we use UK data due to its reporting standards for directors rather than anything specific about its corporate loan market. The use of residential assets and personal guarantees as a security for corporate loans is widespread across the world including in the United States (see online Appendix Section B.2 for cross-country evidence).

Costly Collateral Pledging.—Pledging a house may improve lending terms due to its liquidation value to the lender in case of default. However, compared to pledging the firm's assets, personal real estate may be a higher powered source of collateral due to a *wedge* between the director's and the lender's valuation of the home; for instance, if moving home is disruptive or comes with other welfare costs (e.g., due to risk or loss aversion). Housing can therefore be more effective than other forms of collateral in mitigating agency problems in credit markets (Coco 2000). Pledging collateral that is costly to lose serves as a signal over the firm's quality ex ante (Bester 1985, 1987). Alternatively, if unobserved borrower effort creates moral hazard problems ex post, then incentives to shirk may be mitigated if the director knows her house is at stake (Boot and Thakor 1994; Tirole 2006, ch. 4).

This has several implications for our empirical work. First, if housing has an additional incentive/signaling effect compared to the firm's assets, this may explain the evidence in Table 1 that one-third of large firms, where directors' homes are also low in value relative to the firm's balance sheet, use personal guarantees. Second, the strength of any additional incentive/signaling effects depends on the wedge in valuations. Our paper focuses on how shocks to real estate values alter firm decisions. How this wedge responds to the shock is key: if it is unresponsive, there is

[13] One simple explanation is that the guarantee is supported by other assets beyond housing.

no additional effect. Third, if the shock increases the difference in valuations, then, *conditional* on pledging the home, the incentive/signaling channel should manifest in greater investment sensitivity to residential real estate values, compared to the firm's property.

However, a priori, the response of the wedge to the liquidation value of the house is unclear.[14] Moreover, the firm's assets may also suffer from a wedge in valuations due to the limited redeployability of these assets. Ultimately, how sensitive firms are to the real estate of their directors, in total and versus other sources of collateral, is an empirical question that we explore.

II. Data

We use accounting data on firms from England, Wales, and Scotland covering the period 2002–2014, merged with transaction-level house price data and loan-level mortgage data.

A. *Data Sources*

Firm Data: BvD.—Our firm-level data are sourced from a large micro dataset of firms' financial accounts provided by Bureau van Dijk (BvD), whose raw source is publicly available filings of firms at Companies House, the registrar of companies in the United Kingdom. The database covers approximately 1.5 million private and public firms per year. Our baseline sample is a fraction of the full database as many firms are not required to report all the variables used in our specification. Our main result still holds when using a different regression design with the largest available sample.

BvD also has information on firm directors. By UK law, all directors must report their full name, date of birth, nationality, and appointment and resignation dates. Directors must also report their usual residential address. Shareholder information is also collected by BvD from the firm's annual return. In the database, 72 percent of directors are shareholders in their firm at some point.

BvD is a live database, which leads to several limitations. First, the firm ownership structure is only accurate at the time of access and not for historical observations. Second, firms that die exit the database after five years. Third, historical information based on past filed accounts has much more missing data than the most recent filings. Fourth, and most importantly, BvD holds live information on who firms' directors are and where they currently live, but holds no *historical* information on these variables. To address these issues, we use archived vintages of the database, sampled roughly every six months, to capture information when it was first published. This greatly improves coverage, allows us to observe the birth and death of firms, and provides accurate information on director status when the accounts were filed. The

[14] On the one hand, emotional attachment to the house could be a function of its amenities and unrelated to property value. On the other hand, the amenity value is partly due to the property's location, and replacing those amenities is increasingly expensive as real estate prices rise. The wedge may even decrease in the home's liquidation value: as discussed, if the value in the home is sufficient, the lender may be willing to transfer a loan from the firm to the director without forcing liquidation. In the region where the decision between liquidating versus a debt transfer is marginal, an increase in house value may help the director keep the property.

use of archived vintages is what makes our empirical strategy possible, by providing historical information on who directors were and where they lived at the time the accounts were filed. Online Appendix Section C discusses our procedure in detail.

Real Estate Price Data: Land Registries.—Our primary sources of house price data are the Land Registry's Price Paid dataset (covering England and Wales) and the Registers of Scotland dataset; these cover the universe of residential property transactions since 1995 (Scotland: 2003). These datasets have two main uses. First, they are used by the Registries to construct monthly repeat sales real estate price indices for 204 British regions (broadly speaking, these regions correspond to local administrative districts or the rural parts of counties).[15] Second, we match the transactions to the addresses of directors in BvD to value directors' homes at the point of purchase/sale.

As regional variation in price dynamics plays an important role in our research design, Figure 1 presents maps of average house price inflation by region in three different subperiods of our sample, showing substantial time-varying regional heterogeneity. The pre-crisis boom was particularly large in Scotland, Wales, and the North of England. The bust of 2007–2009 also displays regional heterogeneity, although the relationship with pre-crisis price inflation is weak. The rise in house prices since 2009 is a phenomenon focused around London and the South East of the country.

Mortgage Data: Product Sales Database.—We use administrative data on all regulated residential mortgages since 2005 at origination and on the stock of outstanding mortgages in 2015 coupled with proprietary data from the Land Registry on whether a property transaction had an attached mortgage.[16] Crucially, the mortgage dataset includes the date of birth of the borrower, and the mortgaged property's full postcode; an area with an average of 17 properties. Hence, we can accurately match directors to their mortgages. Coupled with the data on the value of directors' homes, we use the mortgage information to calculate their home equity.

B. *Measuring Real Estate Holdings*

An immediate identification concern is that the choice of real estate holdings, both by directors and firms, will be endogenous. For example, firms could invest in real estate in anticipation of future growth, or directors could buy bigger homes when the firm is doing well. To address this, we follow the corporate finance literature and rely on fluctuations in the *price* rather than the quantity of real estate owned, the *intensive* margin of collateral (Benmelech and Bergman 2009). Specifically, we fix the composition of real estate holdings of firms and directors at the start of the

[15] We use the Land Registry's previous methodology to compute regional house price indices (Calnea Analytics 1995). The current methodology, introduced in 2016, relies on hedonic regression and has different regional coverage. However, the underlying data used are the same in both cases, and where there is precise overlap the indices are well correlated. Scottish regional house prices are computed by the Registers of Scotland in partnership with the ONS.

[16] UK residential mortgage data are taken from the Product Sales Database (PSD) provided by the UK Financial Conduct Authority. The FCA Product Sales Data include regulated mortgage contracts only, and therefore exclude other regulated home finance products such as home purchase plans and home reversions, and unregulated products such as second charge lending and buy-to-let mortgages.

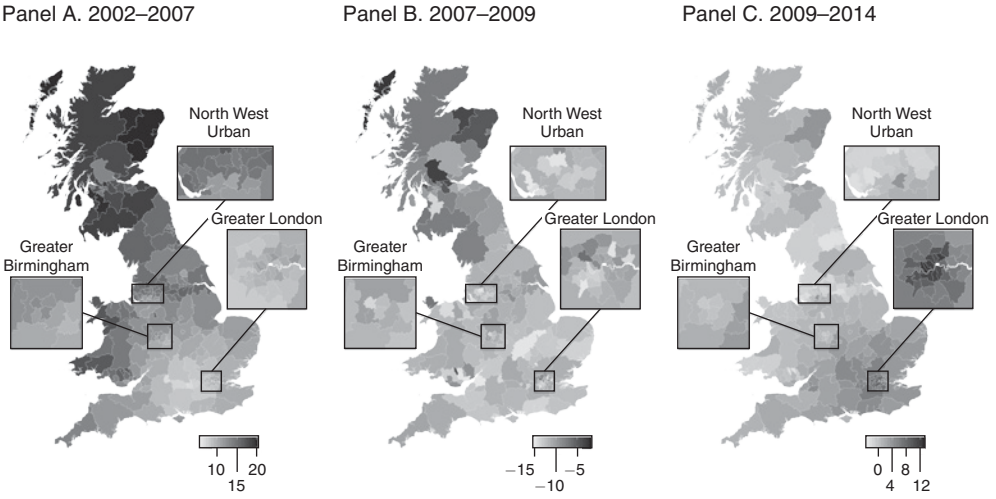

FIGURE 1. BRITISH REGIONAL HOUSE PRICE DYNAMICS

Notes: The figure shows average annual house price inflation in percent for each of the 204 British regions in our dataset over three time periods: 2002–2007, 2007–2009, 2009–2014.

sample in 2002 and then use the local real estate price index to value real estate holdings throughout the sample. We discuss further identification issues in Section III.

Corporate Real Estate.—To measure corporate real estate, we use the balance sheet item *Land and Buildings* from BvD. Specifically, the variable *Corporate* $RE_{i,t}$, for firm i at time $t \geq 2002$ in region j is given by[17]

$$\text{Corporate } RE_{i,t} = L^{B}_{i,2002} L^{P}_{j,t}, \tag{1}$$

where $L^{B}_{i,2002}$ is the book value of *Land and Buildings* in 2002 and $L^{P}_{j,t}$ is the local real estate price index in region j at time t (with the normalization $L^{P}_{j,2002} = 1$). A firm's region is defined as the one where its *Registered Office* is located.

Directors' Residential Real Estate.—We explain our methodology to value directors' homes in detail in online Appendix Section E, including diagnostics of the matching algorithm.[18] However, director real estate holdings is the key variable in our analysis so we highlight the steps in its construction here. The addresses of directors are recorded as unstructured strings of text in BvD (except postcodes that

[17] Note that while our firm-level data are annual, firms' accounts refer to different dates in the year based on the timing of their financial year end. Our real estate price data are monthly and when we use price indices to construct our variables we use the index observed in the month the accounts were filed.

[18] In online Appendix Section E.3, we also discuss changes in legal requirements for directors to report their address. From 2009, directors had the option to ask Companies House not to make their address publicly available. This has no impact on our analysis as we can still see where the director lived in 2002 since the law was not imposed retrospectively. Regardless, we show that stopping our sample in 2008 does not affect our results.

are recorded in separate fields). We use an algorithm that searches these strings for regular expressions to determine the director's house number/name and flat number/name. These two bits of information, coupled with the postcode, are sufficient to uniquely identify a property in the United Kingdom.

We match the cleaned address to the Land Registry, finding the date and price of every transaction at that property.[19] If there is no transaction in the Land Registry, we use the property valuation at the time of the earliest observed remortgage, if applicable. We then estimate the value of the property at dates away from the relevant transaction/remortgage using the local house price index. Our measure of total directors' residential real estate for firm i at time t is then given by

$$\text{Residential } RE_{i,t} = \frac{|D_i|}{|\tilde{D}_i|} \sum_{d \in \tilde{D}_i} L^d_{i,2002} L^P_{h_d,t}, \tag{2}$$

where $L^d_{i,2002}$ is the estimated home value of director d working at firm i in 2002, and $L^P_{h_d,t}$ is the regional house price index of the region h_d where the director lives in 2002 (with the normalization $L^P_{h_d,2002} = 1$). We are often unable to value the homes of all directors. This occurs if we fail to either match the property to the transaction-level database or if we do not observe a remortgage. In total, we can match and value 58 percent of director addresses; this number rises to 65 percent for directors at our baseline sample of firms. In equation (2), the term D_i is then the set of directors at firm i and $\tilde{D}_i$ is the set of matched directors. Essentially, we first calculate the average of $L^d_{i,2002} L^P_{h_d,t}$ across matched directors, which we then multiply by the total number of directors.[20]

Additional Property Calculations.—We use our mortgage data to calculate the directors' loan to value (LTV) ratio, defined as the total value of the residential mortgages of directors over the total value of their homes. Moreover, a concern with our residential real estate measure is that directors may have levered their homes differently, thus have different levels of residential wealth. To address this, we use our mortgage data to estimate the value of directors' home equity. This comes at the cost of observations (we must see directors sign a new mortgage) and raises measurement issues as the first mortgage contract is observed at different (possibly endogenous) dates for each director. However, we use this series, *Residential Equity*, as an additional robustness check replacing our baseline *Residential RE* measure. We discuss the details of this estimation and the construction of LTVs in online Appendix Section F.

Throughout our analysis we maintain the assumption that a director owns her house. This is a reasonable approximation. Using title deeds and census data, we estimate that ∼90 percent of directors are homeowners (see online Appendix Section E.6). To measure the distance between the firm's location and the director's

[19] The director's purchase (sale) price of the property is the first transaction before (after) the director first (last) lists the address in BvD. When the purchase price is observed, we rely solely on it as it is independent of future behavior and information. If no purchase is recorded (because the property was bought before 1995), then we use the sale price.

[20] This means that we can include firms where not every director is matched in our sample and abstract from differences in the match rate between firms. Online Appendix Section E.5 shows there is little systematic difference between matched and unmatched directors. Section E.3 discusses the reasons for failed matches in detail.

address, we use the UK grid reference for each location's full postcode. We convert the grid reference into a latitude and longitude and calculate the relevant ellipsoidal distance as the crow flies.

C. *Sample Selection and Summary Statistics*

Our sample includes private and public limited liability firms and follows the literature in excluding firms operating in certain industries (online Appendix Section C.5 provides details). We also exclude firms that have a parent with an ownership stake larger than 50 percent, to ensure that the accounts have the highest degree of consolidation and to prevent double counting of subsidiaries. We drop observations with missing data on our measures of firm activity (investment, wages, and employment), financing variables (issued equity, directors loans, and short-/long-term debt), control variables, and our measures of real estate holdings. This leaves us with, in our baseline sample, 32,244 firm-year observations and 6,431 unique firms. The exact sample size for each specification is reported in the regression tables.

