Market concentration in homebuilding and the macroeconomy

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We investigate the impact of increasing concentration in local residential construction markets on housing cycle dynamics. We show that the increase in concentration has led to greater unit price volatility, less production, and fewer vacant unsold units. Our results imply that the greater concentration has decreased the value of new housing by 19% of the value of net private fixed investment. Because housing is a determinant of the business cycle these findings provide further evidence that the secular decline in competitive intensity in the American economy is altering macroeconomic dynamics[1].

1 Introduction

The housing market cycle is an integral leading component of the overall business cycle. As Edward Leamer noted in a speech to Federal Reserve leadership in 2007, the housing market has led business cycles in eight of the last ten recessions (Leamer, 2007). (Since this speech, a housing downturn played a crucial role in yet another recession.) As of 2016, ho using consumption accounts for 16% of total personal consumption expenditures and 11% of GDP (Bureau of Economic Analysis, 2017b). Primary residential mortgages account for two-thirds of all household debt (Board of Governors of the Federal Reserve System, 2017). Accordingly, housing is central to households' consumption and investment decisions (Hurst and Stafford, 2004) and household consumption during recessions is heavily influenced by their decline in housing wealth Mian et al. (2013); Mian and Sufi (2016). Accordingly, the housing market cycle is an important component of overall macroeconomic dynamics and in particular the transmission of financial shocks to the real economy (Guerrieri and Uhlig, 2016).

In the Great Recession and its aftermath the market structure in the production of new housing shifted. Local market concentration in residential construction increased drastically. Home builders are aware of the lower competition and consider it beneficial to their business; a May 2017 Wall Street Journal article featured the headline "Fewer Home Builders Means Happier Home Builders" (Lahart, 2017).

This shift in the competitive environment impacts the dynamics of housing markets. As noted by Mueller (1995), the real estate market cycle is driven by firms competing to build quickly to satisfy unmet demand and gain a first-mover advantage in a growing market:

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> In a competitive capitalistic market, developers must speculate and start the process of planning development or building new products earlier than the actual demand materializes to edge out other developers who also want a share of the market. In the absence of collusion, this speculative behavior, along with the lumpy nature of real estate product, makes it easy to overshoot actual needs.

The theoretical framework of Mueller (1995) broadly informs market participants' understanding of real estate cycle dynamics. Media reports similarly emphasize the role of competition between builders in driving supply in the commercial Schnurman (2010), retail (Sandler, 2000), and residential (O'Connell, 2011; Gopal, 2016) construction sectors. However, to date, the role of competitive intensity in generating a rush to build housing has not been investigated empirically.

In this study we investigate how competition between homebuilders drives the trajectory of housing cycles. We use a novel panel data set to demonstrate that market concentration affects housing market dynamics. Specifically, we show that the secular decline in competitive intensity over the last decade has led to fewer housing units built, a decline in the inventory of vacant unsold housing units, and greater price volatility. This micro-focused approach provides a complement to the approach in the macroeconomic literature (as reviewed in Piazzesi and Schneider (2016)) of modelling variation in the housing construction sector with highly volatile total factor productivity.

1.1 Market concentration in housing construction

Local housing markets are often dominated by a single large firm. For example, between 2005 and 2016, Baker Residential built 37% of all new housing units in Bayonne, NJ and Technical Olympic built 47% of all new housing units in Centreville, VA. Moreover, concentration has been falling over time. The Craftmark Group was responsible for 3% of new units in Annapolis, MD between 2005 and 2007 but 43% of new units between 2014 and 2016 and Baker Residential built no units in Middletown, NY between 2005 and 2007 but 37% of new units between 2014 and 2016. All of these firms are large national builders active throughout the United States.

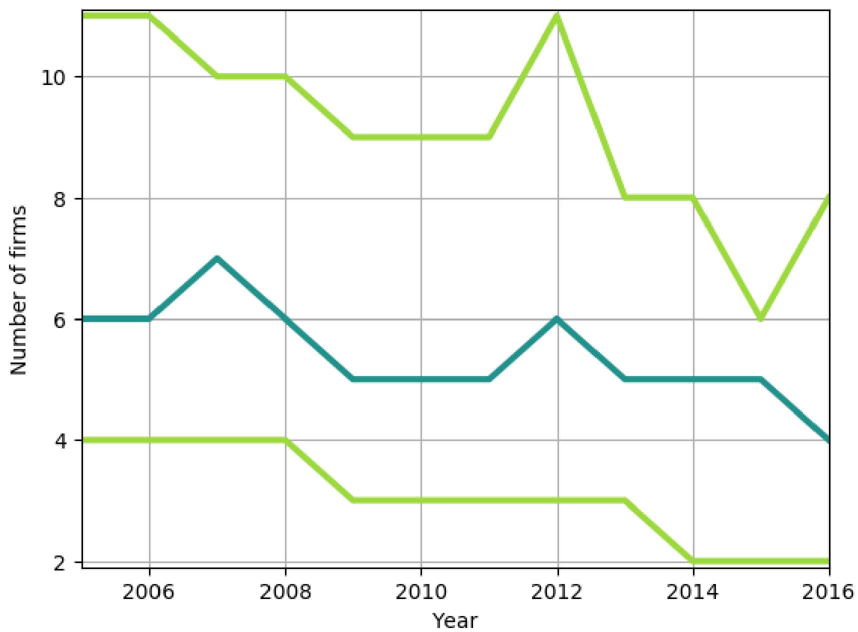
Figure 1 number of firms accounting for 90% of housing construction in markets in our sample[2]. Over the sample period, the number of firms in the median market has fallen from six to four. By the end of the sample period the bottom quartile of markets have two or fewer firms producing 90% of all new housing. Figure 2 shows the distribution of Herfindahl indices across markets in the sample as of 2006 and in 2015. For regulatory purposes the United States Department of Justice and the Federal Trade Commission deem any market with a Herfindahl index between 1500 and 2500 to be "moderately concentrated" and a Herfindahl index in excess of 2500 to be "highly concentrated" (U.S. Department of Justice and Federal Trade Commission, 2010). As shown, the entire distribution of Herfindahl indices has shifted towards higher concentration during this period. By 2015 60% of markets surpassed the "highly concentrated" threshold. Martín and Whitlow (2012) note that this shift is a relatively new phenomenon from the 2000s onwards.

Three sets of circumstances have driven the increase in market concentration over this period:

1. Dozens of firms including some large homebuilders filed for bankruptcy in 2008 in the wake of the housing market downturn (Thompson, 2009). Highly active firms in our sample which filed for bankruptcy

[2] As discussed in Section 3.2.1, our sample includes 132 housing markets in the northeastern United States.

Figure 1: Number of firms accounting for 90% of housing construction. The dark line shows the median market and the light lines show the first and third quartiles.



include Caruso Homes (Merle, 2008), Woodside Homes (Beebe, 2012), WCI Communities (Kessler, 2008), and Gemcraft (Mirabella, 2009). The process of bankruptcy appears to have impeded these firms' ability to construct new housing for several years.

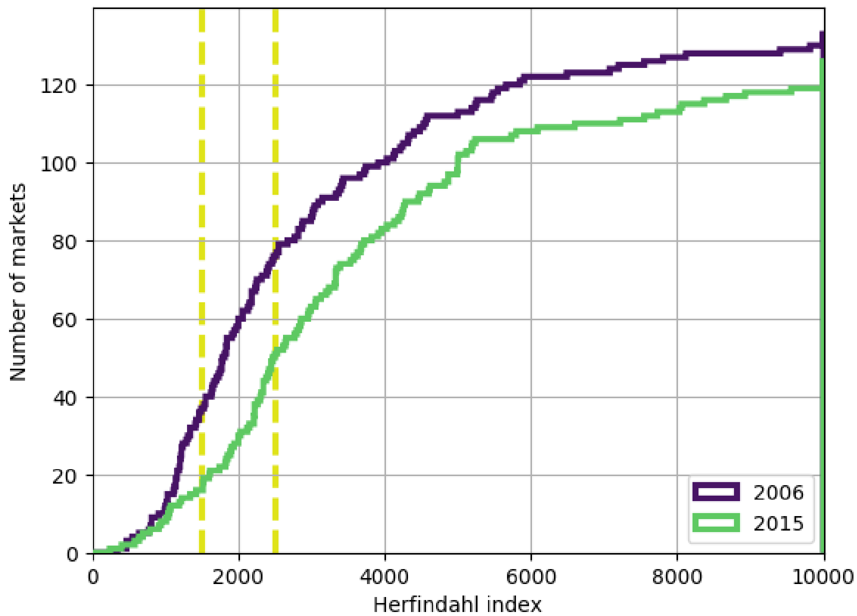
2. A federal legislative stimulus measure late in 2009 increased the ability of homebuilders to include previous years' losses in their taxes. Graham and Kim (2009) study the measure; they find that "the liquidity effect of the proposed increase in the carryback period appears substantial, at least in the case of Pulte Homes". This change in rules provided particular benefit to Lennar (Cook, 2010) as well as Toll Brothers, KB Homes, and other large national firms that had been active in markets most vulnerable to the housing market downturn (Barr, 2010). According to Corkery and Drucker (2009), the thirteen largest homebuilders expected $2.4 billion of tax refunds in 2009 as a result of the rule change.

