Productivity Shocks of Dominant Companies and Local Housing Markets

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Abstract

We extend the literature on the influence of firm-level characteristics on the housing markets, by exploring the association of dominant firms' productivity shocks with the local housing prices. Using a sample of all U.S. firms in COMPUSTAT during 1980-2017, we find that the MSA-level aggregate productivity shocks of dominant firms explain a significant portion of the local MSA's housing price changes, with other housing price determinants controlled. It takes about one year or more for the shocks to propagate through the local housing markets, making them a viable future housing price predictor. Productivity shock – housing price relation is stronger in areas with a more rigid housing supply and with tighter links to the local non-dominant industry peers, but is absent on a zipcode level indicating a geographically diffuse effect. These findings provide helpful insights for real estate practitioners and policymakers, especially in areas with a higher concentration of large companies.

JEL classification: R30, G30, E30

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1. Introduction

We often observe that large firms exert a large influence on the various aspects of their local economies, including their local housing markets. For instance, in 2007, for the first time in history, the top three leading U.S. automakers, General Motors, Ford, and Chrysler, experienced substantial drops in their market shares (falling below 50 percent), resulting in the soaring of the unemployment rate of their headquarters state Michigan to "a frightening 14.9 percent" and the subsequent crash of the local housing markets.[1] During the same year, the pharmaceutical giant Pfizer closed its major lab Lipitor in Ann Arbor, a Michigan city that was relatively immune to the auto-crisis, leading to the job loss of 2100 local employees and the corresponding crash in the local housing market.[2] A more recent example is related to the location decision of Amazon's second headquarter. According to a Curbed report in 2019, "From June 2018 to June 2019, the median asking price for a single-family home in ZIP code 22202, home to Amazon's planned Northern Virginia headquarters, skyrocketed a whopping 99.9 percent—essentially doubling over that period…" [3] Large firms really make a difference! However, the effects of firm-level shocks on the local economy are not well understood and documented in the literature. In this study, we try to make a stride by exploring how the firm-level productivity shocks of U.S. large firms relate to their local housing markets.

There are quite a few studies on the effects of economy-wide shocks on the fluctuation of fundamentals in the literature. These studies have focused on the effects of the aggregate national or local economic shocks (such as inflation, oil price, or policy shocks) while ignoring the firm-level shocks, which they argue would average out in the aggregate. In the same vein, prior real estate research uses economy-wide shocks to explain housing price changes. For instance, Glaeser and Gyourko (2007) relate the housing price dynamics to macroeconomic factors such as interest rate and the local economic factors, including population and time-varying local economic shocks.

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[1] See article titled "From rough ride to respectable: Michigan wins for most improved" by Scott Cohn, at *CNBC* on July 11, 2017, available from https://www.cnbc.com/2017/07/11/michigan-automakers-from-a-rough-ride-to-a-new-manufacturing-economy.html.

[2] See article titled "A Story Of Devastation And Rebirth: The Former Pfizer Research Labs In Ann Arbor" by John LaMattina, at *Forbes* on June 11, 2018, available from https://www.forbes.com/sites/johnlamattina/2018/06/11/a-story-of-devastation-and-rebirth-the-former-pfizer-research-labs-in-ann-arbor/#281ede424425.

[3] See article titled "Amazon HQ2 ZIP code sees doubling in median list price for single-family homes: report" by Andrew Glambrone, at *Curbed* on July 16, 2019, available from https://dc.curbed.com/2019/7/16/20696217/amazon-hq2-arlington-crystal-city-home-prices.

Holding a different view, several studies suggest that aggregate firm-level shocks do affect the fundamentals of the economy. Gabaix (2011) reports that the aggregation of the idiosyncratic firm-level shocks of the largest 100 U.S. firms can explain about one-third of variations in the national output growth. Inspired by this study, Jannati (2020) shows that the productivity shocks to the largest 100 U.S. firms can spill over through intra-sector links, direct trade links, knowledge externality and state income tax payments to other firms in their states and potentially aggregate to affect the national economy. Related to these studies, our paper explores how the aggregation of firm-level productivity shocks of the largest U.S. firms affect these firms' local housing price movements. We focus on these firms' productivity shocks rather than their performance shocks (which usually relate to their sales growth, market share growth, profitability growth and/or employee growth), because we think productivity shocks are relatively more influential to the local economy and local housing markets due to their more direct associations with technology and efficiency improvements, which are more likely to spillover to other firms. As far as we know, this is the first study that links firm-level productivity shocks to the local real estate prices. Our paper is also different from real estate studies that examine the association of the housing price movements with the time variation in the local economic factors (e.g., employment or the local aggregate production output), such as Titman, Wang and Yang (2014), as we propose that firm-level shocks can explain a significant portion of local economic fluctuations.

Our study also extends the literature on the impact of local firms on housing markets. For instance, Butler, Fauver and Spyridopoulos (2019) show that the listing decisions of local firms help create new jobs and increase local employment, leading to an increase in the local housing price and per capita income through economic spillover effects. Nguyen, Staer and Yang (2022) demonstrate that firms' initial public offerings increase local housing prices by affecting local economic expectations and residents' wealth. Looking from a different perspective, this study focuses on how large firms affect the housing price movements in the local areas.

The hypothesized relation between the aggregation of the largest firms' productivity shocks and local housing price movements can be positive or negative. There are a few channels that may lead to a positive relation: (1) The "financial constraint" channel: a positive shock to productivity may lower unit product costs and hence the associated non-housing consumption goods' prices; correspondingly, the aggregation of largest firms' productivity shocks may reduce the households' overall non-housing consumption costs, which can help relax their financial constraints, increasing the demand and hence the prices for local housing. (2) The "expansion and employment" channel: a positive shock to the productivity may improve production efficiency, reducing non-housing consumption goods' prices and hence increasing the demand for these goods, which will promote the expansion of the same lines and related lines of business, increasing the overall employment[4], pushing up the local housing demand and hence the corresponding housing prices. (3) The "gentrification" channel: big companies headquartered in a city are important local tax payers and investors to local education (such as college sponsorships), infrastructure (such as developing stadium and other sports arenas) and social and wealth fare programs, therefore their productivity shocks can generate positive externalities that make the city and its surrounding area more appealing and expensive places. (4) The "spillover" channel: the productivity shocks of largest firms can have spillovers to other firms in the same area, via intra-sector links, direct trade links, knowledge externality, and state income tax payment (as explained in Jannati, 2000). A positive shock of a dominant firm can hence boost the local economy and housing markets. Note that the effects via the first three channels could also be amplified with strong spillovers via the last channel.

On the other hand, the productivity shocks can negatively affect the local housing prices through the "efficiency and labor substitution" channel: the efficiency improvement from a positive shock can reduce the need for labor, and correspondingly the aggregation of productivity shocks of largest firms can reduce the overall employment level [5], lowering the demands and hence the housing prices. This channel can also be stronger with more prominent spillovers of productivity shocks of these largest firms to other firms.

Motivated by these conflicting hypotheses, we have launched this study to explore the net direction of the relation between the leading companies' productivity shocks and their local housing price movements. Using a sample consisting of all U.S. firms in the COMPUSTAT database and the data of FHFA housing price indices for 403 MSAs during 1980-2017, we find that on average the aggregation of the productivity shocks of dominant firms (in terms of revenues) in an MSA does

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[4] A positive relation between productivity growth and employment change is found in studies such as Francis and Ramey (2004), Nordhaus (2005), and Chang, Hornstein and Sarte (2006). Chen and Semmler (2018) show that productivity growth may negatively affect employment in the short run, while their long-run relation is more likely to be positive.
[5] A negative relation between productivity growth and employment change is found in studies such as Gali (1999), Gali and Rabanal (2004), Basu, Fernald and Kimball (2006), and Junankar (2013).

explain a significant portion of the housing price changes in this MSA, with the shock-housing price relation appearing positive, when we control for the other housing price determinants. It takes about one year or more for the influence of the shocks to propagate through the local housing markets, making the MSA-level aggregate local dominant firms' productivity shocks a viable predictor for the future MSA-level housing price trends.[6] As expected, these influences are more robust in areas with more rigid housing supply, and when the dominant firms have tighter links to the local non-dominant industry peers, a finding to support the positive relation justification based on the spillover channel. However, we do not find evidence to support the justifications based on the financial constraint channel and the expansion and employment channel, probably because both these channels work for much larger geographical scope than the local MSAs. Furthermore, the positive relation between the productivity shocks and local housing price changes seems absent when the aggregation is at the zipcode level. A possible explanation is that a larger firm tends to exert influence over a larger geographical area as compared to a smaller firm with a relatively larger influence over its more immediate neighborhood.