All accounting variables that enter our regressions, including real estate holdings, are scaled using the using the BvD variable *Turnover*, from the previous accounting year.[21] To prevent outliers distorting the results, all ratios are winsorized at the median plus/minus 5 times the interquartile range.[22]

Table 2 presents summary statistics on variables of interest for our sample of firms. The median values of BvD variables *Turnover*, *Total Assets*, and *Number of Employees* in the whole sample are about £12.0 million, £8 million, and 107, respectively. By UK categorizations, our median firm is a medium sized enterprise (50–249 employees). Small firms ($<$50 employees) form roughly the lower quartile of our sample while large firms ($\geq$250 employees) form the upper quartile.

In the population, the majority of firms by number have less than 50 employees: as Table 3 shows, 97 percent of UK private sector firms (with at least 1 employee) have less than 50 employees. In that sense, our sample is not representative.[23] However, our coverage improves when considering the proportion of activity in our industries covered rather than the number of firms. Specifically, firms in our sample cover around 20 percent of the total assets and 18 percent of employment. Still, we undersample smaller firms. We address this in two ways. First, in Section VI we estimate weighted versions of our baseline regression, using the officially published aggregate shares of investment across the size distribution, to ensure that the weight placed on each firm size group aligns with their aggregate contribution. Second, we present results in Section VII using a much wider sample of firms (covering around

[21] Alternatively, we could have followed Chaney, Sraer, and Thesmar (2012) in using property plant and equipment as the scaling variable. However, unlike their dataset, ours is not limited to listed large firms, but includes many small firms with small amounts of fixed assets. The choice of *Turnover* as a scaling variable is therefore better suited to our sample, and avoids over-weighting smaller firms with small holdings of fixed assets (due to leasing equipment, for instance). The coefficient on *Residential RE* is robust to scaling by *Total Assets.*

[22] This follows Chaney, Sraer and Thesmar (2012). Our results are robust to winsorizing these variables at the 5/95 percent level. An exception is the changes in firm liabilities and employment, where the interquartile range is near to or equal to zero. For these variables we use a 2/98 percent winsorization.

[23] Online Appendix Section C.6 further discusses how the size distribution in our sample compares with the aggregate.

Table 2—Firm Summary Statistics

Variable	Mean	Median	25th percentile	75th percentile	Standard deviation	Observations
Levels						
Turnover (£000s)	142,318	11,922	5,534	31,379	1.255e+06	32,244
Total assets (£000s)	150,419	8,040	3,711	21,144	1.377e+06	32,244
Number of employees	1,182	107	50	258	11,343	32,244
Residential real estate (£000s)	3,535	2,143	1,228	3,934	4,830	32,244
Corporate real estate (£000s)	29,221	1,118	73.09	4,201	351,374	32,244
Number of directors (2002)	4.196	4	3	5	1.890	32,244
Ratios (to lagged turnover)						
Investment	0.0403	0.0169	0.00263	0.0573	0.0922	32,244
Residential real estate	0.389	0.166	0.0637	0.427	0.535	32,244
Residential equity	0.162	0.0701	0.0257	0.183	0.224	14,909
Corporate real estate	0.215	0.0754	0.00613	0.225	0.335	32,244
Cash	0.0102	0.00126	−0.0449	0.0534	0.134	32,244
Profit	0.0306	0.0286	0.00519	0.0664	0.0912	32,244
Change in remuneration	0.0132	0.00754	−0.00690	0.0298	0.0566	32,244
Change in employment	0.000251	4.51e−05	−0.000441	0.000740	0.00235	32,244
Change in issued equity	0.00532	0	0	0	0.0270	32,244
Change in director loans	−1.24e−05	0	0	0	0.0100	32,244
Change in ST debt	0.0121	0.00549	−0.0215	0.0385	0.0857	32,244
Change in LT debt	0.00667	−0.00278	−0.0168	0.00757	0.0921	32,244

Notes: The statistics are calculated using the sample of observations for the baseline regression, covering the period 2002–2014. This excludes firms who have an ownership stake greater than 50 percent, operate in certain industries, and report the main variables of interest for our regressions. Full details on sample selection are given in Section IIC. *Residential real estate* is defined by equation (2), and *Corporate real estate* is defined by equation (1). *Residential equity* is defined in Section IIB. *Investment* is defined as the change in *fixed assets* plus *depreciation*. *Cash* is defined as *bank deposits* less *bank overdrafts*. *Profit* is defined as *operating profit*. *Change in remuneration* is defined as the change in *remuneration*. *Change in employment* is defined as the change in *number of employees*. *Change in issued equity* is defined as the change in *issued capital* plus the change in the *share premium account. Change in director loans* is defined as the sum of the change in *long-term director loans* and *short-term director loans* liabilities. *Change in ST debt* is defined as the sum of the change in *short-term loans and overdrafts* and *trade credit* less the change in *short-term director loans*. *Change in LT debt* is defined as the change in *long-term debt* less the change in *long-term director loans*. All ratios are winsorized. The changes in firm liabilities and employment are winsorized at the 2/98 percent level. All other ratios are winsorized at the median plus/minus 5 times the interquartile range.

Table 3—Size Distribution (Percent)

	Regression sample	Aggregate data			
Number of employees	Number of firms	Number of firms	Investment share	Turnover share	Employment share
1–9	4.9	80.8	15.0	12.3	18.2
10–49	19.9	16.0	14.3	16.2	18.6
50–249	50.0	2.6	14.4	15.0	15.2
250+	25.3	0.6	56.3	56.5	47.9
All	100	100	100	100	100

Notes: The table shows the size distribution of firms in our baseline regression sample, and in the aggregate, as well as the share of aggregate activity accounted for by firms of different sizes. The statistics are broken down by the number of employees a firm has: 1–9; 10–49; 50–249; or 250+. The first column shows the proportion of observations in our baseline regression sample of 32,244 firm-year observations in each size bucket. The following four columns use aggregate data for 2014, restricted to the industries in our regression sample (see online Appendix C.5), and firms with at least 1 employee. The first of these columns shows the number of firms in each size bucket, whilst the next three columns show the proportion of, respectively, aggregate investment, turnover, and employment accounted for by firms in each size bucket. Aggregate data on the number of firms, employment, and turnover shares come from the ONS's *Business Population Estimates For The UK And Regions, 2014.* The aggregate data on investment (defined as "total net capital expenditure") come from the ONS's 2015 *Annual Business Survey.*

FIGURE 2. MEDIAN RATIO OF RESIDENTIAL AND CORPORATE RE TO TOTAL ASSETS BY FIRM SIZE

Notes: The figure shows how the ratios of residential and corporate real estate to total assets vary by firm size. The statistics are calculated using the sample of observations for the baseline regression, covering the period 2002–2014. This excludes firms who have an ownership stake greater than 50 percent, operate in certain industries, and report the main variables of interest for our regressions. Full details on sample selection are given in Section IIC. *Residential Real Estate* is defined by equation (2), and *Corporate Real Estate* is defined by equation (1). Both real estate measures are scaled by *Total Assets*. The figure displays the median values of these ratios for different firm size buckets. The firm size buckets are based on the mean *Number of Employees* at the firm (left panel) and the *Total Assets* in the current period (right panel).

2.1 million firm-year observations) making use of the fact that *Total Assets* is near universally reported.

The median firm has four directors and between them they own homes worth about £2.1 million. In contrast, the median firm's own real estate holdings are only worth £1.1 million. As demonstrated in Figure 2, the relative importance of the two types of real estate depends on the size of the firm. For relatively small firms, residential real estate is large compared to the size of the balance sheet; this is in contrast to corporate real estate. This pattern reverses for larger firms. The home values of a firm's directors do not scale proportionately with the firm's size, whereas the value of the firm's own real estate tends to be a relatively stable share of assets (excepting the smallest firms). The crossing point for the relative importance of the two types of real estate is at a firm size of 250 employees or about £15 million in assets, which corresponds closely to the UK thresholds for an SME.

Table 4 presents summary statistics on the firm directors in our sample. The median director is 52 years old, has spent 18 years working as a director and held positions across 3 different industries. This highlights that our directors are experienced, and re-emphasizes that our results are not driven by first-time entrepreneurs. The median director also owns a house worth £600,000, which is considerably more than the average UK house price of £160,000 over our sample period.

Two-thirds of directors live in a different region from their firm and the median director lives 11 miles away from her firm. The latter is in line with the 10 miles that the average UK worker has to travel to work (2011 UK census). However, one-quarter of directors live more than 30 miles away from their firm. We use these individuals to identify a group of firms where the directors' home values are less affected by real estate prices in the vicinity of the firm.

Table 4—Director Summary Statistics

Variable	Mean	Median	25th percentile	75th percentile	Standard deviation	Observations
Director house value (£000s)	1,043	615.9	347.8	1,150	1,660	95,523
Director outside firm region	0.657	1	0	1	0.475	78,029
Director distance from firm (miles)	32.95	11.01	4.366	31.11	56.97	77,714
Director age (years)	52.79	52.29	44.79	60.10	11.03	145,885
Male directors	0.847	1	1	1	0.360	144,341
Non-UK directors	0.0556	0	0	0	0.229	145,532
Experience (years)	35.39	18.25	8.750	39.58	59.16	145,911
Number of industries worked in	3.644	3	1	5	3.167	145,911
Firms with at birth	2.006	1	0	2	7.925	145,911
Firms that have failed	3.231	1	0	3	10.32	145,911

Notes: The statistics are calculated for all the directors in the sample of observations used for the baseline regressions (2002–2014). This excludes firms who have an ownership stake greater than 50 percent, operate in certain industries, and report the main variables of interest for our regressions. Full details on sample selection are given in Section IIC. Director house value is the value of individual director houses as described in online Appendix Section E. Director outside firm region is a dummy variable that takes the value 1 when a director's matched address is in a different region to their firm's location. Director distance from firm is the distance between a director's house and their firm's location, as defined in Section IIB. Full definitions of remaining director variables are given in online Appendix Section D.

III. Empirical Strategy

We estimate the following regression for firm i, operating in region j, in industry l, at date t:

$$(3)\qquad Investment_{i,t} = \alpha_i + \delta_{j,t} + \mu_{l,t} + \eta \times Residential\ RE_{i,t} + \beta \times Corporate\ RE_{i,t} + \gamma \times controls_{i,t} + \varepsilon_{i,t}.$$

where *Investment* is the change in BvD variable *Fixed Assets* plus BvD variable *Depreciation*; *Residential RE* and *Corporate RE* are defined as in equations (2) and (1); and α_i, $\delta_{j,t}$, and $\mu_{l,t}$ are firm, region-time, and industry-time fixed effects. We cluster standard errors using NUTS 3 regions. This is a coarser regional definition than in the Land Registry dataset, and we use it to address potential spatial correlation in housing markets.[24] Excepting this, the term region refers to those defined by the Land Registry.

As is standard in firm-level investment regressions (Hubbard 1998), *controls* includes measures of cash-flow. We use (i) *Profit* (BvD variable *Operating Profit*) as a proxy for cash generated and (ii) *Cash* (BvD variables *Bank Deposits* less *Bank Overdrafts*) to measure liquid assets on hand. Both enter the regression lagged by one period.[25] As mentioned, all variables in our regression enter as ratios to the lag of firm *Turnover*. Hence, the estimates of η and β have a £ per £ interpretation.

[24] There are 134 NUTS 3 regions in Great Britain, including 5 in London. We adjust these to ensure the Land Registry regions are always a subset, reducing the set to 130 regions. Specifically, we combine East and West Cumbria; South and West Derbyshire, and East Derbyshire; West and North Northamptonshire; and North and South Nottinghamshire. Our results are very similar if we cluster by the Land Registry regions.

[25] A proxy for Tobin's q is also typically included as a control variable; however, as our dataset includes mainly private firms, this is not observable. Instead, similar to Catherine et al. (2017), the 2-digit industry-time fixed effects, $\mu_{l,t}$, are used to capture changes in investment opportunities for industries.

However, *Residential RE* does not scale naturally with firm size. To prevent any spurious correlation arising from this, we include $1/Turnover_{i,t-1}$ as an additional control.

In further regressions, we explore how various firm characteristics govern the strength of the investment response to both *Residential RE* and *Corporate RE*. To do this we divide firms into two (or more) groups based on the characteristic of interest (e.g., firm age). For the case of two groups $g = \{g_1, g_2\}$ we run the following specification:

$$
\begin{aligned}
(4)\quad Investment_{i,t} = {} & \alpha_i + \delta_{j,t} + \mu_{l,t} + \sum_{w=1}^{2} \eta_w \times \mathbf{1}_t[i \in g_w] \times Residential\ RE_{i,t} \\
& + \theta \mathbf{1}_t[i \in g_1] + \sum_{w=1}^{2} \beta_w \times \mathbf{1}_t[i \in g_w] \times Corporate\ RE_{i,t} \\
& + \gamma \times controls_{i,t} + \varepsilon_{i,t},
\end{aligned}
$$

where $\mathbf{1}_t[i \in g_w]$ is an indicator function equal to 1 when firm i belongs to group w at time t, and 0 otherwise. We present the estimates of η_1 and η_2 adjacent to each other in the regression tables and present results for tests of equality of the two coefficients. This enables easy comparison of the total response of firms in either group to $Residential\ RE_{i,t}$.

At this stage it is informative to consider issues that may affect the identification of η and how these have been addressed by our baseline regression design. Consider the terms in equation (2). The initial value of directors' homes, $L^d_{i,2002}$, may be correlated with omitted factors that govern the firm's behavior, but this is a time-invariant term that is absorbed by the fixed effect α_i. The same applies to the number of directors and matched directors, respectively $|D_i|$ and $|\tilde{D}_i|$. It is also the case that $L^P_{h_d,t}$, the house price index for the director's region, is typically correlated with the firm's real estate price index ($L^P_{j,t}$). In turn $L^P_{j,t}$ could affect the firm's investment opportunities; for example, because an increase in local real estate prices fuels local consumption (Mian and Sufi 2011). Region-time fixed effects, $\delta_{j,t}$, partially address this. We also include the price index in the *month* that the firm files its accounts, $L^P_{j,t}$, to control for real estate price effects due to differences in a firm's financial year end. This combination of controls is sufficient to account for the average effect of local real estate prices and of any time-invariant director characteristics on firm behavior.

