Online Appendix

Home Values and Firm Behaviour

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A Additional Regressions

A.1 Determinants of 2002 Director House Value

Our baseline regression includes a number of director characteristics, averaged at the firm-level, interacted with the house price index in the firm's region. This section explores the explanatory power these characteristics have for the 2002 value of director housing, $L^d_{i,2002}$. To do this we run a linear regression at the director level of $L^d_{i,2002}$ (in £000s) on quintiles of the following director characteristics in 2002: (i) the director's age; (ii) the number of directorships held; (iii) the number of firms the director has worked for; (iv) the number of industries she has been a director in; (v) her cumulative years of experience, across all directorships held; (vi) the number of directorships resigned; (vii) the number of firms where the director was present from the birth of the firm; (viii) the number of directorships at firms that since died; (ix) a dummy for the director being a non-UK national; (x) and a dummy for director gender.[50] The regression also includes a firm fixed effect, which is included in the baseline regression, and also a (director) region fixed effect. The standard errors are clustered at the regional level.

The results of this regression are shown in Table A1. Due to the large number of regressors, Table A1 presents the result of this regression in matrix form, with columns for each of the quintiles of a given characteristic. As shown in Table A1, a number of director characteristics have an economically and statistically significant impact on director house values. For example, relative to the youngest quintile of directors, the houses of the oldest quintile are worth around £130,000 more in 2002. Individuals that held more directorships in 2002 also had more valuable houses, with these increasing in value by £75,000, moving from the lowest to highest quintile of current directorships. Further, experience is also highly important, over and above age. The houses of the directors in the top quintile of experience are worth over £150,000 more than those of the directors in the bottom experience quintile. Overall, around 40% of the variation in director house prices is explained in this regression.[51]

[50] The definitions and calculations of these characteristics are covered in detail in Section D of the Online Appendix. For some characteristics, for example being a male director, there are less than five categories, and the regression includes the non-redundant categories.

[51] If we exclude the director region fixed effect (this does not appear in the baseline regression: the region-time fixed effect in the baseline regression is for the firm's region) we obtain similar estimates, albeit with a slightly lower adjusted R^2 of 31%.

Table A1: **Director Characteristics and 2002 House Value**

2002 Director House Value (£000's)				
	Director Characteristic Quintile			
	Quintile 2	Quintile 3	Quintile 4	Quintile 5
Director Age	33.58**	61.81***	95.42***	128.43***
	(14.86)	(20.74)	(27.56)	(23.17)
No. Current Directorships	33.23	76.56**	77.05*	73.83**
	(23.69)	(30.57)	(42.19)	(36.90)
No. Historical Directorships	5.97	-31.22	-46.83	-97.96**
	(20.12)	(32.73)	(39.93)	(43.42)
No. Industries Held Directorships	-18.79	21.22	41.28	57.72
	(23.10)	(27.64)	(37.08)	(41.06)
Directorship Experience	22.23	73.45***	79.73***	153.47***
	(23.65)	(23.76)	(23.50)	(36.67)
No. Directorships Left		43.66***	76.13***	78.06***
		(14.91)	(26.29)	(22.07)
No. Directorships Present From Firm Birth		43.27**	39.21	52.37*
		(17.06)	(31.98)	(28.18)
No. Directorships Where Firm Died			20.44	-16.37
			(25.23)	(32.59)
Non-UK Director				67.85
				(41.02)
Male Director				7.19
				(12.93)
Observations	10535			
Adjusted R^2	0.39			
Region FE	Yes			
Firm FE	Yes			

Region clustered standard errors in parentheses

$^{*}p < 0.10, ^{**}p < 0.05, ^{***}p < 0.01$.

Notes: This Table reports the link, at the director level, between the 2002 value of director homes (see Online Appendix E) and 2002 director characteristics (see Online Appendix D for definitions of director characteristics and variable construction) for the directors in the baseline regression sample. The value of director homes is winsorised at the median ± 5 times the interquartile range. Standard errors, clustered by NUTS 3 region, in parentheses. The Table presents the results of *one* regression, shown in matrix form: the regression of 2002 director home value on 2002 quintiles of director characteristics, including region and firm fixed effects. For some variables, for example being a male director, there are less than five categories, and the Table presents the result of the non-redundant categories.

A.2 First Stage Regression for Real Estate Price Instrument

This section describes our instrumental variable strategy for fluctuations in regional real estate prices. We instrument for local real estate prices by interacting local geographical constraints on housing supply with aggregate shifts in the interest rate on 2-year 75%-LTV mortgages (the most common

Table A2: **First Stage Regression for Real Estate Price Instrument**

Real Estate Prices	
	Baseline
	(1)
$constraints_k \times r_t$	-9.4999***
	(2.977)
Observations	37800
Adjusted R^2	0.95
Time FE	Yes
Region FE	Yes

Standard errors clustered at the region level in parentheses
$^{\star}p < 0.10, ^{\star\star}p < 0.05, ^{\star\star\star}p < 0.01$.

Notes: The Table reports the results for the estimation of Equation A1 over the sample period Jan-1995 to Jan-2016 for 150 English regions. The dependent variable, real estate prices, is defined in log levels. The explanatory variable is the regional share of developable land that was developed in 1990 ($constraints_k$) interacted with as the 2-year 75%-LTV UK mortgage rate (r_t). Standard errors, clustered by NUTS 3 region, in parentheses. Region and time fixed effects both included.

UK mortgage contract).[52] When mortgage rates fall, the demand for real estate rises. The intuition behind our instrument is: if local housing supply is very inelastic, then increased demand will translate mostly into higher prices rather than more housing. Our measure of local housing supply constraints is the share of all developable land that had been developed by 1990. The data are from Hilber and Vermeulen (2016) who originally derived the measure from the Land Cover Map of Great Britain using satellite images, allocating land to 25 cover types on a 25 meter grid.[53] We thus estimate, for region k, at date t, the following first-stage regression to predict house prices:

$$L^P_{k,t} = b_{0k} + b_{1t} + b_2 \times constraints_k \times r_t + u_{kt}, \tag{A1}$$

where $constraints_k$ measures constraints on land supply at the regional level while r_t is the nation-wide mortgage rate at monthly frequency. The terms b_{0k} and b_{1t} are region and time fixed effects respectively. Region specific shocks to real estate prices, some of which are potentially due to the behaviour of the firm, are contained in u_{kt}.

We estimate this equation over the period January 1995 until January 2016. Table A2 presents the results of the regression. The estimate on b_2 is highly significant (the marginal F-statistic is 10.2) and has the intuitive negative sign.

To give context to the coefficient estimate, note that the mean of $constraints_k$ is 37%, which implies for the average region a 1 percentage point increase in mortgage rates translates into an additional 3.5% fall in house prices compared to a region where no land was developed in 1990.

[52] This was the most standard mortgage product in the UK during our sample.

[53] The data covers England (excluding the local authorities in Scotland and Wales), so we only include 150 local authorities in our regressions using the instrumented series.

Alternatively, a one standard deviation tightening in our measure of supply constraints (27% shift in the developed land share) causes an additional 2.5% fall in house prices for every 1 percentage point increase in the interest rate.

Since u_{kt} contains the terms we wish to abstract from, we can generate an instrumented house price index using the fitted values from Equation A1, $\hat{L}^P_{k,t}$. Specifically, we replace $\hat{L}^P_{k,t} = L^P_{h_d,t}$ for $k = h_d$ in Equation 2 and replace $\hat{L}^P_{k,t} = L^P_{j,t}$ for $k = j$ in Equation 1 and use these new variables as instruments for *Residential* $RE_{i,t}$ and *Corporate* $RE_{i,t}$.[54] At the firm-level, the first stage F-stat for the joint significance of the two real estate instruments is 6948.

A.3 Placebo Test: Directors Leaving

This section provides further details on the decomposition of *Residential RE* into the real estate of the directors that are still at the firm, and those who have since left. Our key measure of director real estate, *Residential RE*, holds the 2002 composition and houses of directors fixed in subsequent years. Some of these directors will subsequently leave the firm, and we split *Residential RE* into two variables: *Residential RE: Directors Present*, and *Residential RE: Directors Left*. Each of these variables are calculated in the same way as *Residential RE*, but for the subset of the 2002 directors that are either still present at the firm, or those that have since left, respectively. A few points on these variables are worth noting. First, as with *Residential RE*, these variables capture the evolving value of the *houses* held by the directors in 2002. Thus, for directors that have since left, we continue to track the same property, even if they have since moved house. Second, we set these variables to zero when there are no directors in the given group. Thus, by construction, in 2002 *Residential RE: Directors Left* is 0 for all firms, as none of the 2002 directors have left.[55] Finally, as the house value is not matched for every director in our sample, *Residential RE: Directors Present* and *Residential RE: Directors Left* need not sum exactly to *Residential RE*.[56]

[54] As discussed in Adelino et al. (2015), this style of instrument may be weak when house prices fall. A drop in demand does not lead to a destruction of the existing housing stock. However, note that, in contrast to the US, the UK did not experience a major nationwide fall in house prices in the crisis period. As a result, in our sample, house prices are rising in 75% of our firm-year observations.

[55] Due to the large number of zeros, the interquartile range of *Residential RE: Directors Left* is close to zero. As with the changes in firm liabilities, we use a 2/98% winsorisation instead.

[56] The imperfect match rate could also affect the number of observations in the regression sample. For example, if only one director leaves the firm, and their house is unmatched, *Residential RE: Directors Left* will be missing. When this occurs we estimate *Residential RE: Directors Left* as the difference between *Residential RE* and *Residential RE: Directors Present*. We use the analogous estimation when *Residential RE: Directors Present* is missing.

Table A3: **Firm Investment and Directors Leaving**

	Investment						
	Dir Pres. Alone	Dir Pres. Alone Non-Zero	Dir Left Alone	Dir Left Alone Non-Zero	Dir Pres. Dir left	Dir Pres. Non-Zero Dir Left	Dir Pres. Dir left Non-Zero
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Residential RE: Directors Present	0.0220**	0.0306***			0.0257***	0.0313***	0.0424***
	(0.009)	(0.008)			(0.009)	(0.008)	(0.014)
Residential RE: Directors Left			-0.0039	0.0027	0.0082	0.0016	0.0060
			(0.007)	(0.014)	(0.007)	(0.008)	(0.021)
Corporate RE	0.0569***	0.0596***	0.0605***	0.0613**	0.0553***	0.0593***	0.0748***
	(0.015)	(0.015)	(0.015)	(0.028)	(0.015)	(0.016)	(0.029)
Cash	0.0774***	0.0845***	0.0779***	0.0759***	0.0773***	0.0845***	0.0883***
	(0.012)	(0.012)	(0.012)	(0.018)	(0.012)	(0.012)	(0.021)
Profits	0.1074***	0.1028***	0.1066***	0.0940***	0.1081***	0.1029***	0.0776***
	(0.016)	(0.017)	(0.016)	(0.019)	(0.016)	(0.017)	(0.022)
P-Value, Equality of Residential Coeffs.	-	-	-	-	0.0791	0.0028	0.0398
Observations	32244	30659	32244	15485	32244	30659	13942
Adjusted R^2	0.25	0.26	0.25	0.27	0.25	0.26	0.30
Add. Firm, Dir. Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region-time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry-time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Firm region clustered standard errors in parentheses

$^{\star}p < 0.10, ^{\star\star}p < 0.05, ^{\star\star\star}p < 0.01$.

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. 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 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. Residential RE: Directors Present calculates Residential RE for the 2002 directors that are still at the firm in subsequent years. Residential RE: Directors Left calculates Residential RE for the 2002 directors that have left the firm in subsequent years. The interquartile range of this latter variable is close to 0 so it's winsorised at the 2/98% level: Online Appendix A.3 provides further details on variable construction. Column (1) presents the baseline regression with Residential RE replaced by Residential RE: Directors Present. Column (2) restricts this sample to observations where Residential RE: Directors Present is non-zero. Columns (3), (4) repeat this with Residential RE: Directors Left. Column (5) includes both Residential RE: Directors Present and Residential RE: Directors Left in the same regression. Column (6) presents the same specification for observations where Residential RE: Directors Present is non-zero. Column (7) further restricts to Residential RE: Directors Left also being non-zero.

Table A3 displays extended regression results utilising this decomposition of *Residential RE*. Column (1) shows the impact of "Residential RE: Directors Present" on firm investment. Column (2) excludes observations where all of the 2002 directors have left the firm. In both cases the estimated coefficient is highly significant and close to the baseline estimated impact of *Residential RE* on firm investment. Columns (3), (4) repeat this for *Residential RE: Directors Left*, showing that the real estate of directors that have since left the firm has an economically and statistically insignificant impact on firm investment. Columns (5)-(7) include both *Residential RE: Directors Present* and *Residential RE: Directors Left* in the regression. They cover: the full sample (presented in the main text); the sample where at least one initial director remains; and the sample where some, but not all, of the 2002 directors have left, respectively. In each case, firm investment responds in an economically and statistically significant way only to the real estate of directors still present at the firm. Moreover, in each case we can reject at the 10% level that the coefficients on *Residential RE: Directors Present* and *Residential RE: Directors Left* are equal.

A.4 Investment Responses By Firm Size and Residential Real Estate

This section explores in greater detail how firm size affects the relationship between director real estate and investment. We first explore how the relationship depends on how valuable director homes are relative to the size of the firm's balance sheet. We measure this as the ratio of *Residential RE*, as defined in Equation 2, to lagged "Total Assets". To trace out the importance of this ratio in a semi-parametric way, we group observations into a number of buckets and estimate a regression in the form of Equation 4. The buckets range from over 150%, where director real estate is worth at least 1.5 times the size of the firm's balance sheet, down to observations where this ratio is less than 15%.[57] Figure A1a graphically displays the results of this regression, including point estimates and 90% confidence intervals for each group. The most striking feature of the figure is the sharp discontinuity for firms where director homes are worth less than 15% of the firm's balance sheet; a group capturing around a third of the observations. Across the rest of the sample the estimated coefficient is roughly constant, although slightly lower for firms where real estate is relatively larger compared to the balance sheet. This latter feature appears to be due to winsorisation of the regression variables: a greater proportion of the observations in buckets with relatively high real estate have the top-coded value of *Residential RE* to lagged "Turnover", removing a substantial amount of variation for these buckets. In Figure A1b we exclude these observations from the regression. In this case, firms with relatively more real estate tend to have a slightly greater response. However, consistent with the results from Figure A1a, the most striking feature is the sharp discontinuity when director real estate is worth less than 15% of the firm balance sheet.

We explore this discontinuity in further detail in Table A4. Column (1) considers just two firm buckets: above (*Residential RE: High RE*) and below (*Residential RE: Low RE*) 15% real estate

[57] Specifically, the buckets considered are: 150%+; 90-150%; 60-90%; 45-60%; 30-45%; 15-30%; 0-15%.

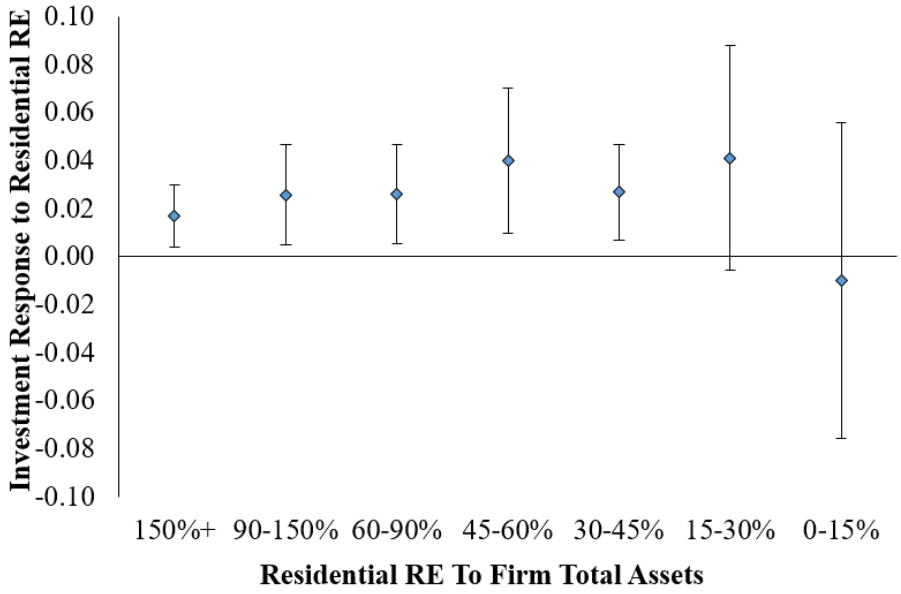
to lagged "Total Assets". As suggested by the figures, there is a sharp discontinuity around this threshold, with a highly statistically significant estimated coefficient of 3.3p above the threshold, and statistically insignificant, and slightly negative coefficient, below it. At the 10% level we can reject the equality of these coefficients. Columns (2)-(3) repeat this analysis for alternative thresholds of 20%, 25% respectively. As shown in both cases, firms below the threshold now have a relatively large positive response, albeit insignificant. Moreover, we can no longer reject the equality of the coefficients above and below the threshold. This suggests that director real estate affects firm investment for firms with real estate to balance sheet size in the range 15-20/25%, and that 15% is the appropriate threshold.

Using this threshold we further explore how the response of firm investment to director real estate varies with other measures of firm size. As in the main text, we create four firm groups, splitting observations along the dimensions of firm size and above/below 15% director real estate to lagged "Total Assets". Columns (4) and (5) of Table A4 present the results of this regression for firm size measured by whether their assets are above/below £10m. The results show that the investment of firms with many assets are still sensitive to director real estate, so long as this real estate is large relative to the size of the firm's balance sheet. Columns (6) and (7) repeat this exercise for sales, with a threshold of £25m.[58]

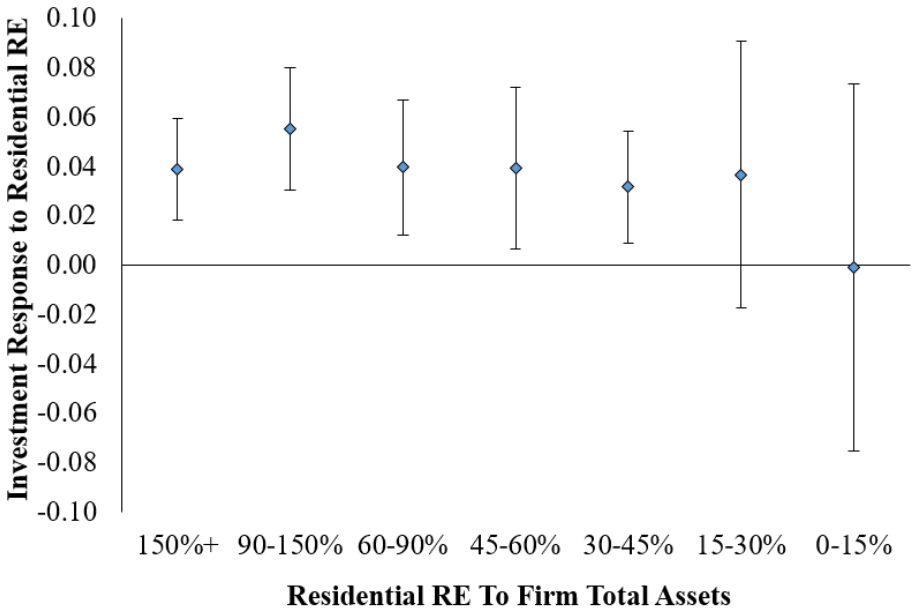
[58]This is the largest turnover threshold that allows for a sufficient number of observations in the high Residential Re, high turnover bucket. It also corresponds closely to the UK turnover-based definition of a large firm prior to 2016 (£25.9m).

Figure A1: **Firm Investment Response By Residential RE To Total Asset Ratio**

(a) **Baseline**



(b) **Excluding Top-Coded Values of Director RE**



Notes: The Figures display the link between residential real estate and firm investment for different buckets of the ratio of Residential Real Estate to the firm's lagged "Total Assets". 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 winsorised at the median $\pm$ 5 times the interquartile range. Standard errors are clustered by firm Nuts 3 region. All regressions include firm, region-time and (2 digit) industry-time fixed effects. Both Figures show the results of interacting Residential RE with a dummy variable indicating different buckets of the ratio of Residential RE to the lag of "Total Assets". The inverse of lagged "Turnover" is also interacted with this dummy variable. The buckets are ratios of real estate to assets of: $\geq$150%; 90–150%; 60–90%; 45–60%; 30–45%; 15–30%; and 0–15%. In Panel A Residential RE is winsorised at the median $\pm$ 5 times the interquartile range. In Panel B, Residential RE is instead trimmed at the median $\pm$ 5 times the interquartile range, removing the top-coded values of Residential RE. The Figures show point estimates as well as 90% confidence intervals.

Table A4: **Investment and Firm Size**

Investment							
	Dir RE/TA Split			Total Assets		Turnover	
	15%	20%	25%	< £10m	≥ £10m	< £25m	≥ £25m
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Residential RE: High RE/TA	0.0333***	0.0307***	0.0300***	0.0283***	0.0397**	0.0272***	0.0904***
	(0.007)	(0.008)	(0.008)	(0.007)	(0.017)	(0.009)	(0.019)
Residential RE: Low RE/TA	-0.0136	0.0223	0.0275	0.0196	-0.0413	-0.0216	0.0170
	(0.030)	(0.028)	(0.027)	(0.083)	(0.041)	(0.038)	(0.074)
Corporate RE	0.0462***	0.0469***	0.0446***	0.0436***		0.0485***	
	(0.016)	(0.016)	(0.016)	(0.016)		(0.016)	
Cash	0.0786***	0.0777***	0.0771***	0.0790***		0.0775***	
	(0.012)	(0.012)	(0.012)	(0.012)		(0.012)	
Profits	0.1094***	0.1104***	0.1104***	0.1098***		0.1112***	
	(0.016)	(0.017)	(0.016)	(0.016)		(0.016)	
P-Value, Equality of Res. Coeffs.	0.0831	0.7556	0.9231	0.9154	0.0709	0.1361	0.2863
Observations	32244	32244	32244	32244		32232	
Adjusted R^2	0.25	0.25	0.25	0.25		0.25	
Add. Firm, Dir. Controls	Yes	Yes	Yes	Yes		Yes	
Region-time FE	Yes	Yes	Yes	Yes		Yes	
Industry-time FE	Yes	Yes	Yes	Yes		Yes	
Firm FE	Yes	Yes	Yes	Yes		Yes	

Firm region clustered standard errors in parentheses

$^{\star}p < 0.10, ^{\star\star}p < 0.05, ^{\star\star\star}p < 0.01$.