We believe the relationship hypothesized and analyzed in this paper contributes to developing a better predictive model for the housing prices. The effect of dominant firms on housing markets is likely to be stronger in other countries where dominant firms constitute a greater part of the economy.

The rest of the paper proceeds as follows. The next section discusses our data sources, research hypotheses and methodologies. We then provide descriptive statistics in the third section. We present our major empirical results in the fourth section. The last section concludes.

2. Data, Hypotheses and Methodologies

2.1. Data

[6] This result is analogous to the findings in Smajlbegovic (2019), Addoum, Kumar and Law (2020) and Ling, Wang and Zhou (2020) that the news on the local economic activities are relevant to a firm's stock price, but the information is diffused slowly to the stock price as the news are not immediately available to the marginal investors of the stock, making the information useful in predicting the stock returns. In addition, the information diffusion is found to be slower for more illiquid stocks. Real estate property markets are also illiquid (hence inefficient), which may explain the delay in reaction to the productivity shocks of dominant firms in the local area.

We use multiple sources to collect data for this study: (1) company information from COMPUSTAT; (2) Metropolitan Statistical Area (MSA) level quarterly Housing Price Indices from FHFA (Federal Housing Finance Agency); (3) MSA-level economic variables from Moody's Economy; (4) MSA-level housing supply rigidity data from the Saiz database; and (5) zipcode level home value index (ZHVI) from Zillow.

We measure the housing price levels at each MSA by the FHFA Quarterly All-Transactions Housing Price Indices (HPI), given this data's wide MSA coverage (for 403 MSAs)[7]. It is also one of the most popular housing price indices applied in real estate literature. The sample period for our MSA-level housing return regressions is from the first quarter of 1980 (the starting year of FHFA's HPI data for most MSAs) to the last quarter of 2017.

We measure the housing price levels at each zipcode by the Zillow Home Value Index (ZHVI) for Single-Family Homes[8]. It is a popular housing price index for zipcodes and reflects the typical value for SFR homes in the 35th to 65th percentile range. The sample period for our zipcode-level housing annual return regressions is from 1998 (as the starting year of ZHVI data is 1997) to 2017.

The primary housing price factor we consider in this study is the dominant firms' productivity shocks. We calculate this variable using net sales and employee data from COMPUSTAT. Following Gabaix (2011), for year y in our sample period, we categorize a firm as the dominant firm if its prior year's net sales is among the top 100 among all firms, or as the non-dominant firm if otherwise. Then, for each firm i, we compute its productivity as:

$$X_{i,y} = Ln\left(\frac{Net\ Sales_{i,y}}{Employees_{i,y}}\right) \quad (1)$$

Correspondingly the annual productivity growth is

$$G_{i,y} = X_{i,y} - X_{i,y-1} \quad (2)$$

and its firm-specific component of the productivity growth is

[7] We also use the FHFA Purchase-Only Housing Price Indices (for 100 major MSAs) for robustness tests, which generate similar results as the FHFA All-Transactions Housing Price Indices do.
[8] Data was downloaded from a file named Zip_zhvi_uc_sfr_tier_0.33_0.67_sm_sa_mon.csv file from Zillow at https://www.zillow.com/research/data/

$$\widehat{G_{i,y}} = G_{i,y} - \overline{G_y} \tag{3}$$

where $\overline{G_y}$ is the average productivity growth of all firms in the same year representing the common shock. Then, we calculate the firm's scaled productivity shock as

$$Scaled\ Shocks_{i,y} = \left(\frac{Net\ Sales_{i,y-1}}{GDP_{y-1}}\right) \widehat{G_{i,y}}. \tag{4}$$

This allows a firm to account for a greater weight if its last year's net sales are a larger portion of the lagged GDP.[9] Following this, for each MSA-year combination, we calculate the MSA-level productivity shocks of dominant firms as the sum of scaled shocks of all dominant firms headquartered in this MSA at this year. Similarly, for each zipcode, at each year, we calculate the zipcode-level productivity shocks of dominant firms as the sum of scaled shocks of all dominant firms headquartered in this zipcode at this year.

We then explore what might influence the effects of productivity shocks on the housing market. One of the possible determinants is the housing supply rigidity of each area. This rigidity is affected by this area's geographic characteristics, existing population or household density, land use regulations, and so on. Multiple variables can measure this rigidity, including (1) the Housing Supply Elasticity generated by Saiz (2010); (2) the Wharton Residential Land Use Regulatory Index; (3) the population density reported by the 2000 Census; and (4) the household density reported by the 2000 Census. Note that all these rigidity measures are based on one-time surveys, so they are cross-sectional data; in addition, these rigidity measures are available by MSA, but not available by zipcode. Correspondingly, in the zipcode housing return regressions, a zipcode-level housing supply rigidity measurement is proxied by the same rigidity measurement for the MSA to which this zipcode belongs.

Another possible determinant for the effects of the productivity shocks is the strength of industry links within each area. If the dominant firms in a particular area exhibit stronger industry links (or, business relations) with the local non-dominant firms, the dominant firms' productivity shocks might have greater spillover effects on the non-dominant firms, resulting in a larger cumulative effect on the local housing markets. We use the Fama-French 48 industry portfolio to

[9] Also note that we measure a firm's productivity shock based on the growth (rather than the level) of its productivity, therefore the productivity shock of a labor-intensive firm can be compared to that of a capital-intensive firm in our sample.

identify a firm's industry, and measure the scaled level of industry link in an area at year y in the following way:

$$Scaled\ Industry\ Link_y = \frac{Sum\ of\ sales\ of\ non\text{−}dominant\ firms\ in\ the\ MSA\ that\ are\ in\ the\ same\ Fama\text{−}French\ industry\ as\ dominant\ firms}{Sum\ of\ sales\ of\ all\ firms\ in\ the\ local\ area}. \quad (5)$$

The local area can be defined as the local MSA, or as the local zipcode. Correspondingly, we can calculate the MSA-level scaled industry link, and the zipcode-level scaled industry link.

In our study for the effects of productivity shocks on the housing prices, we control for the changes in several local economic variables which include: the employment (estimated from the raw data from the U.S. Bureau of Labor Statistics), population (estimated from the raw data from the U.S. Census Bureau), GMP (estimated from the raw data from the U.S. Bureau of Economic Analysis), and so on. These data are available at the MSA level, but not available at the zipcode level. Correspondingly, in the zipcode housing return regressions, a zipcode-level economic variable change rate is proxied by the change rate of the same variable for the MSA to which this zipcode belongs.

2.2. Hypotheses and Methodologies

This study explores whether productivity shocks of dominant firms are associated with their headquarter cities' housing price changes, and if so, what is the extent of the association and what factors may influence this association. We use two ways to define the local area: the local MSA and the local zipcode. Correspondingly, we develop the MSA-level and zipcode analyses.