Our baseline specification, therefore, essentially compares investment by two firms operating in the same region, where one firm has a director with an expensive house located in a region where house prices appreciate rapidly, and another has a director with a cheap house whose value is stagnant. Hence, there are two main sources of variation differentiating these two firms: the initial value of director homes ($L^d_{i,2002}$), and the house price index in the region where the director lives ($L^P_{h_d,t}$), which may be different from $L^P_{j,t}$. Furthermore, the number of directors, $|D_i|$, can also vary across firms but this is less important for our results.

Despite our extensive use of fixed effects, our findings could still be confounded if our real estate measures are correlated with other omitted factors. These endogeneity concerns can be loosely split into two categories. First, as described, $L^P_{h_d,t}$ could be correlated with other shocks that the firm faces (e.g., to local economic demand).

If the firm's sensitivity to these shocks is correlated with $L^d_{i,2002}$, then our results may be biased. Second, the initial value of director real estate, while predetermined, is an endogenous choice. It may be that $L^d_{i,2002}$ is correlated with omitted director or firm characteristics that govern how sensitive the firm is to real estate prices. For example, firms with older directors own more valuable homes and could be more conservative in the face of real estate price fluctuations.

In our baseline specification, we attempt to address this by augmenting our control set with other observed characteristics of the firm's directors, interacted with $L^P_{j,t}$.[26] Online Appendix Section A.1 shows that these director characteristics explain 30–40 percent of the variation in $L^d_{i,2002}$, with director age and experience being particularly important in explaining the initial 2002 house value. We also control for firm-level characteristics, following Chaney, Sraer, and Thesmar (2012), by including in $controls_{i,t}$: dummy variables for which quintile of the 2002 size (measured by *Total Assets*), age, and return on assets (measured by *Operating Profit* over *Total Assets*) distributions the firm sits in, interacted with $L^P_{j,t}$. We then run further robustness checks below to address these identification concerns.

IV. Baseline Results

A. *Effect on Investment*

Table 5 reports our estimates from different versions of equation (3). The seventh column presents our baseline specification: a £1 rise in the total value of the residential real estate holdings of a firm's directors causes the firm's investment to increase by £0.03. Equivalently, the coefficient on *Corporate RE* suggests that every £1 increase in the value of the firm's own real estate holdings causes a £0.05 increase in investment (for comparison, Chaney, Sraer, and Thesmar 2012 report a figure of $0.06). For the average firm, this implies that corporate real estate has a 70 percent stronger impact on investment than residential real estate. However, as discussed in the introduction, the aggregated value of director real estate is four times larger than the real estate held by owner-occupying firms, suggesting the aggregate effect on investment through residential real estate is potentially larger.

Columns 1–6 build up from the simplest specification and add additional controls until we reach the baseline. Column 1 presents the pooled, bivariate relationship between investment and *Residential RE*, yielding a coefficient of £0.008; however, the inclusion of between variation in $L^d_{i,2002}$ makes this figure hard to interpret. Column 2 includes a firm fixed effect and finds that, within the same firm, a £1 increase in *Residential RE* raises investment by £0.048. Adding time fixed effects of increasing granularity (columns 3–4) reduces this coefficient to around £0.042. As region-time fixed effects wash out the linear effect of regional economic

[26] Specifically, for each firm we compute in 2002 the following: (i) the average age of directors; (ii) the share of directors who are male; (iii) the share of directors who have a non-UK nationality; (iv) the average number of firms each director works for and (v) has ever worked for; (vi) the average number of industries each director has worked in; (vii) the average experience that each director has (defined as time since first appointment); (viii) the average number of firms the directors have resigned from; (ix) the average number of firms that each director has been a part of at birth and (x) at death. Additional detail on the calculation of these variables is presented in online Appendix Section D. For each of these 10 variables, we then place each firm into one of five quintiles based on where they sit in the 2002 distribution and include the interaction of the quintile dummies with $L^P_{j,t}$ in $controls_{i,t}$.

Table 5—Firm Investment and the Real Estate Channels

	Investment						
	Residential RE (1)	Adding firm fixed effects (2)	Adding region-time fixed effects (3)	Adding industry-time fixed effects (4)	Adding firm controls (5)	Adding corporate RE (6)	Adding director controls (7)
Residential RE	0.0077	0.0477	0.0431	0.0420	0.0374	0.0297	0.0298
	(0.002)	(0.007)	(0.007)	(0.007)	(0.007)	(0.008)	(0.008)
Corporate RE						0.0510	0.0511
						(0.016)	(0.016)
Cash					0.0773	0.0771	0.0777
					(0.013)	(0.013)	(0.012)
Profits					0.1084	0.1097	0.1092
					(0.017)	(0.017)	(0.016)
Observations	32,244	32,244	32,244	32,244	32,244	32,244	32,244
Adjusted R^2	0.00	0.21	0.23	0.23	0.25	0.25	0.25
Add. firm controls	No	No	No	No	Yes	Yes	Yes
Add. director controls	No	No	No	No	No	No	Yes
Region-time fixed effects	No	No	Yes	Yes	Yes	Yes	Yes
Industry-time fixed effects	No	No	No	Yes	Yes	Yes	Yes
Firm fixed effects	No	Yes	Yes	Yes	Yes	Yes	Yes

Notes: This table reports the link between residential real estate, corporate real estate, and firm investment. The sample covers reporting UK firms over the period 2002–2014. The dependent variable, *Investment*, is defined as the change in *Fixed Assets* plus *Depreciation*. *Residential RE* is the total value of residential property held by directors of the firm, holding the composition of directors and their properties fixed in 2002, updating the value through time with changes in their respective regional house price indices, as defined in equation (2). *Corporate RE* is the 2002 book value of firm *Land and Buildings* iterated forward using the regional house price index, as defined in equation (1). *Cash* and *Profits* enter with a lag. All of these variables are scaled by the lag of firm *Turnover*. *Add. firm director controls* comprises of quintiles for firm and director characteristics in 2002 interacted with the house price index in the firm region; the firm's regional house price index; and the inverse of lagged *Turnover* (see Section III). All ratios are winsorized at the median $\pm$ 5 times the interquartile range. Standard errors, clustered by firm NUTS 3 region, in parentheses. Column 1: the effect of residential real estate excluding all further controls. Column 2 adds a firm fixed effect. Column 3 further adds region-time fixed effects. Column 4 further adds industry-time fixed effects. Column 5 adds *Cash*, *Profits*, and the additional firm controls. Column 6 adds *Corporate RE*. Column 7 adds the *additional director controls*, and is the baseline specification.

developments, the fall in the coefficient is consistent with other factors potentially driving both real estate prices and investment decisions, biasing the estimate in column 2 upwards. Adding firm-level controls (column 5) also diminishes the estimate. This is especially true of the inclusion of *Corporate RE* (column 6) which reduces the coefficient to £0.03.[27] The coefficient on *Residential RE* is partially confounded if we fail to control for firm-level developments, particularly the value of the firm's buildings. In contrast, director-level controls make little difference to the estimate (column 7).

In addition to increasing investment, a rise in *Residential RE* also affects a firm's use of labor inputs. Online Appendix Section A.12 shows that a £1 rise in *Residential RE* increases the firm's total wage bill by £0.033 and number of

[27] Flipping the empirical exercise around and omitting *Residential RE* from the specification in column 6 raises the coefficient on *Corporate RE* to 0.06, which is perfectly consistent with Chaney, Sraer, and Thesmar (2012).

Table 6—Residential Real Estate and Local Economic Conditions

	Investment							
		Firm type		Director different regions	Director-firm distance		Bank time fixed effects	IV
	Baseline	Tradables	Non-tradables		>30 miles	≤30 miles		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Residential RE	0.0298	0.0349	0.0291	0.0305	0.0315	0.0256	0.0413	0.0269
	(0.008)	(0.017)	(0.008)	(0.008)	(0.014)	(0.008)	(0.011)	(0.008)
Corporate RE	0.0511	0.0673	0.0451	0.0404	0.0516		0.0598	0.0467
	(0.016)	(0.030)	(0.020)	(0.020)	(0.015)		(0.019)	(0.016)
Cash	0.0777	0.0779		0.0678	0.0773		0.0859	0.0802
	(0.012)	(0.012)		(0.012)	(0.012)		(0.013)	(0.013)
Profit	0.1092	0.1096		0.1153	0.1106		0.1152	0.1013
	(0.016)	(0.016)		(0.020)	(0.017)		(0.021)	(0.017)
p-value, equality of residential coefficients	—	0.7432		—	0.7053		—	—
Observations	32,244	32,244		23,501	32,035		23,878	29,299
Adjusted R^2	0.25	0.25		0.25	0.25		0.27	0.25
Add. firm, director controls	Yes	Yes		Yes	Yes		Yes	Yes
Region-time fixed effects	Yes	Yes		Yes	Yes		Yes	Yes
Industry-time fixed effects	Yes	Yes		Yes	Yes		Yes	Yes
Bank-time fixed effects	No	No		No	No		Yes	No
Firm fixed effects	Yes	Yes		Yes	Yes		Yes	Yes

Notes: This table reports the link between residential real estate, corporate real estate, and firm investment. The sample covers reporting UK firms over the period 2002–2014. The dependent variable, *Investment*, is defined as the change in *Fixed Assets* plus *Depreciation*. *Residential RE* is the total value of residential property held by directors of the firm, holding the composition of directors and their properties fixed in 2002, updating the value through time with changes in their respective regional house price indices, as defined in equation (2). *Corporate RE* is the 2002 book value of firm *Land and Buildings* iterated forward using the regional house price index, as defined in equation (1). *Cash* and *Profits* enter with a lag. All of these variables are scaled by the lag of firm *Turnover. Add. firm, director controls* comprises of quintiles for firm and director characteristics in 2002 interacted with the house price index in the firm region; the firm's regional house price index; and the inverse of lagged *Turnover* (see Section III). All ratios are winsorized at the median ± 5 times the interquartile range. Standard errors, clustered by firm NUTS 3 region, in parentheses. All regressions include firm, region-time, and (2 digit) industry-time fixed effects. Column 1 presents the baseline results. Columns 2–3 include the interaction of both *Residential* and *Corporate RE* with a dummy indicating whether the firm is in the tradables sector, proxied by being in the manufacturing sector. Column 4 repeats the baseline estimation with the estimated value of director properties based only on directors that live in a different region from the firm. *Residential RE* is then estimated as this average value multiplied by the total number of directors in the firm (in all regions). Columns 5–6 include the interaction of *Residential RE* with a dummy indicating whether the directors of the firm live more than 30 miles from the firm on average. Column 7 adds bank-time fixed effects to the regression, where a firm's bank is identified as the holder of a secured charge (loan) against the firm's assets. In column 8 *Residential RE* and *Corporate RE* are instrumented as described in online Appendix A.2.

employees by 0.0009; equivalent to a £1.1 million increase (in 2005 prices) resulting in a net employment increase of one worker.

B. *Endogeneity Concerns*

This subsection considers robustness checks to address identification concerns. In line with the reasoning above, we split these tests into two groups: (i) those related to the endogeneity of real estate prices; and (ii) those related to the endogeneity of the initial value of director homes.

Separating House Values from Local Economic Conditions.—Table 6 presents robustness tests designed to address the link between *Residential RE* and local economic conditions. Column 1 repeats our baseline. We then consider if there is a differential response for manufacturing firms whose output is tradable, so local

demand effects should be less relevant (Mian and Sufi 2014). Columns 2–3 show the results, with no notable difference between the two types of firm, consistent with local demand effects not driving our results.

Another way of addressing this issue is to exploit the spatial variation in directors' locations. For example, if our baseline results were explained by firms' excessive sensitivity to local demand, we would expect our coefficient estimate to fall when considering firms with directors who live in a region either far from their firm or one with different house price dynamics. Whereas, in line with our central thesis, if our results are explained by directors reacting to changes in their house values, we should not see any difference in the coefficients. In this vein, column (4) shows results when we recompute our residential real estate measure using information only for directors who live in different regions from the firm (we treat directors living in the same region as unmatched). Our regions can still be confined to relatively small geographical areas (there are 33 regions in London, for instance). Hence, as a second check, we also consider how the distance between the directors' homes and the firm's location affects our results. Columns 5–6 show results when splitting firms by the average distance the director lives from the firm ($>$ or $\leq$ 30 miles). The coefficient estimates in columns 5–6 are consistent with our baseline specification, suggesting our results are not explained by economic developments in the firm's region beyond their impact on the director's house price.

The behavior of banks may also confound our estimates. For instance, the firm may bank with a bank that is active in the regions where the directors live, and hence credit supply could be sensitive to real estate prices in directors' home regions. For firms with secured debt, we observe the name of the bank that holds the loan: we match firms to their creditor banks and include bank-time fixed effects in the regression to control for credit supply. Column 7 shows results for the subsample where we can include bank-time fixed effects. Again, the coefficients are similar to the baseline.

For large firms in small regions, the firm's behavior may also be directly driving real estate prices. To address this, we construct an instrument for regional real estate prices by using the strategy adopted by Mian and Sufi (2011); Chaney, Sraer, and Thesmar (2012); and Chetty, Sándor, and Szeidl (2017) among others. We regress regional house prices on the interaction of the interest rate with a regional housing constraints proxy: the share of all developable land that had been developed by 1990 (Hilber and Vermeulen 2016). The fitted values then provide alternative regional house price indices independent of the firm's decisions. We recompute our firm-level real estate measures with these new indices and use them as instruments to reestimate equation (3) (see online Appendix Section A.2, where we also show the instrument is relevant). Column 8 presents results when we use our instruments for residential and corporate real estate, again with no meaningful difference to the baseline.