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. 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 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. Column (1): 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%, or not. Columns (2)–(3) repeat this for thresholds of 20%, 25% respectively. Columns (4)–(5): Residential RE is interacted with a dummy variable indicating (i) whether the lagged "Total Assets" of the firm is at least £10 million or not; and (ii) whether the ratio of Residential RE to the lag of "Total Assets" is at least 15% or not. This dummy variable takes on 4 values. Columns (6)–(7): Residential RE is interacted with a dummy variable indicating (i) whether average firm annual turnover is at least £25million or not; and (ii) whether the ratio of Residential RE to assets is at least 15% or not. 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)–(7).

A.5 Further Results on Director LTV, Financial Constraints and Shareholder Status

This section presents some additional results accompanying the analysis in Section V.C. First, Table A5 presents results on the relationship between director LTV and firm-level financial constraints, where the high/low values of the firm-level financial constraint index are calculated relative to the median value at the firm level (i.e. the same within firm index as used in Columns (5)-(6) of Table 9). As can be seen, this generates the same conclusions as when between firm heterogeneity in the financial constraint index is used (as in Table 13).

Second, Table A6 presents a three way sort, by director LTV, firm-level financial constraints and a breakdown between shareholder and non-shareholder director residential real estate. This estimation is run on a sample of private firms for whom we observe both director LTV and shareholder status. No coefficient on *Residential RE* is statistically significant but the point estimates suggest that firms are most sensitive to *Residential RE* when the directors have a high LTV ratio, the firm appears financially constrained and the real estate under consideration belongs to directors who are shareholders.

A.6 Using Real Estate Measures as Instruments For Firm Financing

Our preferred explanation for our regression results is that an increase in real estate values increases investment by relaxing financial constraints. In the main text, we confirm both that investment and financing at the firm-level respond in a manner consistent with this explanation and that their responses are of consistent scale. In this section of the Online Appendix, we draw the two specifications together by asking how an increase in financing affects investment using our real estate measures as instruments for changes in financing. Our regression specification is:

$$Investment_{i,t} = \alpha_i + \delta_{j,t} + \mu_{l,t} + \phi \times \Delta Financing_{i,t} + \gamma \times controls_{i,t} + \varepsilon_{i,t}, \tag{A2}$$

which is equivalent to Equation 3, with the same controls, fixed effects, and with the real estate variables replaced by $\Delta Financing_{i,t}$. The term $\Delta Financing_{i,t}$ is defined along the lines of the dependent variables in Table 11; however, since we only have two instruments, we focus solely on the change in total debt and on the change in issued equity rather than different elements of debt liabilities.

Table A7 presents the results from this specification. Based on the reasoning that an increase in real estate unlocks additional financing that can then be spent on investment, we would expect ϕ to be near one, and, for the most part, this is what emerges from the regression specification. This confirms that the firms who are increasing their borrowing in response to an increase in real estate values are the same ones who are investing more.

Turning to the results in more detail: the first three columns focus solely on debt issuance by

Table A5: **Director LTV and Firm Financial Constraints: Using Within Firm Variation**

Investment		
	Fin. Con. (Within Firm)	
	Low	High
	(1)	(2)
Residential RE × High LTV	0.0287***	0.0404***
	(0.011)	(0.010)
Residential RE × Low LTV	0.0229**	0.0340***
	(0.009)	(0.009)
Corporate RE	0.0746***	
	(0.019)	
Cash	0.0806***	
	(0.015)	
Profit	0.1354***	
	(0.022)	
Observations	23975	
Adjusted R^2	0.26	
Add. Firm, Dir. Controls	Yes	
Region-time FE	Yes	
Industry-time FE	Yes	
Firm FE	Yes	
Firm region clustered standard errors in parentheses		
$^{\star}p < 0.10, ^{\star\star}p < 0.05, ^{\star\star\star}p < 0.01$.		

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. 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 winsorised 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 Section G of the Online Appendix. All regressions include firm, region-time and (2 digit) industry-time fixed effects. Columns (1)-(2): Residential RE is interacted first with a dummy variable indicating whether the LTV ratio of the company's directors is at least ('High LTV') or below ('Low LTV') 85% and second 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.

Table A6: **Director LTV, Shareholder Status and Firm Financial Constraints**

Investment: Private Firms										
Director:	Shareholders			Non-Shareholders			Shareholders		Non-Shareholders	
Constraint:	Within Year						Within Firm			
	Low	Medium	High	Low	Medium	High	Low	High	Low	High
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Resi RE: High LTV	0.0022	0.0010	0.0569	-0.1060	-0.0915	-0.0095	0.0057	0.0398	-0.0438	-0.0510
	(0.028)	(0.023)	(0.037)	(0.087)	(0.080)	(0.071)	(0.023)	(0.025)	(0.062)	(0.066)
Resi RE: Low LTV	-0.0114	-0.0108	0.0137	-0.0554	-0.0182	-0.0393	-0.0047	0.0084	-0.0411	-0.0292
	(0.021)	(0.022)	(0.022)	(0.057)	(0.059)	(0.052)	(0.020)	(0.020)	(0.052)	(0.049)
Corporate RE	0.0686***						0.0679***			
	(0.024)						(0.024)			
Cash	0.0829***						0.0876***			
	(0.020)						(0.020)			
Profit	0.1024***						0.1030***			
	(0.029)						(0.030)			
Observations	12749						12749			
Adjusted R^2	0.28						0.29			
Add. Firm, Dir. Controls	Yes						Yes			
Region-time FE	Yes						Yes			
Industry-time FE	Yes						Yes			
Firm FE	Yes						Yes			

Firm region clustered standard errors in parentheses

$^{\star}p < 0.10, ^{\star\star}p < 0.05, ^{\star\star\star}p < 0.01$.

Notes: This Table reports the link between residential real estate, corporate real estate, and firm investment. The sample covers reporting private UK firms over the period 2002-2014 where the average LTV ratio of the firm's directors can be calculated, the value of residential real estate is non-missing for both shareholders and non-shareholders, and the financial constraint index described in Section G of the Online Appendix can be computed. 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 winsorised 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. Columns (1)-(6) present results for the Residential RE held by shareholders and non-shareholders separately, with both interacted first with a dummy variable indicating whether the LTV ratio of the company's directors is at least ('High LTV') or below ('Low LTV') 85%, and second 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 (7)-(10) replace the second dummy variable with a dummy 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.

Table A7: **Effect of Debt on Investment Using Real Estate As An Instrument**

	Investment			
	Debt Instr. w/ Resi. RE	Debt Instr. w/ Corp. Re	Debt Instr. w/ Both	Debt & Equity Instr. w/ Both
	(1)	(2)	(3)	(4)
Total Debt	1.1687**	0.7358***	0.8124***	0.8089***
	(0.504)	(0.177)	(0.186)	(0.223)
Issued Equity				1.5933
				(1.301)
Cash	-0.0638	-0.0113	-0.0205	-0.0002
	(0.065)	(0.028)	(0.030)	(0.037)
Profits	0.0412	0.0647**	0.0606**	0.0825**
	(0.049)	(0.027)	(0.030)	(0.037)
Observations	32244	32244	32244	32244
K-Paap F-Stat	4.00	13.08	7.11	4.97
Hansen's J-stat	–	–	1.97	–
Add. Firm, Dir. Controls	Yes	Yes	Yes	Yes
Region-time FE	Yes	Yes	Yes	Yes
Industry-time FE	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Instrument	Residential RE	Corporate RE	Both	Both

Firm region clustered standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Notes: The Table reports the link between 2SLS regressions of investment on firm financing variables, using residential real estate and corporate real estate as instruments for the financing variables. 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. Total Debt is defined as the sum of the change in "Short Term Loans and Overdrafts", "Trade Credit", and "Long Term Debt", less the change in "Short Term Director Loans" and "Long Term Director Loans". Issued Equity is the sum of the change in "Issued Capital" and the "Share Premium Account". 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 winsorised at the median ± 5 times the interquartile range, except for financing variables which are winsorised at the 2/98% level. 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) reports the 2SLS regression of Investment on Total Debt, using Residential RE as the excluded instrument. Column (2) instead uses Corporate RE as the excluded instrument, whilst Column (3) uses both Residential and Corporate RE as excluded instruments. Column (4) presents the regression of Investment on Total Debt and Issued Equity, using Residential RE and Corporate RE as excluded instruments.

the firm with different configurations of instruments. One can see that the coefficient is always statistically indistinguishable from one and it is reassuring that the over-identification test is not rejected. The fourth column adds equity issuance into the specification. This does not alter the coefficient on debt. However, the coefficient on equity is imprecisely estimated: one and zero both lie with the 95% confidence interval. It is also worth recognising that *Residential RE* is not a strong instrument for changes in firm liabilities; however, as we show in Table 11, it does have a statistically significant impact on a firm's liabilities, and we are not relying on it as an instrument in our baseline regression.

A.7 The Debt/Equity Margin

In Section V.B we argued that firms seemed to fund the new investment resulting from an increase in *Residential RE* partly by issuing equity (which we interpret as the directors taking out a personal loan and using the proceeds to expand their equity stake in the firm) and partly by the firm borrowing directly (which we interpret as the directors personally guaranteeing the firm's debt). The latter margin seemed more important for the average firm in our sample.

In this Appendix we explore some of the determinants of the debt/equity margin. In Section I we discussed the conceptual merits of guarantees versus equity injections. We argued that guarantees are likely to be beneficial for firms that (i) have a more complicated shareholder structure, as guarantees can enable cross-pledging without effecting the ownership structure of the firm; (ii) have taxable cashflows which makes the tax shield associated with corporate debt more valuable; and (iii) have other assets that can be liquidated or have directors with substantial outside wealth, so the conditionality of a guarantee (that the creditor must first pursue the firm's assets) is potentially more valuable too. Furthermore, it is worth noting that in general larger firms are more likely to have these three factors: a complex shareholder structure, positive tax bills, and liquidatable assets. So we would expect a general relationship between the use of guarantees and size.

To assess these arguments, we start by returning to the survey evidence presented in Section I. As described, the borrowers' survey asks what security was used to obtain credit and the answer to this question can be separated, *inter alia*, by guarantees and residential property (we combine the personal and mixed property categories). Two caveats are worth noting at this point. First, the two categories are not mutually exclusive: the borrower can report using both personal guarantees and residential property. Second, the potential responses do not clearly distinguish between a guarantee secured against residential real estate and a personal loan for commercial purposes secured against residential real estate (the former will manifest as debt on the firm's balance sheet, the latter as equity). It is reasonable to assume that some of the firms who report borrowing directly against real estate are referring to secured guarantees.

With these caveats in mind, Table A8 presents the proportion of firms that report using residential property and personal guarantees as security, broken down by various other firm-level characteristics.

First, Columns (1) and (2) consider the break down by firm employment. As can be seen, guarantees seem more predominant among larger SMEs. It is also worth noting that our regression sample overweights larger firms relative to smaller enterprises: this could generate a relatively small equity response relative to debt in Table 11.

We now turn to the remaining Columns in Table A8. Here we consider different questions in the survey that proxy for, respectively, the complexity of the firm's shareholder structure, the likelihood that the firm has a positive tax bill, and the value of the conditionality associated with personal guarantees. Note that the share of respondents that provide an answer varies across questions, so overall proportions vary between questions as the effective sample varies. However, the relative proportions using guarantees versus residential property is still revealing. As a proxy for shareholder complexity, Columns (3) and (4) break down the different forms of security by whether the firm reports being majority owned by a single family. Single family firms should find it easier to manage shareholdings and seem to rely less on guarantees. Columns (5)-(6), and (7)-(8) consider two different proxies for the firm having a positive tax bill. First, whether the firm reports that the main reason it holds cash balances is to pay taxes, and second whether the firm reports that taxes are a major challenge facing its business. In both cases, paying tax is associated with the greater use of guarantees. Last, Columns (9) and (10) consider the ratio of the principle owner's wealth outside the firm to the firms net assets as a proxy for the benefits of the conditionality associated with a guarantee. When there is more outside wealth to be protected, a guarantee is more likely to be used.

We now turn to our regression analysis to explore which factors matter in the debt/equity response to an increase in *Residential RE* and whether our results match the survey. Note that, unlike the lenders' survey, the borrowers' survey cannot be matched with the BvD data. This means that we cannot use equivalent proxies for shareholder complexity, tax bills, etc. Instead we condition on different variables available in the BvD dataset.

The results are summarised in Table A9. The upper part of the Table considers a decomposition measured by size (employment). As with Table 10, larger firms expand their balance sheets by more following an increase in *Residential RE* but the composition of the change is also size dependent. For small firms, 37% of the increase is equity financed (taking the point estimates as given) whereas for larger firms it is just 15%. This is consistent with the survey evidence that larger firms make more use of guarantees rather than using personal assets as security directly.

The lower part of the Table considers alternative slices of the data. Here, we drop the analysis of long-term debt for compactness, as the coefficient estimates tend to be insignificant and near zero. First, as a proxy for the complexity of the firm's shareholder structure, we consider firms with more than two shareholder-directors.[59] As can be seen, firms with multiple shareholder-directors use more debt finance, which is consistent with guarantees being useful to resolve complex ownership

[59]The sample includes public firms. If we focus solely on private firms we reach a similar conclusion, although the difference is a little less distinct.

Table A8: **Survey Evidence on Guarantees versus Residential Property As Security**

	Size		Ownership		Taxes				Owner's Assets	
	Employees		Single Family		Main reason for holding cash		Main challenge facing business		Wealth ex-Firm /Firm Net Assets	
	< 50	$50 - 250$	$\geq 50\%$	$< 50\%$	*yes*	*no*	*yes*	*no*	$\geq 50\%$	$< 50\%$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Residential Property	33%	9%	32%	25%	8%	24%	24%	32%	29%	42%
Personal Guarantee	9%	19%	6%	22%	14%	7%	19%	8%	12%	1%
Neither	58%	73%	62%	53%	78%	69%	57%	60%	60%	57%

Notes: 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. 'Residential Property' in the Table refers to the share of respondents who answer either (e) personal property (e.g. house) or (f) mixed property (e.g. flat above shop). Personal guarantee refers to the share who answer (g) personal or directors guarantee. See notes to Table 1 for the complete list of potential answers that can be given to this question. Responses are weighted using the sampling weights provided by the surveys. We exclude firms that operate in the real estate and construction sector (note that no firms operating in the financial or mining sectors are included in the survey) and only include for-profit limited liability companies. Numbers may not sum due to rounding. Columns (1) and (2) split respondents based on their response to the question *How many people, including you, work in this business?* which is available for all Firms in the sample. Columns (3) and (4) split by the answer to the yes/no question *Is 50% or more of the business owned by a single family?* (53% of firms answer this question). Column (5) and (6) split by the answer to the question *What are the main reasons why you hold money on deposit?* (55% of firms respond) Firms that answer '4. For tax/national insurance' are included in Column (5), remaining reponding firms are included in Column (6). Columns (7) and (8) split by the answer to the question *On a scale of 1-10 (where 1 is no problem and 10 is critical problems) how would you rate the severity of the problems faced by your business in the following areas: v. Taxes and Regulation?* (98% of firms respond). Firms that respond 8 or greater are considered to have taxation as a main challenge facing the business. Columns (9) - (10) use the questions *What is the total amount of assets held by your business?* and *What is the total amount of liabilities owed by your business?* and *Excluding the value of the business what is your approximate total net worth. That is, all your personal assets minus all your personal debts?* to compute the ratio of the owners wealth excluding the firm to the net assets of the firm (30% of firms allow for this calculation).

Table A9: **Determinants of Equity versus Debt Issuance**

Liability:	Issued Equity		ST Debt		LT Debt	
	≤ 250	> 250	≤ 250	> 250	≤ 250	> 250
	(1)	(2)	(3)	(4)	(5)	(6)
Resi RE	0.0065***	0.0199**	0.0188*	0.0280	-0.0075	0.0835***
	(0.002)	(0.009)	(0.010)	(0.032)	(0.013)	(0.027)
Corporate RE	-0.0077		0.0288*		0.0360*	
	(0.005)		(0.016)		(0.020)	
Observations	32244		32244		32244	
Adjusted R^2	0.30		0.00		0.05	

(a) Size (Employment)

Liability:	Shareholder Directors				Positive Tax Bill			
	Issued Equity		ST Debt		Issued Equity		ST Debt	
	≤ 2	> 2	≤ 2	> 2	Yes	No	Yes	No
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Resi RE	0.0099***	0.0037	0.0211**	0.0200*	0.0084***	0.0088***	0.0249**	0.0194*
	(0.003)	(0.002)	(0.010)	(0.010)	(0.002)	(0.002)	(0.010)	(0.010)
Corporate RE	-0.0058		0.0318**		-0.0059		0.0315**	
	(0.005)		(0.016)		(0.005)		(0.015)	
Observations	32244		32244		32244		32244	
Adjusted R^2	0.30		0.00		0.30		0.00	

Firm region clustered standard errors in parentheses

$^{\star}p < 0.10, ^{\star\star}p < 0.05, ^{\star\star\star}p < 0.01$.

(b) Other factors

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". 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". 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 winsorised at the median $\pm$ 5 times the interquartile range, except for the financing variables which are winsorised at the 2/98% level. Standard errors, clustered by firm NUTS 3 region, in parentheses. All regressions include firm, region-time and (2 digit) industry-time fixed effects. Sub-Table A: Columns (1)–(2): Issued Equity is the dependent variable and Residential RE is interacted with a dummy variable indicating whether average employment is at least 250 or not; Columns (3)–(4) and Columns (5)–(6) repeat this exercise with Short Term Debt and Long Term Debt as the dependent variable respectively. The inverse of lagged "Turnover" is also interacted with the dummy variable in all specifications. Sub-Table B: Liability row shows whether Issued Equity or Short Term Debt is the dependent variable. Columns (1)–(2) and (3)–(4): Residential RE is interacted with a dummy variable indicating whether the firm currently has more than 2 director-shareholders or not. Columns (5)–(6) and (7)–(8): Residential RE is interacted with a dummy variable indicating whether the firm recorded a positive value for 'Taxation' in the previous year's profit and loss account. The inverse of lagged "Turnover" is also interacted with the dummy variable in all specifications.

structures. On average, only 16% of the new finance raised following an increase in Residential RE comes from equity when there are more than 2 director-shareholders at the firm. This compares to 32% for firms with at most 2 shareholder-directors. Next, we consider firms that report paying tax in the previous accounting year. Both taxpayers and non-taxpayers inject a similar amount of new equity following a rise in *Residential RE*, but taxpayers raise more debt. Specifically, firms that paid tax in the previous period raised 25% of the finance through equity, compared to 31% for the firms that paid no tax. This is consistent with firms that would benefit from an increased tax shield making more use of guarantees.

It is important to emphasise that the interpretation of the results in Table A9 are only based on the point estimates. Equity issuance is a relatively rare event in our sample which makes obtaining precise estimates difficult. In many cases the differences are not statistically significant. Nonetheless, it is encouraging that the point estimates align with both the survey evidence and our intuitive priors.

A.8 Sensitivity to Residential Real Estate by Industry Correlation with the Housing Market

This section considers how our coefficient of interest varies with the sensitivity of the firm's industry to the housing market. To compute industry-level sensitivities, we use administrative data on firm sales at yearly frequency from the ONS, which covers the universe of all VAT-registered businesses in the UK.[60] Our sample period is 1997-2014 and covers about 48 million observations in total. We estimate the following regression:

$$\Delta Sales_{i,t} = \beta_l \Delta HP_{j,t} + \varepsilon_{i,t}, \tag{A3}$$

where $\Delta Sales_{i,t}$ is the growth rate of sales of firm i at time t, working in industry l (using the 2-digit 2003 SIC definition), located in region j; $\Delta HP_{j,t}$ is the house price growth in region j in time t; our estimated parameter of interest is β_l which measures the average response of sales growth of firms, working in industry l, to changes in regional house prices.

Table A10 shows results for firms split based on their industry's relationship with the regional housing market. As can be seen, the response of investment to Residential Real Estate is nearly identical for high (above the median) and low (below the median) beta industries.

[60]This work was produced using statistical data from the ONS. The use of the ONS statistical data in this work does not imply the endorsement of the ONS in relation to the interpretation or analysis of the statistical data. The work uses research datasets which may not exactly reproduce ONS aggregates.

Table A10: **Residential Real Estate and Industry Correlation with Housing Market**

Investment			
		Industry Beta	
	Baseline	Below Median	Above Median
	(1)	(2)	(3)
Residential RE	0.0305***	0.0307***	0.0303***
	(0.008)	(0.011)	(0.011)
Corporate RE	0.0560***	0.0616***	0.0515**
	(0.017)	(0.018)	(0.023)
Cash	0.0756***	0.0755***	
	(0.013)	(0.013)	
Profit	0.1051***	0.1052***	
	(0.018)	(0.018)	
P-Value, Equality of Residential Coeffs.	-	0.9775	
Observations	31751	31751	
Adjusted R^2	0.24	0.24	
Add. Firm, Dir. Controls	Yes	Yes	
Region-time FE	Yes	Yes	
Industry-time FE	Yes	Yes	
Firm FE	Yes	Yes	

Firm region clustered standard errors in parentheses

$^{\star}p < 0.10, ^{\star\star}p < 0.05, ^{\star\star\star}p < 0.01$.