We start with the MSA-level analysis. Our first regression model is to regress the MSA housing returns on the MSA's aggregate scaled productivity shock of dominant firms and/or its lagged terms, while controlling for the lagged MSA housing returns to address the serial correlations of housing returns documented in the real estate literature (for instance, Case and Shiller, 1989). We also control for the local economic changes, by including the MSA-level growth rate in employment, gross metropolitan product GMP, or population, to ensure that the effects of productivity shocks implied by the regression results are not due to local economic changes. The sign and significance of the scaled productivity shocks variables in the regression will be used to test the influences of productivity shocks on the local housing markets. If j is the MSA indicator, the regression takes the following function form:

$$R_{j,q} = \varphi + \sum_{i=1}^{3} \omega_i R_{j,q-i} + \sum_{k=m}^{n} \theta_k S_{j,q-k} + \mu F_{j,q} + \varepsilon_{j,q} \,. \tag{6}$$

In this regression, q is the quarter index. $R_{j,q}$ is the jth MSA's year-over-year housing return at quarter q, $R_{j,q-i}$ is the i −year lagged annual return, with $i = 1, 2, 3$. $S_{j,q-k}$ is the k −year lagged local aggregate scaled productivity shocks of dominant firms, with $k = m, m+1, \dots, n$, where $n \geq m \geq 0$. Note that it measures the current quarter value when with $k = 0$. $F_{j,q}$ is a variable that reflects $j -$ th MSA economic change during the current quarter. φ is a constant, ω_i , θ_k and μ are coefficients, and $\varepsilon_{j,q}$ is the error term. We include three lagged annual housing returns as these serial correlation terms are found to be influential to housing returns by prior research. For instance, Case and Shiller (1989), Campbell et al. (2009), and Titman, Wang, and Yang (2014) find that 1-year or 6-month lagged terms positively affect house price change rate, while reversal usually occurs after 6 months till the 3rd year. The coefficients of the scaled productivity shock variables, θ_k, can indicate whether housing returns are affected by the local productivity shocks of dominant firms and how soon we can observe the effects. We use the linear regression to estimate the coefficients, controlling the year and quarter fixed effects, and our standard errors are robust to clustering by MSAs and/or quarter counts (note that there are 152 quarter clusters in our 38-year sample period, from 1980 to 2017). In another robustness test, we try to control for variations of economic conditions (observed and unobserved) across state and time by including in regression state-quarter count joint fixed effects (7600 state-quarter count fixed effects in total for 50 states and 152 quarter clusters). Regression (6) above will be used to test the following hypothesis:

[Hypothesis 1] The housing return increases in the current and/or previous quarters' scaled productivity shocks of local dominant firms, that is in regressions (6), $\theta_k > 0$, *for* $k \in [m, m+1, \dots, n]$, where $n \geq m \geq 0$.

If our results support this hypothesis, it suggests that the relations between the dominant firms' productivity shocks and the local housing return via the positive-relation channels such as the financial constraint channel, the expansion and employment channel, the gentrification channel, and the spillover channel, dominate their relations via the negative-relation channels such as the efficiency and labor substitution channel.

Our second regression model adds an MSA-level housing supply rigidity measurement and its interaction term with the productivity shock variables into regression (1). Housing supply rigidity is an important factor associated with the higher local housing prices (see Glaeser, Gyourko, and Saiz (2008), Saiz (2010), and Titman, Wang, and Yang (2014)). As a result, the positive effect of local productivity shocks on the housing price changes mentioned in Hypothesis 1 can be magnified by the local housing supply rigidity. We will test this prediction using the regression:

$$R_{j,q} = \varphi' + \sum_{i=1}^{3} \omega'_i \, R_{j,q-i} + \sum_{k=m}^{n} \theta'_k \, S_{j,q-k} + \beta' G_{j,q} + \sum_{k=m}^{n} \gamma'_k \, G_{j,q} S_{j,q-k} + \mu' F_{j,q} + \varepsilon_{j,q}' \tag{7}$$

where $G_{j,q}$ is one of the $j-$th MSA's housing supply rigidity measurements mentioned for quarter q. Its interaction with the productivity shocks variable $S_{j,q-k}$ is captured by $G_{j,q}S_{j,q-k}$. Other variables are similar as in regression (1): φ', ω'_i, θ'_k, β', γ'_k and μ' are coefficients, and $\varepsilon_{j,q}'$ is the error term. This regression will be used to test the following hypothesis:

[Hypothesis 2] The effect in Hypothesis 1 is stronger when the housing market supply is more rigid; that is, the interaction terms $G_{j,q}S_{j,q-k}$ $(k = m \ to \ n)$ in regression (7) are positive.

Our third regression model adds the MSA-level industry link measurement and its interaction term with the productivity shocks variables into regression (6). Via the "spillover" channel mentioned earlier, when the dominating firms have tighter links to the local non-dominating industry peers, the productivity shocks of the dominant firms will have larger industry spillover effects on the local business, resulting in more prominent aggregate effects on the local housing market. We will hence test the prediction that a stronger local industry link will magnify the productivity shock effects on the housing markets. Correspondingly, we develop a regression that follows the format of regression (7), but replacing the supply rigidity measurements $G_{j,q}$ with $L_{j,q}$, which is the $j-$th MSA's industry link measurement for quarter q. Its interaction with the productivity shocks variable $S_{j,q-k}$ is captured by $L_{j,q}S_{j,q-k}$. This regression will be used to test the following hypothesis:

[Hypothesis 3] The effect in Hypothesis 1 is stronger when the local industry links are tighter, that is, the interaction terms $L_{j,q}S_{j,q-k}$ $(k = m\ to\ n)$ *are positive.*

Furthermore, the "financial constraint" channel indicates that the effects predicted by Hypothesis 1 can be stronger when the local residents are generally more financial constrained. Correspondingly, we develop a regression that follows regression (7), but replacing the supply rigidity measurements $G_{j,q}$ with , the $j-$th MSA's poverty dummy for quarter q, which is 1 if the local average per capita income divided by the local CPI (Consumer Price Index) is below its sample median. We use this variable to reflect the general financial constraint level of local residents. Its interaction with the productivity shocks variable $S_{j,q-k}$ is captured by $P_{j,q}S_{j,q-k}$. This regression will be used to test the following hypothesis:

[Hypothesis 4] The effect in Hypothesis 1 is stronger when the local residents are generally more financial constrained (proxed by the local poverty level), that is, the interaction terms $P_{j,q}S_{j,q-k}$ $(k = m\ to\ n)$ *are positive.*

Finally, the "expansion and employment" channel indicates that the effects predicted by Hypothesis 1 can be stronger when the local area has more capacity to expand its business and employment, which can be proxied by its current unemployment rate. Correspondingly, we developed a regression that follow regression (7), but replacing the supply rigidity measurements $G_{j,q}$ with $U_{j,q}$, the $j-$th MSA's unemployment rate for quarter q. Its interaction with the productivity shocks variable $S_{j,q-k}$ is captured by $U_{j,q}S_{j,q-k}$. This regression will be used to test the following hypothesis:

[Hypothesis 5] The effect in Hypothesis 1 is stronger when there is more capacity for business expansion and employment growth (reflected by a higher local unemployment rate), that is, the interaction terms $U_{j,q}S_{j,q-k}$ $(k = m\ to\ n)$ *are positive.*

These are our major empirical tests for our MSA-level analyses. We conduct similar zipcode-level analyses, except that the housing returns are annual and measured at the zipcode level, the dominant firms' productivity shocks are aggregated at the zipcode level, and the sample period is from 1998 to 2017. The testing results will be presented in Section 4 of this paper.

3. Descriptive Statistics

Our MSA productivity shocks data covers a 38-year period, from 1980 to 2017. Following the previous studies on productivity shocks, such as Gabaix (2011) and Jannati (2017), we exclude: (1) firms not located in the USA; (2) oil and oil-related firms (with SIC codes 2911, 5172, 1311, 4922, 4923, 4924 and 1389) and energy firms (with SIC codes between 4900 and 4940), the sales of which are most affected by worldwide commodity prices rather than productivity shocks; and (3) financial firms (with SIC codes between 6000 and 6999), the sales of which do not fit the measure in this paper. We also require firms to have positive sales and employee data for the current and previous years. There are 158171 firm-year observations from 16155 unique firms in COMPUSTAT during our 38-year sample period. They are located in 4615 unique 5-digit zip codes. There are 278 firms that have been at least once in top 100 firms by net sales. They are located in 230 unique 5-digit zip codes. This sample is used to calculate MSA-level aggregate productivity shocks of dominant firms.