In Table 7 we decompose our results further by systematically switching off the sources of variation that constitute *Residential RE*. We define three new measures (formally defined in online Appendix Section D.4): (i) *Residential RE: same house*, which replaces $L^{d}_{i,2002}$ with the cross sectional average of director house values in 2002, equivalent to assuming all directors live in a house with the same initial value; (ii) *Residential RE: same region*, which replaces $L^{P}_{h_d,t}$ with $L^{P}_{j,t}$, equivalent

Table 7—Residential Real Estate: Sources of Variation

	Investment					
					Price index orthogonalization	
	Same house (1)	Same region (2)	Same number of directors (3)	Same region and number of directors (4)	Full sample (5)	Not all dir. in firm region (6)
Residential RE: same house	−0.0001					
	(0.007)					
Residential RE: same region		0.0308			0.0252	0.0152
		(0.007)			(0.013)	(0.013)
Residential RE: same number of directors			0.0277			
			(0.010)			
Residential RE: same region and number of directors				0.0161		
				(0.008)		
Residential RE: orthogonalized					0.0093	0.0334
					(0.019)	(0.019)
Corporate RE	0.0600	0.0503	0.0526	0.0555	0.0504	0.0377
	(0.015)	(0.016)	(0.016)	(0.015)	(0.016)	(0.019)
Cash	0.0778	0.0777	0.0776	0.0778	0.0777	0.0678
	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)	(0.012)
Profit	0.1069	0.1096	0.1084	0.1084	0.1095	0.1154
	(0.016)	(0.016)	(0.016)	(0.016)	(0.016)	(0.020)
Observations	32,244	32,244	32,244	32,244	32,244	23,501
Adjusted R^2	0.25	0.25	0.25	0.25	0.25	0.25
Add. firm, director controls	Yes	Yes	Yes	Yes	Yes	Yes
Region-time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry-time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes

Notes: The table reports the link between residential real estate, corporate real estate, and firm investment. The sample covers reporting UK firms over the period 2002–2014. The dependent variable, *Investment*, is defined as the change in *Fixed Assets* plus *Depreciation*. *Residential RE* is the total value of residential property held by directors of the firm, holding the composition of directors and their properties fixed in 2002, updating the value through time with changes in their respective regional house price indices, as defined in equation (2). *Corporate RE* is the 2002 book value of firm *Land and Buildings* iterated forward using the regional house price index, as defined in equation (1). *Cash* and *Profits* enter with a lag. All of these variables are scaled by the lag of firm *Turnover. Add. firm, director controls* comprises of quintiles for firm and director characteristics in 2002 interacted with the house price index in the firm region; the firm's regional house price index; and the inverse of lagged *Turnover* (see Section III). All ratios are winsorized at the median ± 5 times the interquartile range. Standard errors, clustered by firm NUTS 3 region, in parentheses. All regressions include firm, region-time, and (2-digit) industry-time fixed effects. Column 1 runs the baseline specification with *Residential RE* replaced by *Residential RE same house*. In column 2 *Residential RE* is replaced with *Residential RE same region*. In column 3 *Residential RE* is replaced with *Residential RE same director*. In column 4 *Residential RE* is replaced with *Residential RE same region and director*. See online Appendix D.4 for full definitions of these variables. Column 5 replaces *Residential RE* with *Residential RE orthogonalized*, (defined in online Appendix Section D.5), and includes *Residential RE same region* as a control. Column 6 runs the same specification as column 5 on the sample of firms where at least one director lives in a different region from their firm.

to assuming all directors live in the same region as their firm; (iii) *Residential RE: same number of directors*, which replaces $|D_i|$ with the cross-sectional 2002 mean, equivalent to assuming all firms have the same number of directors. As can be seen in column 1, the coefficient on our residential real estate measure goes to zero when all directors are assumed to live in a house of the same value, whereas assuming all directors live in the same region as their firm (column 2) has almost no impact on

the coefficient. Assuming all firms have the same number of directors (column 3) lowers the coefficient a little but we cannot reject that the coefficient is the same as the baseline.

Two important conclusions arise from this. First, column 1 suggests that our results are not driven by an excess sensitivity of the firm to the real estate prices in the directors' regions per se. Such a sensitivity could arise either because directors who live in high price growth regions are better placed to take advantage of investment opportunities, or because the demand in the directors' regions matters for the firm (e.g., due to commuting patterns). These effects do not appear to be present: $L^P_{h_d,t}$ only has explanatory power when interacted with $L^d_{i,2002}$.

Second, the result in column 2 shows that variation in $L^d_{i,2002}$ drives our baseline estimate. Exploiting spatial heterogeneity in director real estate prices is not needed for our baseline results; many directors live near their firm and so setting $L^P_{h_d,t} = L^P_{j,t}$ is a good approximation. At face value, this is perhaps worrisome. It may indicate that our findings are explained by $L^d_{i,2002}$ being correlated with factors that govern how sensitive the firm is to local economic conditions, rather than anything specific about the price dynamics that a director faces. To mitigate this concern, first note that while variation in $L^d_{i,2002}$ is necessary for our results, it is not sufficient. As shown in column 4, when this is the only source of variation, the coefficient estimate is around one-half of the baseline.[28] Second, note that the coefficient estimate does not rise notably when we assume that all directors live in the firm's region. This is inconsistent with our results being explained by the firm's sensitivity to local economic conditions, as *Residential RE: same region* has an even stronger correlation with local real estate prices and hence the local economy.

Still, there is the question of whether the spatial heterogeneity in director real estate prices is relevant. To show that it is, we exploit regional variation in prices to an extreme and compute for, each possible pair $(L^P_{h_d,t}, L^P_{j,t})$, the director's regional house price index *orthogonalized* with respect to the firm's regional house price index; we then recompute *Residential RE* using these orthogonalized indices, to produce *Residential RE: orthogonalized* (see online Appendix Section D.5 for further details). The two series, *Residential RE: same region*, *Residential RE: orthogonalized* essentially span the variation in the baseline series. Including the two together in the regression allows us to ask how much additional explanatory power comes from the price index in the director's region. As shown in column 5, in the baseline sample, the orthogonalized measure does not have much explanatory power. However, this is driven by firms whose directors all live in the same region as their firm. By construction, for these firms, there is no time series variation in *Residential RE: orthogonalized*, as there is no portion of the director's house price index that is orthogonal to the firm's. To relax this, in column 6, we restrict the sample to firms where at least one of the 2002 directors live in a different region to their firm. We obtain a similar estimate to the baseline regression, even when controlling for *Residential RE: same region*. Moreover, in this regression, the estimated coefficient

[28] Formally, we define a new measure *Residential RE: same region and number of directors* (see online Appendix Section D.4), which assumes all directors live in the same region and all firms have the same number of directors. For firms in the same region the only source of variation in residential real estate is the average initial house price of their directors.

Table 8—Residential Real Estate and Initial Real Estate Holdings

	Investment					
		Pre-1995	2002 directors		Multifirm	Control for
	Baseline	house purchase	Present	Left	directors	director pay
	(1)	(2)	(3)	(4)	(5)	(6)
Residential RE	0.0298	0.0288	0.0257	0.0082	0.0310	0.0469
	(0.008)	(0.011)	(0.009)	(0.007)	(0.010)	(0.017)
Corporate RE	0.0511	0.0350	0.0553		0.0559	0.0427
	(0.016)	(0.023)	(0.015)		(0.017)	(0.032)
Cash	0.0777	0.0692	0.0773		0.0804	0.0602
	(0.012)	(0.019)	(0.012)		(0.012)	(0.018)
Profit	0.1092	0.1055	0.1081		0.1067	0.1285
	(0.016)	(0.022)	(0.016)		(0.020)	(0.024)
p-value, equality of residential coeffs.	—	—	0.0791		—	—
Observations	32,244	20,826	32,244		26,800	16,334
Adjusted R^2	0.25	0.25	0.25		0.25	0.27
Additional firm, director controls	Yes	Yes	Yes		Yes	Yes
Region-time fixed effects	Yes	Yes	Yes		Yes	Yes
Industry-time fixed effects	Yes	Yes	Yes		Yes	Yes
Firm fixed effects	Yes	Yes	Yes		Yes	Yes

Notes: The table reports the link between residential real estate, corporate real estate, and firm investment. The sample covers reporting UK firms over the period 2002–2014. The dependent variable, *Investment*, is defined as the change in *Fixed Assets* plus *Depreciation*. *Residential RE* is the total value of residential property held by directors of the firm, holding the composition of directors and their properties fixed in 2002, updating the value through time with changes in their respective regional house price indices, as defined in equation (2). *Corporate RE* is the 2002 book value of firm *Land and Buildings* iterated forward using the regional house price index, as defined in equation (1). Cash and profits enter with a lag. All of these variables are scaled by the lag of firm *Turnover*. *Additional firm, director controls* comprises of quintiles for firm and director characteristics in 2002 interacted with the house price index in the firm region; the firm's regional house price index; and the inverse of lagged *Turnover* (see Section III). All ratios are winsorized at the median $\pm$ 5 times the interquartile range. Standard errors, clustered by firm NUTS 3 region, in parentheses. All regressions include firm, region-time, and (2 digit) industry-time fixed effects. Column 1 presents the baseline regression. Column 2 calculates *Residential RE* excluding properties bought between 1995 and 2002, treating these as unmatched. Columns 3 and 4 split *Residential RE* into the real estate of the 2002 directors still at the firm (column 3) and those that have since left (column 4). The interquartile range of this latter variable is close to 0 so it's winsorized at the 2/98 percent level: online Appendix Section A.3 provides further details on variable construction. Column 5 adds a proxy for director skill for firms where at least one director has directorships at multiple companies. For such firms, it includes the interaction of the house price index with five quintiles of the average growth in *Total Assets* at the directors' *other* companies (see online Section Appendix D.2). Column 6 augments the control set with the lagged average pay of directors and the salary of the highest paid director; these terms enter linearly and interacted with the firm region house price index.

for *Residential RE: same region* is insignificant. These results show that house prices in the director's region matter for firm investment over and above house prices in the firm's region, corroborating the mechanism running from director real estate to firm investment.

The Endogeneity of Initial Real Estate Holdings.—Table 8 presents robustness checks designed to address the potential endogeneity of directors' initial real estate holdings. As described, by fixing the value of directors' real estate in 2002, we prevent any shocks that jointly determine directors' demand for housing and the firm's investment after the sample starts, from distorting our estimates. However, it could still be that directors' housing choice in 2002 reflected knowledge about how the firm would perform in the early years of our sample, or that the initial

housing value reflects omitted time-invariant heterogeneity correlated with differing firm-level sensitivities to the housing cycle.

We observe housing transactions from 1995 onward. In column 2 we utilize this and focus on directors whose property was purchased prior to 1995 (treating directors who bought between 1995 and 2002 as unmatched). With this specification, which yields similar results, there is now a gap of at least seven years between the director's decision to buy her home and the start of the sample. The housing choice is, thereby, more likely to have been made for historical reasons, and unrelated to the firm. Moreover, as the years prior to 1995 featured low real house prices in the United Kingdom, our results do not seem to be driven by directors who bought their house during a boom.

In columns 3–4 we exploit the fact that some directors leave their firm over the sample period. If the initial value of director real estate is correlated with omitted firm-level characteristics governing the sensitivity of the firm to real estate prices, then a director's resignation should not alter the coefficient estimate on that director's real estate. In contrast, if the director's real estate works as a source of finance, then investment should be insensitive to the value of a director's initial home once she leaves the firm. Columns 3–4 confirm the latter: once a director leaves the firm, her home value no longer matters for investment.[29] This result also further alleviates the local demand concerns of the prior section: if home values only matter for firm investment because they proxy for local demand, the value of the director's house would affect firm investment regardless of whether the director still worked at the firm.

A test based on leavers only addresses omitted firm-level heterogeneity. The director herself may also determine the firm's sensitivity to real estate prices through how she manages the company. One specific concern is that more skillful directors can better take advantage of opportunities presented by expansions and also own more expensive houses. In columns 5–6, we run additional checks on subsamples where we observe additional information on directors. First, we exploit the fact that some directors hold directorships at more than one firm at a time. For this subset of directors we are able to calculate an additional proxy for their skill: the average growth rate in *Total Assets* in *other* firms that they are directors of (see online Appendix Section D.2 for the definition). This is a more limited sample, and the critical source of variation is then different, but overlapping, combinations of directors across firms. However, the variable is advantageous in that it is based on realized information of firm performance rather than just director characteristics. We place firms into one of 5 quintiles based on where they sit in the annual distribution of this average asset growth variable and include the interaction of these quintile dummies with $L^P_{j,t}$ as additional controls. Second, for a smaller subsample of firms we also observe the average and maximum remuneration paid to directors.[30] As pay is correlated with both director skill and the ability to buy an expensive house, we rerun our baseline regression including these two variables both linearly and interacted with $L^P_{j,t}$. Columns 5–6 both deliver similar results to the baseline.

[29] Moreover, we can reject at the 10 percent level that the real estate of leavers has the same impact as that of the remaining directors. Online Appendix Section A.3 provides details on variable construction and further results.

[30] We use BvD variables *Director Remuneration/Number of Directors*, and *Highest Paid Director* as additional controls.

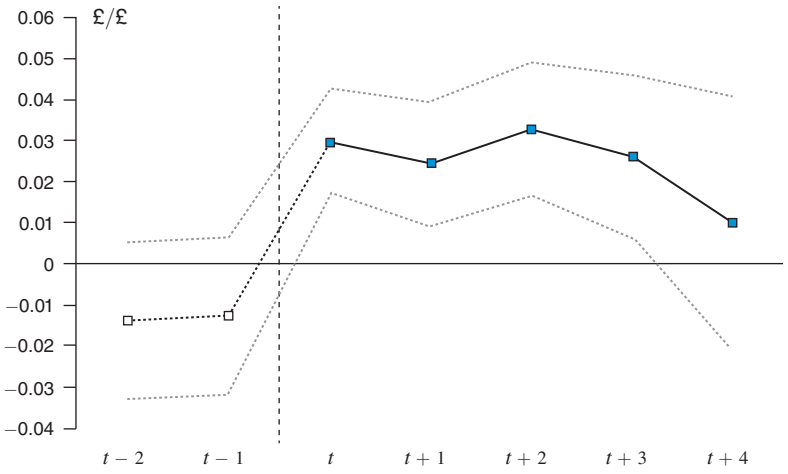

FIGURE 3. DYNAMIC EFFECTS OF RESIDENTIAL REAL ESTATE ON INVESTMENT

Notes: The figure reports the dynamic impact of residential real estate on investment (estimates of η^h, with the model defined as in footnote 31). See notes to Table 5 for detail on the baseline specification and sample. The 90 percent confidence bands are constructed using standard errors clustered by firm NUTS 3 region.