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 Real Estate 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 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. Column (1) presents the baseline regression on the same sample as Columns (2)-(3). Columns (2), (3): both Residential RE and Corporate RE are interacted with a dummy variable indicating whether a firm is in a high or low beta industry, as defined in Online Appendix A.8.

A.9 Weighted Regressions

This section runs weighted regressions, which ensures that the weight placed on different firm size groups aligns with their aggregate contribution. As shown in Table 3 in the main text, whilst firms with at least 250 employees account for 25% of the observations in our sample, they account for over half of aggregate investment. Similarly, our sample relatively under-weights the smallest firms with less than 10 employees, who account for 5% of our sample, but 15% of aggregate investment. We construct investment weights for the four firm size groups shown in Table 3, based on the ratio of their share of the aggregate contribution to their share of observations in our regression sample.

The results of the weighted regressions are presented in Table A11. Column (1) shows the baseline result whilst Column (2) shows the investment-weighted regression. Columns (3)-(4) repeat this exercise, weighting the firm size groups by their contribution to aggregate turnover, and employment, respectively. Again, the results are very similar to our baseline estimates. In Column (5) we weight firms by the residential real estate held by their directors. This places more weight on firms whose directors hold more real estate, and consequently sees a greater change in value for a given percentage change in house prices. In this case, the estimated investment sensitivity is actually larger than the baseline.

Table A11: **Weighted Regressions**

	Investment					
	Baseline	Investment Weighted	Turnover Weighted	Employment Weighted	Sample Residential RE Weighted	Population Residential RE Weighted
	(1)	(2)	(3)	(4)	(5)	(6)
Residential RE	0.0298***	0.0314***	0.0308***	0.0276**	0.0472***	0.0327*
	(0.008)	(0.012)	(0.011)	(0.012)	(0.011)	(0.017)
Corporate RE	0.0511***	0.0709***	0.0714***	0.0691***	0.0335	0.0461
	(0.016)	(0.019)	(0.019)	(0.019)	(0.022)	(0.047)
Cash	0.0777***	0.0791***	0.0795***	0.0769***	0.0670***	0.1112***
	(0.012)	(0.016)	(0.015)	(0.015)	(0.024)	(0.029)
Profit	0.1092***	0.1136***	0.1189***	0.1000***	0.1191***	0.0441*
	(0.016)	(0.025)	(0.024)	(0.024)	(0.027)	(0.023)
Observations	32244	32244	32244	32244	32244	32244
Adjusted R^2	0.25	0.33	0.33	0.32	0.31	0.56
Add. Firm, Dir. Controls	Yes	Yes	Yes	Yes	Yes	Yes
Region-time FE	Yes	Yes	Yes	Yes	Yes	Yes
Industry-time FE	Yes	Yes	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes

Firm region clustered standard errors in parentheses

$^{\star}p < 0.10, ^{\star\star}p < 0.05, ^{\star\star\star}p < 0.01$.

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 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. Column (1) runs the baseline regression. Column (2) runs a weighted regression where the weight placed on different firm size groups (by employment) aligns with their contribution to aggregate investment (Online Appendix A.9 provides further details). Columns (3)–(4) repeat this with weights instead reflecting, respectively, shares of aggregate turnover, and employment. Column (5) runs a regression where observations are weighted by the firm's 2002 value of Residential RE. Column (6) runs a weighted regression where the weight placed on different firm size groups (by assets) aligns with their share of aggregate director residential property. The firm groups are defined by the lagged value of a firm's "Total Assets". The buckets are: <£1m; £1m-£2.5m; £2.5m-£5m; £5m-£10m; £10m-£50m; £50m+.

As discussed in the main text, we estimate £/£ regressions not elasticities. This implies that when it comes to the aggregation exercise in Section VI, taking the coefficient weighted by aggregate investment is actually not appropriate. Instead, the right weighting variable is the share of residential real estate held by a firm's directors. To see this, let i index firms, with R_i and I_i denoting the residential real estate owned by the directors of the firm, and the firm's investment, respectively. Let $R = \sum R_i$ and $I = \sum I_i$ be aggregate residential real estate and aggregate investment. Suppose, consistent with the exercise in Section VI, all firms experience a proportionate increase in real estate values:

$$\frac{\Delta R_i}{R_i} = \alpha \; \forall_i$$

Then

$$\frac{\Delta I}{\Delta R} = \frac{\sum \Delta I_i}{\Delta R} = \sum \frac{\Delta I_i}{\Delta R_i} \frac{\Delta R_i}{\Delta R}$$

But

$$\frac{\Delta R_i}{\Delta R} = \frac{\Delta R_i}{\sum \Delta R_i} = \frac{\alpha R_i}{\sum \alpha R_i} = \frac{R_i}{R}$$

This means the aggregate effect of a change in Residential RE on investment is given by:

$$\frac{\Delta I}{\Delta R} = \sum \frac{\Delta I_i}{\Delta R_i} \frac{R_i}{R}$$

The corresponding aggregate elasticity is given by:

$$\frac{\Delta I}{\Delta R} \frac{R}{I} = \frac{R}{I} \sum \frac{\Delta I_i}{\Delta R_i} \frac{R_i}{R}$$

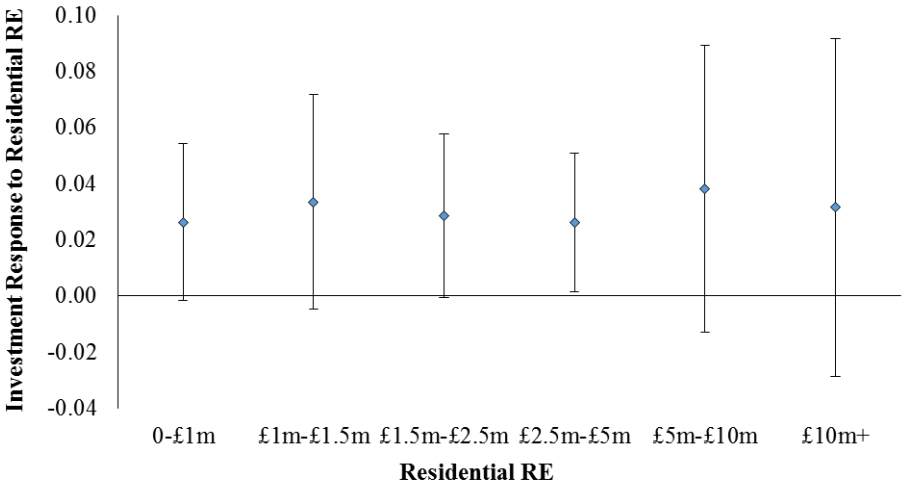
Since we estimate $\frac{\Delta I_i}{\Delta R_i}$ at the firm level, it follows that for aggregation we should weight the estimates by $\frac{R_i}{R}$: the firm's share of aggregate director residential real estate. That is exactly what we do in Column (5) of Table A11, using $\frac{R_i}{R}$ measured within sample. However, as we have discussed, our sample is not representative of the size distribution of firms. To address, in Column (6) we do the following: (i) we exploit the fact that "Total Assets" is well reported for almost all firms in our sample, as is Residential Real Estate; hence we can form an accurate estimate for the share of aggregate residential real estate held by firms in different portions of the asset distribution (we use the same 6 buckets as in Figure 4). (ii) We then reweight the regression sample to ensure that the weight placed on different firms in groups by assets matches that group's share of director residential real estate holdings in the population. As can be seen, this yields a very similar point estimate to the unweighted baseline.[61]

The explanation for why weighting by residential real estate makes little difference becomes clear upon inspecting Figure A2. This figure presents results from a regression where we group firms into

[61] This regression, which reweights all the coefficients, is a more formal version of the aggregation exercise undertaken in Section VI. Both methods result in very similar coefficient estimates for Residential RE.

six buckets by their 2002 residential real estate level. The figure presents the point estimate for the sensitivity of investment to *Residential RE* for each group, along with 90% confidence intervals. As can be seen, the level of *Residential RE* alone makes little difference to the sensitivity of the firm to an increase in *Residential RE*. In short, this implies $\sum \frac{\Delta I_i}{\Delta R_i} \frac{R_i}{R} \approx \sum \frac{\Delta I_i}{\Delta R_i}$, and weighting by residential real estate shares makes little difference.

Figure A2: Investment Response by Residential RE



Notes: The Figure displays the link between residential real estate and firm investment for different buckets of Residential RE. 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 winsorised at the median ± 5 times the interquartile range. Standard errors are clustered by firm Nuts 3 region. All regressions include firm, region-time and (2 digit) industry-time fixed effects. The Figure shows the results of interacting Residential RE with a dummy variable indicating different buckets of the firm's 2002 value of Residential RE. The buckets of Residential RE are 0-£1m; £1m-£1.5m; £1.5m-£2.5m; £2.5m-£5m; £5m-£10m; £10m+. The Figure shows point estimates as well as 90% confidence intervals.

A.10 Aggregate Response of Investment to Corporate Real Estate

The main text showed that the aggregate response of investment to director real estate is driven primarily by small firms. This section of the Online Appendix shows that, in contrast, the effects of a price increase running through corporate real estate holdings is mainly through large firms.

We first consider the aggregate contributions when firm size is measured by "Number of Employees". As there is no aggregate data on the holdings of Corporate Real Estate broken down by firm employment, we use the fact that the mean ratio of corporate real estate holdings to "Turnover" is almost identical for SMEs (<250 employees) and large firms ($\geq$ 250 employees) in our sample. In aggregate, across all industries, turnover is split 46% to SMEs and 54% to large firms, suggesting that corporate real estate is split 54-46 between large firms and SMEs. Plugging in the necessary figures based on our size regression in Table 10, we obtain an estimate that a 1% price increase raises investment demand by 0.07% via the behaviour of large firms and 0.04% via SMEs.

The results are starker when we measure firm size by their "Total Assets". As "Land and Buildings" is well-reported by firms (and "Total Assets" is universally reported) we can estimate the share of Corporate Real Estate based on the wider sample of all UK firms in the industries of our baseline regression sample. Whilst small firms (< £10m in assets) make up over 99% of firms, they typically own very little Corporate Real Estate (indeed the median firm owns none), and we estimate that they only hold 11% of aggregate Corporate Real Estate, with large firms (≥ £10m in assets) holding the remaining 89%. The point estimates in Table 10 imply that a 1% increase in real estate prices raises investment demand by 0.08% due to large firms and 0.01% due to small firms.

A.11 Measurement of Corporate Real Estate

Table A12 presents additional results to address concerns regarding the measurement of corporate real estate holdings.

A potential criticism of our estimated results for the corporate real estate measure is the use of residential house prices to proxy changes in the market value of commercial real estate. We therefore re-estimate the baseline regression using commercial real estate prices to compute our measure. The data on CRE prices comes from the Investment Property Databank. However, as this is only available for a range of major UK cities (as opposed to local authority level), we lose around 50% of the observations compared to the baseline estimates in Table 4 of the main text. The results, presented in Column (2) of Table A12, show similar coefficient estimates for both corporate and residential real estate, suggesting that the use of residential real estate prices is not a bad proxy.

We also assume that the appropriate price index with which to value a firm's real estate is the index for the region where its registered office (using the BvD field "R/O Full Postcode") is located. This may be problematic if the firm has buildings in multiple different regions. We do, however, see in our dataset the addresses of all locations where the firm has operations (BvD field "Trading Addresses"). Columns (3) and (4) in Table A12 presents results which interact our real estate measures with a dummy indicating if firms operate in one unique region or have operations outside the region of their registered office, with similar results for both groups.

Table A12: **Corporate Real Estate: Identification**

	Investment						
					2002	Lagged Book Value	
			Firm Dispersion		Market Value		Non Land-Build.
	Baseline	CRE	Single-Region	Multi-Region	Land	Investment	Investment
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Residential RE	0.0298***	0.0229**	0.0284***	0.0333***	0.0275*	0.0443***	0.0213***
	(0.008)	(0.009)	(0.008)	(0.009)	(0.015)	(0.008)	(0.006)
Corporate RE	0.0511***	0.0701**	0.0516***	0.0489**	0.1030**	-0.0728***	0.0637***
	(0.016)	(0.029)	(0.016)	(0.019)	(0.050)	(0.011)	(0.008)
Cash	0.0777***	0.0578***	0.0774***		0.0772***	0.0691***	0.0443***
	(0.012)	(0.014)	(0.012)		(0.015)	(0.012)	(0.008)
Profit	0.1092***	0.1151***	0.1091***		0.1080***	0.1108***	0.0840***
	(0.016)	(0.019)	(0.016)		(0.029)	(0.016)	(0.011)
P-Value, Eq. of Res. Coeffs.	-	-	0.3821		-	-	-
Observations	32244	15043	32244		12078	31238	30692
Adjusted R^2	0.25	0.26	0.25		0.24	0.25	0.29
Add. Firm, Dir. Controls	Yes	Yes	Yes		Yes	Yes	Yes
Region-time FE	Yes	Yes	Yes		Yes	Yes	Yes
Industry-time FE	Yes	Yes	Yes		Yes	Yes	Yes
Firm FE	Yes	Yes	Yes		Yes	Yes	Yes

Firm region clustered standard errors in parentheses

$^{\star}p < 0.10, ^{\star\star}p < 0.05, ^{\star\star\star}p < 0.01$.

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 Real Estate 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 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. Column (1) presents the baseline results. Column (2) calculates Corporate RE by iterating forward the 2002 book value of "Land and Buildings" using a commercial real estate price index instead of the house price index. Columns (3), (4) include interactions of both Residential and Corporate RE with a dummy variable taking the value one when all of a firm's trading addresses are in a single region. Column (5) calculates Corporate RE using the market, rather than book, value of "Land and Buildings" in 2002. This is calculated using a *LIFO* recursion, with the market value of land in the base year taken from the value of "Land and Buildings" when the firm was first incorporated. Column (6) calculates Corporate RE using the one-year lagged book value of "Land and Buildings", iterated forward using the regional house price index. Column (7) uses the same definition of Corporate RE, but with investment, excluding investment in "Land and Buildings", as the dependent variable.

The book value of "Land and Buildings" in 2002 may be a poor proxy for their market value. To address this, we impute market values from the book values by adopting the recursion method used in Hayashi and Inoue (1991), Hoshi and Kashyap (1990) and Gan (2007) amongst others, which treats the valuation of land in a "last in, first out" (LIFO) fashion. The recursion can be written as follows:

$$
\begin{aligned}
L^Y_{i,t} &= \begin{cases} L^Y_{i,t-1}\frac{L^P_{j,t}}{L^P_{j,t-1}} + dB_{i,t} & if\ dL^B_{i,t} \geq 0 \\ L^Y_{i,t-1}\frac{L^P_{j,t}}{L^P_{j,t-1}} + dB_{i,t}\frac{L^P_{j,t}}{L^A_{i,t-1}} & if\ dL^B_{i,t} < 0 \end{cases} \\
L^A_{i,t} &= \begin{cases} L^P_{j,t} & if\ dL^B_{i,t} \geq 0 \\ L^A_{i,t-1} & if\ dL^B_{i,t} < 0, \end{cases}
\end{aligned}
\tag{A4}
$$

where $L^Y_{i,t}$ is the market value of land owned by firm i at time t in region j, $L^P_{j,t}$ is the market price of land in region j at time t, $L^A_{i,t}$ is the price at which land was last bought by firm i, and $dL^B_{i,t} = L^B_{i,t} - L^B_{i,t-1}$ is the change in the book value of land, $L^B_{i,t}$, owned by firm i.

To implement this method one needs to make an assumption regarding the market value of land in the base year, $L^Y_{i,0}$. We take as the base year the first recorded value of "Land and Buildings" within three years of incorporation, at which time we assume that the market value and book value of "Land and Buildings" are the same. Additionally, whenever the book value of "Land and Buildings" is zero, we infer that the market value is also zero.

Given a time series for $L^Y_{i,t}$, we then recompute our corporate real estate measure by fixing land holdings at the market value in 2002, $L^Y_{i,2002}$, and iterating forward using the regional price index. Column (5) of Table A12 shows a larger point estimate for corporate real estate when doing this, with a very similar estimate for residential real estate.

We also test the extent to which our choice to fix the initial stock of "Land and Buildings" in 2002, as opposed to letting it vary after this date, may influence our results. To do this we redefine our measure as:

$$
Corporate\, RE_{i,t} = L^B_{i,t-1}\frac{L^P_{j,t}}{L^P_{j,t-1}},
$$

where $L^B_{i,t-1}$ is the previous year's book value of "Land and Buildings" reported by the firm. This means that investment decisions in previous years now affect our real estate measure (although, for obvious reasons, we do not include investment in the current period). Column (6) of Table A12 presents the regression estimates when corporate real estate values are redefined in this fashion. The coefficient on corporate real estate is now negative and remains highly significant. An explanation for this result is that investment in "Land and Buildings" may have a negative serial correlation: if a firm bought a building in the previous period, it is unlikely to invest in a new building in the current period, which would bias down the coefficient estimate. Indeed, as shown in Column (7), if

one looks at investment excluding "Land and Buildings" the coefficient on corporate real estate is positive once more and has a similar value to the baseline regression in Column (1). This finding illustrates our reasoning behind the use of our baseline corporate real estate measure. Importantly for the robustness of our main result, the coefficient on residential real estate remains highly significant and of similar magnitude when using this alternative definition of corporate real estate.

A.12 Labour Market Implications

The increases in the value of real estate can also have implications for a firm's use of labour inputs as well as physical capital. To test this we alter our left hand side variable and consider two separate labour inputs: (i) the change in the "Remuneration" paid to employees; and (ii) the change in the "Number of Employees". As per our other specifications, we scale both variables by the lag of the firm's "Turnover". However, since "Number of Employees" is a real variable we convert "Turnover" into real terms using the UK CPI when re-scaling.

Table A13 reports the estimates for the effect of real estate on labour market outcomes. A £1 rise in our residential real estate measure increases the firm's total wage bill by around £0.033. The equivalent figure for corporate real estate is £0.033. The employment estimate (0.0009) can be interpreted as an increase of £1.1 million (in 2005 prices) in residential real estate values resulting in the hiring of approximately one additional worker. The equivalent figure is one worker for every £650 thousand increase in corporate real estate values.

Table A13: **Firm Employment and Wages**

Labour Market Variables		
	Change in Remuneration	Change in Employment
	(1)	(2)
Residential RE	0.0332***	0.0009***
	(0.006)	(0.000)
Corporate RE	0.0332***	0.0015***
	(0.011)	(0.000)
Cash	0.0043	0.0003
	(0.006)	(0.000)
Profit	0.1455***	0.0037***
	(0.011)	(0.000)
Observations	32244	32244
Adjusted R^2	0.21	0.18
Add. Firm, Dir. Controls	Yes	Yes
Region-time FE	Yes	Yes
Industry-time FE	Yes	Yes
Firm FE	Yes	Yes

Firm region clustered standard errors in parentheses
$^{\star}p < 0.10, ^{\star\star}p < 0.05, ^{\star\star\star}p < 0.01$.

Notes: This Table reports the link between residential real estate, corporate real estate, and two employment variables. The sample covers reporting UK firms over the period 2002-2014. Change in Remuneration is the change "Remuneration", whilst Change in Employment is the change in "Number of Employees". 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 winsorised at the median ± 5 times the interquartile range, except for Change in Employment which is winsorised at the 2/98% level. 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 Change in Remuneration is the dependent variable. In Column (2) the change in employment is the dependent variable.

A.13 Estimates Pre- and Post- Crisis

Table A14 considers how the link between real estate and investment varies in the pre- (2002-2006) and post-crisis (2007-2014) periods. The results show that the effect of directors' residential real estate on firm investment is very similar in both 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.

Table A14: **Estimates for Pre- and Post- Crisis Period**

Investment		
	Time Period	
	Pre-2007	Post-2007
	(1)	(2)
Residential RE	0.0321***	0.0314***
	(0.008)	(0.008)
Corporate RE	0.0650***	0.0408**
	(0.016)	(0.017)
Cash	0.0791***	
	(0.012)	
Profit	0.1101***	
	(0.016)	
P-Value, Eq. of Res. Coeffs.	0.8636	
Observations	32244	
Adjusted R^2	0.25	
Add. Cont.	Yes	
Reg-time FE	Yes	
Ind-time FE	Yes	
Firm FE	Yes	
Firm region clustered standard errors in parentheses		
$^{\star}p < 0.10, ^{\star\star}p < 0.05, ^{\star\star\star}p < 0.01$.		

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. Cont. 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 $\pm$ 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. Columns (1)-(2) include the interaction of both Residential and Corporate RE with a dummy variable indicating whether the observations fall within the 2002-2006 or the 2007-2014 period.

B Further Evidence on Home Values and Corporate Financing

B.1 Further Evidence of Personal Guarantee Usage

In this Appendix we provide further evidence on personal guarantee usage. The results draw on the Bank of England's 2015 survey of UK SME and Mid-Corporate Lending, merged with BvD data, as introduced in Section I of the main text.

First, Table B1 presents the results on guarantee usage broken down by the industry of the borrowing firm. As can be seen, guarantee usage seems to be fairly uniformly distributed among different industrial sectors of the economy.

Table B1: Personal Guarantees By Industry

	Secured By Guarantee
Agriculture	44%
Manufacturing	48%
Wholesale & Retail	50%
Transport & Information	43%
Food and Accommodation	45%
Professional and Administrative	59%
Human Health	51%
Other Services	36%

Notes: The Table presents results 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 £250k, and whose annual revenue was no more than £500million. We reweight the sample to correct for some oversampling of certain loan types by the Bank of England that was done for regulatory purposes. To facilitate comparison with our regression results we exclude lending to firms in mining and quarrying, construction, financial and insurance activities, and commercial real estate sectors. We further restrict the sample to limited liability companies that are not subsidiaries in Scotland, England, and Wales. Moreover, we merge the survey 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. The Table shows the fraction of bank-business lending relationships (weighted by number) that were secured by a personal guarantee, response (e), broken down by the industry of the firm.