The MSA productivity shocks data are then merged with the FHFA housing price indices data and the local economic variables data. The FHFA data covers the HPI indices for 403 MSAs during the 38-year sample period from 1980 to 2017. The statistical analyses of the key variables for our MSA-level regression analyses, HPI return, employment growth rate, and MSA scaled shock level, are summarized in Panel A of Table 1. There are originally 61,256 MSA-quarter observations with the MSA scaled shock data available. After excluding observations without HPI data or local economic variables, we end up with a sample of 52,957 MSA-quarter observations.

< Insert Table 1 about here>

Panel B of Table 1 provides the summary statistics of the key variables for our zipcode-level regression analyses. In the Top 100 firms sample, there are about 2,000 zipcode-year observations with the zipcode aggregated scaled productivity shock data available during the 20-year sample period from 1998 to 2017. After excluding observations without the ZHVI data or local economic variables, we end up with a sample of 1989 zipcode-year observations. For the Top 1000 sample, there are approximately 20,000 zipcode-year observations for the zipcode scaled productivity shock data.

4. Main Regression Results

4.1 Effects of Productivity Shocks of Dominant Firms on Local Housing Price Changes

We now report results from the panel data regressions of housing returns following regression in equation (6), which is to test Hypothesis 1 that the local housing return increases in the current and/or previous quarters' scaled productivity shocks of local dominant firms, with the local area defined as local MSA or local zipcode where a dominant firm is headquartered. The results are reported in Tables 2 and 3.

4.1.1. Effects on local MSA housing price

Table 2 displays the results from the regression of the MSA-level housing price changes (which we name as housing returns). Panel A reports the regression results for all MSAs with year fixed effects and quarter fixed effects. In regression specification (1), we include the 1-year lagged return, 2-year lagged return, 3-year lagged return, as well as the MSA-level scaled shock and its 1-year lagged term and 2-year lagged term. In other regression specifications, we also include an MSA-level economic variable to control for the local economic conditions. This control variable is the annual employment change rate in specification (2), the annual GMP change rate in specification (3), and the annual population change rate in specification (4). Standard errors are adjusted for the clustering by MSA and the quarter count. Consistent with prior research, housing returns in all regression specifications exhibit a short-term momentum (with the 1-year lagged return significantly positive) and a long-term reversal (with the 3-year lagged return significantly negative). Additionally, as expected and consistent with the findings in the literature, the change rates of employment, GMP, and population all positively affect the housing return.

< Insert Table 2 about here>

The Panel A results show that the MSA scaled shock variables have positive coefficients in all specifications, and additionally, the 1-year lagged term and/or the 2-year lagged term are significant at the 5-10% levels. In specification (4) when the population growth rate is used to control local economic conditions, all three shock variables are significantly positive, but the 1-year lagged term appears to be the most influential shock variable based on the coefficient magnitude and the significance level. Furthermore, the overall influence from three shock variables is stronger than in other regression specifications. This is probably because the local employment growth rate and local GMP growth rate might be related to local dominated firms' productivity shocks, so their existences in the regressions might reduce the effects of productivity shocks. Our results are in line with the prediction of **Hypothesis 1** that the housing return increases in the current and/or previous quarters' scaled productivity shocks of local dominant firms. Specifically, the results indicate that generally, it takes about one year or more for the productivity shocks of the dominant firms in an area to influence the local housing price changes; and additionally, the population growth rate may be a better local economic control variable than employment growth rate and GMP growth rate.

We then conduct several robustness tests, with their results reported in other panels of Table 2. Panel B is similar to Panel A except that the fixed effect is the state – quarter_count joint fixed effect (instead of the year fixed effect and quarter fixed effect). As mentioned earlier, this joint fixed effect can help control for variations of economic conditions (observed and unobserved) across state and time. We find that the 1-year lagged MSA scaled shock is significantly positive in all four specifications at the significance level of 5-10%, and the effect is the strongest when the local population growth rate is used to control for the local economy (from the coefficient size and significance level). The shock variables of the current year and 2-years lagged are not significant in this Panel.

Given that only 62 MSAs in our sample have ever had at least one top-100 dominant firm in at least one year during our sample period, we re-estimate regressions in Panel A for the panel data of these 62 MSAs only. The results are displayed in Panel C, and they are in general similar to the results in Panel A, with the 1-year lagged term and/or the 2-year lagged term significant at the 5-10% levels, and the cumulative effect of all shock variables being the strongest when the population growth rate is used as the local economic control variable.

Since the previous panels (especially Panel B) indicate the dominance of the 1-year lagged shock term among all three shock variables in affecting the local MSA housing returns, in another robustness test reported in Panel D, we re-estimate regressions in Panel B by including only one shock variable – the 1 year lagged shock term. We now see that this shock term is significantly positive at a 5-10% level in all the regression specifications. Again, the effect is the strongest when the population growth rate is used to control for the local economic situation.

As mentioned above, the population growth rate is a better local economic control variable than other local factors such as the employment growth rate and the GMP growth rate, as the latter might be related to the productivity shocks; and additionally, the 1-year lagged scaled shock is the more influential shock variable. Correspondingly, we conduct another robustness test by re-estimating regression (6) to include this 1-year lagged term as the only shock variable, controlling for the population growth rate. The results are reported in Panel E, with various regression specifications corresponding to the different combinations of fixed effects and clustering adjustments. We find that the 1-year lagged scaled shock is positive at a 1-5% significant level in all the specifications.

In summary, our MSA-level regression results from all the panels in Table 2 consistently confirm the prediction in **Hypothesis 1** that the housing return increases in the current and/or previous quarters' scaled productivity shocks of local dominant firms. They also suggest that it generally takes about one year or more for the shocks to reach the local MSA housing markets.

4.1.2. Effects on local zipcode housing price

Table 3 displays the results of the tests for the effects of firm-level productivity shocks on neighboring zipcode house price returns. We include the current zipcode-level dominant firms' scaled productivity shock and its 1-year and 2-year lagged terms. The control variable for the local economic situation is the annual growth rate of the local population, which is proxied by the population growth rate of the MSA where the zipcode is located, due to the lack of sufficient data for the zipcode-level population.

< Insert Table 3 about here>

Panel A exhibits the results when dominant firms are still defined as the top-100 firms by revenue. Four regression specifications are presented, with the dependent variables being the ZHVI returns, which are the annual change rate of Zillow Home Value Index for homes within a circle of 5-mile, 10-mile, 20-mile and 30-mile radius from the center of the zipcode. We find that the ZHVI returns do exhibit a short-term momentum, as they are positively related to their 1-year lagged terms at the 1% significance level. The local population growth rate is also positively related to the ZHVI returns at the 5-10% significance level. However, none of the shock variables appear significant in any regression specification. A possible explanation is that a larger firm tends to exert influence over a larger geographical area as compared to a smaller firm with a relatively larger influence over its more immediate neighborhood.

To alleviate the possible problem that there might be too few zipcodes to have top 100 firms, we conduct a robustness test for the zipcode analysis by defining dominant firms as top 1000 firms by revenue. The corresponding results are exhibited in Panel B, which are essentially similar to those in Panel A. Our findings that the dominant firms' productivity shocks are influential to the local MSA housing prices but not the local zipcode housing prices indicate that the geographic range of the influences of dominant firms is wide.

4.2. Influences of Housing Supply Rigidity

We next explore what might affect the magnitudes of the effects predicted by Hypothesis 1. One factor we consider is the local housing supply rigidity. Following the evidence in Titman, Wang, and Yang (2014) and Saiz (2010), we conjecture that local housing supply rigidity, an important determinant for the housing price changes, might also determine the magnitudes of the effects of productivity shocks on the local housing markets. We implement a regression setup from equation (7) to test the prediction from **Hypothesis 2** that the effects in Hypothesis 1, that is, the effects of the productivity shocks of dominant firms on the local housing price changes, are stronger when the local housing supply is more rigid.

We regress the MSA-level housing returns on the explanatory variables included in Panel E of Table 2, as well as the local housing supply rigidity and its interaction with the productivity shocks variables. In this table, we report the results with the local housing supply rigidity measured by the Saiz Housing Supply Elasticity. This elasticity data is available for 252 MSAs in our sample. Table 4 exhibits the results. Two regression specifications are developed to correspond to the uses of two different sets of fixed effects, with specification (1) incorporating the year fixed effect and the quarter fixed effect, and specification (2) incorporating the state and quarter-count joint fixed effect. The standard errors are adjusted for the quarter-count clustering.