C. *Dynamic Effects*

The effects in Table 5 are contemporaneous. To explore the dynamic response, we re-specify equation (3) as a local projection, by altering the dependent variable to $Investment_{i,t+h}$, and estimate the impact for different horizons h.[31] Figure 3 presents estimates of η^h as an impulse response, where the horizon 0 response of 0.03 corresponds to the baseline estimate in Table 5 (as a placebo test we also present results for two lags of investment and find insignificant effects). The investment response is relatively stable over the current year and the next three years, before decaying and becoming statistically insignificant. The cumulative increase in investment is therefore around 12p for a £1 increase in *Residential RE*. In unreported results we find that *Residential RE* itself behaves like a random walk: a £1 increase in real estate values persists throughout the five-year horizon without any additional propagation or decay. We can therefore interpret the dynamic response in Figure 3 as the response to a permanent £1 increase in *Residential RE* at time t.

As the regression includes time fixed effects, the dynamic response holds factor prices fixed and cannot be explained by external investment adjustment costs. Other mechanisms could explain the result. First, it could be explained by internal adjustment costs at the firm level (Cooper and Haltiwanger 2006). Second, it could reflect the time taken to plan and implement a new project (Kydland and Prescott 1982); previous studies estimate time-to-build effects of 2–3 years (Del Boca et al. 2008). Finally, if the rise in investment is due to a relaxation of a collateralized borrowing limit, the dynamic response may be explained by delays in loan approvals or lenders

[31] Specifically, we estimate: $Investment_{i,t+h} = \alpha_i^h + \delta_{j,t}^h + \mu_{l,t}^h + \eta^h \times Residential\ RE_{i,t} + \beta^h \times Corporate\ RE_{i,t} + \gamma^h \times controls_{i,t} + \varepsilon_{i,t}^h$ for each horizon h.

taking time to update valuations.[32] The dynamic response could be reconciled with financial constraints as specified by Iacoviello (2015), where the value of collateral affects available financing with some delay.

V. Heterogeneity and Mechanisms

In this section we present results on how heterogeneity at the firm and director level affects the sensitivity of firm investment to the value of their directors' residential real estate. We argue that the patterns of heterogeneity are consistent with an increase in residential real estate causing an increase in firm-level investment via a relaxation of collateral constraints.

A. *Firm Heterogeneity*

Financial Constraints.—To explore how the firm's reaction to residential real estate varies with a direct proxy for firm-level financial constraints, we use a version of the Whited and Wu (2006) index re-estimated on our data. The procedure is standard and we describe it in online Appendix Section G. A higher value of the index corresponds to tighter financial constraints.[33]

Table 9 presents the results using this index. Column 1 shows the baseline specification on the sample where the index is non-missing. We follow Chaney, Sraer, and Thesmar (2012) and split firms into three tertiles based on the annual distribution of the index. Columns 2–4 present the results. The investment sensitivity to director and firm real estate is greater for the most constrained firms. The point estimate for director real estate is around 30 percent higher for the most constrained firms. The difference is not statistically significant. This may reflect measurement issues with the index and that the index may also be correlated with cross-sectional characteristics, like size, which bias results against a large difference. To address this, columns 5–6 show how the investment sensitivity to director real estate varies *within the same firm* for periods when it is more or less constrained (compared to firm's own median value).[34] The responsiveness of investment to both director and firm real estate is higher, both economically and statistically, when the firm is more constrained.

Firm Size.—The discussion in Section I suggests that the sensitivity of investment to *Residential RE* depends on firm size. There are two distinct considerations. First, for larger firms, director real estate is less likely to be material relative to a firm's financing needs (see Figure 2). Second, however, if housing collateral serves to

[32] Online Appendix Section B.3 presents evidence on how frequently banks value property collateral.

[33] As argued by Kaplan and Zingales (1997) and emphasized by Chaney, Sraer, and Thesmar (2012), it is unclear a priori how financing constraints affect the sensitivity of investment to real estate values. However, the prediction is that financial constraints should generate a differential response to changes in real estate values even if the exact sign is ultimately an empirical question. See Hubbard (1998) for a survey of the literature on whether (Fazzari, Hubbard, and Petersen 1988) or not (Kaplan and Zingales 1997) estimated investment-cash-flow sensitivities can be used as proxies for financing constraints.

[34] Here we use above/below medians rather than three tertiles as we have fewer observations at the level of each firm.

Table 9—Heterogeneous Responses: Financial Constraints

	Investment					
		Financial constraint index				
		Heterogeneity within year			Heterogeneity within firm	
	Baseline (1)	Low index (2)	Medium index (3)	High index (4)	Low index (5)	High index (6)
Residential RE	0.0269	0.0216	0.0212	0.0282	0.0230	0.0310
	(0.008)	(0.008)	(0.009)	(0.008)	(0.007)	(0.008)
Corporate RE	0.0593	0.0412	0.0609	0.0696	0.0456	0.0654
	(0.016)	(0.015)	(0.017)	(0.017)	(0.016)	(0.016)
Cash	0.0768		0.0798		0.0848	
	(0.012)		(0.012)		(0.013)	
Profit	0.1083		0.1136		0.1178	
	(0.016)		(0.016)		(0.016)	
p-value, equality of residuals	—		0.3319		0.0003	
Coeffs. for low, high index						
Observations	31,462		31,462		31,462	
Adjusted R^2	0.25		0.25		0.26	
Add. firm, director controls	Yes		Yes		Yes	
Region-time fixed effects	Yes		Yes		Yes	
Industry-time fixed effects	Yes		Yes		Yes	
Firm fixed effects	Yes		Yes		Yes	

Notes: This table reports the link between residential real estate, corporate real estate, and firm investment. The sample covers reporting UK firms over the period 2002–2014. The dependent variable, *Investment*, is defined as the change in *Fixed Assets* plus *Depreciation*. Residential RE is the total value of residential property held by directors of the firm, holding the composition of directors and their properties fixed in 2002, updating the value through time with changes in their respective regional house price indices, as defined in equation (2). *Corporate RE* is the 2002 book value of firm *Land and Buildings* iterated forward using the regional house price index, as defined in equation (1). *Cash* and *Profits* enter with a lag. All of these variables are scaled by the lag of firm *Turnover. Add. firm, dir. controls* comprises of quintiles for firm and director characteristics in 2002 interacted with the house price index in the firm region; the firm's regional house price index; and the inverse of lagged *Turnover* (see Section III). All ratios are winsorized at the median $\pm$ 5 times the interquartile range. Standard errors, clustered by firm NUTS 3 region, in parentheses. All regressions include firm, region-time, and (two digit) industry-time fixed effects. The table uses the financial constraint index described in online Appendix Section G. Column 1 presents the baseline results for observations where the financial constraint index is non-missing. Columns 2–4: both *Residential RE* and *Corporate RE* are interacted with a dummy variable indicating whether the firm is in the lower third, middle third, or highest third of the financial constraint index across all firms in a given year. Columns 5–6: both *Residential RE* and *Corporate RE* are interacted with a dummy variable indicating whether, in a given year, the firm is in the lower half or highest half of the values of the financial constraint index taken by that firm over time.

either additionally signal quality ex ante, or align incentives ex post, *Residential RE* could still affect investment when its value is low relative to the value of the firm.

In Table 10, we first consider how the sensitivity of investment to real estate values changes across firm size. We consider two groups: small and medium-sized firms ($<$250 employees using the UK classification or $<$£10 million in assets), and large firms ($\geq$250 employees or $\geq$£10 million in assets). The employment thresholds correspond to the lower three quartiles and upper quartile of our sample, respectively. Columns 1–2 use the regression specification in equation (4) and show that residential real estate only has a statistically significant effect among SMEs when size is measured using employment. However, the point estimate is higher for large firms (£0.066) than smaller firms (£0.025). Moreover, columns 3–4 show that larger firms react significantly when we define size using assets.

TABLE 10—HETEROGENEOUS RESPONSES: SIZE

	Investment							
	Employment		Total assets		Dir RE/TA		Employment	
	<250 (1)	≥250 (2)	<£10m (3)	≥£10m (4)	≥15% (5)	<15% (6)	<250 (7)	≥250 (8)
Residential RE	0.0249	0.0663	0.0241	0.0344	0.0333	−0.0136		
	(0.010)	(0.051)	(0.007)	(0.015)	(0.007)	(0.030)		
Res. RE: high RE/TA							0.0275	0.0753
							(0.010)	(0.049)
Res. RE: low RE/TA							−0.0128	−0.0097
							(0.038)	(0.092)
Corporate RE	0.0428	0.0620	0.0492	0.0402	0.0462		0.0455	
	(0.019)	(0.032)	(0.017)	(0.019)	(0.016)		(0.016)	
Cash	0.0775		0.0777		0.0786		0.0787	
	(0.012)		(0.012)		(0.012)		(0.012)	
Profit	0.1089		0.1102		0.1094		0.1087	
	(0.016)		(0.016)		(0.016)		(0.016)	
p-value, equal res. coeffs.	0.4634		0.3802		0.0831		0.1958	0.2953
Observations	32,244		32,244		32,244		32,244	
Adjusted R^2	0.25		0.25		0.25		0.25	
Add. firm, dir. controls	Yes		Yes		Yes		Yes	
Region-time fixed effects	Yes		Yes		Yes		Yes	
Industry-time fixed effects	Yes		Yes		Yes		Yes	
Firm fixed effects	Yes		Yes		Yes		Yes	

Notes: This table reports the link between residential real estate, corporate real estate, and firm investment. The sample covers reporting UK firms over the period 2002–2014. The dependent variable, *Investment*, is defined as the change in *Fixed Assets* plus *Depreciation. Residential RE* is the total value of residential property held by directors of the firm, holding the composition of directors and their properties fixed in 2002, updating the value through time with changes in their respective regional house price indices, as defined in equation (2). *Corporate RE* is the 2002 book value of firm *Land and Buildings* iterated forward using the regional house price index, as defined in equation (1). *Cash* and *Profits* enter with a lag. All of these variables are scaled by the lag of firm *Turnover*. *Add. firm, dir. controls* comprises of quintiles for firm and director characteristics in 2002 interacted with the house price index in the firm region; the firm's regional house price index; and the inverse of lagged *Turnover* (see Section III). All ratios are winsorized at the median ± 5 times the interquartile range. Standard errors, clustered by firm NUTS 3 region, in parentheses. All regressions include firm, region-time, and (2 digit) industry-time fixed effects. Columns 1–2: both *Residential* and *Corporate RE* are interacted with a dummy variable indicating whether the average *Number of Employees* at the given firm is within 0–249 (small and medium sized enterprises) or ≥250 (large). Columns 3–4: both *Residential* and *Corporate RE* are interacted with a dummy variable indicating whether the lagged *Total Assets* of the firm exceed £10 million. Columns 5–6: *Residential RE* is interacted with a dummy variable indicating whether the ratio of *Residential RE* to the lag of *Total Assets* is at least 15 percent. Columns 7–8: *Residential RE* is interacted with a dummy variable indicating (i) whether employment is at least 250; and (ii) whether the ratio of *Residential RE* to the lag of *Total Assets* is at least 15 percent. This dummy variable takes on 4 values. The inverse of lagged *Turnover* is also interacted with the dummy variable in the specifications of columns 1–8.

This could be taken as evidence of an incentive/signaling effect. An alternative explanation is that there are large firms where directors' houses are valuable enough to be a material source of collateral upon liquidation. These could be firms with many employees but low capital intensity. Or they could be large firms with rich owners, such that the real estate of the directors is of a value commensurate to the firm. In columns 5–6 we illustrate this by splitting firms instead by the ratio of *Residential RE* to lagged *Total Assets*. Once the joint value of directors' homes falls below 15 percent of the firm's assets (this holds for one-third of the observations in the sample) there is no longer any sensitivity of investment to *Residential RE*. In online Appendix Section A.4, we demonstrate the robustness of this threshold.

Taking this a step further, in columns 7–8 we consider a four-way split: firms with greater or less than 250 employees, and firms where the combined value of the directors' homes is greater or less than 15 percent of assets (online Appendix Section A.4 has the equivalent results from a four-way split that cuts by assets rather than employment). Around 30 percent of firms with above 250 employees have director real estate worth at least 15 percent of the total assets of the firm. As can be seen, it is firms, small or large, where the directors' houses are valuable relative to the firm's assets that account for the sensitivity of investment to *Residential RE*.

While the *Residential RE* to asset ratio seems an important determinant of the firm-level response, it is still the case that, conditional on the directors' houses being valuable relative to the firm's balance sheet size, large firms with many employees respond more to *Residential RE*. This may be because these firms are better able to lever up a given increase in net worth. As columns 1–2 show, firms with many employees are somewhat more responsive to *Corporate RE* as well (although in neither case is the difference between small and large firms statistically significant).