3. In recent years large national homebuilders in our data set have merged with other national homebuilders. In particular, Pulte Homes and Centex merged in 2009 to create (at the time) the largest homebuilding firm in the country (Clifford, 2009), Tri Point merged with Weyerhauser in 2013 (Sorkin, 2013), and Standard Pacific and Ryland merged to form CalAtlantic in 2015 (Hudson, 2015)[3].

These changes had economically meaningful impacts for the markets in our sample. For example, the Elliott Building Group was present in several markets in Pennsylvania and New Jersey but following its bankruptcy

[3]Consolidation has continued after the end of our sample. Specifically, in 2017 Lennar purchased WCI Communities (Lane, 2017b) and then merged with CalAtlantic (Bray and Goldstein, 2017) to form the largest homebuilding firm in the country (Builder Magazine M&A, 2017; Gara, 2017). In the same year DR Horton purchased Forestar Group at the culmination of a bidding war with Starwood Capital Group (Lane, 2017a)

Figure 2: Cumulative distribution of Herfindahl indices for all markets in the sample in 2006 and in 2015. The dashed lines denotes the Federal Trade Commission standard for “moderately concentrated” and “highly concentrated” markets.



in 2007 (Crocker, 2007) it was no longer active in our sample. Conversely, the national-scale Pulte Homes accounted for a much larger share of housing construction in many markets after the introduction of federal stimulus. In Germantown, MD the Pulte Homes share of closings increased from 22% for the years from 2006 through 2008 to 48% for the years from 2010 through 2012 while in Odenton, MD its share increased from zero to 26% over the same period. Taken together, these changes to the competitive environment appear to have favoured the largest firms and led to much of the increase in concentration shown in Figure 1.

It is worth emphasizing that the homebuilding industry recognizes the advantages of being the dominant firm in a concentrated local market. Lahart (2017) reports that builders are more optimistic about their future success following a reduction in local competitive intensity. Builder Magazine M&A (2017) cites an analyst asserting that the merger of Lennar and CalAtlantic to “dominate the housing market” in areas where both firms were active in explaining the benefits of the merger.

In addition to these strategic considerations larger homebuilding firms benefit from substantial cost advantages relative to smaller firms. O’Hollaren (2017) enumerates several of these advantages including economies of scale, the ability to handle design and development in-house, and joint ventures with government and industry as well as name recognition and financing packages for consumers. Martín and Whitlow (2012) notes that large firms also benefit from bulk purchases that lower the cost of materials, superior access to capital markets, and land inventories that allow for less costly production of new housing. Khouri (2015) reports that when Standard Pacific and Ryland Group merged to form CalAtlantic the combined firm was able to reduce its corporate staff by 10%. Lane (2017a) notes that the merger of Lennar and CalAtlantic would allow for greater efficiencies in purchasing materials and land as well as hiring labour. Porter (2003) suggests that larger firms’ access to large volumes of patient capital through corporate bond markets and greater staff capabilities makes them better equipped to navigate local land use regulation.

Given these strategic and cost advantages enjoyed by the largest homebuilding firms it seems likely that the current consolidation will persist and that many local markets will remain highly concentrated. McGraw Hill Construction (2006) predicts that "homebuilder profitability will favor large multi-regional players" while O'Hollaren (2017) notes that "revenue is increasingly concentrated among the largest businesses in the industry". Accordingly, the role of high concentration in housing market cycle dynamics merits further investigation.

1.2 Literature review

In light of the integral role of housing in the macroeconomy, understanding firms' strategic decisions in the production of new housing has implications for understanding not only urban growth but also business cycle dynamics. As discussed in Davila and Korinek (2016) the literature on these cycles has largely focused on financial frictions — particularly the roles of incomplete markets and collateral constraints. He and Kondor (2016) investigates how the impact of the financial frictions change over the business cycle to generate investment "waves". However, theoretical results including Grenadier (2002) indicate that industry competitiveness plays a role as firms in a more competitive industry will rush to take advantage of scarce investment opportunities. Aguerrevere (2003) provides theoretical evidence that in an oligopolistic industry where building new capacity takes time and future demand is uncertain, firms may increase their capacity and the volatility of output prices may increase with the number of firms.

These results are particularly salient in the context of an economy where competitive intensity is declining across a range of industries from 1980 through the present day. Autor et al. (2017a) and De Loecker and Eeckhout (2017) document this transition[4]. De Loecker and Eeckhout (2017) connect the increased market power to higher markups. These studies suggest that the secular decline in competition may be driving long-run trends on macroeconmic dynamics. Azar et al. (2017) document the wage-setting market power of firms that dominate their local labour markets; as in our study, the authors focus on market power within local geographic markets. Gutiérrez and Philippon (2017) find a relationship between high market concentration and lower aggregate investment in industries in the United States in the 2000s. The low-competition environment has recently attracted attention in the policy literature (Galston and Hendrickson, 2018). We provide firm-level causal empirical results on the relationship between competitive intensity, the rush to make irreversible investment decisions, and volatility in an oligopolistic market.

This study also brings a new perspective to a literature that seeks to understand the connection between housing construction and price dynamics. As reviewed in Gyourko (2009), recent improvements in data availability and the experience of the dramatic housing market cycle in the 2000s have motivated research on the determinants of housing production. Equilibrium models of the housing market that explicitly include the development sector include Poterba (1984), Topel and Rosen (1988), DiPasquale and Wheaton (1994), Grimes and Aitken (2010), and Liu et al. (2016). Recent research has also addressed the optimal development time. Among others, Mayer and Somerville (2000b) builds on theoretical results from Capozza and Helsley (1990) to estimate the parameters of a structural model and Murphy (2015) studies the firm's optimal

[4] Autor et al. (2017a) attribute much of the increase in competition to the dominance of "superstar" firms with high profits and a low labour share (Autor et al., 2017b). This explanation seems less applicable in the context of homebuilding as the industry is characterized by few productivity innovations that could drive changes to the labour share (McKinsey Global Institute, 2017). Section 1.1 discusses some likely explanations for the increase in market concentration in residential construction.

timing and quantity construction decisions. Bulan et al. (2009) find that competition matters for the timing of development decisions by reducing the importance of volatility in determining when to build. Epple et al. (2010) and Combes et al. (2015) estimate housing production functions assuming price-taking atomistic firms. This study contributes by showing the integral role of market concentration in driving construction and price dynamics.

Finally, this study provides insight into observed differences in the response of housing supply to changes in demand across different cities. Previous research attempts to explain cross-sectional differences in the supply of new housing in terms of scarcity of buildable land (Saiz, 2010) or regulatory constraints (Mayer and Somerville, 2000a; Green et al., 2005; Glaeser et al., 2008). Particularly relevant to the present research are Glaeser et al. (2008) and Paciorek (2013) which connect these supply constraints to the intensity of housing market cycles. The level of competition in the housing construction industry varies greatly across local housing markets. However, to our knowledge, the empirical literature has not previously examined the relationship between market concentration and cross-sectional variation in housing market cycles.

1.3 Novel contributions

The novel contribution of this paper is primarily empirical. We document a steady decrease in competitive intensity in local residential construction markets and examine the impacts of this decrease. We conduct a counterfactual to examine the macroeconomic consequences of the growing market concentration.

To provide economic context for our results we construct a theoretical model of oligopolistic firms choosing the timing of irreversible construction decisions in the context of uncertain future demand. This simple model is intended to capture stylized theoretical results in the real options literature (as introduced by Spatt and Sterbenz (1988), Grenadier (1996), Grenadier (2002), Aguerrevere (2003), and others) in a two-period model with multiple symmetric firms. As in those studies, the model predicts a greater rush to build early in markets with greater competition. Following the resolution of the uncertainty, prices fall. Specifically, prices fall more drastically in more concentrated markets because firms in these markets have greater price-setting power. This prediction is similar to the insights of Klemperer and Meyer (1989) and other studies from the industrial organization literature that investigate the relationship between competition and uncertainty in oligopoly: markets with more competition reflect uncertainty through production volume while markets with less competition reflect uncertainty through prices.

We use a data set that identifies the firm that produces each new unit of housing sold in our sample area to document the rising market concentration in the residential construction market and investigate its impact on market dynamics. While this data set is widely used in the private sector, this study appears to be the first economic research to use this data set in academic research. We develop an instrument for the intensity of concentration to identify the causal relationship between market concentration and housing market cycles.

Our results indicate that more competitive markets have more drastic cycles with higher levels of production and a greater tendency towards overbuilding (as measured by the stock of vacant finished units). This study is the first to empirically test this widely held qualitative intuition. However, we also show that more competitive markets have less drastic price fluctuations as greater competition reduces firms' ability to set prices appreciably above marginal cost.

To understand the economic magnitude of these results, we use our parameter estimates to investigate a counterfactual scenario where housing market competition remains at its high pre-recession level across the United States. Under this counterfactual, much more housing would be built; the annual value of new housing sold would rise by \$147 billion and the number of housing units under construction or vacant and unsold would rise by 687,000.

The remainder of this article is organized as follows. First, we introduce a theoretical model that provides a framework for understanding how the rush to build can lead to overbuilding in a market with growing demand and high competition. Then, we introduce the data set and outline the empirical approach for testing the model's theoretical predictions. Finally, we present empirical results and describe the economic significance of our estimates in the context of the national housing market.