Second, in a similar vein to the analysis in Section V, Table B2 considers the use of guarantees based around different proxies for financial constraints. Columns (1)-(4) consider additional questions within the survey: what the lender thinks about the likelihood that the firm will default, and the strength of the firm's trading prospects. Firms that the lender considers either at risk of default or to have weak prospects are more likely to use guarantees. Columns (5)-(10) make use of the merged BvD data and confirm that guarantees are more likely to be used when the firm is levered, when the firm scores highly on our estimated financial constraints indexed (as in Section V.A), or when the directors are highly levered.

Table B2: Personal Guarantees and Financial Constraints

Secured By Guarantee									
Likelihood of Default		Firm Trading Prospects		Firm Leverage		Firm Fin. Con. Index		Director Home LTV	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
High	75%	Weak	67%	≥75%	62%	Upper Tertile	53%	≥85%	72%
Medium	62%	Fair	52%	35%-75%	43%	Middle Tertile	33%	60%-85%	44%
Low	47%	Good	41%	<35%	20%	Lower Tertile	20%	<60%	42%

Notes: The Table presents results 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 £250k, and whose annual revenue was no more than £500million. We reweight the sample to correct for some oversampling of certain loan types by the Bank of England that was done for regulatory purposes. To facilitate comparison with our regression results we exclude lending to firms in mining and quarrying, construction, financial and insurance activities, and commercial real estate sectors. We further restrict the sample to limited liability companies that are not subsidiaries in Scotland, England, and Wales. Moreover, we merge the survey 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. The Table shows the fraction of bank-business lending relationships (weighted by number) that were secured by a personal guarantee, response (e), across a number of groups. *Likelihood of Default* splits firms by the bank's view on the likelihood of the firm defaulting in the next 12 months, grouped into "High" ('already defaulted' or 'almost certain'), "Medium" ('probable', 'likely', or 'possible'), and "Low" ('unlikely' or 'remote'). *Firm Trading Prospects* splits firms by the bank's view on the firm's future trading prospects, where "Weak" groups together the responses "Weak" and "Very Weak". *Firm Leverage* splits by firm leverage, defined as the ratio of the balance sheet items "Total Liabilities" to "Total Assets". *Firm Fin. Con. Index* splits firms into three equal groups of an estimated financial constraint index (see Section G of the Online Appendix). *Director Home LTV* splits firms by the average Loan to Value ratio the firm directors have on their personal mortgage (see Section F of the Online Appendix).

Last, in keeping with the results in Section V.C, we consider the joint interaction of firm financial constraints and director LTV in Table B3. As can be seen, guarantees are most prevalent when both the firm and the director are likely to be constrained.

Table B3: Personal Guarantees and Firm, Director Financial Constraints

Secured By Guarantee		
	Director Home LTV	
Firm Fin. Con. Index	≥85%	<85%
Above Median	66%	36%
Below Median	48%	19%

Notes: The Table presents results 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 £250k, and whose annual revenue was no more than £500million. We reweight the sample to correct for some oversampling of certain loan types by the Bank of England that was done for regulatory purposes. To facilitate comparison with our regression results we exclude lending to firms in mining and quarrying, construction, financial and insurance activities, and commercial real estate sectors. We further restrict the sample to limited liability companies that are not subsidiaries in Scotland, England, and Wales. Moreover, we merge the survey 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. The Table shows the fraction of bank-business lending relationships (weighted by number) that were secured by a personal guarantee, response (e), across a number of groups. *Firm Fin. Con. Index* splits firms into two equal groups of an estimated financial constraint index (see Section G of the Online Appendix). *Director Home LTV* splits firms by the average Loan to Value ratio the firm directors have on their personal mortgage (see Section F of the Online Appendix).

B.2 Cross-country Comparison

As mentioned in the main text, a recent Bank of England survey of major lenders shows that about 50% of lending to SMEs and mid-size corporations was secured with a personal guarantee. Table B4 summarises previous research confirming that similar numbers were obtained for other countries.

In the US, Bathala et al. (2006) conducted a survey among 201 privately-owned SMEs and found that about 53% of these firms used guarantees from major stockholders, officers or directors as a form of covenant for bank loans. Using the National Survey for Small Business Finances (conducted by the Federal Reserve Board), Meisenzahl (2014) reports that in the 1998 and 2003 waves, about 54% of firms gave guarantees to receive bank credit. Ono and Uesugi (2009) employs data from the Survey of the Financial Environment conducted by the Small and Medium Enterprise Agency of Japan in October 2002. They document that the use of collateral and guarantees are 71.7% and 66.7%, respectively. Calcagnini et al. (2014) uses information on loans from a large sample of Italian non-financial firms and document that about 40% the total number of loans were secured with a guarantee. Peltoniemi and Vieru (2013) uses a Finnish confidential contract-level corporate loan database to document that personal guarantees are used in about 30% of the loans. Davydenko and Franks (2008) studies incidents of corporate bankruptcies, and find that French banks are very likely to activate the entrepreneur's guarantees with about 35% of total collateral comprising of guarantees at default. In Spain, CEET (2010) shows that about 80% of SMEs are required to offer some form of collateral when applying for a bank loan, and about 35% of collateral is made up of guarantees. Carroll et al. (2015) uses data from the Irish Department of Finance SME Credit Demand Survey and finds that the probability of guarantee usage is decreasing in number of employees, turnover, age and profitability. They also provide strong evidence on the complementarity between guarantees and real estate collateral: "For loans without any specific collateral item attached, personal guarantee usage is 29% whereas for firms that post a specific security such as land, property, machinery or other assets, personal guarantee usage is 59%" (p. 2).

Table B4: **Cross-country Comparison of Personal Guarantees**

Country	Paper	Use of PGs	Notes
Australia	Connolly et al. (2015)	>UK/US	as a % of new SME loans
Ireland	Carroll et al. (2015)	33%	as a % of new SME loans
Japan	Ono and Uesugi (2009)	67%	as a % of new SME loans
Italy	Calcagnini et al. (2014)	40%	as % of number of new loans
Finland	Peltoniemi and Vieru (2013)	30%	as % of number of new loans
France	Davydenko and Franks (2008)	35%	value at default as % of total collateral
Spain	CEET (2010)	30-45%	as a % of new SME loans
UK	BoE	29%	as a % of new SME loans
	Franks and Sussman (2005)	50-60%	as % of loans to distressed companies
USA	Bathala et al. (2006)	53%	as a % of new SME loans
	Meisenzahl (2014)	54%	as a % of new SME loans

Notes: The Table provides a summary of the results from the recent empirical literature. The %-values typically capture the share of the number of loans at origination that are secured by a personal guarantee of a company director. The exception is Davydenko and Franks (2008) that focuses on firms with loan exposure at default.

The international prevalence on the use of personal assets as collateral is tempered by some institutional differences with the UK. For example, Davydenko and Franks (2008) studies corporate bankruptcies in Europe and finds that the direct use of residential and commercial real estate collateral is similar in the UK and Germany, but it is much less prevalent in France where the bankruptcy code is less creditor friendly so that recovery rates from real estate collateral is much lower (and often zero). As a result, guarantees are the most often-used collateral in France, which in default can be realised directly by the bank. In the US, the prevalence of personal guarantees among SMEs documented above means that default of these firms typically result both in personal and corporate bankruptcy procedures (Agarwal et al., 2005). While corporate bankruptcy law is fairly homogeneous in the US, there is large heterogeneity in personal bankruptcy law across US states (Gropp et al., 1997). This implies that the use of personal guarantees in the US is largely driven by the exact treatment of personal bankruptcy code in the given state, and states with more lenient personal bankruptcy laws are associated with reduced corporate credit supply (White, 2016). Homestead laws in some US states, that limit creditor's access to assets not explicitly pledged, also tighten the distinction between unsecured guarantees and the direct pledging of personal assets as collateral.

An additional issue pertains to the degree of complementarity among different means of financing as well as bank monitoring. The empirical evidence suggests that personal guarantees and business collateral are strong substitutes (Avery et al., 1998). Interesting heterogeneity remains in terms of whether guarantees and real estate collateral substitute or complement bank monitoring. Jimenez et al. (2006) found evidence in Spain for substitutability, as banks with a lower level of expertise in small business lending use collateral and guarantees more intensively. In contrast, Ono and Uesugi (2009) shows that in Japan, where firms tend to have multiple bank relationships, there is a free rider problem in that neither bank has the incentive to monitor the firm. This problem is mitigated by

a bank taking collateral which makes the given bank's loan senior to other creditors' claims, giving rise to complementarity between collateral and monitoring. We investigate this issue in the context of the UK in a separate paper (Anderson et al., 2018).

B.3 Asset valuations

This section provides further information on how banks value property when it is used as collateral. These results draw on the Bank of England's 2015 survey of UK SME and Mid-Corporate Lending, introduced in Section I of the main text. As shown in Table B5, banks value property used as collateral in 98% of cases. The valuation is professional 90% of the time: an independent surveyor visits the property and reports the value back to the bank. In other cases, the bank values the property internally: for instance, the credit analyst uses information on the most recent transaction value of the property.

This survey is skewed towards lending relationships involving larger loans, where at least £250 thousand is being borrowed, so the fixed cost of a surveyor may be less relevant. This may lead us to overstate the reliance on professional vs internal valuations. Furthermore, the survey results refer to any property, not just residential real estate. Nonetheless, as discussed in Section I of the main text, at a minimum, a credit analyst will consult public information on the value of a property, and perform a credit check on the mortgages held against it, when a residential property is pledged as security or listed on a statement of means.

Once a loan has been issued, creditors also typically revalue the property if the loan terms are adjusted. The Bank of England survey reveals that if a bank holds property as collateral, and the total credit exposure to a company has increased in the last two years, then the property was valued within two years of the last set of accounts in 70% of cases (see Table B6).

The Bank of England survey does not contain information on the valuations themselves. The UK Survey of SME Finance, also introduced in Section I of the main text, does, however.[62] Using this we can compute an implicit loan-to-value (LTV) ratio: loans that are uniquely secured by a guarantee or residential real estate have a median LTV of 65%. This is identical to the median LTV of other loans, suggesting no meaningful difference in pledgeability.

[62] We use the question *"What was the value of this security when the loan/mortgage was obtained?"*.

Table B5: **Property Valuation Method When Property Secures Bank Lending**

	Valuation Method
Professional Valuation	90%
Internal Bank Valuation	4%
Other	4%
N/A	2%

Notes: The Table presents the results of 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 £250k, and whose annual revenue was no more than £500million. To facilitate comparison with our regression results we exclude lending to firms in mining and quarrying, construction, financial and insurance activities, and commercial real estate sectors. We further restrict the sample to limited liability companies that are not subsidiaries in Scotland, England, and Wales. We reweight the sample to correct for some oversampling of certain loan types by the Bank of England that was done for regulatory purposes. The Table shows the method of the latest property valuation when the bank holds property as collateral.

Table B6: **Frequency of Property Valuation When Credit Exposure Increases**

	Fraction of Lending Relationships With Property Collateral Revalued Within X Years
Last 2 Years	70%
Last 3 Years	81%
Last 4 Years	87%
Last 5 Years	89%

Notes: The Table presents the results of 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 £250k, and whose annual revenue was no more than £500million. To facilitate comparison with our regression results we exclude lending to firms in mining and quarrying, construction, financial and insurance activities, and commercial real estate sectors. We further restrict the sample to limited liability companies that are not subsidiaries in Scotland, England, and Wales. We reweight the sample to correct for some oversampling of certain loan types by the Bank of England that was done for regulatory purposes. The Table rows show the fraction of bank-business lending relationships to have revalued property within the given number of years of the firm's most recent accounts, when the bank holds property as collateral, and the credit exposure to the business has increased in the last two years.

C UK Accounting Data

C.1 Firm Reporting Rules in the United Kingdom

The statutory reporting requirements for firms registered in the United Kingdom are mainly governed by the Companies Act 2006 and prior to that the Companies Act 1985. The last provisions of the Companies Act 2006 came into force on 1 October 2009. This means that firms in the United Kingdom used varying reporting standards during our sample period, with the most relevant change in standards for our purposes being the treatment of director's addresses which is discussed in detail below. The Act covers private and public limited companies. Other types of companies, for instance Partnerships or LLPs, are covered by separate legislation but have their own reporting standards and still must file accounts to the registrar. As described below, these are omitted from our analysis to ensure a consistent legal basis for the type of firm under consideration.

Companies House is the Registrar of companies in the UK. The agency has the responsibility for examining and storing all the statutory information that companies in the UK are required to supply. Companies House also has the responsibility to make the filed information public. There are, however, some exceptions to what a firm (or individuals that run or exert significant control over a firm) have to make publicly available. While Companies House filings often go hand in hand with firm tax returns (annual accounts can be filed jointly with a tax return), the information held by the Registrar is not directly used for the purposes of calculating corporation tax. Tax returns by firms are dealt with separately by Her Majesty's Revenue and Customs, the United Kingdom Tax Authority.

Reporting Requirements At the end of a firm's fiscal year the firm must prepare a set of statutory annual accounts that they file with Companies House. These include a version of the firm's balance sheet and profit and loss account. All limited firms are required to report in one way or another to Companies House. However, reporting requirements, particularly over the annual accounts, vary by firm size (see part 1 of the Companies House guide for additional details).

Companies House must also be informed of the firm's name, registered office, share capital and charges against the firm's assets for the purposes of securing a loan. Firms must also maintain, *inter alia*, a register of directors (including the director's usual residential address). If any of these details change the firm must inform Companies House via an event driven filing. Key for our purposes is the information on directors' usual residential addresses. One of the last provisions to be implemented in the Companies Act 2006, on 1 October 2009, allowed firm directors the right to only publicly disclose a service address rather than a usual residential address (although directors are still required to report their residential address to Companies House). In Online Appendix E.3.2 we show that this change in the law does not have a meaningful impact on our results.

Time Lags Firms have 21 months from incorporation to file their first set of accounts with Companies House. Subsequent annual accounts must be filed within 9 months of the firms fiscal year end for private firms and 6 months of the firm's year end for public companies. Firms can amend the accounts retrospectively to fix errors and present data revisions. Firms can also amend the end of their accounting year (but not retroactively), which can lead to irregular accounting windows of lengths different than a year. However, firms must file accounts every 18 months.

Event driven Companies House filings have shorter time lags. For instance, all appointments, changes to personal details and cessations of a firm's directors should be reported to Companies House within 14 days of the changes being made.

C.2 BvD's Collection and Coverage of Firms in the United Kingdom

Companies House is the original source of our data but our direct source is Bureau van Dijk (BvD) who aggregate the data and provides a workable interface to access it. For the United Kingdom and the Republic of Ireland, BvD provides firm-level data through a product called FAME (Financial Analysis Made Easy). This is distinct from the more commonly used Amadeus and Orbis products provided by BvD which cover firms at the European and Global level, respectively (although UK firms form a subset in both data sets).

BvD does not source its data from Companies House directly. In between Companies House and BvD is another data provider, Jordans, with whom we have no direct contact. Jordans serve as the direct source for BvD. In the FAME user guide, BvD describes the logistics of the data collection procedure as follows:

Once accounts are filed at Companies House they are processed and checked, put onto microfiche and made available to the public. Companies House aim for a turnaround time of 7-14 days, however this will increase at peak times (October).

Jordans collect data from Companies House daily and transfer it from microfiche to their database with a turnaround time of 3-5 days. This may take longer at peak times of the year (October) and also if figures appear to be incorrect and need to be rechecked with Companies House.

Bureau van Dijk collect data from Jordans on a weekly basis and create the appropriate search indexes to link with the FAME search software. These indexes are then tested and published to the internet server within 48 hours of receiving the data.

In theory, this time frame would imply that most live companies in the BvD database would have their latest accounts filed within the past year (9 months after the firm's financial year plus one-two months of processing time) but lags of two years are not uncommon. Given that lags can occur at four different stages (the filing stage and the three processing stages that follow), we have not been able to determine the root cause of this.

There are four sub-databases in FAME (A, B, C and D) which are ordered by the size of the firm as determined by different thresholds in their accounts (e.g. balance sheet size). We have access to

and use data from all four databases to achieve the widest possible coverage.

There is conflicting information regarding how long inactive companies remain in the FAME database. When the Bank of England contacted BvD regarding this issue, BvD's claim was that Jordans (their data provider) would only keep inactive companies in the database for five years, so those firms would be lost from the source material. However, BvD would then (on a quarterly cycle) re-upload the missing companies from their own archives ensuring that no data lost from FAME or their other products. However, this claim may not be accurate. From inspecting different vintages of the FAME data set it seemed that firms did exit the database. For instance, almost 50% of firms in the database in January 2005 were not present 10 years later. Furthermore, some 3 million companies left the database between 2013 and 2014. We discuss this issue in more detail below.

C.3 Treatment of the BvD UK Accounting Data

C.3.1 The Sample of BvD Vintages Used

The Bank of England received DVDs and later Blu-Ray discs from BvD on a monthly basis. These discs contained a snapshot of the FAME database for UK firms during the month in question. We refer to these discs as different vintages of the database. From month to month, the database is updated both as firms filed new annual accounts and as firms conducted event driven filings with Companies House (such as form CH01 which is used to notify Companies House of a change in the details of a firm's directors). However, for the majority of firms there is no change from one month to the next as no new filings take place.

Our general principle was to sample these discs at a six monthly frequency. We did not pursue a higher frequency as the cost in terms of the amount of time needed to process each disc and the capacity required to store the information was excessive given how little additional information would be gained. The recorded information for an individual firm does not change so frequently as to require multiple observations within a six month period. In principle, since accounts are typically filed on an annual basis, we could have also sampled the discs annually and still have guaranteed that for any given firm, all the annual accounts filed over our sample period would have appeared as the most recent observation in at least one of the sampled discs. However, we chose biannual sampling for two reasons. First, firms can occasionally have irregular filing periods, if a firm changes its financial year end date, and file twice within a year. Second, as described above, director and other firm information can change outside of accounting periods. These are so-called event driven filings (e.g. when a director moves house). By sampling discs at a biannual frequency we are less likely to have event driven filings causing a deviation between the non-accounting information accurate as of when the disc was produced and the accounting information that is accurate as of the account filing date.

Over the course of the past decade some of the Bank of England's discs have been lost or become damaged so we are not able to pick the same months in every year to conduct our sampling. We chose the last available monthly disc in each half of the year - i.e. June and December are our preferred

discs for any given year. If either June or December were not available we substitute in May or November etc. If no disc was available in a half year (for instance, if there are no discs available between January and June) we would use the next available disc in the following half of the year. The complete list of discs used is below:

January 2005, December 2005, June 2006, December 2006, May 2007, December 2007, June 2008, December 2008, May 2009, December 2009, June 2010, September 2010, September 2011, December 2011, April 2012, November 2012, August 2013, December 2013, June 2014, September 2014, August 2015.

C.3.2 Download Strategy

We focus on companies that have either a registered office or primary trading address in England, Wales or Scotland. We exclude Northern Ireland from our sample as the Province lacks some of the necessary property price data. Our downloads were conducted in regional blocks within each vintage and we extracted data for both active and inactive companies. All the data we use is denominated in GBP. The discs have an inbuilt panel structure in the sense that it is possible to download up to 10 years of historical observations for a firm in each vintage of the database. We exploited this by downloading the most recent observation for each firm and two years of lags for vintages in the middle of our sample. For the first vintage (January 2005) in the sample we downloaded five years of lagged data (ten years in the case of Land and Buildings data) to add additional historical coverage. For the final vintage, August 2015, we downloaded the full 10 years of data in order to evaluate the benefits of using the archived vintages versus a single snapshot of the database.

C.4 Merging the Discs into a Combined Firm Panel

Each firm in the UK is assigned a unique Companies House Registration Number (CRN) upon formation which stays with the firm throughout its lifetime. The CRN may change if Companies House chooses to adopt a new numbering format (see Section 1066 of the Companies Act 2006). Fortunately this did not happen over our sample period thus we use the CRN as an identifier to determine the same firms across different vintages of FAME. This allows us to build a firm-level panel using information across all vintages. The benefits the merged panel structure brings over a single vintage with 10 lags of data in terms of firm coverage and reporting of variables is set out following the explanation of the firm panel construction.

Information held on firm directors across all the discs is separately combined to form a panel of director characteristics, as discussed in Online Appendix D. The firm and director panels are then merged for the regression analysis.

C.4.1 Treatment of the First Vintage

In the first vintage (January 2005), we use the additional lagged accounting information to generate historical observations of the firm accounts. The dates of historical accounts are generated using the "Statement Date" of the latest set of accounts and the "Number of Months" covered by the accounting period (12 months in the vast majority of cases) to iterate backwards. For young firms, this process can generate purported accounting periods before the firm was born. To correct for this, all generated historical observations where the "Incorporation Date" is after the statement date are dropped.

As discussed above, information on firm directors can change outside of accounting periods, for example if a new director is appointed to the firm or if they move house. To determine which of the directors present at the firm in January 2005 were present in the firm at the time of the generated historical accounts, we use the "Director Appointment Date". We retain directors for all generated historical accounts whose statement date is before the director's appointment date. To account for directors who may have moved house since the time of the historical accounts and January 2005, we use information on the transaction dates of the addresses listed with BvD, through merging to the property transactions databases of the Land Registry (for England and Wales) and Registers of Scotland (for Scotland), as discussed in detail in Online Appendix E. Information on the director's address is taken to be correct historically for historical accounts whose statement date is after the most recent transaction of the director's property prior to January 2005, at which date it is inferred that they bought their house.