B. *Firm Financing*

We now turn to how firms finance the increase in investment. Recall that residential real estate can affect firm funding either via granting a claim on directors' homes when guaranteeing a loan to the firm, or via directors extracting home equity to inject capital into the firm. The latter can take the form of insider debt financing (director loans) or new equity. To explore the channels by which increased real estate values are converted into firm funding, we estimate the effects of real estate on changes in specific parts of the liability side of firms' balance sheets. Specifically, we rerun our specification with four liability measures as left-hand-side variables: (i) new equity issuance; (ii) change in director loan liabilities; (iii) change in short-term debt; and (iv) change in long-term debt.[35]

The results for these four variables are presented in columns 1–4 of Table 11. A £1 increase in *Corporate RE* increases long-term debt by £0.037. Short-term external debt increases by an additional £0.032 and the sum has the same magnitude as the £0.05 increase in investment. Intuitively, the change in the value of the firm's real estate does not lead to a change in issued equity. The negative coefficient on director loans (only significant at 10 percent level) suggests that a small part of the external financing arising from an increase in *Corporate RE* is used to repay loans from insiders.

Residential real estate has a significant effect on both equity issuance and short-term debt: a £1 increase in the value of directors' homes increases net equity and short-term external debt by about £0.009 and £0.021, respectively. The effect on long-term external borrowing is negligible and statistically insignificant.

There are three key takeaways from these results. First, the total effect, summing across liabilities, is very similar to the baseline £0.03 increase in investment reported

[35] Equity issuance equals the sum of the change in BvD variables *Issued Capital* and the *Share Premium Account*. Director loan liabilities equal BvD variables *Long Term Director Loans* plus *Short Term Director Loans*. Short-term external debt equals BvD variables *Short Term Loans and Overdrafts* plus *Trade Credit* less *Short Term Director Loans*. Short-term loans are supposed to refer to maturities less than a year but there may be some discrepancies across firms. Long-term external debt financing equals BvD variables *Long Term Debt* less *Long Term Director Loans.*

TABLE 11—FIRM FINANCING AND REAL ESTATE CHANNELS

	Financing							
					Debt response by employment splits			
					ST debt		LT debt	
	Issued equity (1)	Director loans (2)	ST debt (3)	LT debt (4)	<250 (5)	≥250 (6)	<250 (7)	≥250 (8)
Residential RE	0.0086	−0.0001	0.0210	0.0023				
	(0.002)	(0.001)	(0.010)	(0.012)				
Residential RE: high RE/TA					0.0222	0.0232	−0.0094	0.0969
					(0.010)	(0.029)	(0.013)	(0.026)
Residential RE: low RE/TA					−0.0081	0.0488	0.0110	−0.0599
					(0.029)	(0.089)	(0.053)	(0.064)
Corporate RE	−0.0059	−0.0027	0.0318	0.0373	0.0252		0.0377	
	(0.005)	(0.002)	(0.015)	(0.019)	(0.016)		(0.020)	
Observations	32,244	32,244	32,244	32,244	32,244		32,244	
Adjusted R^2	0.30	−0.02	−0.00	0.04	0.00		0.05	
Additional firm, director controls	Yes	Yes	Yes	Yes	Yes		Yes	
Region-time fixed effects	Yes	Yes	Yes	Yes	Yes		Yes	
Industry-time fixed effects	Yes	Yes	Yes	Yes	Yes		Yes	
Firm fixed effects	Yes	Yes	Yes	Yes	Yes		Yes	

Notes: This table reports the link between residential real estate, corporate real estate, and firm financing. The sample covers reporting UK firms over the period 2002–2014. Issued equity is the sum of the change in *Issued Capital* and the *Share Premium Account* whilst Director Loans is the sum of the change in *Long-Term Director Loans* and *Short-Term Director Loans* liabilities. *Short-Term Debt* is defined as the sum of the change in *Short-Term Loans and Overdrafts* and *Trade Credit* less the change in *Short-Term Director Loans*. *Long-Term Debt* is defined as the change in *Long-Term Debt* less the change in *Long Term Director Loans. Residential RE* is the total value of residential property held by directors of the firm, holding the composition of directors and their properties fixed in 2002, updating the value through time with changes in their respective regional house price indices, as defined in equation (2). *Corporate RE* is the 2002 book value of firm *Land and Buildings* iterated forward using the regional house price index, as defined in equation (1). All of these variables are scaled by the lag of firm *Turnover. Additional firm, director controls* comprises of quintiles for firm and director characteristics in 2002 interacted with the house price index in the firm region; the firm's regional house price index; and the inverse of lagged *Turnover* (see Section III). All ratios are winsorized at the median ± 5 times the interquartile range, except for the financing variables which are winsorised at the 2/98 percent level. Standard errors, clustered by firm NUTS 3 region, in parentheses. All regressions include firm, region-time, and (2 digit) industry-time fixed effects. Columns 1–4 have, respectively, *Issued Equity*; *Director Loans*; *Short-Term Debt*; and *Long-Term Debt*, as the dependent variable. Columns 5–6: the dependent variable is *Short-Term Debt* and *Residential RE* is interacted with a dummy variable indicating (i) whether employment is at least 250; and (ii) whether the ratio of residential RE to assets is at least 15 percent (see notes to Table 10 for further details). This dummy variable takes on 4 values. Columns 7–8 repeat this exercise with *Long-Term Debt* as the dependent variable. The inverse of lagged *Turnover* is also interacted with the dummy variable in the specifications of columns 5–8.

in Table 5. In online Appendix Section A.6, we draw Tables 11 and 5 together into a single specification by regressing investment on changes in liabilities, using our real estate measures as instruments. We find that £1 more debt (or equity) financing identified through increased real estate values leads to around £1 more investment. The firms that invest in response to increased real estate values are also the ones who borrow more.

Second, the finding that roughly a third of the observed increase in investment is funded by new equity issuance, suggests that direct cash injections from directors is the less important marginal source of finance unlocked via *Residential RE*. Instead, the estimated debt response is consistent with *Residential RE* operating via increasingly valuable personal guarantees that expand the borrowing capacity of the firm. We explore this choice between debt and equity further in online Appendix

Section A.7, using both survey evidence and regression analysis. To summarize, there is some evidence that larger firms rely more on guarantees. The same is true for firms with complex shareholder structures between directors, or firms that would benefit from a tax shield; this in line with the discussion on the merits of guarantees in Section I.

Third, it is short-term debt that responds to an increase in *Residential RE*. This is consistent with theories of maturity choice under agency problems. Short-term debt can force firms to disgorge intermediate cash-flows that may otherwise exacerbate ex post incentive problems (Holmström and Tirole 2000). Alternatively, short-term debt can serve as a signal about firm quality (Flannery 1986), or be the appropriate response to firms' private information about refinancing risk (Diamond 1991, 1993). Importantly, however, the financial frictions that result in the firm relying on short-term debt to finance investments coincide with the reasons why directors need to pledge residential real estate in the first place: the need to send costly signals and to avert moral hazard problems (as emphasized by Tirole 2006, p. 204).

Interestingly, this maturity response is heterogeneous.[36] As in Table 10, columns 5–8 in Table 11 split the sample into small and large firms with high and low *Residential RE* to asset ratios. As with investment, it is only the debt of firms where the directors' houses are worth more than 15 percent of the firm's assets who respond. However, for larger firms it is long-term, not short-term, debt that reacts, suggesting the friction that forces smaller firms to borrow short term is less relevant for larger firms. This chimes with the notion that larger firms are less financially constrained along certain dimensions; despite the fact that both types of firms appear to be pledging personal assets as collateral.[37]

These findings on maturity structure are a secondary contribution of this paper. There are few datasets that can estimate the within-firm response of debt maturity to aggregate shocks for a sample dominated by private firms. Exceptions, consistent with our evidence, include (i) Kalemli-Ozcan, Laeven, and Moreno (2018), showing that short-term debt is commonly used by smaller, private European firms, which affects the sensitivity of firms to aggregate shocks; and (ii) Dinlersoz et al. (2018) which shows that, for US private firms, short-term debt is used to finance growth in expansions and was the main source of deleveraging in the Great Recession.

C. *Director Heterogeneity*

Shareholders versus Non-Shareholders.—Directors who only have a managerial role have less incentive than owners to pledge personal assets to support the firm. Hence if the channel operates via increasingly valuable homes being used as collateral by firms, we would expect to see a stronger effect for directors who are also shareholders. This also serves as an additional check of our identification strategy: if our results are due to omitted factors generating excess firm sensitivity to real

[36] Unfortunately, equity issuance is a relatively rare event, hence we do not have sufficient variation in the *Issued Equity* series to obtain precise estimates when splitting the sample.

[37] This finding comes with the caveat that when we split along the dimension of assets rather than employment we no longer obtain precise estimates on the response of liabilities and the point estimates no longer have a clear economic interpretation.

TABLE 12—HETEROGENEOUS RESPONSES: SHAREHOLDERS VERSUS NON-SHAREHOLDERS

	Investment by private firms					
	Shareholder sample		Non-shareholders		Both nonzero	
	(1)	Shareholders (2)	(3)	Both (4)	Shareholders (5)	Both (6)
Residential RE	0.0205				0.0478	
	(0.011)				(0.020)	
Res. RE: shareholders		0.0394		0.0393		0.0770
		(0.019)		(0.019)		(0.039)
Res. RE: non-shareholders			0.0139	0.0117		0.0168
			(0.044)	(0.044)		(0.089)
Corporate RE	0.0371	0.0333	0.0438	0.0327	0.0320	0.0240
	(0.024)	(0.023)	(0.023)	(0.023)	(0.043)	(0.042)
Cash	0.0734	0.0742	0.0735	0.0741	0.1224	0.1220
	(0.017)	(0.016)	(0.017)	(0.016)	(0.031)	(0.030)
Profit	0.0730	0.0721	0.0716	0.0725	0.0599	0.0594
	(0.024)	(0.024)	(0.024)	(0.024)	(0.033)	(0.033)
Observations	17,277	17,277	17,277	17,277	6,049	6,049
Adjusted R^2	0.27	0.27	0.27	0.27	0.27	0.27
Add. firm, director controls	Yes	Yes	Yes	Yes	Yes	Yes
Region-time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry-time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Firm fixed effects	Yes	Yes	Yes	Yes	Yes	Yes

Notes: This table reports the link between residential real estate, corporate real estate, and firm investment. The sample covers private reporting UK firms over the period 2002–2014 where both *Res. RE: shareholders* and *Res. RE: non-shareholders* are non-missing. The dependent variable, *Investment*, is defined as the change in *Fixed Assets* plus *Depreciation*. *Residential RE* is the total value of residential property held by directors of the firm, holding the composition of directors and their properties fixed in 2002, updating the value through time with changes in their respective regional house price indices, as defined in equation (2). *Corporate RE* is the 2002 book value of firm *Land and Buildings* iterated forward using the regional house price index, as defined in equation (1). *Cash* and *Profits* enter with a lag. All of these variables are scaled by the lag of firm *Turnover*. *Add. firm, director controls* comprises of quintiles for firm and director characteristics in 2002 interacted with the house price index in the firm region; the firm's regional house price index; and the inverse of lagged *Turnover* (see Section III). All ratios are winsorized at the median $\pm$ 5 times the interquartile range. Standard errors, clustered by firm NUTS 3 region, in parentheses. All regressions include firm, region-time, and (2 digit) industry-time fixed effects. Column 1 presents results of the baseline specification for private firms where the value of residential real estate is non-missing for both shareholders and non-shareholders. Columns 2–3 show results when we separately control for the *Residential RE* of shareholders and non-shareholders, whilst column 4 shows results when we control for both. Column 5 presents the baseline results for the sample of private firms where the residential real estate of shareholders and non-shareholders are both nonzero. Column 6 shows results when we separately control for the residential real estate of shareholders and non-shareholders on this sample.

estate prices, then there is no reason for a dichotomy between shareholders and non-shareholders.

Private and public firms have different rules regarding declarations of shareholdings. Moreover, the shareholder/non-shareholder distinction is less relevant for public firms where ownership is likely to be diffuse. Hence, in this subsection we focus only on the firms in our sample which are private and we can observe two new measures: *Residential RE shareholders* and *Residential RE nonshareholders* (see online Appendix Section D.3 for exact definitions). This leaves us with 3,687 unique firms.

Table 12 shows results for this sample. In columns 2–4, we split *Residential RE* into shareholders and non-shareholders, and include these variables in the regression separately and together. The effect is stronger for shareholders (£0.04) with no

statistically significant effect for non-shareholders. The prevalence of shareholders amongst a firm's directors is correlated with other firm characteristics, such as size. Therefore, a stronger test is to look solely within firm and compare how the same firm reacts when a shareholder-director's home increases in value compared to a director who is just a manager. Hence, in columns 5–6, we focus only on firms where both the shareholders and non-shareholder measure is nonzero (this leaves us with 1,236 unique firms). Column 5 presents the baseline specification for this subsample. Column 6 shows again that the investment response is statistically significant only in the case of director-shareholders.

Responses by Director LTV.—If a rise in director residential real estate values causes increased investment via relaxing financial constraints, one would expect not just the firm's financial position to govern the strength of the response, but also the financial position of the directors themselves. Recall (Section I) that guarantees are typically junior to existing mortgages. This section explores how our estimates are affected by the LTV ratio directors have on their home. Our prior is that high-LTV directors should be more sensitive to an increase in real estate values. This could either reflect that as low-LTV directors are not borrowing against the house, despite having a large amount of equity, a marginal increase in housing wealth is unlikely to alter the director's behavior. In other words, low-LTV directors are less likely to be financially constrained. Alternatively, if some low-LTV directors are financially constrained, then a low-LTV suggests that they are only able to lever up a given increase in net worth to a lesser extent and hence are less sensitive to a rise in *Residential RE*.

We split the sample around an LTV threshold of 85 percent, which corresponds to a high LTV residential mortgage in the United Kingdom.[38] Seventeen percent of firm-year observations are in the high-LTV bucket. Table 13 presents the results. Column 1 presents the baseline specification estimated on the sample of firms where we can compute our LTV measure. The coefficient is similar to the full sample. Column 2 then compares firms in the high and low LTV buckets: as can be seen, firms whose directors have a high LTV ratio respond more strongly to *Residential RE* (although a formal statistical test cannot reject equality).