2 Theoretical model

This model illustrates the strategic behaviour of firms competing to provide housing in a market with uncertain demand. Specifically, n symmetric risk-neutral profit-maximizing non-discounting firms indexed by i each choose to build housing $h_{i1} \geq 0$ at $t = 1$ which is sold at $t = 2$ and housing $h_{i2} \geq 0$ at $t = 2$ which is sold at $t = 3$. This housing production process is analogous to the model of real estate development in the real options framework in Grenadier (1996) that predicts a rush to build in a duopoly market. Firms face a fixed cost of construction c for each unit built. The price of housing in period t is $p_t(D_t, H_t) = \Lambda + D_t - H_t$ where D_t is the housing demand in period t and H_t is the total stock of housing in period t. Restricting the parameters to ensure $\Lambda > c$ ensures positive prices and construction decisions in all states. Both the demand for housing and the total stock of housing are persistent; their realizations at $t = 2$ affect their values at $t = 3$.

Firms make their construction decisions before the demand is realized in the following period. At $t = 2$, the demand D_2 is $D_2 = Z$ for some $Z > 0$ with probability $\alpha \in (0, 1)$ and $D_2 = 0$ with probability $1 - \alpha$. At $t = 3$ the growth in demand is deterministic. Specifically, $D_3 = D_2 + Z$.

Meanwhile, housing stock evolves deterministically and housing does not depreciate. The total stock of housing at $t = 2$ is $H_2 = \sum_i h_{i1}$ while the stock at $t = 3$ is $H_3 = \sum_i (h_{i1} + h_{i2})$.

The solution concept is a subgame perfect equilibrium. At $t = 3$ firms sell whatever housing they have built at the prevailing price. At $t = 2$ firms choose how much housing to build to sell in period $t = 3$ conditional on their construction decisions at $t = 1$. At $t = 1$ firms choose how much housing to build to sell in period $t = 2$ taking into account the effect of this decision on future decisions. This yields a symmetric subgame perfect equilibrium.

2.1 Equilibrium outcome

We solve for the symmetric subgame perfect equilibrium by backwards induction. The objects of interest are the construction decisions of focal firm i at periods $t = 1$ and $t = 2$. Throughout the notation $-i$ denotes the decisions of all firms other than the focal firm i.

At period $t = 2$, the firm chooses construction h_{i2} to finish and sell at period $t = 3$ taking into account the decisions of all other firms and taking the realization of the stochastic demand term D_2 as given:

$$h_{i2}^* = \text{argmax}_{h_{i2}} \left\{ \left(\Lambda + D_2 + Z - h_{i1} - h_{-i1} - h_{i2} - h_{-i2} - c\right) h_{i2} \right\} \tag{1}$$

Let $\pi_{i2}(h_{i1}, D_2)$ denote the maximized value of the right-hand side of Equation 1. At period $t = 1$, the firm chooses construction h_{i1} to finish at period $t = 2$ taking into account the decisions of all other firms, the effect of h_{i1} on next-period excess demand D_2, and the equilibrium play at period $t = 2$:

$$h_{i1}^{*} = \text{argmax}_{h_{i1}} \left\{ \left(\Lambda + \mathbb{E}\left[D_2\right] - h_{i1} - h_{-i1} - c\right) h_{i2} + \mathbb{E}\left[\pi_{i2}\left(h_{i1}, D_2\right)\right] \right\} \tag{2}$$

In Equation 2, the operator $\mathbb{E}[\cdot]$ denotes the expectation over the realization of demand at $t = 2$. To solve for equilibrium, take first-order conditions for $t = 2$, substitute into $t = 1$, and impose symmetry. Then, each firm's equilibrium construction decisions at $t = 1$ can be expressed in terms of the number of firms n as follows:

$$h_{i1}^{*} = \frac{n+2}{n^2+3n+1}\left(\Lambda - c\right) + \frac{n+2+\alpha}{n^2+3n+1} Z \tag{3}$$

Each firm's equilibrium construction decisions for $t = 2$ in the high-demand state (i.e. the $D_2 = Z$ state) is as follows:

$$h_{i2}^{H*} = \frac{1}{n^2+3n+1}\left(\Lambda - c\right) + \frac{n^2+(4+\alpha)n+2}{\left(n^2+3n+1\right)\left(n+1\right)} Z \tag{4}$$

Finally, each firm's equilibrium construction decisions for $t = 2$ (i.e. the $D_2 = Z$ case) can be expressed in terms of its construction decisions at $t = 1$ and the realization of demand D_2 as follows:

$$h_{i2}^{L*} = \frac{1}{n^2+3n+1}\left(\Lambda - c\right) + \frac{(1+\alpha)n+1}{\left(n^2+3n+1\right)\left(n+1\right)} Z \tag{5}$$

2.2 Testable implications

This equilibrium model generates several empirically testable implications regarding the relationship between the number of firms n and equilibrium outcomes. In particular, the total first-period construction, the share of total construction in the first period, and (under additional assumptions) the change in prices between periods are strictly increasing in n.

Proposition 1. *The total quantity of housing built at $t = 1$ is strictly increasing in the number of firms n.*

Proof. See Appendix A.1. □

Proposition 1 is possibly unsurprising; an increase in construction volume with competitive intensity is a standard result in theoretical models of oligopoly. However, in this case, the timing of the construction is noteworthy. Specifically, as the number of firms increases, the share of construction occuring in the first period increases as well:

Proposition 2. *The ex ante expected ratio of first-period construction to second-period construction is increasing in the number of firms n.*

Proof. See Appendix A.2. □

Qualitatively, Proposition 2 captures the "rush to build" in an environment with many firms. As the number of firms increases, firms are increasingly willing to build in the first period to capture the potential demand before their rivals build.

Proposition 3. *Suppose $\Lambda - c > 4Z$. Then, $\mathbb{E}[p_3] > p_2$ and $\mathbb{E}[p_3] - p_2$ is decreasing in n.*

Proof. See Appendix A.3. □

Proposition 3 captures the volatility in prices in a market with a high degree of concentration. Qualitatively, if firms' incentive to rush to compete is lessened then firms supply less in the first period prior to the realization of uncertainty. This leads to larger price movement between $t = 2$ and $t = 3$.

3 Empirical approach

We test the propositions outlined above via reduced-form instrumental variable regressions. For each outcome variable y, we estimate the following specification across firms j, markets m and years t:

$$y_{mtj} = \beta COMP_{mt} + \gamma X_{mt} + \lambda_m + \mu_t + \kappa_j + \nu_{mt} + \varepsilon_{mtj} \tag{6}$$

In Equation 6, $COMP_{mt}$ is a measure of competition intensity and X_{mt} is a vector of covariates including measures of demand and competition. All results include a full set of fixed effects:

1. Place fixed effects λ_m control for persistent differences in regulatory environment, existing land uses, and other time-invariant characteristics.

2. Year fixed effects μ_t control for macroeconomic conditions.

3. Firm fixed effects κ_j control for the possibility that different firms may have systematic differences in their construction costs, access to capital, or other variables influencing firm strategy.

When estimating Equation 6 we cluster standard errors at the market-year level as this is the level of variation in competition.

3.1 Market definition

We define markets for new housing following the Census definition of places. These include incorporated municipalities (e.g. Camden, NJ or Annapolis, MD) as well as Census-designated places in unincorporated areas (e.g. Columbia, MD or Levittown, PA). To exclude very small markets which may have limited construction activity, we only include places with a population of at least $25,000$ (according to 2015 five-year American Community Survey estimates). Places are a reasonable market delineation for new housing as they approximately match the spatial range over which consumers search for new housing.

Previous literature in housing markets has used the metropolitan statistical area as a unit of analysis. However, this does not appear to be a plausible market delineation from the point of view of the homebuying consumer. As noted by Rozenfeld et al. (2011) and others, MSAs are composed of collections of counties and therefore reflect a combination of historical political boundaries and modern economic conditions. Moreover, counties are very large and heterogeneous in terms of income, built environment, travel time to work, and other attributes.

Examples from our sample area illuminate this within-MSA heterogeneity. According to 2015 five-year ACS estimates, median household income in city of Baltimore is $\$42,241$ while the median in Ellicott

City is $114,916. This is reflected in house prices; estimates from Zillow suggest an average house price of $114,400 in the city of Baltimore compared with $514,500 in Ellicott City. Counties are also large and heterogenous; in Baltimore County (which had a Census population estimate of 831,128 as of 2015) Hampton had a 2015 median household income of $114,821 compared to $48,434 in Essex. These large differences are highly salient to market delineation. As documented by Liu et al. (2016) and others, the market dynamics for expensive and inexpensive housing within the same county can differ sharply. Moreover, counties often have shapes drawn for administrative convenience in previous centuries rather than natural communities; Baltimore County and Prince George's County wrap around the city of Baltimore and the District of Columbia and Montgomery County wraps around the northwest part of the city of Philadelphia.

Outside of the large urban centres in the sample, places also generally coincide more closely with school catchment boundaries. For example, in Maryland, Gaithersburg High School, Rockville High School, Owings Mills High School, Catonsville High School, and Glen Burnie High School all serve catchment areas which closely resemble the boundaries of their respective cities and Census-designated places. Existing empirical evidence including Barrow (2002) suggests that households with children are sensitive to local public schools and therefore that these catchment boundaries are salient to residential location decisions.

Moreover, using places as the definition of real estate markets is more in keeping with the empirical results on buyers' housing search preferences presented in Piazzesi et al. (2015). The authors find that one-quarter of prospective buyers in the Bay Area search in only a single zipcode. The remaining three-quarters tend to search among a tight cluster of zipcodes; the median search has a mean geographic distance of 3.2 miles and a car travel time of 13.1 minutes between zipcode centroids. This is comparable in scale to the places in our sample.

