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Housing booms, reallocation and productivity

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Abstract

I establish that US public firms holding real estate have persistently lower levels of productivity than non-holders. Rising real estate values relax collateral constraints for companies that own real estate and allow them to expand production. Consequently, an increase in house prices reallocates capital and labor towards inefficient firms, with negative consequences for aggregate industry productivity. Industries with a stronger relative increase in real estate values see a significant decline in total factor productivity, and the within-industry covariance between firm size and productivity declines. My results suggest a novel channel through which real estate booms affect productivity and have implications for monetary policy.

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Keywords: housing boom, collateral, misallocation, productivity, low interest rates.

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1 Introduction

Firms pledge their real estate as collateral, so rising real estate prices increase collateral values and relax firms' financial constraints (Chaney, Sraer and Thesmar, 2012). While rising collateral values and credit could lead to economic expansion and higher efficiency (Kiyotaki and Moore, 1997; Holmstrom and Tirole, 1997), recent studies highlight negative consequences of higher asset values and credit booms on productivity (Schularick and Taylor, 2012; Borio et al., 2016; Gorton and Ordonez, 2016).[1] Since interest rates are a key driver of real estate prices (Jordà, Schularick and Taylor, 2015), understanding the effects of housing booms on productivity is particularly relevant in a world of low interest rates. So far, we lack empirical evidence on the relation between house prices, firms' real estate collateral, and aggregate productivity.

This paper uses data on US listed firms and shows that rising real estate prices negatively affect industry productivity, because they lead to a reallocation of capital and labor towards inefficient firms. I construct real estate holdings for a large sample of firms from 1993 to 2008 and confirm that an increase in firms' real estate values relaxes collateral constraints. Higher collateral value significantly increases firms' debt, investment, and employment, as shown by Chaney, Sraer and Thesmar (2012).

However, I establish a robust negative correlation between firm real estate assets and productivity: firms with a higher share of real estate over fixed assets exhibit persistently lower levels of productivity than firms with a lower share. Total factor productivity (TFP) of firms that hold 50% of their fixed assets in the form of real estate is 15-20% lower than that of firms that own no real estate, even when controlling for firm size and age, as well as unobservable trends at the industry level.[2] Both facts combined imply that inefficient firms expand, relative to more productive firms, when real estate values increase.

Aggregating to the industry level, I provide evidence that the collateral-induced reallocation of resources negatively affects industry productivity. A 10% increase in

[1]Between 1980 and 2007, the correlation between house price growth and TFP growth equals 0.48 in years of house price growth below 5%, and 0 in years of house price booms with growth exceeding 5%. For utilization-adjusted TFP, the respective correlations are 0.39 and -0.10.

[2]The negative relation between real estate and productivity is similar in terms of magnitude and significance independently of the chosen method used to estimate productivity. Further, firms with a higher share of real estate out of fixed assets also have persistently lower investment rates, spend less on research and development, and have fewer sales per employee.

average real estate values leads to a relative decline in TFP by 0.6% at the four-digit industry level. The effect is economically sizeable. During the housing boom real estate prices grew around 4% per year, and productivity increased by an average of 1.75% annually. Poor allocation of resources across firms explains the negative effect of real estate values on industry productivity: the covariance between firm size and productivity declines as house prices rise. The decline implies that unproductive firms grow faster than productive firms.

To further highlight the reallocation channel, I split industries by their dispersion of initial real estate across firms. For misallocation to play a role, firms' constraints must be relaxed asymmetrically. If each firm has a similar share of real estate out of total assets, there would be no dispersion across firms. Rising real estate prices would allow all firms to borrow more to the same extent, so there would be no change in relative firm size, and thus no reallocation. I establish that reallocation reduces productivity by relatively more in industries with a higher initial dispersion of real estate holdings across firms. For a given increase in real estate values, industries at the 75^{th} percentile of initial dispersion experience a decline in TFP that is twice as large relative to firms at the 25^{th} percentile. Industries with higher initial dispersion also experience a stronger decline in the covariance term.

The negative effect of rising real estate prices on industry productivity arises because unproductive firms grow and make up a larger fraction of industry output, relative to more productive firms. If real estate prices had no effect on firms' output share, there would be no reallocation and no decline in aggregate industry productivity. To obtain such a 'counterfactual' scenario, I fix firms' relative size (i.e. their respective shares of industry value added) at the beginning of the sample period and shut down the reallocation channel. Results show an economically and statistically insignificant effect of changes in real estate values on industry productivity once firm size remains constant. This finding provides further support for the mechanism.

Identification follows a two-pronged approach. First, I instrument MSA-level real estate prices with the interaction of local housing supply elasticities and the long-term interest rate (Saiz, 2010). The intuition is that decreases in long-term interest rates lead to higher demand for housing. How strongly local house prices react depends on the local supply elasticity. If it is cheap to build new houses and increase supply, then a decrease in rates will have a modest effect on housing prices. If the elasticity is low, the increase in demand will translate into higher prices. Second, whenever possible, I control for confounding unobservable time-varying factors at the industry and location level through the inclusion of industry*time and MSA*time fixed effects. In essence, I compare firms with different real estate values within the same industry and MSA.

The negative correlation between real estate and productivity is robust to a wide range of different specifications. I estimate productivity based on Olley and Pakes (1996), Levinsohn and Petrin (2003), and Wooldridge (2009), or as the simple residual in a Cobb-Douglas production function. To circumvent potential measurement issues in productivity estimates, I also compute alternative measures of firm performance: labor productivity, the share of capital expenditure over fixed assets, the share of research and development expenditure over total assets, and the log of total sales per employee. For each measure, regressions yield a highly significant and strongly negative relation with firms' initial real estate share. These results obtain even among firms of similar size and age and conditional on MSA*year and industry*year fixed effects, i.e. among firms in the same city and industry. Accounting explicitly for real estate when estimating productivity yields an almost identical estimate.