C.4.2 Treatment of Multiple Observations on the Same Firm Accounts

Since we sample from BvD at a biannual frequency, the same set of firm accounts frequently appear in multiple different BvD vintages (up to a maximum of 21 observations on the same accounts). The next step in the formation of the merged panel is to bring together these multiple observations on the same set of accounts. At this point the data set is restricted to companies that report the statement date of their accounts, allowing a given set of firm accounts to be uniquely identified using the CRN and statement date. The data is broken up into three groups that are treated differently, summarised by the following three paragraphs.

Variables Never Revised by Later Data As discussed above, information on directors is event-driven, and can change outside of firm accounting periods. To ensure accuracy, for all director variables, we retain information from the earliest vintage where the accounts are filed. In particular, we omit information on directors appointed after the vintage when the accounts were first published. Multiple trading addresses listed by the firm are treated in the same manner.

Variables Only Revised by Later Data When Initially Missing A small number of other variables such as the "Company Status" and the "Primary Sic Code" (the primary industry to which the firm belongs) can be changed independently of the firm accounts but take a unique value per firm at a given point in time, and are less likely to change over time. For these variables information is used from the earliest vintage in which the accounts appear. However, in contrast to director information, as these variables are less likely to change over time, the initial observations on a variable are replaced with subsequent observations if it is initially missing. Table C1 provides a stylised example of this for variables with and without missing data. This treatment also covers lagged accounting information by vintage.

Table C1: **Treatment of Duplicate Accounts I**

Variables *Only* Revised When Missing

Firm	BvD Vintage	Account Date	Variable X	Variable Y
1	A	31/03/2006	x_A	
1	B	31/03/2006	x_B	y_B
1	C	31/03/2006	x_C	y_C

Resolved Accounts

Firm	BvD Vintage	Account Date	Variable X	Variable Y
1	n.a.	31/03/2006	x_A	y_B

Variables Always Revised by Later Data Unless Subsequently Missing The remaining data are accounting variables such as "Land and Buildings" and "Number of Employees" that are specific to the accounting period in question. Firms revise their historical accounts over time and using the panel structure such revisions are captured. The general principle is to use the latest data on the firm's accounting period for these variables, capturing improvements made to the accounts from subsequently filed revisions. Sometimes these data revisions are only filed for the variables that have changed, which can result in missing values on non-revised variables in later discs. To circumvent this problem, the latest non-missing data is taken for this group of variables. Table C2 provides an example of this, for variables with and without missing data. As with the prior group of variables the treatment here is also applied to lagged accounting information.

Table C2: **Treatment of Duplicate Accounts II**

Variables Revised *Unless* Missing

Firm	BvD Vintage	Account Date	Variable W	Variable Z
1	A	31/03/2006	w_A	z_A
1	B	31/03/2006	w_B	z_B
1	C	31/03/2006	w_C	

Resolved Accounts

Firm	BvD Vintage	Account Date	Variable X	Variable Y
1	n.a.	31/03/2006	w_C	z_B

C.4.3 Treatment of Downloaded Lagged Accounting Information

Following the data harmonisation in the prior step, for each firm statement date there is a unique observation for every variable. This includes the current value of accounting variables at each statement date, as well as two years of lagged accounts. The next step combines this lagged accounting data with data from previous accounts, to incorporate revised accounting data. The first step is to identify and treat missing accounts.

Identifying and Treating Missing Accounts The firm data is set to panel form using the firm CRN and "Statement Date" of accounts. Before harmonising lagged accounting data with previous accounts it is determined if any firm account observations are missing. Using the "Statement Date" and "Number of Months" variables (length of the accounting period) it is determined if successive accounts are the correct number of months apart. Prior to treatment, 97.8% of firm observations have no accounts missing, with 1.8% having one set of accounts missing and 0.1% having two accounts missing. Accounts are generated where missing accounts are identified (up to four missing accounts), with the statement date set as the "Statement Date" of the subsequent accounts less the "Number of Months" in the accounting period associated with that statement date (taking the last day of the month in question). For the generated accounts, variables without lagged accounting data are assumed to take the same value as at the first statement date after the missing accounts. Following this treatment, 99.81% of firm observations have no accounts missing. As with the treatment for the first vintage, observations on firm directors appointed after the "Statement Date" for the generated accounts are removed. Variables with lagged accounting data are treated for the missing accounts in the same way as for the rest of the data set, as discussed next.

Harmonisation of Accounting Data. As accounting data can be revised, our general principle is to use the latest available non-missing data. A stylised set of accounts are presented in Table C3. When there are no accounts missing for a firm and accounting data has not been revised, the diagonal entries in the table will be the same. Thus, for example, the current value of variable x in

the 2006 accounts will be the same as the first lag of x in the 2007 accounts, which will in turn be the same as the second lag of x in the 2008 accounts: $x_{C,2006} = x_{L1,2007} = x_{L2,2008}$. Where accounting revisions occur these values will differ.

Table C3: **Treatment of Lagged Accounting Information**

Firm	Account Date	No. Months	Variable X, Current	Variable X, Lag 1	Variable X, Lag 2
1	31/03/2006	12	$x_{C,2006}$	$x_{L1,2006}$	$x_{L2,2006}$
1	31/03/2007	12	$x_{C,2007}$	$x_{L1,2007}$	$x_{L2,2007}$
1	31/03/2008	12	$x_{C,2008}$	$x_{L1,2008}$	$x_{L2,2008}$
1	31/03/2009	12	$x_{C,2009}$	$x_{L1,2009}$	

Resolved Accounts

Firm	Account Date	No. Months	Variable X, Current	Variable X, Lag 1	Variable X, Lag 2
1	31/03/2006	12	$x_{L2,2008}$	n.a.	n.a.
1	31/03/2007	12	$x_{L1,2008}$	n.a.	n.a.
1	31/03/2008	12	$x_{L1,2009}$	n.a.	n.a.
1	31/03/2009	12	$x_{C,2009}$	n.a.	n.a.

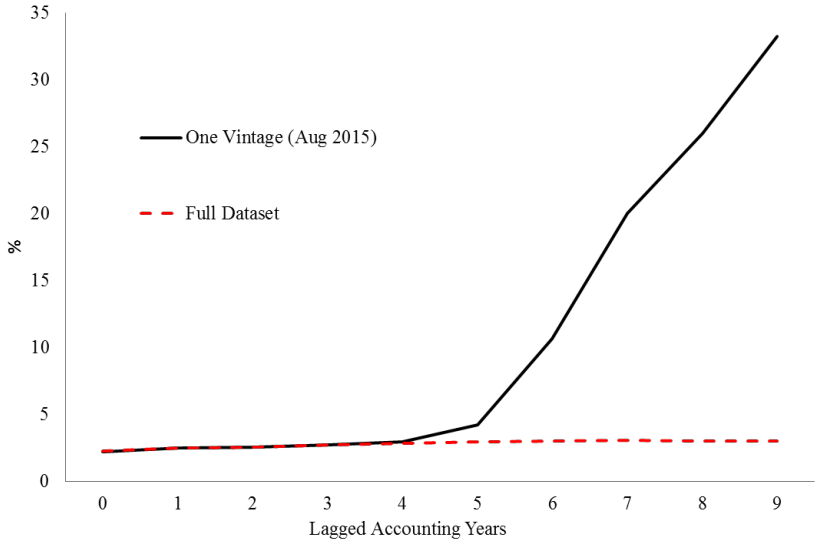
Consider the 2006 accounts in Table C3. No accounts are missed for the subsequent two accounts between the 2006 accounts and the two that follow (with the time between accounts equal to the number of months covered by each of the accounts that follow) so the current data, $x_{C,2006}$, and the elements running down the diagonal of the table, $x_{L1,2007}$ and $x_{L2,2008}$ refer to the same accounting variable over the same time period. In the first instance, the twice lagged accounts from two periods ahead are used to update variable x as this is non-missing. Thus, in the resolved accounts shown below (for 2007, 2008 only), the value is $x_{L2,2008}$ (which may or may not differ from $x_{C,2006}$). Contrast this with the 2007 accounts. In this case, the twice lagged accounts from two periods ahead has a missing value for x. Further, the latest available non-missing data is the lagged accounts from one period ahead, and so the resolved value for x in the 2007 accounts is $x_{L1,2008}$. With all accounting variables treated in this way the first and second lags in the accounts are dropped, leaving only the current value of x at the accounting date, as shown in the resolved accounts.

C.4.4 Enhancement of Data Coverage Through Combining Vintages

The final combined panel of firms, comprised of companies with non-missing statement dates, contains 28.9 million firm-account observations, with 4.8 million unique firms. The combination of data across several vintages has significant advantages over data extracted from a single vintage:

- First, and most straightforwardly, with a maximum of 10 sets of accounts being accessible from a given vintage, by using multiple historical discs, a greater time period can be covered.
- Second, even within the time period covered by the 10 lagged accounts, our merged dataset brings significant benefits in terms of coverage of the accounting information firms report. To

Figure C1: **Proportion of Observations with Total Assets Missing**

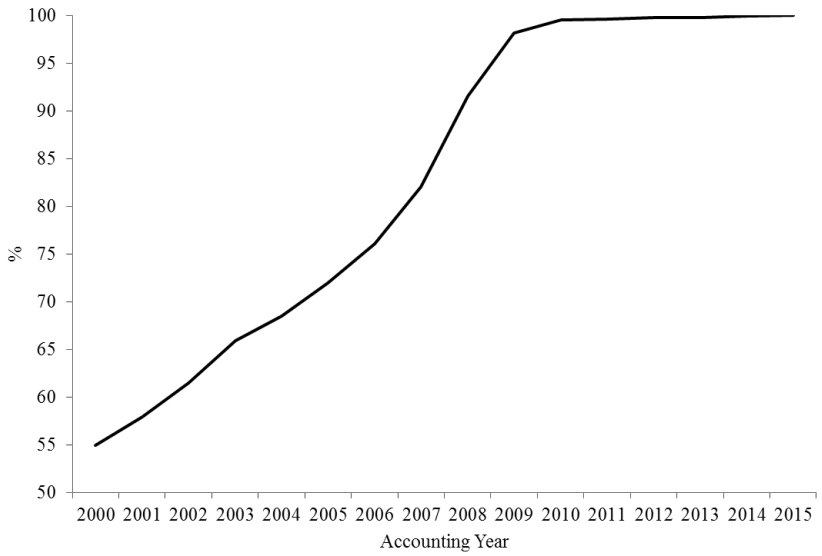


Notes: The Figure displays the proportion of total assets missing among companies with a non-missing statement date. *One vintage* refers to the 10 lagged accounts downloaded for the companies present in the August 2015 vintage. *Full dataset* refers to the final panel of firms produced from the 21 vintages from 2005 to 2015, as described above, covering the same period.

demonstrate this, we downloaded 10 accounts for each firm from the August 2015 vintage and compared the value of firm's "Total Assets", a particularly well-reported variable, to the same variable over the same set of 10 accounts using the data as created from the our combined dataset using all 21 vintages. The proportion of observations for which "Total assets" are missing from each data set is shown in Figure C1. Using the combined dataset, "Total Assets" is consistently well-reported, as shown in red, with data missing for only around 3% of firm observations throughout the sample. Data downloaded only from the 2015 vintage has similar coverage of "Total Assets" for the first five accounts, before dropping off substantially, with around a third of observations missing this data by the final lagged accounts.

- Third, the combined dataset has significantly greater coverage of firms. Figure C2 displays the proportion of companies present in each accounting year in our combined dataset that are still present in the August 2015 vintage. Only 55% of the companies that filed accounts in 2000 are still present in the August 2015 vintage. Note, this is not the requirement that the firm *accounts* from 2000 are present in the 2015 vintage, only that information on the *firm* itself is still present. The difference in asset reporting in Figure C1 is driven largely by firms exiting the database before the 2015 vintage. Indeed, 94% of the firm observations where "Total Assets" is reported in the full panel but not from the 2015 vintage have had their "Company Status" become no longer *Live* at the a date prior to 2015.

Figure C2: **Fraction of Firms Present in August 2015 vintage**



Notes: The Figure displays the proportion of firms in each statement year, as derived from the full set of 21 vintages, that are present in the August 2015 vintage.

C.5 Sample Selection

Our key sample selection criteria are articulated in the main text; for completeness here we describe the conditions under which companies and observations can enter our sample.

- We restrict our sample to only include limited liability, for profit companies to which the Companies Act applies. Specifically, we include "Private Limited", "Public AIM", "Public Quoted", "Public Not Quoted". This information is contained in the "Legal Form" field in the FAME database.

- For a firm-year observation to be included, the firm must have had a "Company Status" of *Live* when the accounts were first filed.

- We exclude firms in certain industries based on the "Primary UK SIC code" field in the FAME database which is available for the 2003 UK Standard Industrial Classification (SIC) codes for all the discs used in our sample. We exclude from the sample firms operating in utilities (2003-SIC: 4011-4100), construction (2003-SIC: 4511-4550), finance and insurance (2003-SIC: 6511-6720), real estate (2003-SIC: 7011-7032), public administration (2003-SIC: 7511-7530), and mining (2003-SIC: 1010-1450). Firms occasionally switch industry; we take the modal value across the firm's observations and resolve ties in favour of the highest number to assign a firm to the same industry for the complete sample.

- We exclude companies that have a parent or are part of a group. Our criteria for doing so is whether the firm reports an ultimate owning company on FAME. Those that do not report

an ultimate owner company or whose ultimate owning company name is the same as the firm name remain in the sample. Crucially, the ownership information in FAME is only accurate as of the vintage of the database. There is no historical information within FAME about whether or not a firm had an ultimate owner. The use of historical vintages of the database allows us to circumvent this issue. As with director information, we always take data on ownership from the earliest vintage available after a company has filed its annual accounts.

- As our empirical analysis relies upon a mix of flows, stocks and changes in stocks, we exclude observations where the accounting period is irregular, e.g. if the firm filed two sets of accounts within a year. Specifically, we use the BvD field "Number of Months Since Last Accounts" and exclude observations where this is not equal to 12 months. Observations where there is no information on the filing date are excluded.

- We exclude companies where no information on the firm's location is recorded. That is to say the "R/O Address", "Primary Trading Address", and the first "Trading Address" fields are all missing.

C.6 Comparison To The Aggregate

This section analyses how representative our regression sample is of UK private sector firms. Table C4 compares the industry coverage of firms in our sample with that of the aggregate, across eight broad industrial groupings.[63] The first two columns show that the proportion of firms in each industrial grouping is similar in the two datasets. Relative to the aggregate, our sample has more manufacturing firms. However, as shown in Table 6, the response of investment to director real estate is similar for manufacturing and non-manufacturing firms. The remaining columns show the respective shares of investment, turnover, and employment by each of the industrial groupings in the aggregate, and in our sample. As with the number of firms, the industrial splits are broadly similar in our sample and the aggregate, again with an over-weighting of manufacturing in our sample.

[63] The industries excluded from our regression sample are omitted.

Table C4: **Industry Distribution**

	No. Firms		Investment		Turnover		Employment	
Industry	Agg.	Sample	Agg.	Sample	Agg.	Sample	Agg.	Sample
Agriculture, Forestry & Fishing	5.1%	1.4%	0.4%	0.4%	1.1%	0.5%	1.7%	1.0%
Manufacturing	8.3%	30.8%	16.7%	44.9%	19.3%	36.0%	13.3%	29.0%
Wholesale & Retail	22.7%	28.4%	19.4%	26.0%	43.6%	36.3%	25.6%	27.7%
Hotels & Restaurants	11.9%	4.9%	5.7%	1.7%	2.8%	4.7%	11.0%	14.3%
Transport, Tele,. & Oth. Bus.	35.8%	25.6%	41.5%	23.1%	26.2%	18.7%	34.1%	24.5%
Education	1.7%	0.5%	6.6%	0.1%	0.5%	0.0%	1.6%	0.1%
Health & Social Work	5.8%	1.9%	3.9%	0.5%	2.1%	0.2%	7.9%	0.8%
Community, Arts & Recreation	8.6%	6.5%	5.8%	3.2%	4.4%	3.6%	4.8%	2.5%
All	100%	100%	100%	100%	100%	100%	100%	100%

Notes: The Table shows the industrial distribution of our baseline regression sample, and the aggregate, both by number of firms, and contributions to total investment, turnover, and employment. The aggregate data is for 2014, and is restricted to the industries in our regression sample (see Online Appendix C.5), and firms with at least 1 employee. The first two columns show the proportion of firms in each industry, both in the aggregate, and our sample. The next two columns show, respectively, the share of aggregate investment by industry, and the share of total investment in our regression sample by each industry. The remaining columns repeat this for turnover and employment. Aggregate data on the number of firms, employment, and turnover shares comes from The *Business Population Estimates For The UK And Regions.* The aggregate data on investment (defined as "Total Net Capital Expenditure") comes from the *Office For National Statistic's Annual Business Survey.*

Table 3 in the main text shows the size distribution of firms in our sample, and in the aggregate. As shown by the first two columns, our regression under-samples smaller enterprises. Specifically, whilst over 80% of firms have less than 10 employees, only 5% of our sample is covered by small firms. Rather, our sample is dominated by small and medium-sized businesses, as opposed to these micro firms. Turning to the third column of Table 3, we see that, whilst only 5% of our sample is covered by firms with less than 10 employees, this group of firms account for around 15% of aggregate investment. Similarly, we underweight large firms relative to their aggregate contribution: they comprise a quarter of our sample, but account for over half of aggregate investment. The last two columns of Table 3 show similar patterns when considering the shares of aggregate turnover and employment. To correct for this, in Online Appendix A.9 we run weighted regressions, which ensures that the weight on firm size groups in our sample matches their contribution to aggregate investment, turnover, and employment, and find similar results to our baseline estimate.

D Director Characteristics

D.1 Construction of the Firm Director Panel

D.1.1 Treatment of Directors Within BvD Vintages

To form the panel of director characteristics, we first extract information on all directors contained in each of the 21 vintages of BvD. Key fields on the personal characteristics are the directors' "Director Full Name" , "Director Surname", "Director Title", "Date of Birth", "Full Address", "Director Full Postcode", "Director Nationality", and "Director Gender".[64] We also collect information on the firms the director is associated with on each date, including its "Registered Number" (CRN, the firm identifier), and the "Director Appointment Date" and "Director Resignation Date" (if applicable) of all roles that the director held at the firm (note that directors sometimes resign and are then reappointed). There can be multiple firm observations for the same director at a given point in time, reflecting their roles at multiple different companies.

Within each vintage, we then clean the data in the following fashion:

- We exclude directors who are firms. Under the Companies Act, every firm must have at least one director who is a natural person; however, the firm may also have additional directors who are themselves firms (director-firms). For instance, an accountancy firm may sit on the board of directors. Including such entities makes no sense from the point of view of our research question. In the earlier vintages of BvD there is not a variable that flags whether a director is a firm or an individual. Instead, we identify director-firms as those whose full name/surname is recorded but the date of birth and first name/initial is missing (as neither of these fields are recorded for directors who are firms but are required for directors who are individuals). As a further measure, we flag director-firms as those whose "Director Full Name" includes one of over 35 common expressions for a firm name such as "Limited", "LTD", "Accountants", "Secretaries" and "Corporation". In the latter vintages of the database there is a variable which explicitly flags whether a director is an individual or a firm ("Director Individual or Company"). Testing against this variable we find that our method for identifying whether a director is an individual or a firm is accurate in over 99.99% of cases. Given this accuracy, for consistency over time, we use the method for flagging director-firms based on missing date of birth and initial throughout the data set.

- All but the first three vintages used (the two in 2005 and the first in 2006) have a variable indicating whether an individual is male or female. For the first three discs, we impute the director's gender using different information. We first use the "Director Title" (e.g. Mr or Mrs) to assign genders. However, some titles are gender-neutral, such as Dr. For these individuals,

[64] For some vintages we only observe "Director Initial"/"Director First Name" and "Director Surname".

the gender is assigned based on the 1000 most popular male and female baby names from the 1970s (to match common ages of the directors by the time of the discs).

- The information on director nationality is condensed into an indicator of whether the director is from the U.K. or not. This includes corrections for a number of different potential spellings that occur, including "UK", "United Kingdom", as well as the countries that make up the UK.

D.1.2 Forming the Director Identification Key

We then combine the information from the 21 vintages of BvD together by generating a key to identify the same individual, both through vintages, and across different companies at a given point in time. Our identification key is formed for individuals based on their first initial, surname, and date of birth. We have sufficient information to compute this key in every BvD vintage we use. We then take the following steps to clean the variables that enter the key:

- The "Director Surname" string is cleaned to remove any prefixes, suffixes, initials and titles that are on occasion mistakenly included in the surname field.

- "Date of Birth" is present in 92% of cases, allowing this form of identification key to be computed for the majority of individuals. In some of the missing cases, the date of birth can be imputed based on repeat observations on an individual at the same company. Specifically, we assume that surname and initial are sufficient to identify an individual *within* a company. With multiple observations on the same director in the same company over time, it is possible that the individual's date of birth is present in some vintages and absent in others. In such cases, the missing date of birth is imputed, so long as the initial and last name are associated with a unique date of birth within the company over time. The date of birth is missing for the remaining group of individuals. However, if their initials and surname are associated with a unique company across all the discs, this is assumed sufficient to uniquely identify them. The individuals that don't fall into these groups (around 5% of the sample) cannot be uniquely identified across companies and over time and are dropped.

Note that on this basis there are 9.7 million unique surname/initial/date of birth combinations. We cannot guarantee that our key identifies every director uniquely, particularly for individuals with common surnames. However, since the population of directors is smaller compared to the country as a whole, collision probabilities are sufficiently low not to introduce meaningful measurement error into our analysis.