< Insert Table 4 about here>

Note that the local house supply elasticity negatively correlates with the local housing supply rigidity; therefore, if Hypothesis 2 is true, it will predict a negative coefficient for the term interacting a local scaled shock variable and the elasticity. As shown in Table 4, this is true for the term interacting the 1-year lagged MSA scaled shock and the housing supply elasticity, with the coefficient negative at a 5-10% significance level in both regressions specifications. In addition, as expected, the elasticity itself is negatively associated with the housing return at a 1-10% significance level. The shock variable itself still has a positive coefficient and it is significant at a 1% level. The results generally confirm a positive interaction between housing supply rigidity and the productivity shock – housing return relationship predicted in **Hypothesis 2**. This can be explained by the fact that housing supply rigidity is a catalyst for local housing price increases. Correspondingly, the positive effects of productivity shocks on the housing price changes are expected to be amplified by the local housing supply rigidity.

4.3. Influences of Industry Links

Another possible determinant of the magnitude of the productivity shock – housing return relationship is the tightness of local industry links, a reflection for the strength of the spillovers from the dominant firms to their related local firms. When the dominant firms have tighter links to the local non-dominant industry peers, intuitively, the productivity shocks of the dominant firms will have larger industry spillover effects on the non-dominant industry peers, thus yielding more prominent cumulative effects on the local housing market. We, hence, implement a regression setup similar as regression (7) to test the prediction in **Hypothesis 3** that a tighter local industry link will magnify the productivity shock effects on the housing markets. Table 5 reports the results.

< Insert Table 5 about here>

Given that Table 2 reports that the productivity shocks of dominant firms exhibit the most noticeable impact on the local housing price changes with a one-year lag, our regressions include the interaction term between the industry link and the 1-year lagged scaled productivity shock. These regressions take the same form as in Table 4 except that the MSA housing supply rigidity is replaced by the MSA industry link with the results shown in Table 5. We find that in both regression specifications, the interaction term has a large, positive and highly significant coefficient that is above 21. This finding generally confirms a positive interaction between the tightness of the local industry link and the productivity shock – housing return relationship predicted in **Hypothesis 3**.

Interestingly, we show that in both regressions, the industry link itself also has a positive effect on the local housing returns at a 1% significance level, suggesting that areas with tighter industry links may be more likely to experience rapid housing price increases. On the other hand, the 1-year lagged scaled productivity shock itself no longer plays any independent role in determining the housing price changes. These results suggest that the dominant firms' productivity shocks affect the local housing markets mainly through their spillover effects to other related firms in the local areas. In practice, many largest firms may have a business sphere of influence beyond their immediate MSAs where their headquarters are located, as, for instance, most of their employees may work and live in other MSAs, or their products are primarily sold to other MSAs. As a result, their productivity shocks might not necessarily be highly associated with the local housing markets. However, if these firms have close business relations with other firms near their headquarters, their shocks may spill over to these related firms, whose business may be more concentrated in the local areas, eventually resulting in a strong indirect response from the local housing markets.

4.4. Influences of Financial Constraints

Now we explore if the local residents' financial constraints can affect the productivity shock – housing return relationship. As conjectured earlier, a positive shock to the productivity of a large firm may lower its unit product costs and hence the associated non-housing consumption goods' prices; as a result, the aggregation of largest firms' productivity shocks may reduce the households' overall non-housing consumption costs, relaxing their financial constraints, increasing their demand and hence the prices for local housing. Following this logic, we may see a stronger productivity shock- housing return relation in an area with residents more financially constrained, as predicted by **Hypothesis 4.** To test the validity of this hypothesis, we re-estimate regression (7), by replacing the supply rigidity with a poverty dummy, an estimate for the local financial constraint level, which is 1 if the MSA-level seasonally adjusted per capita income divided by the CPI (that is, Consumer Product Index for Urban Consumer – All Items, index 1982-84=100, seasonally adjusted) is below its cross-sample median, and 0 if otherwise. Table 6 reports the results.

< Insert Table 6 about here>

Like in Table 5, our regressions include the term interacting the poverty dummy and the 1-year lagged scaled productivity shock. We find that in both regression specifications, the 1-year lagged scaled productivity shock is positive at the 1% significance level, confirming the role of dominant firms' productivity shocks to their local housing markets. Meanwhile, the poverty dummy is negative at the 1% significance level. As expected, housing prices grow more slowly in poorer areas. However, we do not find that the shock-poverty interaction term has any significant influence on the local housing returns. This is against the prediction of **Hypothesis 4** that the productivity shock-housing return relation is stronger when the local residents are more financial constrained. A possible explanation is that most dominant companies are very large, as such that their products and services are consumed at the national or even international levels, therefore the price drops due to the efficiency improvement will benefit the consumers everywhere, regardless of wealthy or poor, weakening the direct wealth effects in a particular location via consumption substitution between its local housing and non-housing consumption goods.

4.5. Influences of Unemployment

We next examine if the local capacity for business and employment growth can affect the productivity shock – housing return relationship. As conjectured earlier, a positive shock to productivity may boost the local housing prices by promoting the expansion of the same lines and related lines of business, increasing the overall employment. This may happen because the enhanced production efficiency after the shock can reduce non-housing consumption goods' prices hence raising the demand and the corresponding production for these goods**.** Following this logic, we may see a stronger productivity shock- housing return relation in an area with more capacity for business expansion and employment growth, as predicted by **Hypothesis 5.** To test the validity of this hypothesis, we re-estimate regression (7), by replacing the supply rigidity with the MSA-level unemployment rate, a proxy for the capacity for expansion and employment. The data of unemployment rate is available for 309 MSAs in our sample. The results are reported in Table 7.

< Insert Table 7 about here>

In both regression specifications, the unemployment rate is negative at the 1% significance level. As expected, housing prices grow more slowly in areas with a higher fraction of labor unemployed. However, we do not find that the shock-unemployment interaction term plays any role in the regression. This does not support the prediction of **Hypothesis 5** that the productivity shock-housing return relation is stronger in areas with higher unemployment rates. One possible explanation for this finding is similar as our explanation for the previous results against Hypothesis 4: dominant companies' products and services are mostly consumed at the national and international levels, therefore the price drops due to the efficiency improvement will increase the demand for these goods from consumers in much wider geographical ranges than merely the local MSA. The corresponding expansion in business and increase in employment will hence be beyond the local constraint.

5. Conclusions

In this study, we extend the sparse literature on the influence of firm-level characteristics on the housing markets from a new angle, by exploring the relationship between the leading companies' productivity shocks and the local housing price movements, which can be positive or negative as predicted by different channels. Using a sample consisting of all U.S. firms in the COMPUSTAT database during 1980-2017, we find that productivity shocks of dominant firms (in terms of revenues) explain a significant portion of the local MSA-level housing price changes, with the latter increasing in the level of the former after we control for other housing price determinants. We also find that it takes about one year or more for the influence of the shocks to propagate through the local housing markets, making shocks in the aggregate level of local dominant firms' productivity a viable predictor for future housing price changes. Interestingly, our analysis with the aggregation at the zipcode level does not provide evidence for the similar relation between the productivity shocks and the local housing price movements, indicating that the influence of dominant firms is geographically more diffuse and less localized. Furthermore, we find that this influence is stronger in areas with a more rigid housing supply, and when the dominant firms have tighter links to the local non-dominant industry peers which suggests stronger spillovers from the former to the latter.

We expect that our findings can provide valuable insights to real estate market participants, including regulators, developers, financiers, brokers, investors, and consumers, as well as decision-makers, particularly in areas with high concentration of large companies and significant industry productivity volatility. For instance, banks have large exposures to local real estate markets. Our findings suggest that the existence of dominant firms in these local markets pose certain types of risks, therefore their existence should be a factor in the estimation of banks' real estate portfolio risks.