Industry-level results are confirmed in regressions that use labor productivity as dependent variables and employment shares as weights, rather than total factor productivity and value added weights. Rising real estate values reduce industry labor productivity and the covariance between firms' labor productivity and employment. Effects are stronger in industries with higher initial dispersion, and fixing firms' employment at the beginning of the sample eliminates the negative effect of reallocation on industries' labor productivity. The similarity in results mitigates concerns that measurement error in value added could confound the estimates.

Literature has established that financial constraints matter for the allocation of capital across firms and that distortions in the allocation of capital matter for aggregate productivity (Hsieh and Klenow, 2009; Gopinath et al., 2017). And yet, there still exists little direct evidence on the origins of these 'wedges' and how they interact with macroeconomic forces. My results provide direct evidence that firm-specific distortions, collateral constraints in terms of real estate, lead to a reallocation of resources across firms.[3] I suggest a novel channel through which real estate booms

[3] Bednarek et al. (2020) show how local real estate markets interact with bank flows and their

affect productivity, which could explain why housing booms are often associated with 'bad booms' (Gorton and Ordonez, 2016; Richter, Schularick and Wachtel, 2017).

The paper further speaks to literature that investigates the relation between low interest rates and productivity. Liu, Mian and Sufi (2019) argue that falling rates increase industry concentration, thereby reducing competition and hurting productivity growth. In a similar vein, Aghion et al. (2019) theoretically show that low interest rates in good times allow inefficient incumbents to remain in the market longer. Since interest rates are a key driver of real estate prices (Himmelberg, Mayer and Sinai, 2005; Jordà, Schularick and Taylor, 2015),[4] the novel mechanism uncovered in this paper, i.e. that rising real estate values benefit inefficient firms, suggests that interest rates that are 'low-for-long' could have undesired side effects on productivity by inflating house prices.

2 Data

Standard & Poor's Compustat Database provides data on listed companies headquartered in the US. Compustat offers extensive data on balance sheet items, including information on firms' land and buildings, for several thousand firms in each year. Compustat data are not representative of the universe of US firms: public companies are generally older and larger than the average firm, a fact that should be kept in mind when generalizing results. Yet public firms employ around one-third of total non-farm employees in the US. Although results in this paper do not necessarily extend to the average firm or industry, understanding how rising real estate prices affect the allocation of labor and capital among listed firms can nonetheless provide insights into the effects of house price booms on productivity.

The sample period ranges from 1993 to 2008. I exclude all firms in finance, insurance, real estate, and mining industries, as well as firms classified as non-operating establishments. Each firm must operate for at least two years. Firms' real estate holdings at the beginning of the sample period are constructed as the sum of buildings, construction in progress, and land and improvements. I then adjust firms' initial

effect on German cities' GDP. Martin, Moral-Benito and Schmitz (2019) show how house price booms affect firms in Spain.

[4]Several papers use interest rates to instrument house prices: see Mian and Sufi (2011); Chaney, Sraer and Thesmar (2012); Chakraborty, Goldstein and MacKinlay (2018).

real estate with real estate price indices at the Metropolitan Statistical Area (MSA) level, provided by the Federal Housing Finance Agency.[5] Following Chaney, Sraer and Thesmar (2012) and Cvijanovic (2014), the main independent variable *real estate value* is defined as the price-adjusted real estate value, standardized by lagged fixed assets (defined as the book value of property, plant and equipment). I denote firms' beginning-of-sample share of real estate over fixed assets as *initial real estate share*.

Firm-level dependent variables are long-term debt, capital expenditure, and employment, all standardized by lagged fixed assets. Firm controls include firms' log of total assets, age (proxied by companies' initial public offering date), market-to-book ratio, return on assets, and Tobin's q. I also compute an index of external financial dependence for each SIC industry, defined as capital expenditures minus cash flow from operations divided by capital expenditures, averaged over the sample period (Rajan and Zingales (1998)).

Firm f's value added-based total factor productivity is estimated at the two-digit industry level following the method developed in Wooldridge (2009). I denote the baseline measure of log productivity as *tfp*. Additionally, I use the methods developed in Olley and Pakes (1996) and Levinsohn and Petrin (2003) to estimate log productivity, denoted as *tfp OP* and *tfp LP*. I also compute the productivity of firm f as the residual of the production function $tfp\ R_{f,t} = y_{f,t} - \alpha\ k_{f,t} - \beta\ l_{f,t}$, estimated at the two-digit level, where y is the log of valued added, k is the log of fixed assets, and l is the log of employment. Further, I compute log labor productivity as the log of value added per employee. All productivity variables are standardized to mean zero and standard deviation (sd) one.

Estimating productivity in Compustat requires intermediate steps. Specifically, Compustat does not provide direct information on value added, nor labor costs. To this end, I construct labor costs as total employment times the average wage index, provided by the Social Security Administration. Value added is defined as sales minus materials, where materials equal net sales (sales minus operating income before deprecation) minus labor costs.[6] To circumvent potential measurement issues that

[5]The method of adjusting real estate values assumes that firms' real estate is predominantly located close to their headquarters. Chaney, Sraer and Thesmar (2012) and Cvijanovic (2014) confirm with the help of firms' 10K files that this is the case for most firms.