D.1.3 Cleaning Across Discs

There can be observations on the same director across their roles in multiple firms or in multiple roles within firms. We use these multiple observations to fill in missing data and correct for inaccuracies

of the data. For the director gender and whether the individual is foreign, we take the modal value across all observations on the individual, with ties resolved in favour of the dominant category in the population (male and U.K. national, respectively). This unique value is then used to fill any missing observations for the individual.

With individuals uniquely identified and their personal characteristics cleaned, the next step is to extract information on the positions held at each firm. The unit of observation now is an individual's role at a given company. These roles are identified based on the Companies House number of the firm, the director identification key, and their appointment and resignation dates at the firm. Several cleaning steps are performed to produce these groups.

- There are a very small number of observations (0.09%) where the appointment date is later in time than the resignation date. From comparing these observations to the Companies House website, it appears that these are due to mistakes in which resignation or appointment dates are conflated from different times an individual worked at the same company. Such observations are dropped. Observations (1.51%) are also dropped for cases where the individual is appointed to the company on the same day as they resign. From comparison to Companies House, these appear to be genuine cases, and in communication with Companies House it was confirmed that this can occur, if, for example, an individual is appointed only for one day to register the company. These observations are excluded as the focus of this paper is on individuals who have a meaningful role at a company.

- The director appointment date is missing for 0.16% of observations. If the individual has at most one role recorded with the firm in every vintage of BvD, we fill in missing appointment dates with data from other vintages. Following this treatment, the appointment date is only missing for 0.05% of observations. The remaining observations are dropped.

- Companies House first collected data on firm directors during 1991 and 1992. To initialise their database, Companies House took a snapshot of existing directors in the most recently filed company accounts. As historical information on appointment dates was not available, the date was simply taken as the date of the most recent company accounts, many of which would be prior to 1991, given the filing lags. To ensure consistency for such cases, appointment dates prior to 1991 are all coded to the 1st of January 1991. This affects around 2% of observations.

- Resignation dates for the same role are naturally missing for vintages of BvD that predate the resignation. We correct for this using the information from subsequent vintages and build a consistent set of appointment and resignation dates for each role the director has at the company (distinguishing between roles when the director has resigned and is reappointed).

In the dataset, it sometimes turns out that an individual is identified as having multiple directorships in the same company at the same time. Ultimately what is of interest for this paper is whether the

individual has a role with the company at a given point in time, not whether there are multiple such directorships. Further cleaning is used to make these roles as parsimonious as possible, documenting the periods when the individual had a role at the company. Consider two roles held by a director in the same company with respective appointment and resignation dates (a_1, r_1), (a_2, r_2). Three types of categories are treated:

1. Duplicate roles: $a_1 = a_2$, $r_1 = r_2$: this is condensed to a single role from a_1 to r_1.
2. Subset roles: $a_1 \leq a_2,\ r_2 \leq r_1$: this is condensed to a single role from a_1 to r_1.
3. Overlapping roles: $a_1 \leq a_2$, $r_1 \leq r_2$: this is condensed to a single role from a_1 to r_2.

This process is run over all roles from all 21 vintages and repeated several times to condense all the roles, enabling treatment of, for example, three overlapping roles which only overlap in pairs.

The final step is to expand the data set to a monthly panel of director roles. This allows for accurate matching with company accounts data, which can be filed in any month of the year. Each role is expanded to a set of monthly observations, running from the last observation on the role to 24 months prior to the appointment date of the director in the role. With almost all company accounts filed at least every 24 months, this allows a match between the director role and the most recently filed accounts prior to their appointment.

D.1.4 Company Information

We selected a small number of well-reported company variables for the calculation of director characteristics:

- "Company Status:" an indicator of whether the firm is live, or in some other state such as dormant or dissolved.
- "Primary SIC Code": the primary industry classification of the company, based on the 2003 UK Standard Industry Classification.
- "Total Assets": the total assets reported on the firm balance sheet.
- "Incorporation Date:" the date the firm was incorporated and registered with Companies House.

Data on these, and other variables, are taken from each of the 21 BvD vintages sampled and combined into a cleaned panel of firm information, following the same account cleaning procedure as the main firm-level data set.

D.2 Calculation of Director Characteristics

We merge the cleaned company information onto the monthly director panel at the months of the company accounts. This firm-level information is then filled out in the monthly panel for all the dates until the next accounts are due to be published (this due date is not proceeded beyond if the subsequent accounts are missing). Specifically, company variables for all dates between the accounting statement at t and the accounting statement at $t+1$ are filled out with information from the accounting statement at t.

We use the combined monthly panel of director information and company information to calculate a number of different characteristics for individuals at monthly frequency, broken into three groups.

Personal Characteristics

- *Age*: the number of days between the individual's date of birth and filing date, expressed in years.
- *Male*: a dummy variable taking the value 1 when the director is male.
- *Non-UK*: a dummy variable taking the value 1 when the director is not a U.K. national.

Metrics Based on Current Information

- *Current Number Of Roles*: the number of live companies the individual is currently a director of in a given month.
- *Average Company Asset Growth*: the average asset growth taken across all the live companies the individual is currently a director of in a given month.

Measures of Experience A significant limitation of analysing director characteristics using BvD data at a given point in time is that prior experience the individual had can be lost. This is because previous roles individuals held are periodically removed as the BvD data set is updated over time. Using information from 21 different vintages of BvD data circumvents this issue and enables accurate calculation of a number of metrics that summarise the experience individuals have had in all their roles, including those in the past. We calculate a number of measures of experience at monthly frequency:

- *Number Of Roles*: the number of different companies the individual has been a director of. This measure does not double-count two separate periods in which an individual is a director at the same company.
- *Experience*: the amount of time the individual has been a director, calculated across all companies. For each month, this metric counts the number of different live companies the individual

was a director of during that month and sums this over time, expressing the result in years. The treatment of overlapping roles in the same company in the prior section enables an accurate calculation.

- *Average Time Spent at a Firm:* average number of years a director spent at each company, derived from the prior two series.
- *Experience Of Leaving Firms*: the number of different companies the individual has resigned from. As with experience of different companies, resignations from the company at two different points in time are not counted twice.
- *Firms With At Birth*: the number of different companies where the individual was appointed in the same month the company was incorporated.
- *Firms That Have Failed*: the number of different companies the individual has worked for that have died. The death of the company is timed to the statement date of the first set of accounts where the "Company Status" is *dissolved.*
- *Number Of Industries Worked In*: the number of different two digit SIC code industries the individual has worked in.

With these director characteristics calculated, company balance sheet variables and variables specific to an individual's role at a given company are dropped and the unit of observation is compressed from an individual's role in a given company to the individual. This results in a monthly panel, with information on individuals and their characteristics through time. This final data set runs from January 1998 to August 2015, and has just over 1 billion observations.

Measures of Skill We calculate an additional proxy for director skill using the average growth rate in "Total Assets" in *other* firms that director is part of. Specifically, let $\mathcal{F}_d$ be the set of all firms where individual d holds directorships. Further, for firm i, let $\hat{N}_i \geq 0$ be the total number of directors at firm i who also hold directorships in *other* firms. Finally, let $TotalAssets_{f,t}$ be the level of "Total Assets" at firm f at time t. Our skill proxy for firm i is then given by $\frac{1}{\hat{N}_i}\sum_{d=1}^{\hat{N}_i}\frac{1}{\left|\mathcal{F}_{d\setminus\{i\}}\right|}\sum_{f\in\mathcal{F}_d\setminus\{i\}}\left(\frac{\Delta TotalAssets_{f,t}}{TotalAssets_{f,t-1}}\right)$. In words, we take the average asset growth at each director's other companies and then average this at the firm-level. In our baseline regression sample two thirds of firms have at least one director who has a directorship in another company elsewhere in the UK (not necessarily in our regression sample).

D.3 Shareholders

As discussed in the main text, shareholder information is collected by BvD from the firm's annual return (form AR01). BvD then matches the director names to shareholder names to generate a

variable indicating whether the director is a shareholder. We define a director as a shareholder of a given firm if she is listed as such at any point in the sample. This is to abstract from a channel where directors become shareholders as their houses appreciate and they have wealth to inject into the firm. Let S_i denote the set of directors in firm i who are also shareholders. We can define two different measures:

$$Residential\ RE\ shareholders_{i,t} = \frac{|D_i \cap S_i|}{\left|\tilde{D}_i \cap S_i\right|} \sum_{d \in \tilde{D}_i \cap S_i} L^d_{i,2002} L^P_{h_d,t},$$

$$Residential\ RE\ nonshareholders_{i,t} = \frac{|D_i \cap S_i^c|}{\left|\tilde{D}_i \cap S_i^c\right|} \sum_{d \in \tilde{D}_i \cap S_i^c} L^d_{i,2002} L^P_{h_d,t}.$$

These correspond to the total value of residential real estate of directors who and who are not shareholders respectively. If all directors are shareholders ($S_i = D_i$) we recode the latter measure to zero and vice versa if no directors report being shareholders.

D.4 Sources of Variation in *Residential RE*

Recall that *Residential RE* is defined as

$$Residential\ RE_{i,t} = \frac{|D_i|}{\left|\tilde{D}_i\right|} \sum_{d \in \tilde{D}_i} L^d_{i,2002} L^P_{h_d,t}, \tag{D1}$$

This measure has three different sources of variation: (i) the initial value of director homes ($L^d_{i,2002}$); (ii) the evolution of the house price index where the directors live ($L^P_{h_d,t}$), which can be different to their firm ($L^P_{j,t}$); and (iii) the numbers of directors in each firm ($|D_i|$). To assess the importance of these three sources of variation we define three alternative series with each source of variation turned off individually:

(i) We assume the directors all live in a house with the same initial value and modify Equation D1, to

$$Residential\ RE\ samehouse_{i,t} = \left(|D_i| \,/\, \left|\tilde{D}_i\right|\right) \sum_{d \in \tilde{D}_i} \bar{L}_{2002} L^P_{h_d,t} \tag{D2}$$

where $\bar{L}_{2002}$ is the mean value of a director's house in 2002;

(ii) We assume the directors all live in the same region as their firm and modify Equation D1, to

$$Residential\ RE\ sameregion_{i,t} = \left(|D_i| \,/\, \left|\tilde{D}_i\right|\right) \sum_{d \in \tilde{D}_i} L^d_{i,2002} L^P_{j,t}, \tag{D3}$$

where $L^P_{j,t}$ is the firm's regional house price index;

(iii) We assume that firms have the same number of directors and modify Equation D1, to

$$Residential\ RE\ samenodirectors_{i,t} = (\bar{N}/\left|\tilde{D}_i\right|) \sum_{d \in \tilde{D}_i} L^d_{i,2002} L^P_{h_d,t}, \tag{D4}$$

where $\bar{N}$ is the mean number of directors per firm in 2002.

We also define a measure

$$Residential\ RE\ sameregion\&nodirectors_{i,t} = (\bar{N}/\left|\tilde{D}_i\right|) \sum_{d \in \tilde{D}_i} L^d_{i,2002} L^P_{j,t}, \tag{D5}$$

so that for firms within the same region the only source of variation in residential real estate is the average initial house price of their directors.

D.5 Construction of *Residential RE: orthogonalised*

To construct this variable, we first construct a house price index in the director's region that is orthogonal to the house price index in their firm's region. Specifically, for each of the 41,616 director-firm regional pairs (we have 204 regional house price indices and $41,616 = 204^2$), we first regress the house price index in the director's region on the house price index in the firm's region, and then take the residual plus the mean of the original series as the orthogonalised index. This series is specific to director-firm regional pairs, and for example, will produce a different series for a director based in Leeds depending on whether their firm is based in Manchester or Liverpool. Note that, when a director lives in the same region as their firm, this series will have no time-series variation. We use these series to construct $Residential\ RE\ Orthogonalised_{i,t}$, which follows the construction of the baseline variable *Residential RE,* but uses the orthogonalised director house price indices in place of the true regional house price indices.

E Matching Residential Addresses of Firm Directors

E.1 Background and General Principles

E.1.1 The Structure of Addresses in the UK

While tedious, it is useful to first lay out what a UK address typically looks likes to fix ideas ahead of explaining how our matching algorithm works. We do not use any street, town or regional information (beyond England and Wales versus Scotland as described below) when matching addresses. Instead, our highest unit of observation is postal codes, or postcodes for short. In the UK, postcodes are 5 to 7 characters separated by a space (for example, "EC2M 1BB"). The final three characters always have the same structure: a number followed by two letters and denote the immediate local area of the property. The first set of characters, between two and four, will always start with one or two letters, and will then be followed by either a single digit number, a two digit number or, as in the example, a number followed by a letter. This first set of characters denote different UK localities so that, for instance, addresses in the same town will have postcodes starting with the same three characters. These patterns make postcodes distinctive and easy to map into the regions we use for our empirical analysis. Furthermore, as far as we are aware, this pattern is unique to the UK and therefore allows us to identify postcodes that are from addresses outside the UK. Crucially, there are close to 1.75 million postcodes in the UK serving just under 30 million unique addresses, meaning that the average number of properties per postcode is about 17 (although the total number of addresses per postcode can vary between 1 and 100).[65] Once we know a director's postcode, we have essentially narrowed down where he or she lives to a small number of properties. In all the databases we use the postcode is a separate field.

For around 80% of addresses in the UK the property can be uniquely identified using its postcode and the house number (i.e. the number of the property on the street). Specifically, for 10,339,712 of the 12,448,142 unique addresses in the England and Wales Land Registry the property can be uniquely identified in this way. For the Scottish Land Registry the equivalent figure is 690 thousand out of 837 thousands.[66] This means that given an unstructured text string for the address, simply isolating the first number and postcode would be sufficient for the purposes of matching in around 80% of cases. (Although this would be a biased set of addresses as it ignores properties that are named or those that are parts of larger buildings such as flats or apartments).

Around 10% or so of addresses in the UK are uniquely identified by a property name (i.e. a string like "the East Farm" or "Green Manor" etc.) and the postcode. Some addresses have both a house name and a house number in which case the name is redundant for matching purposes. For example, if a property is called The Manor, 72 High Street; there should never be another be another property

[65] See here. Postcodes that identify a single address tend to be for commercial properties that receive a lot of post and are less relevant in the residential sphere.

[66] Note, the Scottish figures are calculated after we have removed transactions with missing information.

at 72, High Street. The name is decorative.

Beyond this set, the structure of the address can get a bit more complicated for four main reasons:

1. When the property number is a range (e.g. 1-2).
2. When the property is part of a bigger building e.g. Flat 1, 6 the Avenue.
3. The address has been entered with a typo.
4. The address is non-residential or has a unusual structure.

As described below, our matching algorithm can work to deal with 1 and 2 above. And while it is possible to adjust for some typos (for example, the incorrect entry of the number 1 with a capital I), it is not possible to write an algorithm that corrects for every possible error. Furthermore, sometimes it is simply not possible to process the address in a coherent way – this is particularly true for non-residential addresses which we are not interested in.

E.1.2 Data Sources

We have three databases containing address information: (i) the director address information from BvD; (ii) the England & Wales Land Registry covering residential property transactions in England & Wales since 1995 and (iii) the Registrars of Scotland covering property transactions in Scotland (both commercial and residential) since 2003. All three record address information in different ways, with only the BvD database recording it as a raw string, so one needs to clean the data first in order to put it in a comparable form.

E.1.3 Our Approach to Matching

Given the fact that UK addresses often have a well defined structure and that the way that address information is recorded across our three data sources is different, we decided to use a precise matching approach as opposed to using fuzzy matching. Our general approach to matching is to generate 5 common variables: (i) *Postcode* – this is listed as a separate string in all databases; (ii) *house_num* – this is a street number, e.g. 1a; (iii) *flat_num* – this is the number of the flat, e.g. flat 15; (iv) *house_name* – this is the name of the building, e.g. The West Building; (v) *flat_name* – this is a potential name for the flat, e.g. Garden Flat. *Flat_name* is the least populated and will be the hardest to match on since it seems like addresses typically have a flat number assigned as well which may not have been listed. Below, we describe some of the rules we use to isolate these 5 individual address elements. It is worthwhile emphasising that sometimes the address information is ambiguous and judgment needs to be used. The way we set up the algorithm means that false positives are unlikely (we have not encountered one in our manual testing). Even so, if a false match were to occur, this would have to be within a postcode meaning that the property values are likely to be similar among addresses (although the transaction dates will of course be incorrect).

The matching algorithm puts together 5 different potential matching strings (string construction using Stata syntax):

1. *matcher1*=*postcode*+("_")+*house_num*+("_")+*flat_num*+("_1") if *house_num* is not missing.

2. *matcher2*=*postcode*+("_")+*house_num*+("_")+*flat_name*+("_1") if *house_num* is not missing.

3. *matcher3*=*postcode*+("_")+*house_name*+("_")+*flat_num*+("_1") if *house_name* is not missing.

4. *matcher4*=*postcode*+("_")+*house_name*+("_")+*flat_name*+("_1") if *house_name* is not missing.

5. *matcher5*=*postcode*+("_")+*house_name*+("_")+*house_num*+("_1") if *house_num* is not missing.

We build each of these 5 matchers in each database, then merge the databases based on each matcher to identify potential shared address information between the land registries and BvD. If more than one matcher works, we have the following preference ordering: $1 \succ 2 \succ 3 \succ 4 \succ 5$.

Some remarks are necessary regarding these matching strings. First, with this structure it is impossible to match based on flat information alone. Second, we also take the step of dropping situations where a particular matcher does not uniquely identify a property within a database; for instance *matcher4* will be unable to uniquely identify numbered flats in a single building. Third, *matcher5* may seem redundant but is designed to address situations where the algorithm incorrectly assigns a flat name to a *house_name*; as it is only relevant in the case of an error we treat it as the match with the lowest priority (see above). Fourth, *matcher1* and *matcher2* will give identical matches if no flat information is available.

E.2 Details of Address Fields in our Three Data Sources

Here we describe how address information is stored in our three databases. In all three databases we clean the address strings in a similar manner, e.g. by removing double spaces, certain punctuation, using a single case, consistent treatment of numbers etc. Furthermore, in our treatment of the individual address fields there are multiple specific cases that we have dealt with in our code. Some of the more common problems are discussed in the following section; however, we do not wish to go into all these often quite tedious details here nor is it practical to do so, instead our cleaning code is available upon request.

E.2.1 The England and Wales Land Registry

This database is the best structured of the three under consideration. Ignoring fields at the street level or above, address information is saved as the postcode and two string fields called the "Primary Addressable Object Name" (*paon*) and "Secondary Addressable Object Name" (*saon*). The secondary address characteristics typically contain information on the sub building, i.e. flat name or number. The *paon* typically contains information on the main building, so house number, house name or the name of the apartment block. Table E1 contains a short extract from the relevant fields from the Land Registry. The data set is also clean: the *postcode* field is 99.9% populated and, when reported, always corresponds to the UK conventions described above. The *paon* variable has only 4,250 missing values out of 21.3 million transactions. Very occasionally (467 cases) *saon* is listed but *paon* is not, in which case we replace the missing *paon* with *saon*. The *saon* variable is less well reported but this reflects the structure of addresses in the UK as described above. Table E2 shows a breakdown of how the addresses fields are recorded for all the unique addresses in the Land Registry (i.e. after we have collapsed addresses that transacted more than once into a single observation; we group by *postcode, paon* and *saon* to do this).

Table E1: **Extract of Address Information from the England and Wales Land Registry**

Land Registry Address Fields			Matching Algorithm Fields			
postcode	*paon*	*saon*	*house_num*	*house_name*	*flat_num*	*flat_name*
PO345DX	EAST GREEN			eastgreen		
SA181UN	38		38			
KT199UG	162		162			
ME142HH	24A		24a			
PO211DQ	44	FLAT 1	44		1	
PO211SU	10 - 12		10-12			
SW147LY	23		23			
SW66RE	28		28			
W129EA	6A		6a			
BN29AB	EBENEZER APARTMENTS, 24	FLAT 27	24	ebenezerapartments	27	

Notes: The Table shows a random extract of 9 unique addresses from the England and Wales Land Registry. The 10th address is selected to show a more complex example. The left half of the table is how the data appears in the raw data. The right half of the table shows how these fields are translated into the field for our matching algorithm.

Table E2: **Breakdown of Address Information in the England and Wales Land Registry**

	Number of Unique Addresses	Share of Unique Addresses (%)
Raw Data		
Report *paon*	12,444,713	99.97
- only report *paon*	11,090,100	89.09
- *paon* is a number*	10,672,552	85.74
- *paon* is a string**	1,369,667	11.00
Report *saon*	1,354,613	10.90
- *saon* contains the word "flat"	870,965	7.00
- *saon* contains the word "apartment"	115,830	0.93
Cleaned Data		
Report *house_num*	11,077,155	88.99
- only report *house_num*	10,339,712	83.06
Report *house_name*	1,731,071	13.91
- only report *house_name*	687,957	5.53
Report *flat_num/flat_name*	933,168	7.50
Total	12,448,142	100.00

Notes: Breakdown of unique addresses appearing in the England and Wales Land Registry. A unique addresses is one where there is a unique combination of *soan, paon* and *postcode.* Excludes addresses in the Land Registry where the *postcode* is missing. Our England and Wales Land Registry data covers transactions over the period Jan 1995 - April 2016.
* *paon* is a number includes cases such as *paon=15C or paon=1-2.*
** all cases where *paon* contains no numeric character (note that *paon* can contain both numbers and letters: e.g. *paon*= "9, Manor House").

Our general approach to identifying the matching variables is the following. First, consider numbers. For the overwhelming majority of observations, the address information will contain only up to two sets of numbers (we define a range like 1-2 as a single set of numbers). If only one number is available then we assign it to *house_num*. If there is a number in both *saon* and a number in *paon*, then we will assign the *saon* number to the *flat_num* and the number in paon to the *house_num* (e.g *saon* = "4", *paon* = "1-2" would imply *flat_num* = "4", *house_num* = "1-2"). If there are two numbers in either *paon* or *saon* then we assign the first to *flat_num* and the second to *house_num*. An exception to this rule would be if we can identify clearly which number corresponds to a flat number (e.g. *paon* = "1, flat 3"), then the algorithm reassigns the ordering appropriately.