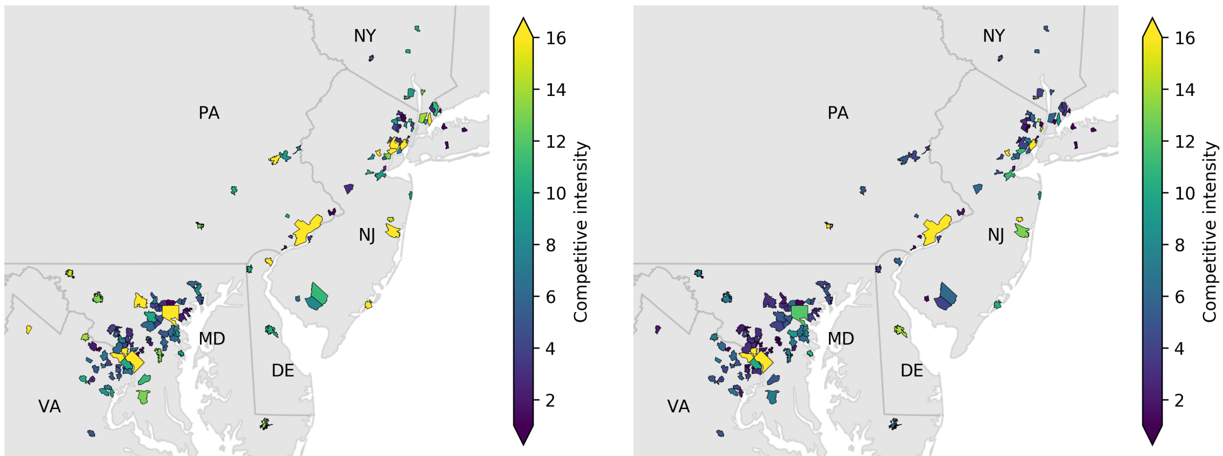
3.2 Measuring competition

In this study we use a data set on residential construction that appears to be novel to the academic literature and construct measures of competition to incorporate this data set in a regression analysis. As well, we outline an instrumentation strategy to account for potential endogeneity between housing market activity and residential construction.

3.2.1 Metrostudy data

To quantify market competition and understand how firms respond to their market power and the market power of their competitors, we require a data set that identifies individual firms' production decisions. The private firm Metrostudy collects exactly this data by monitoring residential development and property transactions to identify the firms building and selling individual housing units at a fine level of spatial disaggregation. Their data collection has covered all housing sales in the past eleven years across a broad geographical extent including all large metropolitan areas and approximately three-quarters of the United States population. This unique data set contains information on individual firms' construction activity in all markets (including the price, quantity, and attributes of new housing units) that is not available from other sources. Metrostudy also includes information on firms' characteristics including the overall scale of their operations. While this data set is widely used in private industry, it appears that it has not been used in the academic literature to date.

Figure 3: Markets included in the Metrostudy data. The degree of competition shown on this map is the number of firms accounting for 90% of construction.



(a) 2006 (b) 2015

Our sample consists of places in the Philadelphia, Washington DC, Baltimore, Allentown, PA, Atlantic City, NJ, Dover, DE Salisbury, MD, Trenton, NJ, and Vineland, NJ metropolitan areas as well as large parts of the New York metropolitan area excluding New York City itself. Figure 3 displays the markets included in the sample. As mentioned above we exclude places with less than $25,000$ residents. This leaves 132 markets with a total population of 9.74 million as of the 2015 five-year ACS estimates.

We measure market concentration by the number of firms building 90% of the housing in a given year. As this excludes small firms building a very small number of highly customized luxury housing units, this effectively captures the number of firms active in the homebuilding market. This measure aligns closely with the theoretical model outlined above. Figures 1 and 2 show the decline in competitive intensity over the sample period.

3.2.2 Instrumenting for concentration

We are interested in the causal effect of concentration on housing market outcomes including the timing of construction, price, and quantity of new housing. The concern that market concentration is an endogenous regressor in Equation 6 is not unreasonable. Endogeneity bias could arise from local shocks that simultaneously impact competition and housing market outcomes. For example, a change to permit approval policy could affect both competition (through changes to barriers to entry) and the number of units produced. To mitigate this concern, we construct an instrumental variable for the level of competition.

To construct this instrument, we use the predicted behaviour of national firms[5]. We forecast both the presence and intensity of construction activity of a national firm j in market m by looking at the activity firm j in all markets other than m. This instrumentation strategy relies on the fact that these national firms have residential construction activity distributed across the United States. Accordingly, an increase or decrease

[5] The Metrostudy data set categorizes each firm as national, regional, local, or micro depending on their total production. The data set includes 42 nationally-active firms.

in their construction activity in all markets other than m is likely driven by changes in access to capital, the success of projects elsewhere, or overarching strategic decisions rather than the conditions in market m in particular. That is, these changes affect competition in market m only through these exogenous factors. This strategy follows the widely-used shift-share instrumentation strategy introduced to the economic literature by Bartik (1991) and Blanchard et al. (1992). Moreover, the rationale for this instrument is similar to the instrument for competitive intensity introduced in Atalay et al. (2017); individual cities are negligible from the point of view of a national firm.

In order to provide causal identification, the variation in the instrument must be driven by variation exogenous to local market conditions (e.g., local changes in permitting processes). The activity of firms in our data is affected by both local and national considerations. Our instrument is based on the local impact of variation in activity resulting from events at the national level. As discussed in Section 1.1 large national firms have been affected over this period by a set of circumstances which have favoured increases in market concentration.

The key identifying assumption is that the behaviour of firm j in markets other than m is not driven by reflection. That is, if the construction decisions in market $-m \neq m$ are substantially related to some conditions in market m, then these instruments does not obey the exclusion restriction. We construct the instrument as follows:

1. Calculate nonparametrically the probability that a given large developer j will be active in market m in period t conditional on its activity in market m at period $t-1$ by averaging across all other markets.

2. Conditional on being active, predict the number of units built by large developer j in market m at time t assuming that its production in market m changed from period $t-1$ to period t proportionally to the average change in production across all other markets $-m \neq m$ from $t-1$ to t. This yields a predicted construction level $\hat{A}_{mtj}$.

3. Calculate the aggregate predicted activity of all national builders $\sum_j \hat{A}_{mtj}$ normalized by the total level of construction in market m at time $t-1$.

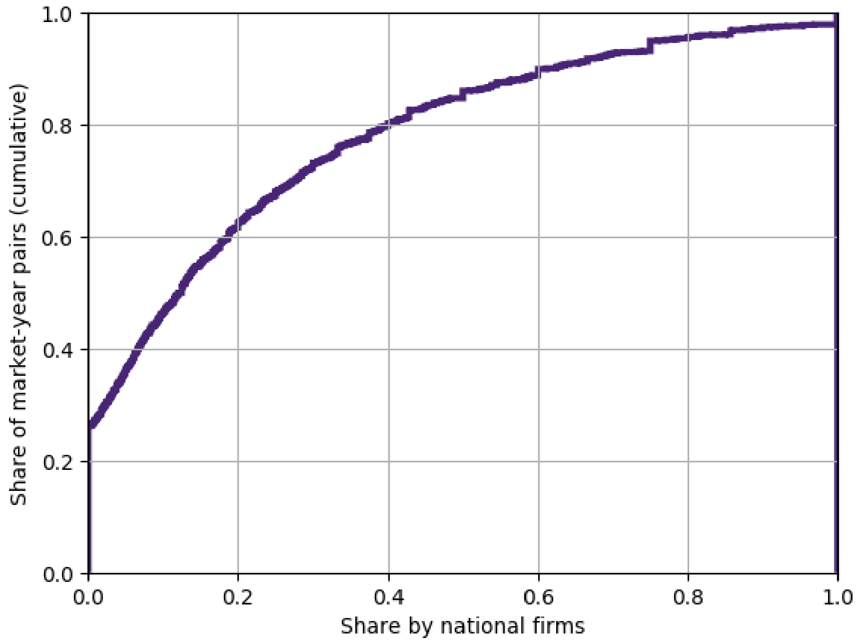
This procedure yields an instrument for competition in market m that derives its variation from the activity of large firms in markets $-m \neq m$.

Although our instrumentation strategy focuses solely on these large national firms it is worth emphasizing that these firms are present and highly active across the markets in our sample. Figure 4 shows the cumulative distribution of the share of production accounted for by national firms in the market-year pairs in our sample. As shown, national firms are active in 74% of market-year pairs in the sample. They account for at least 10% of production (and therefore impact the number of firms accounting for 90% of production) in 54% of the sample and account for the majority of construction in 15% of the sample.

3.3 Measuring demand

To estimate Equation 6, we require a measure of demand for housing in market m at time t. Ideally, this measure should be exogenous to the condition of the housing market in m at t. We use the number of jobs accessible from place m as a measure of demand. Specifically, we calculate the number of jobs within fifty

Figure 4: Cumulative distribution of the share of units accounted for by national firms across all market-year pairs.



miles[6] of housing market m using data from the Quarterly Census of Employment and Wages. To avoid potential endogeneity between economic activity in market m and housing construction in market m we follow papers including Bayer et al. (2007) by only considering jobs outside the county in which m is located.