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Table 1: Summary Statistics

[Panel A] MSA-level data

Variable	N	Mean	Min	Max	Std. Dev.
Return	52957	.0360	-.5281	.7117	.061
MSA_scaled_shock	61256	1.38e-06	-.0046	.0055	.0002
GMP growth rate	61256	.0548	-.3408	.5144	.0466
employment growth rate	61256	.0147	-.2841	.2207	.0296
population growth rate	61256	.0107	-.3552	.3080	.0136

Panel A presents the summary statistics for the main dependent and independent variables for the MSA-level analysis for the sample period 1980-2017. *Return* is an MSA-level HPI quarterly return. *GMP growth rate*, *employment growth rate* and *population growth rate* are the MSA-level year-on-year change rates measured quarterly. *MSA_scaled_shock* is the firm-level productivity shock aggregated over all firms at time *t* domiciled in an MSA.

[Panel B] Zip code-level data

Variable	N	Mean	Min	Max	Std_Dev
zip_5m_ret	1950	0.04	-0.31	0.27	0.07
zip_10m_ret	1982	0.04	-0.29	0.26	0.07
zip_20m_ret	1982	0.04	-0.28	0.25	0.07
zip_30m_ret	1987	0.04	-0.28	0.24	0.07
zip_scaled_shock_t100	1989	0.00	-0.01	0.01	0.00
zip_scaled_shock_t1000	19919	0.00	0.00	0.01	0.00
MSA population growth rate	1989	0.01	-0.01	0.05	0.01

Panel B presents the summary statistics for the main dependent and independent variables for the zipcode-level analysis for the sample period 1998-2017. *Zip_#m_ret* is constructed as follows: circle with radius of # miles (#=5,10, 20 or 30) is plotted around the firm H.Q. zip code centroid, then for this circle the annual zip code housing returns within the circle are averaged to build a zip code-level housing price return index following Hartman-Glaser, Thibodeau, and Yoshida (2019). Annual housing returns on the zip code level are calculated from Zillow Home Value Index (ZHVI). *Zip_scaled_shock_t100* (*Zip_scaled_shock_t1000*) is the top 100 (1000) firms' productivity shock aggregated over all firms at time *t* domiciled in a zipcode. *MSA population growth rate* is the year-on-year MSA population change rate calculated using the 4^{th} quarter.

Table 2: Effects of productivity shocks on MSA-level housing price

[Panel A] All MSAs (with year fixed effect and quarter fixed effect)

VARIABLES	(1) return	(2) return	(3) return	(4) return
1-year lag return	0.5101***	0.4560***	0.4777***	0.4820***
	(0.000)	(0.000)	(0.000)	(0.000)
2-year lag return	0.0725**	0.0724**	0.0693**	0.0685**
	(0.024)	(0.019)	(0.025)	(0.029)
3-year lag return	-0.1489***	-0.1208***	-0.1381***	-0.1466***
	(0.000)	(0.000)	(0.000)	(0.000)
MSA_scaled_shock	1.6326	1.1211	0.6177	2.6389*
	(0.284)	(0.389)	(0.626)	(0.066)
1-year lag_MSA_scaled_shock	3.6522*	2.8516	3.1645*	4.1622**
	(0.051)	(0.122)	(0.059)	(0.028)
2-year lag_MSA_scaled_shock	2.0103	2.4301**	2.3758*	2.7050**
	(0.135)	(0.047)	(0.060)	(0.021)
employment growth rate		0.5155***		
		(0.000)		
GMP growth rate			0.2481***	
			(0.000)	
population growth rate				0.6230***
				(0.000)
Constant	0.0201***	0.0139***	0.0087***	0.0146***
	(0.000)	(0.000)	(0.000)	(0.000)
Observations	48,854	48,854	48,854	48,854
R-squared	0.5270	0.5577	0.5472	0.5416
YEAR FE	YES	YES	YES	YES
QTR FE	YES	YES	YES	YES
Clustering by MSA and quarter_count	YES	YES	YES	YES

[Panel B] All MSAs (with state – quarter_count joint fixed effect)

VARIABLES	(1) return	(2) return	(3) return	(4) return
1-year lag return	0.2732***	0.2487***	0.2581***	0.2541***
	(0.000)	(0.000)	(0.000)	(0.000)
2-year lag return	0.0846***	0.0842***	0.0824***	0.0814***
	(0.000)	(0.000)	(0.000)	(0.000)
3-year lag return	-0.0671***	-0.0558***	-0.0621***	-0.0639***
	(0.000)	(0.002)	(0.001)	(0.001)
MSA_scaled_shock	-0.0602	-0.3701	-0.3501	0.2889
	(0.941)	(0.637)	(0.647)	(0.721)
1-year lag_MSA_scaled_shock	2.6973*	2.2505*	2.2185*	2.9096**
	(0.067)	(0.082)	(0.096)	(0.041)
2-year lag_MSA_scaled_shock	0.8057	0.8452	0.8209	1.1243
	(0.562)	(0.508)	(0.534)	(0.379)
employment growth rate		0.3243***		
		(0.000)		
GMP growth rate			0.1675***	
			(0.000)	
population growth rate				0.4868***
				(0.000)
Constant	0.0249***	0.0209***	0.0171***	0.0204***
	(0.000)	(0.000)	(0.000)	(0.000)
Observations	47,965	47,965	47,965	47,965
R-squared	0.8060	0.8134	0.8110	0.8114
State-quarter_count FE	YES	YES	YES	YES
Clustering by MSA and quarter_count	YES	YES	YES	YES

[Panel C] 62 MSAs that have top-100 dominant firms

VARIABLES	(1) return	(2) return	(3) return	(4) return
1-year lag return	0.5823***	0.5235***	0.5367***	0.5590***
	(0.000)	(0.000)	(0.000)	(0.000)
2-year lag return	0.0149	0.0211	0.0154	0.0144
	(0.682)	(0.541)	(0.657)	(0.676)
3-year lag return	-0.1183***	-0.0890***	-0.1080***	-0.1167***
	(0.000)	(0.000)	(0.000)	(0.000)
MSA_scaled_shock	1.2920	0.6261	-0.1968	2.3004*
	(0.315)	(0.555)	(0.846)	(0.052)
1-year lag_MSA_scaled_shock	3.1700*	2.2123	2.5300*	3.6681**
	(0.057)	(0.180)	(0.071)	(0.034)
2-year lag_MSA_scaled_shock	1.6240	2.0928*	2.2214*	2.3123**
	(0.205)	(0.066)	(0.057)	(0.032)
employment growth rate		0.6573***		
		(0.000)		
GMP growth rate			0.3879***	
			(0.000)	
population growth rate				0.6553***
				(0.000)
Constant	0.0203***	0.0116***	0.0006	0.0142***
	(0.000)	(0.000)	(0.796)	(0.000)
Observations	9,274	9,274	9,274	9,274
R-squared	0.5654	0.6011	0.5970	0.5779
YEAR FE	YES	YES	YES	YES
QTR FE	YES	YES	YES	YES
Clustering by MSA and quarter_count	YES	YES	YES	YES

[Panel D] All MSAs (including only one shock variable: 1-year lagged MSA scaled shock)

VARIABLES	(1) return	(2) return	(3) return	(4) return
1-year lag return	0.2733***	0.2402***	0.2486***	0.2567***
	(0.000)	(0.000)	(0.000)	(0.000)
2-year lag return	0.0845***	0.0732***	0.0767***	0.0773***
	(0.000)	(0.000)	(0.000)	(0.000)
3-year lag return	-0.0671***	-0.0637***	-0.0668***	-0.0677***
	(0.000)	(0.001)	(0.000)	(0.000)
1-year lag_MSA_scaled_shock	2.6922*	2.3963*	2.4092*	2.8705**
	(0.063)	(0.078)	(0.069)	(0.043)
employment growth rate		0.2823***		
		(0.000)		
GMP growth rate			0.1603***	
			(0.000)	
population growth rate				0.3005***
				(0.000)
Constant	0.0249***	0.0224***	0.0180***	0.0225***
	(0.000)	(0.000)	(0.000)	(0.000)
Observations	47,965	47,965	47,965	47,965
R-squared	0.8060	0.8116	0.8105	0.8081
State-quarter_count FE	YES	YES	YES	YES
Clustering by MSA and quarter_count	YES	YES	YES	YES