Turning to the name variables. The general principle is similar, *flat_name* will be a string in *saon, house_name* a string in *paon.* We take the obvious step of removing any identified numbers from these strings and any sub strings that also align with the street. One source of ambiguity is whether, when *paon* is just a number, the string in *saon* is the *house_name* or the *flat_name.* We then use some simple keyword tests to assign the string to the appropriate field.

As the registry is a database of transactions and we wish to identify all the transactions at a particular address, we convert the registry to a wide format using the three raw address fields to isolate unique addresses before matching.

E.2.2 The Registers of Scotland

The Registers of Scotland database has a similar structure to its English equivalent; the four relevant address fields are *subbuilding, buildingname, propertynumber* and *postcode.* Between them *buildingname* and *propertynumber* are supposed to contain similar information as *paon* above except that *propertynumber* is a numeric field (all other fields are strings). If the property is identified by a number then *propertynumber* is populated; properties that have property numbers that contain a string (e.g. 11a) or a range (1-2) are listed in *buildingname.* Similarly *subbuilding* contains is similar information to *saon* above. Table E3 contains an extract from the database.

Table E3: **Extract of Address Information from the Registers of Scotland**

Registers of Scotland Address Fields				Matching Algorithm Fields			
postcode	*propertynumber*	*buildingname*	*subbuilding*	*house_num*	*house_name*	*flat_num*	*flat_name*
AB245PD	34		FLAT F	34		f	flatf
AB253DB	20			20			
AB210LY	6			6			
AB116UQ		51C		51c			
AB116JB	162						
AB116JR		32A		32a			
AB219UT	19			19			
AB423DW		2 WESTERTON		2	westerton		
AB23UE	27	FLAT E		27		e	flate
AB219LQ		MILLDALE 68-72	FLAT 4	68-72	milldale	4	

Notes: The Table shows a random extract of 9 unique addresses from the Registers of Scotland database. The 10th address is selected to show a more complex example. The left half of the table shows how the data appears in the raw data. The right half of the table shows how these fields are translated into the field for our matching algorithm.

Table E4: **Breakdown of Address Information in the Registers of Scotland Database**

	Number of Unique Addresses	Share of Unique Addresses (%)
Cleaned Data		
Report *house_num*	774,004	92.42
- only report *house_num*	690,708	82.47
Report *house_name*	87,875	10.39
- only report *house_name*	55,048	6.57
Report *flat_num/flat_name*	69,142	8.26
Total	837,491	100.00

Notes: A unique addresses is one where there is a unique combination of *house_num, house_name, flat_name, flat_num* and *postcode.* Addresses that emerge from transactions where any of the postcode, date, price, or all of *buildingname, propertynumber* and *subbuilding* are missing, are excluded. Our Registers of Scotland data covers transactions over the period April 2003 - September 2014.

The data in the Registers of Scotland database is less clean than the England and Wales Land

Registry. Many more observations are missing (e.g. the postcode is missing for 197,871 observations), and there is less consistency in the way information is recorded across the different fields between observations (compare for instance the first and second to last observation in Table E3). If the observed transaction has insufficient information to form a match (which is the case when either *postcode* is missing or all three of the other variables are missing) then we drop the observation. We also exclude transactions where the price paid or the date of the transaction is missing. This leaves us with 1,376,888 usable transactions.

Despite these issues there is sufficient data quality to determine our four matching fields for 837,401 unique addresses. Our approach to numbering is to use *propertynumber* in the first instance to identify *house_num.* In the case where *propertynumber* is missing (e.g. the fourth row in Table E3), we would then isolate the number from *buildingname* (51c). If *buildingname* and *propertynumber* report conflicting numbers we assume that the former is the *flat_num.* If *propertynumber* is missing, we would prioritise numbers in *buildingname* over *subbuilding* for *house_num* with a number in latter being used for the *flat_num.* An exception of this latter rule is if *buildingname* is clearly marked as referring to a flat (e.g. *buildingname=*"FLAT 2"*, subbuilding=56* would mean that we assign *flat_num=2* and *house_num=56).*

For the *name* fields, we prioritise strings in *buildingname* for *house_name* and strings in *subbuilding* for *flat_num.* We also attempt to extract *flat_name* from the strings using keyword searches in case the string contains multiple elements of an address.

The inconsistency in the way the same information can be recorded across fields in the Registers of Scotland database means that it is possible that the same address is entered in two different ways in the raw data. To address this, we first cleaned the address information for each transaction and then determined unique addresses using our cleaned data fields. Table E4 presents the breakdown of the address information for the cleaned data.

As with the England and Wales registry we convert the Scottish registry into a wide format. However, for the reasons discussed in the previous paragraph, we group transactions by the cleaned address fields rather than the raw data.

E.2.3 Director Addresses in BvD

In BvD there are two fields that contain director address information: *directoraddress* and *directorpostcode.*[67] The latter is equivalent to the postcode in the other two databases. There is a small data quality issue regarding postcodes: in about 0.3% of cases directors give the shortened 3 digit version (corresponding to the region where the address is located) rather than the full postcode. We attempt to correct for this by exploiting our panel structure by looking at multiple address listings by the same director (where the property number matches) to try to complete the postcode.

The field *directoraddress* is the full address of the director written as string with each line of the

[67] In some vintages of BvD these fields are titled *directorfulladdress* and *directorfullpostcode.*

address separated by a comma. For reference, to use a publicly available address rather than that of an individual, the Bank of England's address would be written as: "Bank of England, Threadneedle Street, London, EC2R 8AH, United Kingdom". We split the full addresses into its individual parts dividing the string about the commas. We focus only on the first two lines of the address as new fields (in the example, we would have two fields "Bank of England" and "Threadneedle Street"). For numbers, we assume that if only a single one exists in the two fields then it corresponds to the *house_num* (including a range like 1-2). If two numbers are present we assume the first is the *flat_num,* unless the string is of the form where the flat number is obvious such as "1 potter street flat 3". *Flat_name* is isolated using key word searches. Having isolated these three terms, any residual string left in the first line of the address is classified as the *house_num.* If there is nothing left in the first line of the address we use the residual string from the second line. With *house_num* we also use a combination of regular expressions and keyword searches to remove road and town names from the string as well as any sub-strings containing the postcode.

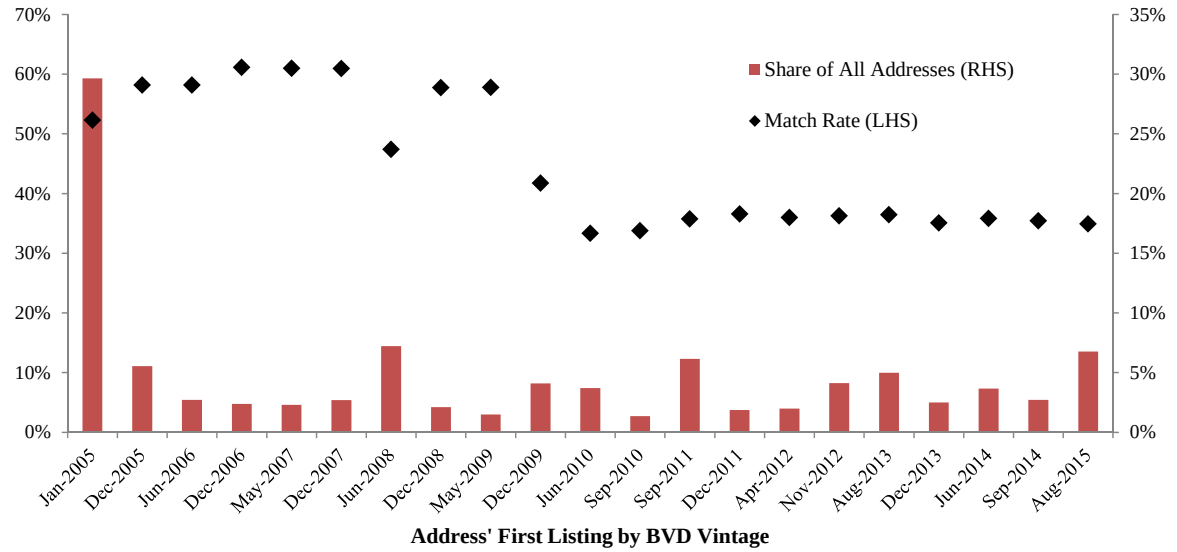
E.3 Performance of the Algorithm

Of all the unique director addresses located in England, Wales, and Scotland listed in Bureau van Dijk, 47% can be matched to at least one transaction in either land registry. The figure for addresses located in England and Wales is 48%, the figure for addresses in Scotland is 35%. The lower match rate in Scotland has two explanations. First, the Registers of Scotland database only contains transactions starting in April 2003. This increases the share of Scottish properties where no transaction has been recorded compared to England and Wales, where there is an additional eight years of transaction information. Second, the increased incidence of missing data in the Registers of Scotland data means that the record of transactions we have for the post 2003 period is less complete. Note also that only 5.8% of directors' addresses are located in Scotland.

Figure E1 presents the match rate for addresses based upon the vintage of the BvD database when the address is first listed as well as the share of addresses that enter the database at each vintage. Two main points stand out. First, there is a break in the match rate that happens around the December 2009 vintage. Prior to that vintage the match rate is a little under 60%, after that vintage the match rate falls to a little below 40%. This is due to a change in the law regarding the disclosure of addresses which we discuss in more detail below. Second, two thirds of the addresses in question entered the BvD database after our first vintage in 2005 and the average rate of entry is somewhat stable at roughly 2700 new addresses per day (calculated as total new addresses divided by days between disks). However, there is an unexplained spike in entry in June 2008 where the rate increases to approximately 4500 new addresses per day with a lull in the period before and after.

Also note that we have presented our match rates in terms of unique addresses, rather than weighting by address incidence. This means that we are potentially putting too much weight on addresses where the director has a short tenure and therefore is of less relevance empirically. However,

Figure E1: **Match Rate across BvD Vintages**



Notes: This chart shows the match rate between director addresses in the BvD and the Land Registry (black diamonds, left hand axis). Specifically, the match rate is calculated as the number of addresses in BvD for which a corresponding transaction can be found in *either* registry divided by the number of properties that have a postcode in England, Wales or Scotland. We present these rates by the the vintage of the BvD database where the address first appears. The bars, right hand axis, represent the share of addresses that first appear in each BvD vintage.

if we sample addresses according to their incidence in the database (i.e. addresses that appear in more director-firm-years get more weight) we also get a match rate of 47%.

As discussed below, we can also obtain an estimate of the value of a director's house through matching director-address pairs to mortgage data. This allows us to match the house value of directors whose properties have not transacted since the start of our Land Registries, but have taken out a new mortgage, for example, a remortgage. Including this additional source of information increases the match rate. The match rate is also higher when we focus on directors who have a current job at a live company, which ensures that address information is kept up to date. Using the Land Registries and mortgage dataset, and focusing on directors with current jobs at live companies, the match rate rises to 58% during the period of our regression sample from 2002-2014. When we further restrict ourselves to the directors of the companies that appear in our regression sample, this match rate rises to 65%.

E.3.1 Manual Tests on the Matching Algorithm

As we only succeed in matching roughly half of directors' addresses to the Land Registries, it is informative to ask what the cause is when our methodology fails to match an address. To explore this, we randomly selected 100 unmatched unique addresses from the September 2010[68] BvD vintage and manually assessed the reason for the failed matches. Of the 100 unmatched addresses, 8 failed

[68]For complete clarity: we used a snapshot of all addresses available at that vintage, not those addresses that were first listed in the September 2010 vintage.

matches were due to differences in the way the addresses were recorded in BvD compared to the Land Registries, for example due to typos. Six addresses were not matched due to obviously being a business address (as opposed to residential addresses). Recall that the England and Wales Land Registry does not include commercial property.[69] The remaining unmatched addresses were addresses that did not appear commercial by inspection (although it is not possible to say with certainty that they are residential) but did still not appear in either land registry. There are two potential explanations for this: either the property has not transacted since 1995 (2003 in the case of Scotland) or the only transactions that took place at the address were those omitted from the Land Registry. In terms of the latter, one relevant omitted set of transactions are the purchase of houses using a Buy-to-Let mortgage. One may be concerned that these are directors that live in rental properties. However, for reasons we describe in the main text this is unlikely. Another culprit is likely business addresses that cannot obviously be classified as commercial by inspecting their names. We discuss the law regarding directors using a commercial address below. It does seem, however, that many of the unmatched addresses are those where the owner has not sold their property since 1995 (2003 in the case of Scotland).

E.3.2 Changes to the Law Regarding the Listing of Director's Usual Residential Addresses

Under Sections 288 and 289 of the Companies Act 1985, the usual residential address of firm directors had to be entered on the public registrar of companies held at Companies House. This address would be published in their firm's accounts and this forms the source of our data on addresses.

From April 2nd 2002,[70] directors had the option to waive this requirement if the director was successful in obtaining a confidentiality order, having demonstrated to the Secretary of State that placing their residential address on the public record would place them or someone living with them at risk of violence or intimidation, for example from political groups. In this case the director could remove their residential address from public record and replace it with a service address at which they could be reached, for example their firm address, with the residential address held securely and only accessible by Competent Authorities. The bar for obtaining such an order is high. We discussed this issue with Companies House and they estimated that less than 1% of directors are beneficiaries of a confidentiality order at any given date.

A more material change in UK law on the 1st October 2009[71] meant that all directors had the option of having a service address displayed publicly rather than their usual residential address after this date. Usual residential addresses are still required alongside service addresses but the former are kept confidential at the director's request. This is the source of the decline in the match rate seen in

[69] The Registers of Scotland dataset does include properties that are purchased by corporations but these are flagged and we exclude them from our analysis.

[70] The insertion of Sections 723B to E into the Companies Act 1985 became effective on this date.

[71] Specifically, the implementation of Sections 162-167 (register of directors) of the 2006 Companies Act.

Figure E1 after the May 2009 vintage of BvD: directors started reporting service addresses, which are commercial and not in the Land Registry, rather than their residential addresses. However, the law was not applied retrospectively: all residential addresses held on public record at Companies House prior to 1st October 2009 continue to be held after this date. Thus, there would not be a material increase in privacy for directors through replacing their residential address with a service address unless the director moved house. In the data there is no spike in new addresses entering the database in 2009/2010: around 1.3 million new addresses entered the database in 2008 compared to 800,000 in 2009 (for the three year period 2006-2008 2.8 million new addresses where registered compared to 2.7 million three years 2009-2011).

For the purpose of our analysis, this legal change has little impact since we fix both the composition of directors and their houses in 2002. Only directors who move or are appointed (for the first time) after 2009 are affected by this change in the law but this variation is not included in our analysis. However, to be completely sure this is not distorting our results, in Table E5 we rerun our baseline specification excluding observations after 2008. The coefficient on residential real estate is still highly significant, and the point estimate is larger.

Table E5: **Firm Investment and the Real Estate Channels: Excluding Observations After 2008**

Investment		
	Baseline	
	2002-2014	2002-2008
	(1)	(2)
Residential RE	0.0298***	0.0422***
	(0.008)	(0.014)
Corporate RE	0.0511***	0.0262
	(0.016)	(0.026)
Cash	0.0777***	0.0961***
	(0.012)	(0.022)
Profits	0.1092***	0.0889***
	(0.016)	(0.025)
Observations	32244	18958
Adjusted R^2	0.25	0.27
Add. Firm, Dir. Controls	Yes	Yes
Region-time FE	Yes	Yes
Industry-time FE	Yes	Yes
Firm FE	Yes	Yes

Firm region clustered standard errors in parentheses
$^{\star}p < 0.10, ^{\star\star}p < 0.05, ^{\star\star\star}p < 0.01$.

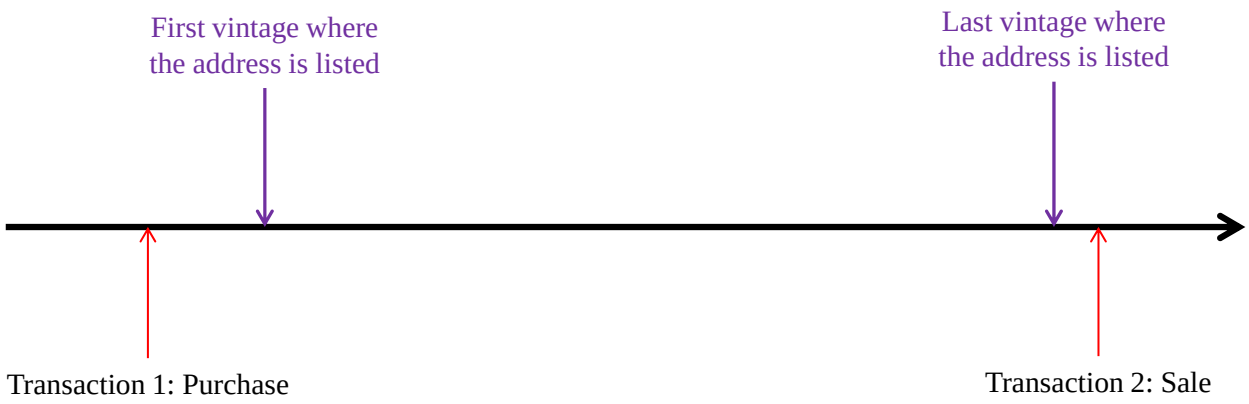
Notes: This Table reports the link between residential real estate, corporate real estate, and firm investment. The sample covers reporting UK firms over the period 2002-2014. The dependent variable, Investment, is defined as the change in "Fixed Assets" plus "Depreciation". Residential RE is the total 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 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. Column (1) is the baseline regression over the full sample period. Column (2) runs the baseline regression from 2002-2008.

E.4 Using Transactions to Value a Director's Home Address

E.4.1 Determining the Dates a Director Lives at a Property

For an address that has been matched to either land registry, we know all the transactions that happen at a particular property since the registry started. The next step is to determine which transactions correspond to the director buying and/or selling their property (recall that throughout this paper we maintain that the director is the owner of the property). Figure E2 presents a diagrammatic representation of the time line we envisage for determining the relevant transactions for a director's property. In the time line, two lines on the upper half of the time line show the dates of the first and

Figure E2: Time line for dating director property transactions: simple case



last vintage of the BvD database where the director lists that particular address as their property.

The lower half of the diagram shows two transactions. Transaction 1 is the first transaction immediately prior to the address first being listed in BvD and will capture the director buying the property. Transaction 2 is the first transaction immediately after the last vintage of BvD where the director registered as living at the the address and will represent the director selling the property.

There may be a "Transaction 0" in the registry, which corresponds to the person who the director bought the property from in the first instance. There may also be a "Transaction 3", where the next owner after director sells the property on. And other transactions beyond that further down the chain.

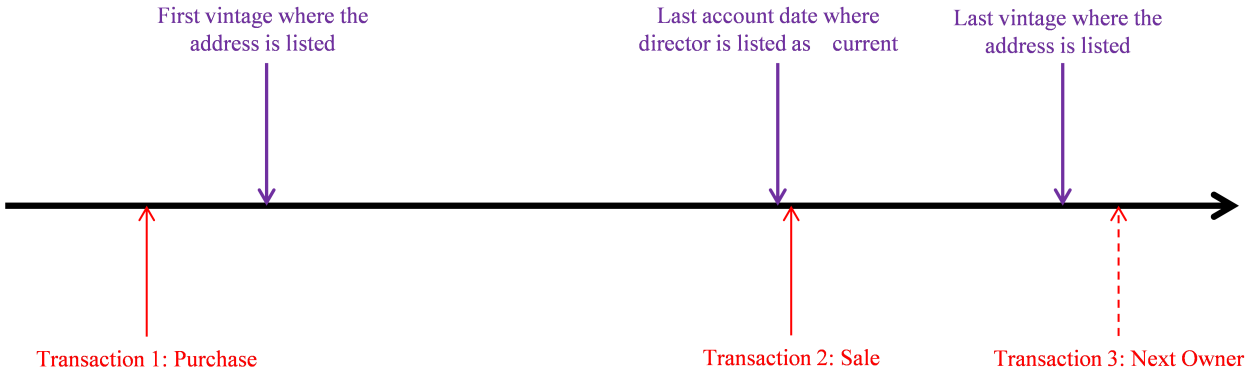
In our data, 80.3% of director addresses conform to this time line, where there is no transaction between the first and last vintage where the address is listed in BvD. Note that Transaction 1 may not exist in the Land Registry if the director bought the property sufficiently far in the past (5.8% of addresses) and Transaction 2 may not exist if the director has not yet sold property (62.9% of addresses). By elimination, for 11.6% of addresses no transaction occurs between the first and last vintage and both Transaction 1 and 2 exist.

The other 19.7% of cases where there is an intermediate transaction can largely be explained by lags in reporting. BvD retains directors in the database after they have resigned (whether the director is currently at the company or has resigned is a field within our data) but firms have no obligation to keep the address information up to date for directors who are no longer present. This means that the last vintage of BvD where the director's address is listed is not an accurate depiction of when the director left the property.

Figure E3 provides a second time line detailing how this issue can emerge and how we address it. In this case, rather than using the last vintage of BvD where the director registers that address, we use the date of the last set of company accounts where the director both registers as living at the address and has a current role at the company.[72] This accounts for an additional 11.6% of addresses.

[72]If the account date is missing we use the date of the last vintage of BvD where the director is listed as current

Figure E3: Time line for dating director property transactions: complex case



As a final step, we also extend the window to include transactions that occur a year prior to the final account date where the director has a current role to allow for lags in the director reporting a new address (2.9% of addresses).