It is worth emphasizing that we are not using this exogenous demand shifter as an instrument for the underlying demand for housing. The underlying demand for housing is unobservable. Realized population growth reflects the equilibrium outcome of changing supply in response to demand. To avoid conflating demand growth with changes in supply, we include this plausibly exogenous demand measure directly as a regressor.

3.4 Measuring construction cost

We use data from RSMeans (as used by Gyourko and Saiz (2006) and others) to account for differences in the cost of construction across markets[7]. We use the "overall" index which comprises the total cost of construction including both materials and labour. The data set includes a price index for each three-digit zipcode and a price index for each year. We map these three-digit zipcodes to the places in our sample and multiply the place index by the year index to obtain a value for each market-year pair.

[6] While this may seem like a lengthy commute, it is not unreasonable in the context of the housing markets in our sample. For instance, 5% of workers in Fredericksburg City, VA, 11% of workers in Orange County, NJ, and 12% of workers in Suffolk County, NY travel to a county more than fifty miles away. Somewhat shorter commutes are even more common; the majority of workers in Loudoun County, VA commute to a county at least 25 miles away (McKenzie, 2013).

[7] As the markets for the materials and labour needed for housing construction are larger than any individual place we regard the construction cost as exogenous.

3.5 Additional covariates

To understand how other differences in market composition could affect housing market dynamics we explore several additional variables in the firm-level regressions. In particular, in order to control for the possibility that firms operating at different scales interact differently, we control directly for the share of construction by national, regional, and micro-sized home building firms[8]. We also include a measure of "established" markets to control for any difference in dynamics between mature markets where most construction is redevelopment and newer markets where most construction is on the urban fringe. Specifically, we include an indicator variable for whether the market's resale share of total sales falls into the top tercile of all markets. As shown below, all regression results are robust to the inclusion of these additional variables.

4 Results and discussion

To understand the relationship between market concentration in the construction of new housing and housing market volatility we estimate regressions of the form specified by Equation 6. In the columns labelled "IV" we instrument for competition using the strategy outlined in Section 3.2.2. Accordingly, our results can plausibly be interpreted as the causal effect of a within-market change in competitive intensity.

4.1 Empirical results

We investigate the relationship between market concentration and cycle dynamics by estimating models of the form specified by Equation 6. We measure concentration using the number of developers accounting for 90% of construction in the market at year t; a higher value indicates greater competitive intensity. We show OLS coefficient estimates as well as the estimates with the instrumental variable for competition. Table 1 shows summary statistics for the data set used in these regressions.

Table 2 shows regression coefficients where the dependent variable is the logarithm of the total value of new housing built. As shown, markets with a greater degree of concentration produce significantly less housing even with after instrumenting for market concentration. This result is consistent with the prediction of Proposition 1 as well as the theoretical prediction in a static oligopolistic market. However, this result is difficult to reconcile with models that assume a competitive sector of atomistic price-taking construction firms.

Proposition 2 predicts a "rush" to build housing in markets with greater competitive intensity. Theoretical studies including Aguerrevere (2003) include similar predictions. We test for the rush to build using two outcome variables. Table 3 shows regression coefficients where the dependent variable is the logarithm of the year-over-year absolute change in the number of housing units produced while Table 4 shows regression coefficients where the dependent variable is the sum of the number of vacant units, model units[9], and units under construction — that is, the total housing supply in the pipeline. The latter measure is scaled to the size of the market by expressing the inventory in terms of months of supply at contemporaneous local absorption rates. As shown, the theoretical prediction is borne out; a greater degree of competitive intensity

[8]As discussed in further detail below, the Metrostudy data contains information on the scale of firms' national operations.
[9]Model units are vacant unsold units used to model the property for prospective buyers.

Table 1: Summary statistics for the regression data. The unit of observation in this table is a market-year-firm tuple.

Variable	N	Median	Mean	Std. dev	Min	Max
Number of firms producing 90%	24944	12.0	24.42	30.18	1	129
Jobs within fifty miles (millions)	24944	3.53	4.32	2.16	0.15	8.49
Construction cost index	21306	1.92	1.92	0.27	1.29	2.52
National firm share	24944	0.08	0.15	0.17	0.00	1.00
Regional firm share	24944	0.08	0.12	0.13	0.00	1.00
Micro firm share	24944	0.67	0.61	0.25	0.00	1.00
Established markets	13812	0.00	0.25	0.43	0.00	1.00
Total value of housing ($ million)	24943	91.10	196.14	245.10	0.10	1390.00
Production volatility	22313	43.00	108.27	167.55	0.00	998.00
Housing units in pipeline (months)	13911	10.315747	23.12	38.59	0.0	667.2
Price volatility (per square foot)	22170	15.93	30.61	54.97	0.08	1364.88
Firms per market-year	1569	10.0	15.90	22.81	1	225
National firms per market-year	1569	2.0	2.36	2.57	0	17
Markets	137					
Years	12					
Firms	8737					

is associated with more drastic price fluctuations as well as a larger supply of housing in the pipeline to construction.

Finally, Proposition 3 predicts that (under certain conditions) price volatility is decreasing in the level of competitive intensity. To test this, we use the absolute proportional change in housing price per square foot $\|p_t - p_{t-1}\| / p_{t-1}$ as the dependent variable. Table 5 shows the results of this regression. As predicted, higher competitive intensity is associated with substantially lower price volatility.

Taken together these empirical results support the intuition widely held by the private sector that the decline in competitive intensity in local housing construction has altered the dynamics of the real estate cycle. More concentrated markets feature lower levels of production, less volatility in production, and greater volatility in prices. These effects are statistically significant and robust to changes in specification.

4.2 Counterfactual exercise

In order to understand the macroeconomic significance of our results, we consider a counterfactual scenario where the level of competition in the housing market in 2015 remained at its pre-recession levels. Suppose that, absent the developments discussed in Section 1.1, the level of competition had held constant at pre-recession levels in markets throughout the United States. What would this imply for the state of the present housing construction market?

In order to extrapolate from our sample to the rest of the United States we use data on the number of firms active in each market from US Census Bureau Zipcode Business Patterns data. We map zipcodes to places using GIS software. Then, we estimate a mapping between the competitive intensity as measured in the Metrostudy place-level data and the competitive intensity implied in the Zipcode Business Patterns data with a flexible polynomial specification in the logarithm of competitive intensity. This provides us with some indication of whether the range of competitive intensity we observe in our Metrostudy sample is qualitatively

Table 2: Regression results where the dependent variable is the logarithm of the total value of housing produced.

	OLS	IV	OLS	IV	OLS	IV
Firms producing 90%	0.12^{***}	1.10^{***}	0.15^{***}	1.36^{***}	0.12^{***}	1.10^{***}
	(9.89)	(6.08)	(12.01)	(5.30)	(9.89)	(6.08)
Jobs within 50 miles	-0.47	7.52^{***}	-0.92^{*}	7.22^{***}	-0.47	7.52^{***}
	(-1.03)	(5.64)	(-2.05)	(4.82)	(-1.03)	(5.64)
Construction cost	-0.053^{*}	-0.47^{***}	0.025	-0.36^{***}	-0.053^{*}	-0.47^{***}
	(-2.01)	(-9.54)	(0.94)	(-7.11)	(-2.01)	(-9.54)
Share national firms			0.80^{***}	0.72^{***}		
			(10.50)	(5.39)		
Share regional firms			-0.10	0.23		
			(-1.25)	(1.78)		
Share micro firms			-0.14^{*}	-1.08^{***}		
			(-2.08)	(-3.46)		
Established market					1.83	4.33^{***}
					(1.37)	(3.94)
First stage		.049 ***		.036 ***		$.053^{***}$
		(9.36)		(7.44)		(9.16)
Observations	21306	15782	21306	15782	21303	15782
R^2	0.755	0.845	0.761	0.837	0.755	0.845

t statistics in parentheses

All specifications include firm, year, and place fixed effects.

The adjusted R^2 for the overall model is reported.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 3: Regression results where the dependent variable is the logarithm of the absolute value of the change of the units of housing produced.

	OLS	IV	OLS	IV	OLS	IV
Firms producing 90%	0.16***	1.46***	0.19***	1.74***	0.16***	1.46***
	(5.56)	(3.81)	(6.31)	(3.33)	(5.56)	(3.81)
Jobs within 50 miles	-0.083	6.79*	-0.96	5.69	-0.083	6.79*
	(-0.08)	(2.40)	(-0.88)	(1.86)	(-0.08)	(2.40)
Construction cost	-0.93***	-1.21***	-0.78***	-1.00***	-0.93***	-1.21***
	(-12.80)	(-11.50)	(-10.70)	(-9.66)	(-12.80)	(-11.50)
Share national firms			1.64***	1.41***		
			(9.02)	(4.89)		
Share regional firms			0.0088	-0.25		
			(0.04)	(-0.95)		
Share micro firms			0.12	-1.44*		
			(0.77)	(-2.20)		
Established market					-2.52*	2.02
					(-2.00)	(0.87)
First stage		.049 ***		.036 ***		.053***
		(9.40)		(7.37)		(9.24)
Observations	18847	15703	18847	15703	18847	15703
R^2	0.319	0.488	0.328	0.487	0.319	0.488

t statistics in parentheses

All specifications include firm, year, and place fixed effects.

The adjusted R^2 for the overall model is reported.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 4: Regression results where the dependent variable is the months of supply of housing (including under construction, model and finished vacant) at contemporaneous absorption rates.