[6]All variables are deflated with the appropriate consumer and producer price indices.

could lead to a spurious negative correlation between real estate and productivity, I also compute alternative measures of firm efficiency that do not require these adjustments: the share of capital expenditure over fixed assets, the share of research and development expenditure over total assets, and the log of total sales per employee.[7]

For identification, I follow a large literature that instruments house prices with the MSA housing supply elasticity, interacted with long-term interest rates (Saiz, 2010).[8] The intuition is that decreases in long-term interest rates lead to higher demand for housing. How strongly house prices react depends on the local supply elasticity. If it is cheap to build new houses and increase supply, then a decrease in rates will have a modest effect on housing prices. If the elasticity is low, the increase in demand will translate into higher prices. I denote the instrumented house price index by $\widehat{hpi}_{msa,t}$. It is important to note that the instrumental variable strategy implies that the identified effects reflect how low interest rates affect firm outcomes (and hence reallocation) *through* real estate values. Additionally, whenever possible, I control for confounding unobservable time-varying factors at the industry and location level through the inclusion of industry*time and MSA*time fixed effects in firm-level regressions. These granular fixed effects control for changes in e.g. industry import penetration or local consumer spending.

Industry variables are averages across firms weighted by value added at the four-digit SIC code level.[9] Industry-level controls are the industry median of beginning-of-sample firm characteristics log of total assets, age, market-to-book ratio, return on assets, and Tobin's q. I interact these industry-level controls with the average yearly industry-level house price index, computed as the exposure of industry i to house prices in each MSA, based on value added shares of firms in the industry. These controls account for the fact that industries differ in the composition of their firm, e.g. in terms of size or profitability.

To shed further light on the role of reallocation at the industry level, I define two

[7]The correlation between the baseline productivity measure *tfp* and each alternative measure of firm performance is positive and significant at the 1% level (unreported).

[8]See, for example, Himmelberg, Mayer and Sinai (2005); Mian and Sufi (2011); Chaney, Sraer and Thesmar (2012); Cvijanovic (2014); Chakraborty, Goldstein and MacKinlay (2018). The first-stage regression is $hpi_{msa,t} = \gamma \, elasticity_{msa} \times mortgage \; rate_t + \delta_{msa} + \tau_t + \epsilon_{msa,t}$, where $P_{t,msa}$ is the MSA real estate price index in year t, $elasticity_{msa}$ denotes local housing elasticity, and $mortgage \; rate_t$ reflects aggregate shifts in the US 30-year mortgage refinancing rate.

[9]Weighting by value added when aggregating follows from most baseline models (*Domar weights*) and is standard in the literature (Hsieh and Klenow, 2009; Gopinath et al., 2017).

additional metrics. For reallocation to play a role, firms within each industry must differ in their real estate share. If a rising tide lifts all boats, there is no relative shift in firm size and hence no reallocation. Instead, rising real estate values must relax financial constraints asymmetrically within each industry, which requires variation across firms in terms of initial real estate shares. I define industries' *initial dispersion* in real estate values as the inter-quartile range of initial real estate (as a share of fixed assets) across all firms within each industry.

Additional, I decompose industry TFP and labor productivity and compute the *covariance* between firms' market share and firm productivity within each industry (Olley and Pakes, 1996; Melitz and Polanec, 2015).[10] The covariance term measures allocative efficiency. In a healthy economy, productive firms should have a larger market share, and an increase in the covariance suggests that productive firms grow. A reallocation towards unproductive firms implies that unproductive firms increase their size, so the covariance declines. Computing the covariance term requires information on firms' value added, which serves as the measure of firm size. In light of the potential measurement issues with value added discussed above, I also compute the covariance between labor productivity and firms' employment share within each industry.

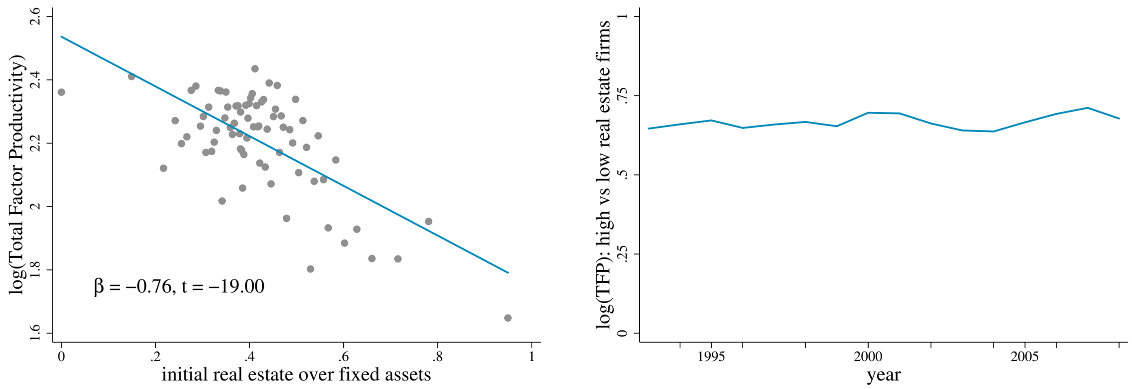
Figure 1 shows a strong and significant negative correlation between firm productivity and real estate holdings. Panel (a) provides a binscatter plot of log TFP on the vertical axis and the beginning-of-sample share of real estate over fixed assets on the horizontal axis. The downward-sloping blue line denotes the linear fit and indicates that firms with a higher initial share of real estate have significantly lower *levels* of productivity. Panel (b) further shows that the difference in productivity levels is persistent over time: firms in the top tercile of the distribution of the initial real estate share are on average two-thirds as productive as firms in the bottom tercile.