[Panel E] All MSAs (including only one shock variable, and population growth rate is controlled)

VARIABLES	(1) return	(2) return	(3) return	(4) return
1-year lag return	0.4822***	0.4822***	0.2542***	0.2542***
	(0.000)	(0.000)	(0.000)	(0.000)
2-year lag return	0.0685**	0.0685**	0.0814***	0.0814***
	(0.000)	(0.028)	(0.000)	(0.000)
3-year lag return	-0.1466***	-0.1466***	-0.0639***	-0.0639***
	(0.000)	(0.000)	(0.000)	(0.001)
1-year lag_MSA_scaled_shock	4.1315***	4.1315**	2.9006***	2.9006**
	(0.000)	(0.017)	(0.000)	(0.036)
population growth rate	0.6214***	0.6214***	0.4866***	0.4866***
	(0.000)	(0.000)	(0.000)	(0.000)
Constant	0.0146***	0.0146***	0.0204***	0.0204***
	(0.000)	(0.000)	(0.000)	(0.000)
Observations	48,854	48,854	47,965	47,965
R-squared	0.5414	0.5414	0.8114	0.8114
Year FE and quarter FE	YES	YES		
State-quarter_count FE			YES	YES
Clustering by MSA and quarter_count		YES		YES
Clustering by quarter_count	YES		YES	

This table presents the results of regression (6) to test the effects of productivity shocks on MSA-level housing price changes for the sample period 1980-2017, in five panels. *Return* is an MSA-level HPI quarterly return, and *1-year lag return*, *2-year lag return* and *3-year lag return* are its 1-year, 2-year and 3-year lagged terms, respectively. GMP growth rate, employment growth rate and population growth rate are the MSA-level year-on-year change rates measured quarterly. *MSA_scaled_shock* is the firm-level productivity shock aggregated over all firms at time *t* domiciled in an MSA, and *1-year lag_MSA_scaled_shock* and *2-year lag_MSA_scaled_shock* are its 1-year and 2-year lagged terms, respectively. *Quarter FE*s are the fixed effects of 1st, 2nd, 3rd, and 4th quarter in a year. State-quarter_count FEs are the state and quarter_count joint fixed effect, where quarter_count include 152 quarters for 38 years of the data (1980-2017). *P*-values are in the parentheses. The stars denote the statistical significance: * significant at 10%; ** significant at 5%; *** significant at 1 %.

Table 3: Effects of firm-level productivity shocks on neighboring zip code house price returns

[Panel A] Dominant firms are top 100 firms

	(1) zip_5m_ret	(2) zip_10m_ret	(3) zip_20m_ret	(4) zip_30m_ret
1-year lag zip_5m_ret	0.496***			
	(0.000)			
2-year lag zip_5m_ret	0.072			
	(0.236)			
3-year lag zip_5m_ret	-0.024			
	(0.690)			
1-year lag zip_10m_ret		0.560***		
		(0.000)		
2-year lag zip_10m_ret		0.047		
		(0.516)		
3-year lag zip_10m_ret		-0.052		
		(0.376)		
1-year lag zip_20m_ret			0.627***	
			(0.000)	
2-year lag zip_20m_ret			-0.007	
			(0.930)	
3-year lag zip_20m_ret			-0.066	
			(0.291)	
1-year lag zip_30m_ret				0.662***
				(0.000)
2-year lag zip_30m_ret				-0.041
				(0.618)
3-year lag zip_30m_ret				-0.061
				(0.371)
MSA population growth rate	0.681**	0.611*	0.500*	0.460*
	(0.049)	(0.063)	(0.067)	(0.087)
zip_scaled_shock	1.619	1.814	1.683	1.382
	(0.148)	(0.126)	(0.130)	(0.185)
1-year lag_zip_scaled_shock	-0.613	-0.332	0.113	0.029
	(0.148)	(0.313)	(0.632)	(0.947)
2-year lag_zip_scaled_shock	0.978	0.957	0.427	0.266
	(0.315)	(0.318)	(0.609)	(0.734)
YEAR FE	Yes	Yes	Yes	Yes
Clustering by MSA and year	Yes	Yes	Yes	Yes
N	1,342	1,366	1,367	1,371
R2	0.735	0.768	0.801	0.813
Adjusted R2	0.730	0.764	0.798	0.810
Residual Std. Error	0.039 (df = 1317)	0.036 (df = 1341)	0.033 (df = 1342)	0.031 (df = 1346)

[Panel B] Dominant firms are top 1000 firms

	zip_5m_ret (1)	zip_10m_ret (2)	zip_20m_ret (3)	zip_30m_ret (4)
1-year lag zip_5m_ret	0.544***			
	(0.000)			
2-year lag zip_5m_ret	0.039			
	(0.430)			
3-year lag zip_5m_ret	-0.090			
	(0.153)			
1-year lag zip_10m_ret		0.582***		
		(0.001)		
2-year lag zip_10m_ret		0.025		
		(0.714)		
3-year lag zip_10m_ret		-0.111*		
		(0.094)		
1-year lag zip_20m_ret			0.632***	
			(0.000)	
2-year lag zip_20m_ret			-0.017	
			(0.797)	
3-year lag zip_20m_ret			-0.112	
			(0.153)	
1-year lag zip_30m_ret				0.660***
				(0.000)
2-year lag zip_30m_ret				-0.042
				(0.553)
3-year lag zip_30m_ret				-0.111
				(0.198)
MSA population growth rate	0.433**	0.428**	0.378**	0.349*
	(0.039)	(0.035)	(0.047)	(0.057)
zip_scaled_shock	2.873	2.820	2.567	2.193
	(0.184)	(0.231)	(0.294)	(0.344)
1-year lag_zip_scaled_shock	-1.096	-0.595	-0.068	-0.294
	(0.223)	(0.385)	(0.916)	(0.714)
1-year lag_zip_scaled_shock	1.450	1.224	0.267	0.126
	(0.391)	(0.434)	(0.844)	(0.922)
YEAR FE	Yes	Yes	Yes	Yes
Clustering by MSA and year	Yes	Yes	Yes	Yes
N	10,519	10,647	10,727	10,754
R2	0.703	0.736	0.762	0.774
Adjusted R2	0.702	0.735	0.762	0.773
Residual Std. Error	0.040 (df = 10494)	0.038 (df = 10622)	0.035 (df = 10702)	0.034 (df = 10729)

This table report the coefficient estimates for a regression of the average zip code-level housing returns around the firm zip code for data during 1998-2017. Dominant firms are defined as top 100 firms by revenue in Panel A, and top 1000 firms by revenue in Panel B. Dependent variable *zip_#m_ret* is constructed as follows: circle with radius of # miles (#=5,10, 20 or 30) is plotted around the firm H.Q. zip code centroid, then for this circle the annual zip code housing returns within the circle are averaged to build a zip code-level housing price return index following Hartman-Glaser, Thibodeau, and Yoshida (2019). Annual housing returns on the zip code level are calculated from Zillow Home Value Index (ZHVI). The independent variables include the 1-year, 2-year and 3-year lagged values of the zip code-level returns for the appropriate circles; the 1-year, 2-year and 3-year lagged values of *Zip_scaled_shock* (which is the firm-level productivity shock aggregated over all firms at time *t* domiciled in a zipcode); and *MSA population growth rate* (which is the year-on-year MSA population changer rate calculated on the 4^{th} quarter). The regression includes annual fixed effects with the standard errors adjusted for clustering for MSA and year following Petersen (2009). *P*-values are in the parentheses. The stars denote the statistical significance: * significant at 10%; ** significant at 5%; *** significant at 1 %.