	OLS	IV	OLS	IV	OLS	IV
Firms producing 90%	0.15***	2.01***	0.15**	3.16**	0.15***	2.01***
	(3.42)	(3.97)	(3.10)	(3.28)	(3.42)	(3.97)
Jobs within 50 miles	1.86	-6.83	1.62	-10.9	1.86	-6.83
	(0.59)	(-1.28)	(0.51)	(-1.51)	(0.59)	(-1.28)
Construction cost	-6.07***	-0.47	-6.08***	2.73	-6.07***	-0.47
	(-9.89)	(-0.24)	(-9.87)	(0.84)	(-9.89)	(-0.24)
Share national firms			0.92**	1.62*		
			(3.17)	(2.47)		
Share regional firms			0.53	1.75*		
			(1.88)	(2.03)		
Share micro firms			0.56*	-1.45*		
			(2.36)	(-2.48)		
Established market					-15.7***	-5.95
					(-5.34)	(-1.11)
First stage		.106 ***		.071 ***		.120***
		(5.66)		(3.94)		(5.11)
Observations	5282	4379	5282	4379	5282	4379
R^2	0.361	0.535	0.364	0.345	0.361	0.463

t statistics in parentheses

All specifications include firm, year, and place fixed effects.

The adjusted R^2 for the overall model is reported.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 5: Regression results where the dependent variable is the logarithm of the absolute value of the change of the price per square foot.

	OLS	IV	OLS	IV	OLS	IV
Firms producing 90%	-0.025	-3.15***	0.035	-3.78***	-0.025	-3.15***
	(-0.78)	(-6.21)	(1.03)	(-5.25)	(-0.78)	(-6.21)
Jobs within 50 miles	-4.53***	-28.2***	-4.16***	-28.0***	-4.53***	-28.2***
	(-3.80)	(-7.62)	(-3.50)	(-6.69)	(-3.80)	(-7.62)
Construction cost	0.031	0.16	-0.052	-0.049	0.031	0.16
	(0.39)	(1.18)	(-0.65)	(-0.35)	(0.39)	(1.18)
Share national firms			-1.60***	-1.05**		
			(-8.09)	(-2.77)		
Share regional firms			-0.39	-0.32		
			(-1.79)	(-0.87)		
Share micro firms			-1.15***	2.75**		
			(-6.51)	(3.12)		
Established market					-3.60**	82.3***
					(-2.61)	(7.67)
First stage		.048 ***		.036 ***		.053***
		(9.33)		(7.42)		(9.13)
Observations	18929	15763	18929	15763	18929	15763
R^2	0.167	0.120	0.173	0.114	0.167	0.043

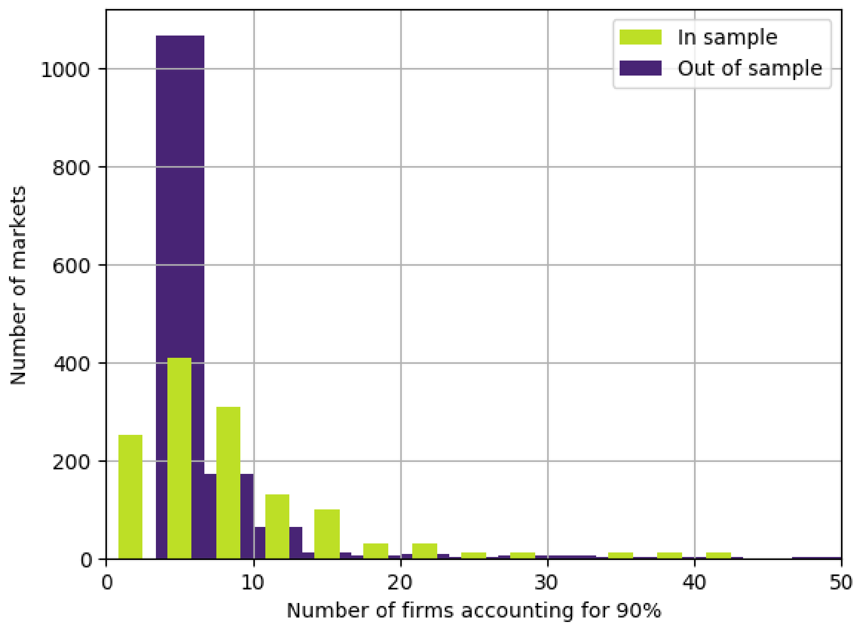
t statistics in parentheses

All specifications include year and place fixed effects.

The adjusted R^2 for the overall model is reported.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Figure 5: Predicted number of firms accounting for 90% of housing construction in each market in the United States based on 2006. Predicted values obtained from fit to Zipcode Business Patterns data. Narrow green bars show Metrostudy markets and broad blue bars show the rest of the United States. The vertical scale of the narrow green bars is increased by a factor of ten for visual clarity.



similar to the range in the rest of the United States.

Figure 5 compares the distribution of competitive intensity (as inferred from Zipcode Business Patterns data) for the markets in our sample with the distribution for the entire United States. As shown, the fit from Zipcode Business Patterns data suggests that the distribution of competitive intensity in our Metrostudy sample is similar to the distribution for the overall United States. However, while the distribution of competitive intensity in our sample is similar to the distribution in the United States overall, the markets in our sample may differ from other markets in other ways. For example, for the seven MSAs in the Saiz (2010) rankings of housing supply elasticity for which the principal city is in our sample, the rankings range from the 27th percentile to the 60th percentile of all ranked MSAs. Accordingly, the markets in our sample may not experience identical dynamics to highly constrained markets (e.g. those in the San Francisco area) or very unconstrained markets (e.g. those in the McAllen, TX area). Moreover, our analysis focuses on places with at least 25,000 residents and therefore excludes small towns and rural areas. We acknowledge these potential limitations to the external validity of this counterfactual exercise.

Next, to understand the national distribution of changes in competitive intensity over our sample period, we estimate a mapping from 2006 levels of competition to 2015 levels of competition using flexible polynomial specification in the logarithm of competitive intensity.

Finally, we assume that both the mapping between Zipcode Business Patterns data and Metrostudy data for competitive intensity and the mapping between 2006 levels of competition and 2015 levels of competition hold not only in our sample but also in all markets across the United States. Then, we apply the full vector of coefficient estimates to aggregate the impact of the change in competitive intensity in housing construction

Table 6: Predicted competition levels and corresponding changes in value of housing supply and months of finished housing supply in all markets in the United States, evaluated at the 25th percentile, median, and 75th percentile of predicted levels of 2006 competition.

	25th	Median	75th
Concentration in 2006	6.22	6.25	6.44
Concentration in 2015	4.63	4.78	5.47
Δ Value of housing supply (%)	-28	-26	-21
Δ Supply in pipeline (%)	-45	-42	-35

to the level of the macroeconomy. This counterfactual provides a plausible estimate of how the reduction in competitive intensity in the post-recession period has affected our outcome variables of interest.

Under this set of assumptions, the median number of firms accounting for 90% of production across all markets in the United States from 2006 through 2015 fell from 6.25 to 4.78 — i.e., a decrease of 24%. Weighting the markets by pre-period population (as measured in the 2015 five-year American Community Survey estimates) does not appreciably alter this result. Table 6 shows the predicted impact on markets across the United States at the quartiles of the distribution of predicted levels of 2006 competition. As shown, the predicted change in competition across the distribution is relatively uniform.

These estimates imply that the decrease in competition has impacted housing markets in economically meaningful ways. The total value of private residential construction in 2015 was $423 billion (U.S. Census Bureau, 2017b). Estimates from Table 6 indicate that absent the decrease in competition, the total value of housing would be on the order of $147 billion greater. The $147 billion difference in construction value is equivalent to 19% of the value of net private fixed investment in the United States economy in 2015 (Bureau of Economic Analysis, 2017a).

The US Census estimated that in 2015 529,000 new single-family units intended for sale started construction and 398,000 new multi-family units intended for sale or rent started construction for a total of 857,000 new units under construction (U.S. Census Bureau, 2017a). Also, in 2015 12% of all housing units in the United States were vacant U.S. Census Bureau (2018) which yields an estimate of 960,000 housing units under construction or vacant and unsold. Parameter estimates from Table 4 suggest that under this counterfactual level of competitive intensity the number of units in the supply pipeline would increase by 687,000 units.

It is worth emphasizing that these back-of-the-envelope calculations likely understate the impact of concentrated housing construction markets. As Hsieh and Moretti (2015) and others have noted, local constraints on housing supply can drive misallocation of labour and this misallocation can have substantial macroeconomic consequences.

5 Conclusion

We use a novel data set to examine the relationship between market concentration and market volatility in the residential construction sector. This data set allows us to document for the first time the high and rising market concentration at the level of individual housing markets. Our empirical results indicate that a higher degree of competitive intensity in local housing construction markets leads to more housing production, lower volatility in prices, and a greater accumulation of vacant finished unit. These findings are compatible not only with the theoretical model in this study but also with the stylized results of the literatures on real estate cycles and oligopoly as well as private industry's understanding of real estate market cycles. Our parameter estimates imply that the increasing concentration in the production in housing has led to a substantial reduction in the volume of housing produced as well as in the inventory of new vacant units.