Table 1, panel (a) provides summary statistics for firm-level variables. For the average firm, initial real estate over fixed assets equals 23%. Two-thirds of all firms report non-zero real estate holdings, and among firms with real estate, it averages 34% of initial fixed assets. The median (average) firm has 857 (7,500) employees and is 35 (38) years old. There are 338 distinct four-digit industries, and the average industry has 23 firms per year. Panel (b) provides summary statistics for industry-

[10]Formally, $a_{i,t} = \bar{a}_t + cov(w_{f,t}, a_{f,t})$, where a denotes the measure of productivity in industry i or of firm f that operates in industry i. w denotes the respective weight of firm f in industry i. The decomposition uses value-added weights for TFP and employment weights for labor productivity.

Figure 1: Firm productivity and real estate

(a) Correlation (b) Over time



Note: Panel (a) provides a binscatter plot at the firm-year level of log TFP (estimated following Wooldridge (2009)) on the vertical axis and the beginning-of-sample share of real estate over fixed assets on the horizontal axis. The blue line denotes the linear fit and indicates that firms with a higher initial share of real estate have significantly lower levels of productivity. Panel (b) plots the ratio of average TFP of firms in the top tercile of the distribution of the initial real estate share over average TFP of firms in the bottom tercile of the distribution of the initial real estate share over time. Firms with higher initial real estate shares are persistently less productive. Data are from Compustat, covering the period 1993 to 2008.

level variables.

3 Empirical Analysis

A. Firm productivity and initial real estate

To examine the relation between firm productivity and initial real estate shown in Figure 1 more closely, I estimate variants of:

$$y_{f,t} = \beta \; initial \; real \; estate \; share_f + controls_{f,t-1} + controls_{f,t} + \tau_t + \varepsilon_{f,t}. \qquad (1)$$

The dependent variable is one of the different measures of firm efficiency, all standardized to mean zero and standard deviation one. $initial \; real \; estate \; share_f$ denotes firms' beginning-of-sample real estate as share of fixed assets. All regressions include the log of total assets and age as firm-level controls, which have been shown to be correlated with firm productivity. Standard errors are clustered at the firm level.

Production functions, capital and labor shares, and hence average productivity and

Table 1: Descriptive statistics

	Mean	St. Dev.	Min.	Max.	Obs.
Panel (a): Firm level					
initial real estate share	0.23	0.24	0.00	1.00	33,431
real estate value	0.23	1.49	0.00	73.76	3,3431
log(sales per employee)	5.01	0.87	0.43	9.56	33,431
investment rate	0.40	0.95	-0.05	33.29	33,431
R&D-to-assets ratio	1.42	4.58	-3.19	71.70	21,953
log(assets)	4.85	2.18	-4.02	12.63	33,431
market-to-book ratio	2.29	3.81	0.18	267.54	33,431
return on assets	-0.03	0.47	-13.87	0.93	33,431
age	37.80	11.00	26.00	71.00	33,431
employees (in thousands)	7.52	30.79	0.00	2100.00	33,431
Panel (b): Industry level					
real estate value	0.20	0.18	0.00	1.23	4,644
log total factor productivity (tfp)	0.00	1.00	-3.90	1.81	4,644
log labor productivity (lp)	-0.00	1.00	-3.55	2.72	4,644
covariance(tfp,value added (VA))	-0.00	1.00	-3.08	5.30	4,644
covariance(lp;labor (L))	0.00	1.00	-4.56	4.39	4,644
initial real estate dispersion	0.26	0.18	0.00	0.93	4,644
external financial dependence	0.00	1.00	-3.73	3.99	4,644

Note: This table provides descriptive statistics (mean, standard deviation, minimum, maximum, and number of observations) for main variables. In panel (a), the unit of observation is the firm-year level. Since all productivity variables are standardized to mean zero and standard deviation one, they remain unreported. In panel (b) the unit of observation is the industry-year level. Data are from Compustat, covering the period 1993 to 2008.

its dispersion vary significantly across industries (Syverson, 2011). To ensure that coefficient β does not reflect the fact that firms in industries with low productivity in general also have higher levels of real estate, each regression includes time-varying fixed effects (τ_t) at the industry level. These fixed effects account for unobservable factors that affect firms operating in the same industry over time. Equation 1 essentially compares productivity of firms that are similar in terms of size and age, but differ in initial real estate shares, within the *same* industry.

Panel (a) in Table 2 reports a significant negative correlation between initial real estate and productivity. In columns (1)-(4), initial real estate shares are associated with lower levels of productivity for each outcome variable (*tfp, tfp OP, tfp LP* or *tfp R*), conditional on firm size, firm age, and unobservable trends at the industry level. The correlation between initial real estate and each individual measure of productivity is significant at the 1% level.[11] Columns (5)-(8) further include time-varying fixed effects at the MSA level to account for the fact that firms operate in different cities and could be subject to unobservable shocks that vary by location. Across columns, coefficients remain highly significant and are only slightly lower in magnitude compared with their counterparts in columns (1)-(4). For example, for *tfp* in columns (1) and (5), productivity is between 0.09 and 0.085 standard deviations, or 15-20%, lower for a firm with a 75% initial real estate share relative to a firm with a 25% share.