We would also expect director- and firm-level financial constraints to interact. A director having a high LTV ratio is unlikely to be a constraint on firm activity if the firm has ample debt capacity of its own. Nor is it obvious that a firm that shows signs of being financially constrained should react to an increase in *Residential RE* if the director already has ample equity in her home. Columns 3–5 of Table 13 show results when we interact director LTV with the firm financial constraint index discussed above (i.e., equivalent to columns 2–4 in Table 9).[39] As can be seen, the most responsive firms to an increase in *Residential RE* are those both with highly levered directors and that are likely to be financially constrained themselves. Moreover, there is a statistically significant, positive difference in the coefficient

[38] Best et al. (2020) analyzes mortgage pricing by LTV in the United Kingdom: crossing a threshold of 85 percent leads to a large jump in the interest rate. This also occurs at an LTV of 80 percent and our results are robust to using this threshold instead.

[39] The equivalent results when we use within firm heterogeneity in financial constraints (i.e., equivalent to columns 5–6 in Table 9) are presented in online Appendix Section A.5. The takeaway is the same.

TABLE 13—HETEROGENEOUS RESPONSES: DIRECTOR HIGH VERSUS LOW LTV

	Investment							
			All firms: fin. con. (within year)				Private	
	All firms (1)	All firms (2)	Low (3)	Medium (4)	High (5)	Private (6)	Share. (7)	Non-share. (8)
Residential RE	0.0348							
	(0.010)							
Residential RE × high LTV		0.0450	0.0133	0.0175	0.0499	0.0310	0.0414	−0.0508
		(0.010)	(0.018)	(0.013)	(0.011)	(0.017)	(0.024)	(0.055)
Residential RE × low LTV		0.0335	0.0184	0.0227	0.0305	0.0169	0.0153	−0.0312
		(0.010)	(0.010)	(0.011)	(0.010)	(0.015)	(0.022)	(0.046)
Corporate RE	0.0656	0.0655		0.0748		0.0442	0.0482	
	(0.019)	(0.019)		(0.019)		(0.023)	(0.024)	
Cash	0.0730	0.0734		0.0767		0.0737	0.0749	
	(0.015)	(0.015)		(0.015)		(0.019)	(0.019)	
Profit	0.1279	0.1278		0.1317		0.1038	0.1018	
	(0.023)	(0.022)		(0.022)		(0.031)	(0.031)	
p-value, equality of residential RE coefficients	—	0.1102		—		0.1304	0.0918	
Observations	24,535	24,535		23,975		13,083	13,083	
Adjusted R^2	0.25	0.25		0.25		0.27	0.27	
Add. firm, director controls	Yes	Yes		Yes		Yes	Yes	
Region-time fixed effects	Yes	Yes		Yes		Yes	Yes	
Industry-time fixed effects	Yes	Yes		Yes		Yes	Yes	
Firm fixed effects	Yes	Yes		Yes		Yes	Yes	

Notes: This table reports the link between residential real estate, corporate real estate, and firm investment. The sample covers reporting UK firms over the period 2002–2014 where the average LTV ratio of the firm's directors can be calculated. The dependent variable, *Investment*, is defined as the change in *Fixed Assets* plus *Depreciation*. *Residential RE* is the total value of residential property held by directors of the firm, holding the composition of directors and their properties fixed in 2002, updating the value through time with changes in their respective regional house price indices, as defined in equation (2). *Corporate RE* is the 2002 book value of firm *Land and Buildings* iterated forward using the regional house price index, as defined in equation (1). Cash and profits enter with a lag. All of these variables are scaled by the lag of firm *Turnover*. *Add. firm, director controls* comprises of quintiles for firm and director characteristics in 2002 interacted with the house price index in the firm region; the firm's regional house price index; and the inverse of lagged *Turnover* (see Section III). All ratios are winsorized at the median ± 5 times the interquartile range. Standard errors, clustered by firm NUTS 3 region, in parentheses. The table uses the financial constraint index described in online Appendix Section G. All regressions include firm, region-time, and (2 digit) industry-time fixed effects. Column 1 presents results of the baseline specification for the sample of firms where we can measure the combined LTV ratio of company directors. Column 2: *Residential RE* is interacted with a dummy variable indicating whether the LTV ratio of the company's directors is at least (high LTV) or below (low LTV) 85 percent. Columns 3–5 add an additional interaction of a dummy variable indicating whether the firm is in the lower third (Low), middle third (Medium), or highest third (High) of the financial constraint index across all firms in a given year. Column 6 repeats column 2 on the sample of private firms where the value of residential real estate is non-missing for both shareholders and non-shareholders, and director LTV can be observed. Columns 7–8: as column 6 except the residential real estate held by shareholders (*Share.*) and non-shareholders (*Non-share.*) are separately interacted with the high LTV ratio dummy.

on *Residential RE* when comparing (i) how firms with low and high LTV directors react to *Residential RE* (p-value 0.0481) conditional on the firm being constrained; and (ii) how firms with low and high financial constraints react to *Residential RE* conditional on the firm having high LTV directors (p-value: 0.0347). However, these differences are no longer statistically significant when we condition on unconstrained firms or low LTV directors, respectively.[40]

[40] This finding is also consistent with survey evidence in online Appendix Section B.1, showing that personal guarantees are most prevalent among firms that appear financially constrained *and* have highly levered directors.

We can also consider the distinction of shareholders versus non-shareholders. Column 6 re-estimates column 1 on the sample of private firms where we can break down *Residential RE* by the shareholder status of directors (similar to the previous subsection) and can observe our LTV measure. Again we see that firms with high-LTV directors respond more. Last, columns 7–8 confirm that the positive response of firms with high-LTV directors is driven by a reaction to the real estate of directors that are shareholders and we can reject the equality of the high versus low LTV coefficients for this group.

The sample size is relatively small when conditioning on shareholder status or director LTVs. Doing a three-way interaction of shareholder status, LTV, *and* firm financial constraints therefore asks a lot of the data. Nonetheless, we present the results of such an exercise in online Appendix Section A.5. No coefficient on *Residential RE* is statistically significant when we cut the data in this manner, but the point estimates are consistent with what one would expect: firms are most sensitive to *Residential RE* when the directors have high LTV, the firm is financially constrained, and the real estate under consideration belongs to directors who are shareholders.

D. *Discussion and Alternative Mechanisms*

We find that the strength of the relationship between residential real estate and firm investment depends on (i) the tightness of estimated measures of financial constraints at the firm level; (ii) whether the directors are shareholders; and (iii) the amount of equity remaining in the directors' homes. Moreover, the response appears to run primarily through short-term debt, particularly for small firms. Taken together, this is evidence that the underlying mechanism is financial constraints.

Based on the relative magnitude of our estimates we can also speculate somewhat about the nature of the underlying financial friction. First, as shown in Table 10, investment is only sensitive to director real estate when the value of this real estate is large relative to the value of the firm. This is consistent with real estate affecting investment through its value as collateral upon liquidation. Prima facie, it is inconsistent with any additional incentive/signaling effects arising from a differing value the director places on her home. However, as discussed in Section I, incentive/signaling effects may be relevant, but invariant to changes in the liquidation value of the director's house.

Second, we find that the £/£ investment response to an increase in *Residential RE* is consistently lower than for *Corporate RE.* If there were additional incentive/signaling effects from pledging residential real estate, the strength of which depended on real estate values, we would expect the effect to be larger. However, unconditionally, a firm is more likely to pledge corporate real estate than director real estate (Table 1). These differences in pledging rates could mask differences in the sensitivity of investment to real estate values conditional on pledging.

Beyond financial constraints, there are other mechanisms that could potentially explain the positive investment response at the firm level. A recent literature, summarized in Malmendier and Tate (2015), has emphasized the role of managerial beliefs, experiences, and preferences in determining how a firm is

run.[41] A shift in home values could alter managerial incentives. For example, directors who experience rapid growth in their housing wealth may take more risks with their firm and be overconfident with investment decisions. Directors who experience losses may be more cautious, or experience anxiety and fail to use investment opportunities. However, given this mechanism is about *managers*, it is inconsistent with our finding that it is the residential real estate of *owners* driving our results. One can argue that, for private firms, only owners have authority and this is why we only find a response for shareholders. However, non-shareholder directors still have a senior role at the firm and are legally responsible for its performance; it seems overly strong to argue that they have no influence on the firm's behavior. In addition, if we look at firms where no director is a shareholder, so there is a larger gap between ownership and control, we still find no effect.[42]

The relationship between investment and home values could also be explained by a wealth effect. However, the standard wealth effect emphasized as a competing story for financial constraints in the literature, whereby a rise in housing wealth causes a household to bring forward consumption spending (Jensen, Leth-Petersen, and Nanda 2014; DeFusco 2018; Kaplan, Mitman, and Violante forthcoming), is ruled out by the positive coefficient. A desired increase in consumption is inconsistent with a director accumulating more capital in her firm, a form of savings.

A rise in housing wealth could, in principle, cause a (shareholder) director to invest more and expand her firm if it alters her portfolio choice problem. As emphasized in Yao and Zhang (2005); Cocco (2005); and Chetty, Sándor, and Szeidl (2017), the effect of housing wealth on portfolio choice problems is complex. The literature highlights two competing effects. First, an increase in housing wealth can lower effective risk aversion and cause the director to increase the riskiness of her non-housing assets (i.e., invest more in the firm). Second, increased housing wealth may cause the director to substitute away from other risky assets, including investments in the firm, either due to increased illiquidity or the riskiness of the overall portfolio. This substitution predicts a negative relationship between home values and firm investment.

To rule out a portfolio choice mechanism, we rely on the fact that the strength of the latter, negative effect, depends on the correlation between home values and the return on investment in the firm. If the firm represents a good hedge against housing risk then an increased concentration of wealth in housing would make the firm an attractive investment. The opposite is true if the firm's performance is tightly correlated with the housing market. In online Appendix Section A.8, we do the following: (i) use administrative ONS data covering the universe of firms to construct, at the 2-digit industry level, the average beta of firms' sales to house prices in the region where they are based; (ii) show that, in our sample, firms in high-beta industries (above the median by industry) respond near identically to changes in directors' residential real estate to those in low beta industries. This is inconsistent with what we would expect to see if a portfolio choice mechanism was at work.

[41] See also Malmendier, Tate, and Yan (2011); Malmendier and Nagel (2011); and Cronqvist, Makhija, and Yonker (2012).

[42] Results available upon request.

VI. Aggregate Consequences

We can combine our firm-level estimates with aggregate numbers for investment and real estate holdings to compute the implicit investment demand shock arising from an increase in real estate prices. In 2014 (end of our sample) the total value of residential property held by all current directors in the United Kingdom, including those at firms outside our baseline sample, was about £1.5 trillion (see online Appendix Section E.E7 for details), with the total value of commercial property of all owner-occupying firms around 4 times smaller at £350 billion (IPF 2016). For comparison, 2014 GDP was £1.8 trillion, so aggregate real estate owned by directors is around 80 percent of GDP, with commercial property held by owner-occupying firms around 20 percent of GDP. Our baseline regression estimates are that a £1 increase in the value of directors' residential real estate increases a firm's investment by £0.030. Similarly, a £1 increase in the value of corporate real estate increases a firm's investment by £0.051. Aggregate UK investment by private non-financial corporations in 2014 was £157 billion. Combining these numbers implies that a 1 percent increase in real estate prices generates a shock to investment demand worth 0.28 percent of total investment through residential real estate, and 0.11 percent through corporate real estate.

Such an elasticity is based on an unweighted regression. As shown in Table 3, our sample under-weights both small and large firms, relative to their aggregate share of investment. Small firms are under-represented in our sample due to variable reporting requirements. Large firms are under-weighted because they contribute disproportionately to aggregate investment. We can reweight our baseline regression to ensure that the weight placed on different firm size groups aligns with each group's aggregate contribution to investment (in online Appendix Section A.9, we explain this weighting in detail, provide regression results, and discuss alternative regimes, e.g., weighting by employment). Since we are undersampling both small and large firms, the net effect of this reweighted regression is similar to the baseline: the point estimate is £0.0314 and the aggregate elasticity based on it is unchanged.