Our counterfactual exercise suggests that the reduction in competitive intensity from 2006 through 2015 led to a 26% decline in new housing production. This is equivalent to 19% of the value of net private fixed investment in 2015. The reduction in housing construction from the increase in local market concentration has meaningful effects on overall macroeconomic investment.

The empirical results of this study indicate potential future directions for macroprudential policy. Regulators in Hong Kong and Korea have attempted to stem housing speculation by setting loan-to-value limits that reflect the perceived degree of risk in residential mortgages (Lim et al., 2011); these rules appear to have had a meaningful impact on house price dynamics in Korea (Igan and Kang, 2011). The efficacy of these policy interventions is predicated upon policymakers' ability to identify the potential for price volatility in different markets. Our research indicates that this may be a particularly significant concern in markets with high levels of concentration.

The study also has implications for policy at the local level. Municipal and regional governments have implemented a wide range of strategies to increase the supply or lower the cost of housing but to date these policies do not appear to take into account the role of competition between builders in providing new housing (Kingsley and Williams, 2007; Bellisario et al., 2016; Kalugina, 2016; MacDonald, 2016). Insofar as local governments can control the level of competitive intensity through permit allocation, our results indicate an novel channel for influencing the cost of new housing.

Housing market cycles are a central component of macroeconomic cycles. In this study, we demonstrate empirically for the first time the impact of local housing market concentration on housing market cycle dynamics. This research provides a direction for new empirical investigation into the housing-driven component of the macroeconomic cycle.

A Proofs of theoretical results

A.1 Proof of Proposition 1

Multiplying Equation 3 by n and differentiating yield the following result:

$$\frac{\partial}{\partial n}\left(nh_{i1}^{*}\right) = \frac{n^2+2n+2}{\left(n^2+3n+1\right)^2}\left(\Lambda - c\right) + \frac{\left(1-\alpha\right)n^2+2n+2+\alpha}{\left(n^2+3n+1\right)^2}Z \tag{7}$$

The right-hand side of Equation 7 is positive for all $n \in \mathbb{N}$.

A.2 Proof of Proposition 2

The construction volume decision at $t = 1$ is h_{i1}^{*} as specified by Equation 3 while the *ex ante* expected construction decision at $t = 2$ is $\alpha h_{i2}^{H*} + \left(1-\alpha\right)h_{i2}^{L*}$ as specified by Equations 4 and 5. Substituting and rearranging yields the following ratio:

$$\frac{h_{i1}^{*}}{\alpha h_{i2}^{H*}+(1-\alpha)\,h_{i2}^{L*}}=\frac{(n+1)\,(n+2)\,(\Lambda-c)+(n+1)\,(n+2+\alpha)\,Z}{(n+1)\,(\Lambda-c)+((1-\alpha)\,n^{2}+(4-2\alpha)\,n+2-\alpha)\,Z} \tag{8}$$

The derivative of the right-hand side of Equation 8 has the same sign as the following expression:

$$\begin{aligned}\operatorname{sign}\left(\frac{\partial}{\partial n}\frac{h_{i1}^{*}}{\alpha h_{i2}^{H*}+(1-\alpha)\,h_{i2}^{L*}}\right)=\operatorname{sign}\Big(&\Big[(\Lambda-c)^{2}+(2+\alpha)\,(\Lambda-c)\,Z+\left(1+2\alpha-\alpha^{2}\right)Z^{2}\Big]\,n^{2}+\\&\Big[2\,(\Lambda-c)^{2}+2\,(1+\alpha)\,(\Lambda-c)\,Z+2\left(1+2\alpha-\alpha^{2}\right)Z^{2}\Big]\,n+\\&(\Lambda-c)^{2}-(1-\alpha)\,(\Lambda-c)\,Z-\left(2-3\alpha+\alpha^{2}\right)Z^{2}\Big)\end{aligned} \tag{9}$$

The right-hand side of Equation 9 is positive for all $n\in\mathbb{N}$.

A.3 Proof of Proposition 3

Substituting h_{i1}^{*}, h_{i2}^{H*}, and h_{i2}^{L*} as specified by Equations 3, 4, and 5 into the demand curve yields the following expression for the *ex ante* expected price change from $t=2$ to $t=3$:

$$\mathbb{E}\left[p_{3}-p_{2}\right]=\frac{n^{2}+4n+1}{(n+1)\,(n^{2}+3n+1)}\,(\Lambda-c)+\frac{(1+\alpha)\,n^{3}+(1+3\alpha)\,n^{2}-(4+\alpha)\,n-2-\alpha}{(n+1)\,(n^{2}+3n+1)}Z \tag{10}$$

Under the assumption $\Lambda-c>4Z$, the right-hand side of Equation 10 is positive for all $n\in\mathbb{N}$. That is, $\mathbb{E}\left[p_{3}\right]>\mathbb{E}\left[p_{2}\right]$. The derivative of the right-hand side of Equation 10 has the same sign as the following expression:

$$\begin{aligned}\operatorname{sign}\left(\frac{\partial}{\partial n}\mathbb{E}\left[p_{3}-p_{2}\right]\right)=\operatorname{sign}\Bigg(&-\frac{n^{4}+8n^{3}+15n^{2}+6n}{(n+1)^{2}\,(n^{2}+3n+1)^{2}}\,(\Lambda-c)+\\&\frac{(\alpha+3)\,n^{4}+(10\alpha+16)\,n^{3}+(22\alpha+29)\,n^{2}+(14\alpha+18)\,n+4+3\alpha}{(n+1)^{2}\,(n^{2}+3n+1)^{2}}Z\Bigg)\end{aligned} \tag{11}$$

Under the assumption $\Lambda-c>4Z$, the right-hand side of Equation 11 is negative for all $n\in\mathbb{N}$.

References

Aguerrevere, Felipe L, “Equilibrium investment strategies and output price behavior: A real-options approach,” *The Review of Financial Studies*, 2003, *16* (4), 1239–1272.

Atalay, Enghin, Ali Hortaçsu, Mary Jialin Li, and Chad Syverson, “How Wide Is the Firm Border?,” Technical Report, National Bureau of Economic Research 2017.

Autor, David, David Dorn, Lawrence F. Katz, Christina Patterson, and John Van Reenen, "Concentrating on the Fall of the Labor Share," *American Economic Review*, may 2017, *107* (5), 180–185.

_ , _ , **Lawrence F Katz, Christina Patterson, John Van Reenen et al.**, "The Fall of the Labor Share and the Rise of Superstar Firms," Technical Report, Centre for Economic Performance, LSE 2017.

Azar, José, Ioana Marinescu, and Marshall I Steinbaum, "Labor Market Concentration," Technical Report, National Bureau of Economic Research 2017.

Barr, Colin, "Handsome government handout for homebuilders," *Fortune*, January 7 2010.

Barrow, Lisa, "School choice through relocation: evidence from the Washington, DC area," *Journal of Public Economics*, 2002, *86* (2), 155–189.

Bartik, Timothy, *Who Benefits From State and Local Economic Development Policies*, Kalamazoo, Mich.: W.E. Upjohn Institute for Employment Research, 1991.

Bayer, P., F. Ferreira, and R. McMillan, "A Unified Framework for Measuring Preferences for Schools and Neighborhoods," *Journal of Political Economy*, 2007, *115 (4)*, 588–638.

Beebe, Paul, "Back from brink, Utah's Woodside Homes downsizes to fit new realities," *Salt Lake Tribune*, December 24 2012.

Bellisario, Jeff, Micah Weinberg, Camila Mena, and Lanwei Yang, *Solving the Housing Affordability Crisis*, Bay Area Council Economic Institute, 2016.

Blanchard, Olivier Jean, Lawrence F Katz, Robert E Hall, and Barry Eichengreen, "Regional evolutions," *Brookings papers on economic activity*, 1992, *1992* (1), 1–75.

Board of Governors of the Federal Reserve System, "Survey of Consumer Finances," 2017.

Bray, Chad and Matthew Goldstein, "Lennar Makes Deal for CalAtlantic as Home Builders Face Challenges," *New York Times*, October 30 2017.

Builder Magazine M&A, "Lennar Corp., CalAtlantic Group Agree to Merge," *Builder*, October 30 2017.

Bulan, Laarni, Christopher Mayer, and C Tsuriel Somerville, "Irreversible investment, real options, and competition: Evidence from real estate development," *Journal of Urban Economics*, 2009, *65* (3), 237–251.

Bureau of Economic Analysis, "Gross and Net Domestic Investment by Major Type," 2017.

_ , "Personal Consumption Expenditures by Function," 2017.

Capozza, Dennis R and Robert W Helsley, "The stochastic city," *Journal of urban Economics*, 1990, *28* (2), 187–203.

Clifford, Catherine, "Pulte Homes in $3.1 billion merger," *CNN Money*, April 8 2009.

Combes, Pierre-Philippe, Gilles Duranton, and Laurent Gobillon, "The Production Function for Housing: Evidence from France," December 2015.

Cook, Christopher D., "Homebuilder Lennar uses federal taxpayer funds to balance its books," *San Francisco Public Press*, July 6 2010.

Corkery, Michael and Jesse Drucker, "Corporate-Tax Break Revives in Budget Plan," *Wall Street Journal*, March 6 2009.

Crocker, Robb, "Elliott Building Group Selling All Assets," *Builder*, October 23 2007.

Davila, Eduardo and Anton Korinek, "Pecuniary Externalities in Economies with Financial Frictions," *The Review of Economic Studies*, 2016.