Panel (b) replicates panel (a), but uses alternative measures of firm efficiency as dependent variables: log labor productivity (*lp*), log sales per employee (*sales/emp*), the investment rate (*inv)*, and the share of R&D expenditure over total assets (*R&D*). Across specifications, firms with a higher share of real estate have significantly lower sales growth, sales per employee, investment rates, and expenditure on research and development. This finding holds in a specification with industry*year fixed effects in columns (1)-(4), as well as in specifications with MSA*year fixed effects in columns (5)-(8). The relation between initial real estate and labor productivity is significant at the 5% level, and significant at the 1% level for all other outcome variables. The effect size is similar across measures (all dependent variables are standardized to mean zero and standard deviation one). Table 2 hence shows a significant negative relation between firms' initial real estate share out of fixed assets and productivity, as well as other measures associated with firm efficiency.

Why are real estate-owning firms less productive than non-owners, even if they are of similar size and age, and operate in the same industry and location (as shown in Table 2)? While a large literature investigates the relation between collateral and the risk of firms and projects (Bharath et al., 2011), work on the relation between collateral and firm productivity is scarce. Aanswering the questions goes beyond the scope of this paper. For the relation uncovered in this analysis, i.e. that reallocation due to rising real estate values can hurt aggregate productivity, the underlying reason why firms that hold real estate are less efficient is of second order importance.[12]

[11] Comparing coefficients and R-squared from a univariate regression of *tfp* on real estate with those obtained from a regression with controls and industry*year fixed effects yields a small change in coefficient size, but a sizeable increase in R-squared by 0.9 percentage points (unreported). Selection on unobservables would hence need to be several magnitudes larger than the selection on observables to render the correlation between real estate and productivity insignificant (Oster, 2019).

[12] Jimenez, Salas and Saurina (2006) provide complementary evidence that borrowers of low cred

Table 2: Real estate and productivity

(a) Productivity

VARIABLES	(1) tfp	(2) tfp OP	(3) tfp LP	(4) tfp R	(5) tfp	(6) tfp OP	(7) tfp LP	(8) tfp R
initial real estate	-0.18	-0.19	-0.27	-0.51	-0.17	-0.17	-0.24	-0.46
	(0.02)	(0.03)	(0.04)	(0.07)	(0.02)	(0.03)	(0.04)	(0.07)
Observations	29,411	29,411	29,411	29,411	29,411	29,411	29,411	29,411
R-squared	0.93	0.87	0.75	0.24	0.94	0.88	0.77	0.29
Industry*Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
MSA*Year FE	-	-	-	-	Yes	Yes	Yes	Yes

(b) Other outcomes

VARIABLES	(1) lp	(2) sales/emp	(3) inv	(4) R&D	(5) lp	(6) sales/emp	(7) inv	(8) R&D
initial real estate	-0.13	-0.24	-0.27	-0.23	-0.14	-0.21	-0.25	-0.23
	(0.06)	(0.06)	(0.03)	(0.03)	(0.06)	(0.07)	(0.04)	(0.03)
Observations	29,411	29,411	29,411	17,345	26,544	26,544	26,544	15,334
R-squared	0.48	0.56	0.21	0.28	0.69	0.60	0.30	0.38
Industry*Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
MSA*Year FE	-	-	-	-	Yes	Yes	Yes	Yes

Note: This table estimates Equation 1. All regressions control for the log of total firm assets and firm age. Columns (1)-(4) include industry*year fixed effects, columns(5)-(8) industry*year and MSA*year fixed effects. Standard errors clustered at the firm level in parentheses. Independent variable *initial real estate* denotes the beginning-of-sample share of real estate over fixed assets. In panel (a), the dependent variables are different measure of firms' TFP. In panel (b), the dependent variables are log labor productivity (*lp*), log sales per employee (*sales/emp*), the investment rate (*inv*), and the share of R&D expenditure over total assets (*R&D*). All dependent variables are standardized to mean zero and standard deviation one. Standard errors in parentheses. Data are from Compustat, covering the period 1993 to 2008.

B. Rising house prices and firm size

To show that rising real estate values raise debt, investment, and employment of firms that own real estate, I follow Chaney, Sraer and Thesmar (2012) and estimate the firm-level regression

$$y_{f,t} = \gamma \; real\ estate\ value_{f,t} + controls_f \times \widehat{hpi}_{msa,t} + \delta_f + \tau_t + \eta_{f,t}. \quad (2)$$

quality pledge more collateral.

Dependent variable $y_{f,t}$ is firm f's debt, investment, or employment in year t. $real\ estate\ value_{f,t}$ denotes firms' initial real estate, adjusted for the evolution of MSA-level house prices with the instrumented house price index $\widehat{hpi}_{msa,t}$. $controls_f$ include beginning-of-sample firm characteristics log total assets, return on assets, market-to-book ratio, and age, interacted with the instrumented house price index. Coefficient γ hence measures the effect of the collateral channel, holding constant any effect of local house prices on firms of different initial size, age, profitability, or growth potential.

Variables δ_f and τ_t denote firm and year fixed effects. To further control for unobserved time-varying trends at the MSA or industry level, I tighten identification by including MSA*time and industry*time fixed effects in some specifications. Industry*year fixed effects control for time-varying shocks at the industry level, such as changes in import competition. MSA*year fixed effects absorb unobservable time-varying shocks at the city level, for example changes in unemployment or consumption. The combination of an instrumental variable strategy and granular fixed effects ensures that coefficient γ measures the collateral channel, and not unobservable demand factors. Standard errors are clustered at the firm level. If an increase in real estate values relaxes financial constraints, then $\gamma > 0$.