However, since our estimate is a £/£ coefficient not an elasticity, weighting by investment shares is not appropriate for aggregation purposes. A £1 increase in investment contributes to aggregate investment in the same manner regardless of the size of the firm. Instead, the correct weighting is the firm's share in the aggregate distribution of residential real estate owned by directors. We show this formally in online Appendix Section A.9. However, to talk through the intuition, let us reconsider the split in the sensitivities to *Residential RE* by assets (as in columns 3–4 of Table 10). While larger firms ($\geq$£10 million in assets) have on average 2.5 more directors, who have homes worth almost 2.5 times as much on average, the weight of numbers means that almost all (£1.4 trillion) of the residential real estate owned by directors is owned by the directors of smaller firms ($<$£10 million in assets). Specifically, we estimate that directors of large firms own real estate worth £55 billion of the £1.5 trillion total. Now consider the estimates above for aggregate investment using our estimates based on assets. A 1 percent price increase raises the value of the real estate of directors of small firms by £14 billion and, in Table 10, we estimate for every £1 increase their firms invest £0.024. This will increase investment demand by £340 million or about 0.21 percent of aggregate investment. In

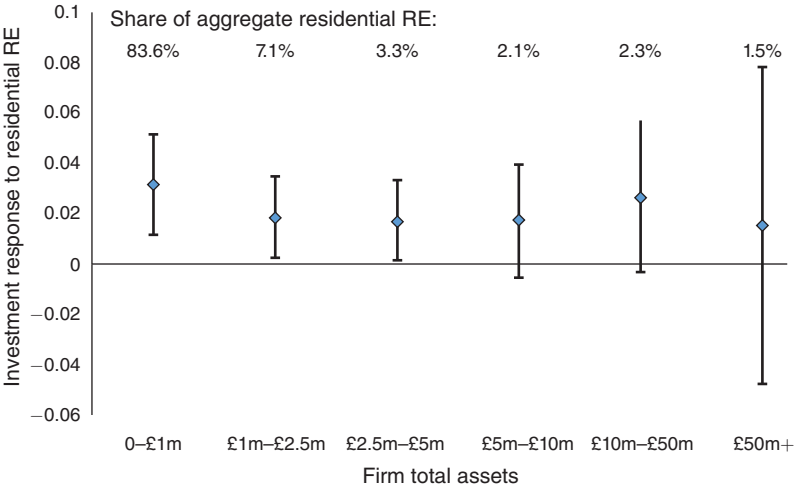

FIGURE 4. INVESTMENT RESPONSE BY TOTAL ASSETS

Notes: The figure displays the link between residential real estate and firm investment for different buckets of the firm's lagged *Total Assets*. See notes to Table 5 for detail on the baseline specification and sample. The figure shows the results of interacting *Residential RE* with a dummy variable indicating different buckets the firm's lagged *Total Assets*. The inverse of lagged *Turnover* is also interacted with this dummy variable. The buckets of *Total Assets* are 0–£1m; £1m–£2.5m; £2.5m–£5m; £5m–£10m; £10m–£50m; £50m+. The figure shows point estimates as well as 90 percent confidence intervals. The top of the figure displays the estimated share of aggregate director residential real estate accounted for by each firm size bucket. This is estimated using the number of firms in each firm size bucket and the average value of residential real estate across firms in each bucket. This calculation uses the full sample of UK companies in the same industries as the baseline regression sample.

contrast, the same price increase raises the home values of directors of large firms by £550 million. The point estimate of £0.034 on large firms implies an increase in investment demand of £19 million (or around 0.01 percent of investment). The takeaway from this is that, since the directors of small firms own almost all the real estate owned by directors, the response of SMEs is critical for the aggregate. The response of larger firms, despite the evidence in Table 10, is not.[43]

Of course, this result is based on one bisection of the sample. To explore further how our aggregation exercise interacts with the size and residential real estate distribution, Figure 4 presents regression estimates of the response of investment to an increase in *Residential RE* by relatively fine-grained buckets of assets (i.e., equivalent to unpacking columns 3–4 in Table 10). The share of aggregate holdings of residential real estate held in total by the directors of firms in each group are presented at the top of the figure. With these groupings the largest response is for the firms with under £1m in total assets (£0.032). The directors of firms in this group hold 84 percent of director residential real estate. In contrast, very large firms,

[43] We obtain a similar result if we split by employment rather than assets (as in columns 1–2 of Table 10). Directors of smaller firms (<250 employees) own £1.45 trillion total in real estate, directors of large firms (≥250 employees) own real estate worth £19 billion. Taking the coefficient estimates in columns 1–2 in Table 10 at face value and repeating the same calculations, we estimate that a 1 percent increase in real estate prices will cause small firms to increase investment demand by £360 million or about 0.23 percent of aggregate investment. In contrast, the same price increase raises the home values of directors of large firms by £190 million. Larger firms increase investment demand by about £13 million (or less than 0.01 percent of investment).

with more than £50 million in assets, are the least sensitive to the value of their directors' real estate, but because those larger firms are relatively rare (just 0.17 percent of firms in the population) their directors hold under 2 percent of total director residential real estate. Combining this information across all the groups gives an estimated aggregate increase in investment demand of 0.27 percent following a 1 percent increase in real estate prices.[44] This is driven almost entirely (90 percent) by the response of firms in the smallest size category.[45]

These calculations are all based on microeconometric estimates and omit general equilibrium feedback effects. We address this in a companion paper (Bahaj, Foulis, and Pinter 2019), where we embed the use of residential real estate as collateral in an estimated DSGE model in the style of Liu, Wang, and Zha (2013). Allowing financially constrained entrepreneurs to borrow against their house, in addition to the firm's assets, to fund their firm, substantially increases the sensitivity of investment to real estate prices in the model; specifically, it doubles the peak response of investment to a housing demand shock. We also document and quantify two general equilibrium forces that determine the aggregate response. First, a standard Kiyotaki and Moore (1997) mechanism amplifies the response: an increase in house prices relaxes collateral constraints, boosts investment, which in turn has a further impact on the price and quantity of collateral held by entrepreneurs, further relaxing collateral constraints, and so on. Second, the response of factor prices can pull in either direction. The increase in investment demand driven by a relaxation of collateral constraints results in the bidding up of factor inputs (e.g., raising the relative price of capital), which diminishes the investment response. However, higher real estate prices also shifts labor supply outwards as households work harder to pay for their housing, putting downward pressure on wages, making investment more attractive. Quantitatively, the net effect of these general equilibrium forces is to amplify the collateral driven shock to investment demand arising from an increase in real estate prices.

VII. Further Robustness

Table 14 presents further robustness tests on the measurement of our variables of interest and our sample selection.[46] Firms may revalue their property when prices increase, generating an automatic correlation between our measure of investment and real estate prices that we do not wish to capture. Alternatively, some firms may invest in property for speculative purposes when prices rise. This may explain the sensitivity between investment and both real estate measures. To address this, we rerun our baseline specification using investment excluding the change in the book value of *Land and Buildings* as the dependent variable. Column 1 of Table 14 presents the results: corporate and residential real estate still both influence investment in other forms of fixed assets. Further, as discussed in online Appendix Section A.12,

[44] The implied aggregate £ on £ coefficient from this exercise is 0.0296, nearly identical to our baseline estimate.

[45] In contrast, the effects of an increase in the price of corporate real estate on investment run mainly through the behavior of large firms (see online Appendix Section A.A10).

[46] There are additional measurement challenges for corporate real estate. Online Appendix Section A.11 addresses these in detail, showing the robustness of our estimates to these issues.

Table 14—Residential Real Estate: Measurement

	Investment							
				Age (years)		House prices		
	Non-RE inv. (1)	Res equity (2)	Contemp. value and IV (3)	<10 (4)	≥10 (5)	Rising (6)	Falling (7)	Large sample (8)
Residential RE	0.0176		0.0388	0.0338	0.0290	0.0293	0.0351	0.0228
	(0.008)		(0.009)	(0.008)	(0.008)	(0.008)	(0.008)	(0.000)
Residential equity		0.0316						
		(0.016)						
Corporate RE	0.0502	0.0713	0.0487	0.0682	0.0472	0.0553	0.0286	
	(0.013)	(0.033)	(0.017)	(0.017)	(0.017)	(0.016)	(0.016)	
Cash	0.0391	0.0973	0.0748	0.0784		0.0789		
	(0.008)	(0.017)	(0.012)	(0.012)		(0.012)		
Profit	0.0828	0.0900	0.1173	0.1095		0.1089		
	(0.011)	(0.029)	(0.017)	(0.016)		(0.016)		
p-value, equality of residual coefficients	—	—	—	0.4087		0.1226		—
Observations	30,692	13,993	31,584	32,244		32,244		2,066,578
Adjusted R^2	0.28	0.29	0.25	0.25		0.25		0.14
Add. cont.	Yes	Yes	Yes	Yes		Yes		No
Reg-time fixed effects	Yes	Yes	Yes	Yes		Yes		Yes
Ind-time fixed effects	Yes	Yes	Yes	Yes		Yes		Yes
Firm fixed effects	Yes	Yes	Yes	Yes		Yes		Yes

Notes: This table reports the link between residential real estate, corporate real estate, and firm investment. The sample covers reporting UK firms over the period 2002–2014. The dependent variable, *Investment*, is defined as the change in *Fixed Assets* plus *Depreciation. Residential RE* is the total value of residential property held by directors of the firm, holding the composition of directors and their properties fixed in 2002, updating the value through time with changes in their respective regional house price indices, as defined in equation (2). *Corporate RE* is the 2002 book value of firm *Land and Buildings* iterated forward using the regional house price index, as defined in equation (1). Cash and profits enter with a lag. All of these variables are scaled by the lag of firm *Turnover*. *Add. firm, director controls* comprises of quintiles for firm and director characteristics in 2002 interacted with the house price index in the firm region; the firm's regional house price index; and the inverse of lagged *Turnover* (see Section III). All ratios are winsorised at the median ± 5 times the interquartile range. Standard errors, clustered by firm NUTS 3 region, in parentheses. All regressions include firm, region-time, and (2 digit) industry-time fixed effects. In column 1 the dependent variable is *Investment*, excluding investment in *Land and Buildings.* In column 2 *Residential RE* is replaced as an explanatory variable by *Residential equity*. In column 3 *Residential RE* is used as an instrument for the contemporary value of director real estate, allowing for changes of directors and director properties since 2002. The marginal *F*-statistic from the first stage regression is 512. In columns 4 and 5 both *Residential RE* and *Corporate RE* are interacted with a dummy variable indicating whether the age of the given firm is at least 10 years in a given year. Columns 6–7 include the interaction of both *Residential* and *Corporate RE* with a dummy variable indicating whether annual house price growth in the firm region is positive or negative. Column 8 estimates the link between *Investment* and *Residential RE* on the more extensive sample size. Specifically, it regresses the change in *Total Assets* on *Residential RE*, with both variables scaled by the lag of *Total Assets* rather than firm *Turnover* (firms need to report information on directors in 2002 and firms with less than £25,000 in assets are excluded).

firms also hire more workers in response to an increase in the value of both types of real estate.

As discussed in Section IIB, defining our residential real estate measure using home values ignores the fact that directors have differing amounts of equity contained within their homes. In column 2, we substitute *Residential RE* with *Residential Equity*. This leaves us with fewer observations; however, the coefficient estimates are again comparable.

Our baseline *Residential RE* measure holds the composition of the directors and where they live fixed in 2002, as changes in these variables are likely to be endogenous. However, this introduces measurement error into our specification: we

misvalue the real estate of directors who move or leave the firm (see also Section IVB for evidence on leavers). To address this, in column 3 we include the value of *Residential RE* based on the current directors, and where they live, at time *t*. This variable is endogenous so we instrument for it using our baseline *Residential RE* measure, obtaining a similar coefficient estimate to the baseline.

Columns 4–5 use the regression specification of equation (4) to separately estimate the sensitivity of investment to real estate collateral for younger and older firms. The effect of residential real estate is almost as important for older firms ($\geq$10 years) as for younger firms. This highlights the contrast between our study and the entrepreneurship literature on the role of housing wealth in financing start-ups (Corradin and Popov 2015; Schmalz, Sraer, and Thesmar 2017). Our findings are just as relevant for mature firms. Columns 6–7 separately estimate the impact of directors' residential real estate on firm investment when house prices are rising versus falling.[47] We cannot reject that the coefficients are equal. Online Appendix Section A.13 shows that the effect of directors' residential real estate on firm investment is very similar in the pre- (2002–2006) and post-crisis (2007–2014) periods. In contrast, the effect of corporate real estate has weakened in the post-crisis period and seems weaker in periods of falling real estate prices.

These results are all conditional on a particular sample of firms who report the necessary information for us to compute our dependent variables and controls. Since reporting requirements vary by firm size and firms can still voluntarily choose to report information, we do not have a representative random sample. Further, we have not used the information that is available for millions of firms in the dataset. To address this, in column 8 of Table 14 we estimate a specification with the largest possible sample. Specifically, we make use of the fact that the variable *Total Assets* is near universally reported in our database. Our dependent variable is then the change in *Total Assets* (as opposed to the change in *Fixed Assets* plus *Depreciation*), and we scale all variables by lagged *Total Assets* rather than *Turnover*. We also drop all other controls except our measure of residential real estate, which is also well reported as all firms must declare director information. This leaves us with around 2.1 million firm-year observations.[48] The point estimate on residential real estate is £0.023, similar to our baseline.[49]

VIII. Conclusion

The global housing boom of the 2000s, and the Great Recession that followed, demonstrated striking correlations between real estate prices and economic activity.

[47] Just over 25 percent of our firm-year observations occur when the regional house price is falling.

[48] Note that we still require that the firm existed in 2002 and that we can value the real estate of at least one director. We also maintain the same sample selection criteria based on industry, firm type, and not being a subsidiary. We also drop firms with less than £25,000 in *Total Assets* as very small values of *Total Assets* distort the estimates as it is used as the scaling variable. However, firms with less than £25,000 in *Total Assets* only account for 0.2 percent of *Total Assets* across firms so their omission should not affect the interpretation of our results.

[49] For comparison, estimating this regression on the baseline sample results in a coefficient estimate of £0.049. Part of this discrepancy may be due to a scaling issue: the maximal sample contains some very small firms with few assets, and consequently very high values of real estate to total assets. This leads to wide variance of the regressor, compressing the coefficient estimates. For example, if we restrict the maximal sample to firms with at least £100k in assets (firms which account for over 99 percent of aggregate firm assets), the coefficient estimate rises to £0.034.

To explain these phenomena, one strand of literature has focused on how consumption is affected by household balance sheets, estimating a marginal propensity to consume out of housing wealth of 5–7 cents on the dollar. A second strand of literature estimates how investment is affected by corporate balance sheets, finding a marginal propensity to invest out of corporate real estate of 6 cents. This paper uncovers a novel channel at the intersection of these two literatures, finding that the marginal propensity of firms to invest out of their directors' housing wealth is 3 pence on the pound. Our evidence suggests that this effect operates via relaxing collateral constraints.

This residential collateral channel is quantitatively important and has implications for structural models evaluating links from real estate prices to the macroeconomy, as well as optimal policy in light of such a relationship. Failing to recognize that a much greater portion of the collateral used by the corporate sector is tied up in housing, relative to the real estate owned by firms, may lead to an underestimation of the impact of real estate prices on investment. Moreover, this channel intimately links the housing market to the supply side of the economy. This complicates how policymakers, both monetary and macroprudential, should react to fluctuations in real estate prices and, to the extent that policy can influence real estate prices, has implications for the transmission mechanism.

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