Table 4: Effect of housing supply elasticity – for all MSAs

VARIABLES	(1) return	(2) return
1-year lag return	0.5026***	0.2510***
	(0.000)	(0.000)
2-year lag return	0.0402	0.0639***
	(0.202)	(0.000)
3-year lag return	-0.1419***	-0.0519***
	(0.000)	(0.002)
1-year lag_MSA_scaled_shock	7.0199***	6.5167***
	(0.002)	(0.001)
house_supply_elasticity	-0.0012*	-0.0011***
	(0.066)	(0.000)
shock and elasticity interaction	-2.2805*	-2.5010**
	(0.075)	(0.029)
population growth rate	0.5767***	0.4334***
	(0.000)	(0.000)
Constant	0.0181***	0.0237***
	(0.000)	(0.000)
Observations	33,534	32,443
R-squared	0.5419	0.8255
Year FE and quarter FE	YES	
State-quarter_count FE		YES
Clustering by quarter_count	YES	YES

This table presents the results of regression (7) to test the effects of housing supply rigidity on the relation between productivity shocks and MSA-level housing price changes for the sample period 1980-2017. *House_supply_elasticity* is generated by Saiz (2010) and available for 252 MSAs during our sample period. *Return* is an MSA-level HPI quarterly return, and *1-year lag return*, *2-year lag return* and *3-year lag return* are its 1-year, 2-year and 3-year lagged terms, respectively. Population growth rate is the MSA-level year-on-year population change rate measured quarterly. *1-year lag_MSA_scaled_shock* is the 1-year lagged term of the firm-level productivity shock aggregated over all firms at time *t* domiciled in an MSA. *Quarter FE*s are the fixed effects of 1st, 2nd, 3rd, and 4th quarter in a year. State-quarter_count FEs are the state and quarter_count joint fixed effect, where quarter_count include 152 quarters for 38 years of the data (1980-2017). *P*-values are in the parentheses. The stars denote the statistical significance: * significant at 10%; ** significant at 5%; *** significant at 1 %.

Table 5: Effect of industry link – for all MSAs

VARIABLES	(1) return	(2) return
1-year lag return	0.4819***	0.2535***
	(0.000)	(0.000)
2-year lag return	0.0686**	0.0809***
	(0.021)	(0.000)
3-year lag return	-0.1467***	-0.0644***
	(0.000)	(0.000)
1-year lag_MSA_scaled_shock	0.4681	-0.8999
	(0.718)	(0.439)
1-year lag_industry_link	0.0170***	0.0150***
	(0.001)	(0.001)
shock and link interaction	21.0515**	21.5693***
	(0.012)	(0.002)
population growth rate	0.6209***	0.4829***
	(0.000)	(0.000)
Constant	0.0144***	0.0204***
	(0.000)	(0.000)
Observations	48,854	47,965
R-squared	0.5417	0.8116
Year FE and quarter FE	YES	
State-quarter_count FE		YES
Clustering by quarter_count	YES	YES

This table presents the results of regression analogous to regression (7) to test the effects of industry link on the relation between productivity shocks and MSA-level housing price changes for the sample period 1980-2017. *1-year lag_industry_link* is the 1-year lagged term of industry link, where industry link is calculated as the sum of sales of non-dominant firms in the MSA that are in the same Fama-French Industry as dominant firms, divided by the sum of sales of all firms in the MSA. *Return* is an MSA-level HPI quarterly return, and *1-year lag return*, *2-year lag return* and *3-year lag return* are its 1-year, 2-year and 3-year lagged terms, respectively. Population growth rate is the MSA-level year-on-year population change rate measured quarterly. *1-year lag_MSA_scaled_shock* is the 1-year lagged term of the firm-level productivity shock aggregated over all firms at time *t* domiciled in an MSA. *Quarter FEs* are the fixed effects of 1^{st}, 2^{nd}, 3^{rd}, and 4^{th} quarter in a year. State-quarter_count FEs are the state and quarter_count joint fixed effect, where quarter_count include 152 quarters for 38 years of the data (1980-2017). *P*-values are in the parentheses. The stars denote the statistical significance: * significant at 10%; ** significant at 5%; *** significant at 1 %.

Table 6: Effect of financial constraint – for all MSAs

VARIABLES	(1) return	(2) return
1-year lag return	0.4713***	0.2403***
	(0.000)	(0.000)
2-year lag return	0.0686**	0.0837***
	(0.022)	(0.000)
3-year lag return	-0.1483***	-0.0659***
	(0.000)	(0.000)
1-year lag_MSA_scaled_shock	4.6023***	3.2691***
	(0.000)	(0.000)
Poverty dummy	-0.0028**	-0.0025***
	(0.014)	(0.000)
shock and poverty interaction	-2.8647	-0.9112
	(0.351)	(0.697)
population growth rate	0.6305***	0.4844***
	(0.000)	(0.000)
Constant	0.0156***	0.0214***
	(0.000)	(0.000)
Observations	46,048	44,979
R-squared	0.5349	0.8097
Year FE and quarter FE	YES	
State-quarter_count FE		YES
Clustering by quarter_count	YES	YES

This table presents the results of regression analogous to regression (7) to test the effects of financial constraint on the relation between productivity shocks and MSA-level housing price changes for the sample period 1980-2017. The financial constraint is estimated by *Poverty dummy*, which is 1 if the MSA-level seasonally adjusted per capita income divided by the CPI (that is, Consumer Product Index for Urban Consumer – All Items, index 1982-84=100, seasonally adjusted) is below its cross-sample median, and 0 if otherwise. *Return* is an MSA-level HPI quarterly return, and *1-year lag return*, *2-year lag return* and *3-year lag return* are its 1-year, 2-year and 3-year lagged terms, respectively. Population growth rate is the MSA-level year-on-year population change rate measured quarterly. *1-year lag_MSA_scaled_shock* is the 1-year lagged term of the firm-level productivity shock aggregated over all firms at time *t* domiciled in an MSA. *Quarter FEs* are the fixed effects of 1st, 2nd, 3rd, and 4th quarter in a year. State-quarter_count FEs are the state and quarter_count joint fixed effect, where quarter_count include 152 quarters for 38 years of the data (1980-2017). *P*-values are in the parentheses. The stars denote the statistical significance: * significant at 10%; ** significant at 5%; *** significant at 1 %.

Table 7: Effect of unemployment – for all MSAs

VARIABLES	(1) return	(2) return
1-year lag return	0.5390***	0.3211***
	(0.000)	(0.000)
2-year lag return	0.0167	0.0570***
	(0.648)	(0.005)
3-year lag return	-0.1690***	-0.1056***
	(0.000)	(0.000)
1-year lag_MSA_scaled_shock	5.1806*	0.5933
	(0.057)	(0.803)
unemployment rate	-0.0013***	-0.0011***
	(0.000)	(0.000)
shock and unemployment interaction	-0.2806	0.3183
	(0.428)	(0.224)
population growth rate	0.5991***	0.4601***
	(0.000)	(0.000)
Constant	0.0226***	0.0263***
	(0.000)	(0.000)
Observations	34,900	34,369
R-squared	0.6167	0.8459
Year FE and quarter FE	YES	
State-quarter_count FE		YES
Clustering by quarter_count	YES	YES

This table presents the results of regression analogous to regression (7) to test the effects of expansion and employment growth capacity on the relation between productivity shocks and MSA-level housing price changes for the sample period 1980-2017. The capacity of business expansion and employment growth is proxied by the MSA-level *unemployment rate*. *Return* is an MSA-level HPI quarterly return, and *1-year lag return*, *2-year lag return* and *3-year lag return* are its 1-year, 2-year and 3-year lagged terms, respectively. Population growth rate is the MSA-level year-on-year population change rate measured quarterly. *1-year lag_MSA_scaled_shock* is the 1-year lagged term of the firm-level productivity shock aggregated over all firms at time *t* domiciled in an MSA. *Quarter FEs* are the fixed effects of 1^{st}, 2^{nd}, 3^{rd}, and 4^{th} quarter in a year. State-quarter_count FEs are the state and quarter_count joint fixed effect, where quarter_count include 152 quarters for 38 years of the data (1980-2017). *P*-values are in the parentheses. The stars denote the statistical significance: * significant at 10%; ** significant at 5%; *** significant at 1 %.