Table 3, panel (a) shows that firms that experience a stronger rise in their real estate value expand production by more. Columns (1)-(3) include firm and year fixed effects, as well as firm controls. In column (1), an increase in real estate values leads to a significant increase in firms' long-term debt. Columns (2) and (3) show a significant positive effect of real estate values on firms' capital expenditure and employment. Columns (4)-(6) saturate the specification with time-varying fixed effects at the MSA and industry level. Results remain similar in terms of sign, size, and significance. In sum, panel (a) in Table 3 shows that rising real estate values relax firms' financial constraints and that firms that own real estate expand production when collateral values rise.

Panel (b) reports results from different robustness exercises. Column (1) excludes firms in the information technology (IT) industries (SIC codes 3500-3699), a high-growth high-productivity sector during the sample period. Results are quantitatively and qualitatively similar to the baseline specification. Column (2) restricts the sample to firms with zero real estate and shows that an increase in local house prices does not

Table 3: Real estate and firm size

(a) Baseline

VARIABLES	(1) debt	(2) inv	(3) emp	(4) debt	(5) inv	(6) emp
real estate value	0.07	0.11	0.05	0.05	0.10	0.04
	(0.04)	(0.03)	(0.02)	(0.02)	(0.03)	(0.02)
Observations	33,431	33,431	33,431	33,431	33,431	33,431
R-squared	0.37	0.23	0.65	0.50	0.39	0.71
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	-	-	-
Industry*Year FE	-	-	-	Yes	Yes	Yes
MSA*Year FE	-	-	-	Yes	Yes	Yes

(b) Robustness

VARIABLES	(1) no IT inv	(2) RE = 0 inv	(3) RE > 0 inv	(4) perm inv	(5) tradable inv	(6) EFD debt
real estate value	0.07		0.08	0.06	0.07	0.09
	(0.02)		(0.02)	(0.02)	(0.03)	(0.04)
house price index (IV)		0.11				
		(0.86)				
real estate value × tradable					0.00	
					(0.04)	
real estate value × external fin. dep.						0.15
						(0.08)
Observations	30,714	10,491	25,479	26,067	37,724	38,121
R-squared	0.22	0.19	0.24	0.16	0.22	0.42
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes

Note: This table estimates Equation 2. Independent variable *real estate value* denotes firms real estate value, adjusted for the development of the instrumented MSA-level house price index. In panel (a), the dependent variables are long-term debt (*debt*), the investment rate (*inv*), and employees (*emp*), all standardized by lagged fixed assets. Columns (1)-(3) include firm and year fixed effects, columns (4)-(6) industry*year and MSA*year fixed effects. Panel (b) provides a set of robustness exercises. All regressions include the interaction of the instrumented MSA-level house price index $\widehat{hpi}_{msa,t}$ and beginning-of-sample firm characteristics log total assets, return on assets, market-to-book ratio, and age as controls. Standard errors in parentheses. Data are from Compustat, covering the period 1993 to 2008.

lead to a significant increase in their investment. This placebo exercise suggests that (instrumented) MSA house prices affect firms with real estate through the collateral channel, and not through unobservable demand effects. Column (3) restricts the sample to firms with non-zero real estate and shows that among the set of firms that own real estate, rising real estate values lead to an increase in investment. Column (4) focuses on the permanent sample of firms, i.e. those firms that appear in the sample for at least 15 years. Results are qualitatively similar to the baseline specification. Column (5) interacts *real estate value* with a dummy *tradable* that takes on value one if a firm is in a tradable industry and zero otherwise. The insignificant coefficient on the interaction term further suggests that results are not due to unobservable local demand effects. Finally, column (6) uses the Rajan-Zingales (1998) measure of external financial dependence and shows that firms in industries that are more dependent on external finance raise more debt when local house prices increase.

C. Real estate values, industry productivity, and reallocation

Results in Table 2 and Table 3 suggest that rising real estate values disproportionately relax collateral constraints for low-productivity firms. To test how the collateral-induced reallocation of resources across firms affects industry productivity, I aggregate the data to the industry level and estimate

$$y_{i,t} = \delta \; real\ estate\ value_{i,t} + controls_i \times \widehat{hpi}_{i,t} + \delta_i + \tau_t + \nu_{i,t}. \tag{3}$$

Index i denotes industries, *real estate value* is the average real estate value within each industry. To control for differences in the underlying fundamentals across firms within each industry, I compute the median of the following variables across firms in each industry at the beginning of the sample: log firm size, age, return on assets, and market-to-book ratio. I then interact all beginning-of-sample industry-level controls with the instrumented industry-average house price index $\widehat{hpi}_{i,t}$. Industry fixed effects δ_i account for unobservable industry characteristics, year fixed effects τ_t control for common trends across industries.

The outcome variable in the baseline specification is log industry total factor productivity or the covariance between firm productivity and firm size within each industry. All dependent variables are standardized to mean zero and standard deviation one. Coefficient δ indicates whether an increase in average real estate values negatively or positively affects industry productivity or the covariance term.

Table 4 reports results. Column (1) in panel (a) uses *tfp* as dependent variable and shows that a rise in average real estate values leads to a decline in productivity at the industry level, significant at the 1% level. A 10% increase in average real estate values decreases productivity by 0.6%. The effect is economically large. During the housing boom real estate prices grew around 4% per year and productivity increased by 1.75% annually, so over a two-year period, the house price boom shaves off half a percent of industry TFP growth.