DiPasquale, Denise and William C Wheaton, "Housing market dynamics and the future of housing prices," *Journal of urban economics*, 1994, *35* (1), 1–27.

Epple, Dennis, Brett Gordon, and Holger Sieg, "A new approach to estimating the production function for housing," *The American Economic Review*, 2010, *100* (3), 905–924.

Galston, William A. and Clara Hendrickson, "A policy at peace with itself: Antitrust remedies for our concentrated, uncompetitive economy," Technical Report, Brookings Institute January 5 2018.

Gara, Antoine, "Lennar And CalAtlantic Strike $5.7 Billion Merger To Create Nation's Largest Homebuilder," *Forbes*, October 30 2017.

Glaeser, Edward L, Joseph Gyourko, and Albert Saiz, "Housing supply and housing bubbles," *Journal of Urban Economics*, 2008, *64* (2), 198–217.

Gopal, Prashant, "As Growth in Apartment Rents Slows, U.S. Developers Press Pause," *Bloomberg News*, July 6 2016.

Graham, John R and Hyunseob Kim, "The effects of the length of the tax-loss carryback period on tax receipts and corporate marginal tax rates," Technical Report, National Bureau of Economic Research 2009.

Green, Richard K, Stephen Malpezzi, and Stephen K Mayo, "Metropolitan-specific estimates of the price elasticity of supply of housing, and their sources," *American Economic Review*, 2005, pp. 334–339.

Grenadier, Steven R, "The strategic exercise of options: Development cascades and overbuilding in real estate markets," *The Journal of Finance*, 1996, *51* (5), 1653–1679.

_ , "Option exercise games: An application to the equilibrium investment strategies of firms," *Review of financial studies*, 2002, *15* (3), 691–721.

Grimes, Arthur and Andrew Aitken, "Housing supply, land costs and price adjustment," *Real Estate Economics*, 2010, *38* (2), 325–353.

Guerrieri, V and Harald Uhlig, "Housing and credit markets: booms and busts," in "Handbook of Macroeconomics," Vol. 2, Elsevier, 2016, pp. 1427–1496.

Gutiérrez, Germán and Thomas Philippon, "Declining Competition and Investment in the US," 2017.

Gyourko, Joseph, "Housing supply," *Annu. Rev. Econ.*, 2009, *1* (1), 295–318.

_ **and Albert Saiz**, "Construction costs and the supply of housing structure," *Journal of regional Science*, 2006, *46* (4), 661–680.

He, Zhiguo and Péter Kondor, "Inefficient investment waves," *Econometrica*, 2016, *84* (2), 735–780.

Hsieh, Chang-Tai and Enrico Moretti, "Housing Constraints and Spatial Misallocation," Working Paper 21154, National Bureau of Economic Research May 2015.

Hudson, Kris, "Economists Assign Blame For Housing Shortage," *The Wall Street Journal*, June 26 2015.

Hurst, Erik and Frank P Stafford, "Home is where the equity is: Mortgage refinancing and household consumption," *Journal of money, Credit, and Banking*, 2004, *36* (6), 985–1014.

Igan, Deniz and Heedon Kang, "Do Loan-To-Value and Debt-To-Income Limits Work? Evidence From Korea," IMF Working Papers 11/297, International Monetary Fund 2011.

Kalugina, Anastasia, "Affordable Housing Policies: An Overview," *Cornell Real Estate Review*, 2016, *14* (1), 10.

Kessler, Aaron, "WCI Communities files for bankruptcy," *Sarasota Herald-Tribune*, August 5 2008.

Khouri, Andrew, "With merger closed, home builders Standard Pacific and Ryland to cut jobs," *Los Angeles Times*, October 1 2015.

Kingsley, G Thomas and Barika Xaviera Williams, *Policies for Affordable Housing in the District of Columbia: Lessons from Other Cities*, Urban Institute, 2007.

Klemperer, Paul D and Margaret A Meyer, "Supply function equilibria in oligopoly under uncertainty," *Econometrica: Journal of the Econometric Society*, 1989, pp. 1243–1277.

Lahart, Justin, "Fewer Home Builders Means Happier Home Builders," *Wall Street Journal*, May 15 2017.

Lane, Ben, "D.R. Horton completes acquisition of real estate developer Forestar Group," *Housing Wire*, October 6 2017.

_ , "Lennar finalizes $643 million acquisition of WCI Communities," *Housing Wire*, February 10 2017.

Leamer, Edward E, "Housing is the business cycle," Technical Report, National Bureau of Economic Research 2007.

Lim, Cheng Hoon, Alejo Costa, Francesco Columba, Piyabha Kongsamut, Akira Otani, Mustafa Saiyid, Torsten Wezel, and Xiaoyong Wu, "Macroprudential policy: what instruments and how to use them? Lessons from country experiences," *IMF working papers*, 2011, pp. 1–85.

Liu, Crocker H, Adam Nowak, and Stuart S Rosenthal, "Housing price bubbles, new supply, and within-city dynamics," *Journal of Urban Economics*, 2016, *96*, 55–72.

Loecker, Jan De and Jan Eeckhout, "The rise of market power and the macroeconomic implications," Technical Report, National Bureau of Economic Research 2017.

MacDonald, Graham, *The Effect of Local Government Policies on Housing Supply*, Terner Center for Housing Innovation at UC Berkeley, 2016.

Martín, Carlos and Stephen Whitlow, "The State of the Residential Construction Industry," Technical Report, Bipartisan Policy Center September 2012.

Mayer, Christopher J and C Tsuriel Somerville, "Land use regulation and new construction," *Regional Science and Urban Economics*, 2000, *30* (6), 639–662.

_ **and** _ , "Residential construction: Using the urban growth model to estimate housing supply," *Journal of urban economics*, 2000, *48* (1), 85–109.

McGraw Hill Construction, "Staying Competitive in Todays Homebuilding Industry," Technical Report, Deloitte 2006.

McKenzie, Brian, "County-to-County Commuting Flows: 2006-10," Technical Report, U.S. Census Bureau 2013.

McKinsey Global Institute, "Reinventing construction: a route to higher productivity," Technical Report, McKinsey & Company February 2017.

Merle, Renae, "Caruso Homes Enters Bankruptcy Proceedings," *Washington Post*, June 25 2008.

Mian, Atif and Amir Sufi, "Who bears the cost of recessions? The role of house prices and household debt," in "Handbook of Macroeconomics," Vol. 2, Elsevier, 2016, pp. 255–296.

_ **, Kamalesh Rao, and Amir Sufi**, "Household balance sheets, consumption, and the economic slump," *The Quarterly Journal of Economics*, 2013, *128* (4), 1687–1726.

Mirabella, Lorraine, "Home builder Gemcraft files for bankruptcy," *Baltimore Sun*, November 13 2009.

Mueller, Glenn R, "Understanding real estate's physical and financial market cycles," *Real Estate Finance*, 1995, *12*, 47–52.

Murphy, Alvin, "A Dynamic Model of Housing Supply," July 13 2015. Working paper distributed online through SSRN Electronic Journal.

O'Connell, Jonathan, "Inside the rush to build Washington apartments, early signs of a bubble," *Washington Post*, June 12 2011.

O'Hollaren, Kelsey, "Home Builders in the US," Technical Report, IBISWorld February 2017.

Paciorek, Andrew, "Supply constraints and housing market dynamics," *Journal of Urban Economics*, 2013, *77*, 11–26.

Piazzesi, Monika and Martin Schneider, "Housing and macroeconomics," *Handbook of Macroeconomics*, 2016, *2*, 1547–1640.

_ **,** _ **, and Johannes Stroebel**, "Segmented housing search," Technical Report, National Bureau of Economic Research 2015.

Porter, M, "The US homebuilding industry and the competitive position of large builders," in "Centex Investor Conference, New York" 2003.

Poterba, James M, "Tax subsidies to owner-occupied housing: an asset-market approach," *The quarterly journal of economics*, 1984, pp. 729–752.

Rozenfeld, Hernán D, Diego Rybski, Xavier Gabaix, and Hernán A Makse, "The area and population of cities: New insights from a different perspective on cities," *The American Economic Review*, 2011, *101* (5), 2205–2225.

Saiz, Albert, "The geographic determinants of housing supply," *The Quarterly Journal of Economics*, 2010, *125* (3), 1253–1296.

Sandler, Lisa, "Developers Are Rushing to Build In Long-Shunned Los Angeles," *The Wall Street Journal*, July 26 2000.

Schnurman, Mitchell, "Why Victory Park Was a Bust," *D Magazine*, January – February 2010.

Sorkin, Andrew Ross, "Home Builders to Merge in $2.7 Billion Deal," *New York Times Dealbook*, November 4 2013.

Spatt, Chester S and Frederic P Sterbenz, "Warrant exercise, dividends, and reinvestment policy," *The Journal of Finance*, 1988, *43* (2), 493–506.

Thompson, Boyce, "Builders Gone Bust," *Builder*, January 19 2009.

Topel, Robert and Sherwin Rosen, "Housing investment in the United States," *The Journal of Political Economy*, 1988, pp. 718–740.

U.S. Census Bureau, "New Residential Construction," 2017.

_ , "Value of Construction Put in Place Survey," 2017.

_ , "Housing Inventory Estimate: Vacant Housing Units for Sale for the United States," 2018.

U.S. Department of Justice and Federal Trade Commission, "Horizontal Merger Guidelines," Technical Report, U.S. Department of Justice August 19 2010.