This leaves 5.0% of addresses with transaction information that is inconsistent with BvD. We wipe transaction information on these addresses and treat the observations as missing. However, it is worth noting that for 2.2% out of those 5% of addresses (or just under half the addresses we wipe) there is no vintage of BvD where a director lists those addresses at a firm where the director's role is current, i.e. the addresses predate the dataset. So it is not surprising that the transaction information does not align.

E.4.2 Calculating the Value of Real Estate Held by a Director

We next value the real estate held by a director. Where a director's address has been matched to one of the Land Registries, we have an estimated purchase and/or sale date, with corresponding purchase/sale prices. In addition, the director-address pair may be matched to the PSD mortgage database, as described in Online Appendix F. This mortgage activity could correspond to the director buying the house, or a subsequent remortgaging.

We use the house price index in the director's region to value the house outside of transaction/mortgaging dates. We pick a reference house value and date, and simply use the house price index to value the property at other dates. In the first instance our preference is to use transaction data for the reference value, as this records the actual transacted price for the house, in contrast to the PSD, where the value of the house associated with a remortgage will be an estimated value. Where we observe both a purchase and sale price for a director's house, we use the purchase price as this will be independent of the director's subsequent behaviour.

This method uniquely values all the matched director properties at all dates in our dataset. To avoid simultaneously counting the value of all properties a director has lived in at different times,

instead.

we set the value of each director-address pair to 0 outside of the estimated dates they lived at the property. This allows us to accurately measure the value of real-estate owned by a director through time, including capturing house moves. For each director we then sum across the value of all matched addresses at each date to calculate the total value of real estate held through time.

E.5 Characteristics of Matched and Unmatched Directors

We next turn to the question of whether there is a significant difference between the characteristics of the directors whose houses we are able to value from those we are not. Table E6 presents summary statistics for a number of director characteristics broken down into directors whose address we can value by matching to either the Land Registries or the Product Sales Database and those we cannot. In general, the characteristics of the two groups are similar, with a few differences. First, directors with unmatched houses tend to be older, with both the mean and median unmatched director being around five years older. This is likely because older directors are less likely to have moved house within the period of our transactions databases, and so we are unable to pick up a housing transaction for their address. Second, non-UK nationals are less likely to be matched. This is unsurprising as they are more likely to live abroad, and we are only able to match UK addresses. Finally, directors with matched addresses tend to be slightly more experienced. This is likely because more experienced directors will list their address across a greater number of our vintages and across a greater number of companies, reducing the impact of typos in listing their address, and improving our chances of a match.

Table E6: **Characteristics of Matched and Unmatched Directors**

	Mean		Median		25%tile		75%tile	
Variable	Matched (M)	Unmatched (U)	M	U	M	U	M	U
Director Age (Years)	47.37	52.13	46.32	52.75	39.73	44.40	54.33	60.13
Male Directors	0.695	0.641	1	1	0	0	1	1
Non-UK Directors	0.0594	0.129	0	0	0	0	0	0
Experience (Years)	7.063	6.844	5.583	5.333	2.833	2.750	9.917	9.667
No. Industries Worked In	1.500	1.376	1	1	1	1	2	2
Firms with at Birth	0.878	0.651	1	1	0	0	1	1
Firms that have Failed	0.378	0.263	0	0	0	0	1	0

Notes: The statistics are calculated for the directors of all live companies in England, Wales, and Scotland over the period 2002-2014. *Matched* refers to directors whose address we are able to value through matching to either the Land Registries or the Product Sales Database. *Unmatched* refers to directors whose address we are not able to value. Director variables are defined in Online Appendix D. All variables except Male Directors and Non-UK Directors are truncated at the 5/95% levels.

E.6 Property Ownership

As discussed in the main text, we estimate that around 90% of directors are homeowners. There are three pieces of evidence to back this claim. First, the 2011 UK census shows that 88% of individuals with occupation "managers, directors, and senior officials", and located in the same age group as the median director in our sample, own the property they live in. Second, in the Registers of Scotland dataset, the names of buyers are recorded. We cross-checked the surnames of all directors matched to a Scottish transaction with the surname of the property buyer, making no correction for typos, and found they matched in 83% of cases. As a third piece of evidence, we randomly sampled 100 matched directors living in England and Wales and manually inspected the address' title deed (which includes the names of owners). We found that 90 of the 100 directors owned the property they lived in, and a further two appeared to be owned by family members of the director.

E.7 Estimating Aggregate Value of Director Real Estate

In each year of our sample t we calculate $V_t = n_{D,t} \times p_{H,t} \times o_t$, where V_t is the total value of residential property held by firm directors in year t, $n_{D,t}$ is the number of distinct individuals with at least one current directorship at a live firm in year t, $p_{H,t}$ is the average house price of these directors in year t, and o_t is the proportion of directors that own the property they live at. For 2014 there are 2.8 million directors and the average value of their properties is £570 thousand. Furthermore, from Online Appendix E.6, the home ownership rate for directors is estimated at around 90%, which we plug in for o_t. The estimate of V_t ranges from around £1 Trillion in 2005 to £1.5 Trillion in 2014.

We can break this estimate down into the share held by directors of SMEs (<250 employees) and large firms (≥250 employees). For SMEs we use our data to obtain the average house value across 2002-2014 for all (matched) directors, £517 thousand. For the directors of firms with at least 250 employees, the average house value is £1.3 million. The average large firm has 5.8 directors versus 4.1 directors for the SMEs in our sample. Finally, less than 1% of firms in the UK are large firms. Assuming the same ownership rate across the two groups, this implies that just under 99% of the total value of director housing is held by the directors of SMEs.

We can also perform a similar calculation when we split firms by their Total Assets, using information from all UK firms in the same industries as the firms in our baseline regression sample. The total amount of housing held by the directors of firms with at least £10m in Total Assets is £6.1m on average, around 5 times larger than for the directors of firms below this threshold (£1.1m). This is due to larger firms having on average 2.5 more directors and them owning houses worth around 2.5 times as much. However, over 99% of firms have less than £10m in Total Assets, implying that just over 96% of the total value of director housing is held by the directors of these firms.

F Computing Housing Equity

This section explains how we estimate the housing equity held by directors, using transaction data and mortgage data.

F.1 Matching Company Directors with Mortgage Contracts

The first step in calculating director home equity is to merge the directors in the BvD database with a loan level database, known as the Product Sales Database (PSD), which covers the universe of regulated mortgage originations in the UK since April 2005. While we cannot observe the name of the mortgagor in PSD, we can see the date of birth of the mortgagor as well as the 6-digit postcode of the property on which the mortgage was taken out. A 6-digit postcode in the UK has, on average, 17 properties attached it. Therefore, these two bits of information (postcode and date of birth) make it very likely that we can uniquely match company directors from BvD with the mortgage contracts they signed with a regulated mortgage provider. We then look at the details of each mortgage contract and, from it, we compute the dynamics of mortgage principal of each company director who has ever had a mortgage in our sample.

F.1.1 The Product Sales Database

The PSD contains information on the characteristics of mortgage contracts at origination, covering more than 10,000,000 contracts. The database contains information on the loan size, date of origination, the valuation of the property, the type (fixed or variable rate) and terms of the mortgage, the initial interest rate, the number of years over which the interest rate is fixed in case of a fixed-rate mortgage, and the type of borrower (remortgagor with or without equity extraction, mover or first-time buyer).

Missing Interest Rate Values Around 32% of mortgage contracts do no report interest rates in the PSD database. Given that we have virtually full coverage on other contract characteristics, we estimate an interest rate model in the spirit of Best et al. (2019) and use the estimated parameters for out-of-sample prediction to fill in the missing interest rate values. The interest rate is modelled as follows:

$$\begin{aligned} r_i = \beta_1 LTV_i + \beta_2 lender_i + \beta_3 type_i \otimes month_i + \beta_4 repayment_i \\ \beta_5 term_i + s_1(age_i) + s_2(income_i) + \nu_i, \end{aligned} \tag{F1}$$

where r_i is the mortgage rate for individual i. LTV_i is a vector of dummies, each corresponding to 0.25%-point LTV bins, starting at the bin 54% and ending with the bin 99%. $lender_i$ is a vector of mortgage provider dummies. $type_i$ is a vector mortgage type dummies. We use 12 different types: standard variable rate (SVR) mortgage, tracker mortgage, or fixed rate mortgage with an introductory

period of 1 year, 2 years,..., 10 years. $month_i$ is vector of month-year dummies associated with the date at which the mortgage was taken out. $repayment_i$ is a dummy controlling for whether the mortgage is capital-and-interest or interest-only. $term_i$ is a vector of dummies capturing the mortgage term. s_1 and s_2 are cubic splines with knots at the quintiles of the distribution of age and income and $\otimes$ denotes the outer product. Given the reasonably good fit (adjusted $R^2 = 0.81$, $N \approx 9.8$ *million*) of the estimated interest rate model F1, we use the estimates to fill in the missing interest rate values via out-of-sample forecasting. We winsorise the fitted values at 0%-points and 15%-points. For the remaining missing interest rate values (because of missing values for some of the RHS variables in F1) we use the 2-year 75% LTV mortgage rate at the time of origination.[73]

F.1.2 Mortgage Principal Calculation

The schedule of a mortgage loan (i.e. the dynamics of the principal over the life of the mortgage) with initial loan amount L, monthly interest rate i, and fixed monthly repayment M can be written as, at month k since origination:

$$P_k = (1+i)^k L - \left[1 + (1+i) + (1+i)^2 + \cdots + (1+i)^{k-1}\right] M, \tag{F2}$$

where the polynomial can be simplified as $1 + (1+i) + (1+i)^2 + \cdots + (1+i)^{k-1} = \frac{(1+i)^k - 1}{i}$. The monthly repayment M is calculated by setting the principal in the final period (N) to zero:

$$M = \frac{i}{(1+i)^N - 1} L (1+i)^N . \tag{F3}$$

Substituting F3 into F2 yields an expression of the principal at any point of time, which is a (non-linear) function of the monthly interest rate on the mortgage, the mortgage term and the initial loan

[73] This affects less than 1% of the sample.

amount. After rearranging, the principal k periods after origination can be written as[74]:

$$P_k = \left[\frac{(1+i)^N - (1+i)^k}{(1+i)^N - 1}\right] L. \tag{F4}$$

F.2 Calculating Residential Equity

For the England & Wales Land Registry we have a variable that indicates, for the period 2002-2014, whether a property was bought with a mortgage or not. We combine this information with mortgage information from the PSD and information on the house value to estimate the equity a director has in their house. In calculating this, we take the first available observation on home equity for a director, and calculate the evolution of home equity assuming no future remortgaging activity. This is to avoid potential endogeneity issues that may arise from subsequent mortgage decisions being correlated with firm performance.

Where the Land Registry dataset indicates that the director's property was bought without a mortgage, and any matched mortgage contract for the director-address pair in the PSD occurs after the month of purchase, the director's principal is calculated as 0 for all dates. In this case the property is bought without a mortgage, and we abstract from the subsequent mortgage activity, which could be endogenous to firm behaviour, e.g. if the director remortgages their property to inject equity into their firm. In all other cases we apply Equation F4 to the first observable mortgage contract of the director in the PSD, ignoring information contained in subsequent remortgaging decisions.

Our measure of residential equity for firm i at time t is then computed as

$$Residential\ Equity_{i,t} = \frac{N_i}{(\widehat{N_i})} \sum_{d=1}^{\widehat{N_i}} \left(L_{i.t}^d - P_{i,t}^d\right), \tag{F5}$$

where $L_{i.t}^d$ is the home value of director d at firm i at time t, calculated as described in Online Appendix E.4.2; $P_{i,t}^d$ is the mortgage principal for director d at firm i at time t, as described above; N_i is the number of directors in firm i, and $\widehat{N_i}$ is the number of directors in firm i whose home equity

[74] In practice, Formula F4 together with the interest rate i are applied to computing monthly payments for mortgages whose terms are typically much longer than the initial period to which the fixed interest rate applies. In the UK, the initial period usually lasts for two years after which the mortgage provider sets a floating interest rate that is typically much higher than the fixed interest rate used in the introductory period. This can be avoided by the borrower remortgaging at the end of the initial period. Mortgagors have a strong incentive to do that so that they avoid paying the higher floating rate. In addition, they can also potentially get a better deal and lock in a more favourable fixed rate if the property has increased in value during the initial period and, as a result, the borrower falls in a lower LTV bucket at the time of remortgaging.

In light of this, we also experimented with an alternative method of calculating principal, whereby we used all subsequent information (following the first observable mortgage decision) available to us. This includes all additional remortgaging decisions in the *flow* of mortgages (PSD 001), and we also used data on the *stock* of mortgages (PSD 007), which covers the outstanding stock of regulated residential mortgages at a point in time (we used H2 2015 as it is the first available vintage of this dataset). In effect, we aimed at computing principal and equity dynamics that have the highest possible degree of accuracy, often making use of information contained in the stock of mortgages as of 2015. When using this alternative method, we did not find any material difference in the investment sensitivity of firms to residential home equity values. These results are available upon request.

we can calculate. For the regressions involving residential equity we exclude observations where the calculated equity is negative.

F.3 Calculating LTV Ratios

In one exercise in the paper we examine how the sensitivity of firm investment to the residential real estate of company directors varies by their indebtedness. For this exercise we calculate the current LTV ratio of a firm's directors. To ensure accurate up-to-date information on the mortgages held by company directors, we use all mortgage data available, following the methodology outlined in Footnote 74. Using this, we estimate the total value of outstanding mortgages held by the company directors, using the average mortgage for matched directors, and the total number of directors. Similarly, we estimate the total value of outstanding property held by company directors, using the average house value for matched directors, and the total number of directors. The LTV ratio of a firm's directors is then the ratio of total mortgage value to total house value.

G Measuring Financial Constraints

We follow the structural corporate finance literature to measure financial constraints (see Strebulaev and Whited (2012) for a recent review). Specifically, we closely follow Whited (1992); Whited and Wu (2006) in using a simple partial-equilibrium model of investment whereby the firm's director chooses investment to maximise the expected present discounted value of future dividends, given by:

$$V_{i0} = E_{i0} \sum_{t=0}^{\infty} \beta d_{it}, \tag{G1}$$

where E_{i0} is the expectations operator conditional on firm i director's time zero information set: β is the one-period discount factor common to all firms; and d_{it} is the firm's dividend. The director maximises G1 subject to two constraints. The first is an identity defining dividends:

$$d_{it} = \Pi\left(K_{it}, v_{it}\right) - \psi\left(I_{it}, K_{it}\right) - I_{it} + B_{i,t+1} - \left(1 + r_t\right) B_{it}, \tag{G2}$$

where K_{it} is the beginning-of-period capital stock, I_{it} is investment during time t; $\psi\left(I_{it}, K_{it}\right)$ is the real cost of adjusting the capital stock, with $\psi_I \equiv \partial\psi/\partial I > 0$, $\psi_K \equiv \partial\psi/\partial K < 0$, $\psi_{II} \equiv \partial^2\psi/\partial I^2 < 0$. The second constraint is the identity governing capital accumulation:

$$K_{it+1} = I_{it} + \left(1 - \delta_i\right) K_{it}, \tag{G3}$$

where δ_i is the firm-specific constant rate of depreciation.

Financial frictions are introduced via a constraint on dividends:

$$d_{it} \geq d_{it}^{\star}, \tag{G4}$$

where $d_{it}^{\star}$ is a firm- and time-varying lower limit on dividends. Let λ_{it} denote the shadow price associated with constraint G4. The Euler-condition for K_{it} is then written as:

$$E_{it}\left[M_{t,t+1}\left(\frac{1+\lambda_{i,t+1}}{1+\lambda_{i,t}}\right)\left\{\begin{array}{r}\Pi_K\left(K_{i,t+1}, v_{i,t+1}\right) - \psi_K\left(I_{i,t+1}, K_{i,t+1}\right) \\ + \left(1-\delta_i\right)\left[\psi_I\left(I_{i,t+1}, K_{i,t+1}\right) + 1\right]\end{array}\right\}\right] = 1 + \psi_I\left(I_{it}, K_{it}\right), \tag{G5}$$

which implies that the marginal adjustment cost and purchase cost (the left-hand-side) must equal the discounted marginal cost of postponing investment to tomorrow (the right-hand-side). We follow the literature by adopting functional forms:

$$\begin{aligned} \Pi_K\left(K_{it}, v_{it}\right) &= \frac{Y_{it} - \mu VC_{it}}{K_{it}} \\ \psi\left(I_{it}, K_{it}\right) &= \left[\alpha_0 + \sum_{m=2}^{M} \frac{\alpha_m}{m}\left(\frac{I_{it}}{K_{it}}\right)^m\right] K_{it} \end{aligned} \tag{G6}$$

where Y_{it} and VC_{it} are firm i's output and variable costs at time t, respectively; μ is a constant mark-up which can also capture the effects of nonconstant returns to scale and therefore need not be strictly greater than one, as noted by Whited (1998). The truncation parameter is set to $M = 2$. Using the functional forms G6 and replacing the expectations operator with an expectational error, ε_{t+1}, we write:

$$M_{t,t+1}\left(\frac{1+\lambda_{i,t+1}}{1+\lambda_{i,t}}\right)\left\{\begin{array}{r}\dfrac{Y_{it}-\mu VC_{it}}{K_{it}}-\left[\alpha_0+\displaystyle\sum_{m=2}^{M}\frac{m-1}{m}\alpha_m\left(\frac{I_{i,t+1}}{K_{i,t+1}}\right)^m\right]\\ +(1-\delta_i)\left[\displaystyle\sum_{m=2}^{M}\alpha_m\left(\frac{I_{i,t+1}}{K_{i,t+1}}\right)^{m-1}+1\right]\end{array}\right\}=\begin{array}{r}1+\displaystyle\sum_{m=2}^{M}\alpha_m\left(\frac{I_{it}}{K_{it}}\right)^{m-1}\\ +\eta_i+\xi_t+e_{i,t+1}\end{array}, \tag{G7}$$

where we also added an unobserved firm fixed effect (η_i) and a time fixed effect (ξ_t) to control for business cycle fluctuations. Given the lack of available Fama and French (1993)-type model of the stochastic discount factor for the UK, we opt to model the SDF as the residual from fitting an AR(2) model to the 1-year UK government bond rate. This is motivated by the tight empirical relationship between interest rate innovations and the SDF implied by a wide set of cross-sectional test portfolios (Pinter, 2016). As for the specification for the shadow price $\lambda_{i,t+1}$, we adopt the following parameterisation in the spirit of Whited and Wu (2006):

$$\begin{aligned}\lambda_{t,t+1}=&\beta_0+\beta_1\left(cash/assets\right)_{i,t+1}+\beta_2\left(dividend\ dummy\right)_{i,t+1}\\ &+\beta_3\left(long-term\ debt/assets\right)_{i,t+1}+\beta_4\log\left(1+age\right)_{i,t+1}\end{aligned} \tag{G8}$$

where the βs are parameters to be estimated. We substitute Equation G8 into G7 and apply the nonlinear GMM estimator to obtain $\lambda_{t,t+1}$ which will be our index of financial constraints. The higher $\lambda_{t,t+1}$, the greater financial constraint firm i faces. We estimate G7 in first differences to eliminate the firm fixed effect, and follow the literature in using instruments dated at $t-2$ to estimate the conditional moment of the form:

$$E_{t-1}\left[z_{i,t-1}\otimes\left(e_{i,t+1}-e_{i,t}\right)\right], \tag{G9}$$

where $z_{i,t-1}$ includes the instruments and the term $(e_{i,t+1}-e_{i,t})$ captures the change in the expectational errors. Our instruments include the Euler equation variables, as well as profit-asset ratio, turnover growth, median long-term debt to asset ratio at the 2-digit industry-level. When estimating the moment condition G9, we follow Whited (1998) in using the iterated GMM estimator, whereby we repeatedly update the weighting matrix until the procedure converges. To evaluate the model, we run the J-test of overidentifying restrictions, which examines how close the sample versions of population orthogonality conditions are to zero (Hansen and Singleton, 1982). The estimation results are presented in Table G1. Overall, the results are consistent with previous estimates of the literature (Whited 1992; Whited and Wu 2006; Kang et al. 2010; Lin et al. 2011). Firms with higher long-term

debt to asset ratios are more likely to be financially constrained, where as firms that pay dividends, have more cash and are older to be less financially constrained. Our index of financial constraint $FinCon_{i,t}$ for firm i at time t is written as:

$$\begin{aligned} FinCon_{i,t} = &- 0.503\,(dividend\ dummy)_{i,t} - 0.429\,(\log(1+age))_{i,t} \\ &+ 0.406\,(long-term\ debt/assets)_{i,t} - 0.327\,(cash/assets)_{i,t} \end{aligned} \tag{G10}$$

We will then explore how the financial constraint index changes the way firms' investment responds to shocks to commercial and residential real estate values.

Table G1: **Euler-Equation Estimates**

	Estimates	St.err.
μ	1.506	0.255
α	0.796	0.658
$dividend\ dummy$	-0.503	0.004
$long-term\ debt/assets$	0.406	0.022
$cash/assets$	-0.327	0.005
$\log(1+age)$	-0.429	0.001

Notes: Calculations are based on a sample of nonfinancial firms covering 1998-2014. Following Whited and Wu (2006), we exclude firms that have more than 3 years of negative turnover growth to isolate financial distress from our measure of financing constraints. Using nonlinear GMM the Model G7 is estimated in first differences with twice lagged instruments. μ is the mark-up, α is the adjustment cost parameter, *dividend dummy* is a dummy taking value 1 if the firm paid dividends in the given year, $long-term\ debt/assets$ is the ratio of long-term debt to total assets, $cash/assets$ is the ratio of cash holdings to total assets and $\log(1+age)$ is firm age. The p-value associated with the $J-test$ is 0.28. The sample uses 31011 firm-year observations.

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