Columns (2)-(4) provide evidence that reallocation explains the decline in productivity: column (2) reports a significant decline in the covariance between firm size (measure by value added) and firm productivity by 0.28 sd for a one-unit increase in average real estate values, implying that resources are allocated towards low-productivity firms. The underlying mechanism for relative reallocation is an asymmetric relaxation of firms' collateral constraints. Firms with high initial real estate value expand relative to firms with low real estate value, so reallocation is expected to be stronger for industries with higher initial dispersion in real estate across firms within each industry. Column (3) interacts real estate value with the initial dispersion and shows that productivity declines by significantly more in response to an increase in real estate values when initial dispersion is higher. Comparing industries that are one standard deviation apart in terms of dispersion, a 10% increase in real estate values decreases productivity by an additional $(-0.47 \times 0.18 =)$ 0.8% in industries with high dispersion. Column (4) further shows that the covariance component also declines by more in industries with higher initial dispersion, in line with the argument that dispersion across firms in terms of initial real estate provides greater scope for inefficient reallocation.

To further illustrate that the decline in productivity is driven by an increase in the size of unproductive firms relative to productive firms, in column (5) I fix firms' relative size (i.e. their respective shares of industry value added) at the beginning of the sample period. In this counterfactual scenario I hence shut down the reallocation channel. If reallocation is the driving force of declining productivity growth, estimating Equation 3 under fixed value-added shares should yield an insignificant coefficient δ. Comparing column (5) with column (1) shows that, when eliminating the reallocation channel, there is an economically and statistically insignificant effect of changes in real estate values on industry productivity.

Table 4: Real estate values, industry productivity, and reallocation

(a) Total factor productivity

VARIABLES	(1) tfp	(2) cov(tfp;VA)	(3) tfp	(4) cov(tfp;VA)	(5) tfp (fix)
real estate value	-0.06	-0.28	0.09	0.14	0.01
	(0.02)	(0.12)	(0.03)	(0.21)	(0.02)
real estate value × initial dispersion			-0.47	-1.33	
			(0.07)	(0.55)	
Observations	4,644	4,644	4,644	4,644	4,644
R-squared	0.99	0.40	0.99	0.40	0.98
Industry FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes

(b) Labor productivity

VARIABLES	(1) lp	(2) cov(lp;L)	(3) lp	(4) cov(lp;L)	(5) lp (fix)
real estate value	-0.14	-0.36	0.25	-0.39	0.04
	(0.06)	(0.12)	(0.10)	(0.20)	(0.06)
real estate value × initial dispersion			-1.27	-0.11	
			(0.26)	(0.53)	
Observations	4,644	4,644	4,644	4,644	4,644
R-squared	0.82	0.45	0.82	0.45	0.80
Industry FE	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes

Note: This table estimates Equation 3 at the industry level. Independent variable *real estate value* denotes industries average real estate value, adjusted for the development of the industry-average instrumented MSA-level house price index. In panel (a), the dependent variables are log productivity and the covariance between productivity and firms' value added shares. In panel (b), the dependent variables are log labor productivity and the covariance between labor productivity and firms' employment shares. All dependent variables are standardized to mean zero and standard deviation one. All regressions include the interaction of the industry-average instrumented MSA-level house price index $\widehat{hpi}_{i,t}$ and beginning-of-sample median values of firm characteristics log total assets, return on assets, market-to-book ratio, and age as controls in each industry. Standard errors in parentheses. Data are from Compustat, covering the period 1993 to 2008.

Panel (b) reports the same specifications, but uses log labor productivity and the covariance between labor productivity and employment shares as dependent variables. Across columns, results are qualitatively similar: rising real estate values reduce industry labor productivity and the covariance between labor productivity and employment. Effects are stronger in industries with higher initial dispersion in real estate shares across firms and in industries that depend more on external finance. The similarity in results mitigates concerns that measurement error in value added explains the findings.

4 Conclusion

This paper shows that changes in real estate values not only affect individual firms, but also lead to a reallocation of labor and capital across firms. The reallocation of resources towards inefficient firms during the housing boom depresses industry productivity, despite rising overall economic output. The paper thus provides a novel channel through which house price booms affect productivity.

My findings have potentially important implications for monetary policy and its effectiveness in stimulating growth. The results suggest that extended periods of low interest rates – a 'low-for-long world' – could have unintended side effects, as interest rates are a key driver of real estate prices (Jordà, Schularick and Taylor, 2015; Williams, 2016). By inflating house prices, low interest rates relax financial constraints asymmetrically. Inefficient firms with real estate collateral expand and depress aggregate productivity, which could mute the effects of lower rates on the real economy.

Monetary policy affects the economy in a number of ways, and the results do not imply that low interest rates are detrimental to welfare in general.[13] Yet the potential negative effects on productivity through reallocation of resources across firms need to be taken into account when evaluating the effectiveness of monetary policy. This is especially relevant in light of the debate whether low interest rates and unconventional monetary policy could further inflate asset prices (Lowe, 2019; Mersch, 2020).

[13] For example, lower rates and higher home values could stimulate entrepreneurship or relax financial constraints for small firms (Doerr, 2019; Bahaj, Foulis and Pinter, 2020).

References

Aghion, Philippe, Antonin Bergeaud, Gilbert Cette, Rémy Lecat, and Hélène Maghin. 2019. "Coase Lecture – The Inverted-U Relationship Between Credit Access and Productivity Growth." *Economica*, 86(341): 1–31.

Bahaj, Saleem, Angus Foulis, and Gabor Pinter. 2020. "Home Values and Firm Behaviour." *American Economic Review*, 110(7): 2225–2270.

Bednarek, Peter, Daniel Marcel Te Kaat, Chang Ma, and Alessandro Rebucci. 2020. "Capital flows, real estate, and local cycles: Evidence from German cities, banks, and firms." *NBER Working Paper*, No. 26820.

Bharath, Sreedhar T, Sandeep Dahiya, Anthony Saunders, and Anand Srinivasan. 2011. "Lending relationships and loan contract terms." *The Review of Financial Studies*, 24(4): 1141–1203.

Borio, Claudio, Enisse Kharroubi, Christian Upper, and Fabrizio Zampolli. 2016. "Labour Reallocation and Productivity Dynamics: Financial Causes, Real Consequences." *BIS Working Paper*, No. 534.

Chakraborty, Indraneel, Itay Goldstein, and Andrew MacKinlay. 2018. "Housing Price Booms and Crowding-Out Effects in Bank Lending." *Review of Financial Studies*, 31(7): 2806–2853.

Chaney, Thomas, David Sraer, and David Thesmar. 2012. "The Collateral Channel: How Real Estate Shock Affect Corporate Investment." *American Economic Review*, 102(6): 2381–2409.

Cvijanovic, Dragana. 2014. "Real Estate Prices and Firm Capital Structure." *Review of Financial Studies*, 27(9): 2690–2735.

Doerr, Sebastian. 2019. "Unintended side effects: stress tests, entrepreneurship, and innovation." *BIS Working Paper*, No. 823.

Gopinath, Gita, Sebnem Kalemli-Ozcan, Loukas Karabarbounis, and Carolina Villegas-Sanchez. 2017. "Capital Allocation and Productivity in South Europe." *Quarterly Journal of Economics*, 132(4): 1915–1967.

Gorton, Gary, and Guillermo Ordonez. 2016. "Good Booms, Bad Booms." *NBER Working Paper*, No. 22008.

Himmelberg, Charles, Christopher Mayer, and Todd Sinai. 2005. "Assessing High House Prices: Bubbles, Fundamentals and Misperceptions." *Journal of Economic Perspectives*, 19(4): 67–92.

Holmstrom, Bengt, and Jean Tirole. 1997. "Financial Intermediation, Loanable Funds, and the Real Sector." *Quarterly Journal of Economics*, 112(3): 663–691.

Hsieh, Chang-Tai, and Peter J. Klenow. 2009. "Misallocation and Manufacturing TFP in China and India." *Quarterly Journal of Economics*, 124(4): 1–55.

Jimenez, Gabriel, Vicente Salas, and Jesus Saurina. 2006. "Determinants of Collateral." *Journal of Financial Economics*, 81(2): 255–281.

Jordà, Òscar, Moritz Schularick, and Alan M. Taylor. 2015. "Betting the House." *Journal of International Economics*, 96(Supplement 1): S2–S18.

Kiyotaki, Nobuhiro, and John Moore. 1997. "Credit Cycles." *Journal of Political Economy*, 105(2): 211–248.

Levinsohn, James, and Amil Petrin. 2003. "Estimating Production Functions Using Inputs to Control for Unobservables." *Review of Economic Studies*, 70(2): 317–341.

Liu, Ernest, Atif Mian, and Amir Sufi. 2019. "Low Interest Rates, Market Power, and Productivity Growth." *NBER Working Paper*, No. 25505.

Lowe, Philipp. 2019. "Unconventional Monetary Policy: Some Lessons From Overseas." *Address to Australian Business Economists Dinner*, November.

Martin, Alberto, Enrique Moral-Benito, and Tom Schmitz. 2019. "The financial transmission of housing bubbles: evidence from Spain." *ECB Working Paper*, No. 2245.

Melitz, Marc J., and Sašo Polanec. 2015. "Dynamic Olley-Pakes Productivity Decomposition with Entry and Exit." *The Rand Journal of Economics*, 46(2): 362–375.

Mersch, Yves. 2020. "Asset Price Inflation and Monetary Policy." *Keynote speech at the celebration of INVESTAS' 60th anniversary*, January.

Mian, Atif, and Amir Sufi. 2011. "House Prices, Home Equity-Based Borrowing, and the US Household Leverage Crisis." *American Economic Review*, 101(5): 2132–56.

Olley, G. Steven, and Ariel Pakes. 1996. "The Dynamics of Productivity in the Telecommunications Equipment." *Econometrica*, 64(6): 1263–1297.

Oster, Emily. 2019. "Unobservable Selection and Coefficient Stability: Theory and Evidence." *Journal of Business and Economic Statistics*, 37(2): 187–204.

Rajan, Raghuram G., and Luigi Zingales. 1998. "Financial Dependence and Growth." *The American Economic Review*, 88(3): 559–586.

Richter, Björn, Moritz Schularick, and Paul Wachtel. 2017. "When to Lean Against the Wind." *CEPR Discussion Paper*, No. DP12188.

Saiz, Albert. 2010. "The Geographic Determinants of Housing Supply." *Quarterly Journal of Economics*, 125(3): 1253–1296.

Schularick, Moritz, and Alan M. Taylor. 2012. "Credit Booms Gone Bust: Monetary Policy, Leverage Cycles, and Financial Crises, 1870-2008." *American Economic Review*, 102(2): 1029–1061.

Syverson, Chad. 2011. "What Determines Productivity?" *Journal of Economic Literature*, 49(2): 326–365.

Williams, John C. 2016. "Measuring the Effects of Monetary Policy on House Prices and the Economy." *BIS Paper*, No. 88b.

Wooldridge, Jeffrey M. 2009. "On Estimating Firm-Level Production Functions using Proxy Variables to Control for Unobservables." *Economics Letters*, 104(3): 112–114.

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