Fewer players, fewer homes: concentration and the new dynamics of housing supply

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Local homebuilding markets have become highly concentrated in the past decade. We document this increase in concentration and use IV regressions to show that it has led to lower production volume, fewer units in the production pipeline, and greater unit price volatility. These results are consistent with a theoretical model in which oligopolistic firms strategically set the timing, volume, and price of their new construction. Our estimates imply that market concentration has decreased the annual value of housing production nationwide by $106 billion. These findings provide further evidence that the secular decline in competitive intensity is altering macroeconomic dynamics[1].

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1 Introduction

Housing production markets have become highly concentrated. Because the supply of new housing is integral to the growth of cities as well as households' consumption and investment decisions, changes to the market structure in this industry have significant impacts on the broader economy. In this study we identify the decline in competitive intensity in local housing construction markets and demonstrate its impact on the price and supply of new housing.

In recent years the supply of new housing has been limited even as the economy has recovered from the Great Recession (Fernald, ed, 2017). As of 2016, the number of new housing units started still lagged the 1975–2000 average by 20.8% despite years of strong economic growth and rising house prices (US Census Bureau, 2018). This limits the ability of workers to move to employment (Hsieh and Moretti, 2015; Ganong and Shoag, 2017; Bunten, 2017), strains the budget of low-income renters (Albouy et al., 2016), and creates unequal distributions of housing wealth (Glaeser and Gyourko, 2018). Accordingly, understanding the determinants of low supply of new housing is essential to ensuring the future health of cities. Other studies have explored potential supply restrictions including regulatory barriers (as reviewed in Gyourko and Molloy (2015)) and scarcity of buildable land (Saiz, 2010). Some homebuilders have also complained of a skilled labour shortage (Goodman, 2018). This study identifies an additional channel — specifically, the rising market concentration in homebuilding.

The production of new housing also has significant implications for the broader economy. Housing consumption accounts for 16% of total personal consumption expenditures and 11% of GDP (Bureau of Economic Analysis, 2017b) and primary residential mortgages account for two-thirds of all household debt (Board of Governors of the Federal Reserve System, 2017). Housing is central to households' consumption and investment decisions (Hurst and Stafford, 2004). Accordingly, the housing market cycle is an important component of macroeconomic cycles and in particular the transmission of financial shocks to the real economy (Guerrieri and Uhlig, 2016). Leamer (2007) finds that housing market cycles are typically driven by fluctuations in the *volume* of production rather than fluctuations in *prices* — that is, new construction is an important margin of adjustment

for housing market dynamics[2].

This study contributes to an emerging literature on the decline in competitive intensity across a range of industries from 1980 through the present day[3] (Autor et al., 2017a; De Loecker and Eeckhout, 2017; Galston and Hendrickson, 2018). Previous studies connected this secular decline in competition to higher markups (De Loecker and Eeckhout, 2017), increased wage-setting power in local labour markets (Azar et al., 2017; Benmelech et al., 2018), and lower aggregate investment (Gutiérrez and Philippon, 2017). Given the integral role of housing in household consumption and investment decisions, the decline in competitive intensity in the homebuilding sector has similarly profound consequences for the broader economy.

In this study we document the high and rising local market concentration in residential construction and investigate the impact of this concentration on market dynamics. We use a novel data panel and an instrumental variable based on the behaviour of large national firms to show that the secular decline in competitive intensity over the last decade has led to reduced construction volumes, a decline in the inventory of vacant unsold housing units, and greater price volatility. These results are compatible with theoretical models of competition and preemption in real estate (Grenadier, 1996, 2000) as well as practitioners' understanding of industry dynamics. A theoretical model of housing construction under oligopoly as described in Appendix C motivates our empirical investigation. A related empirical study is Somerville (1999) which finds a positive cross-sectional correlation between concentration and market outcomes. Our study contributes to the literature by documenting the confluence of circumstances in the past decade which have generated the high degree of concentration in local housing markets and by using a novel panel of detailed housing microdata to measure the causal effect of rising concentration.

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, market outcomes would be very

[2]Leamer (2015) attributes the distinctive dynamics of the most recent housing market cycle to the specific confluence of monetary policy and mortgage securitization at the time.

[3]Autor et al. (2017a) attribute much of the increase in concentration 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 the homebuilding industry which has experienced few productivity innovations (McKinsey Global Institute, 2017). We discuss circumstances that have contributed to the market concentration in homebuilding in Section 2.

different. The annual volume of new housing would be $106 billion higher (equivalent to 3.4% of private fixed investment or 0.6% of gross domestic product). Approximately 150,000 additional housing units would be built each year. Housing price volatility would decline by over 50%.

2 Market conditions

Housing production is highly concentrated in local markets[4]. For example, 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, between 2005 and 2016. Moreover, concentration has risen over the past decade. 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.

Figure 1 shows the high concentration in the local housing markets in our sample. Over the sample period, the share of production by the largest firms in each market increased and the number of firms producing 90% of new units decreased. By 2016, two or fewer firms produced at least 90% of new housing in the most concentrated quartile of markets.

Figure 2 compares the distribution of Herfindahl indices across markets in the sample in 2006 and in 2015. 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 rising concentration is a new phenomenon from the 2000s onwards.

Three changes to the national environment have contributed to the increase in market concentration over this period:

1. Many homebuilding firms filed for bankruptcy in 2008 in the wake of the housing market

[4]Our data set includes information on housing production and market concentration in the northeast United States between 2005 and 2016. We describe the data set in detail in Section 3.2.1. We define local housing markets in Section 3.1.

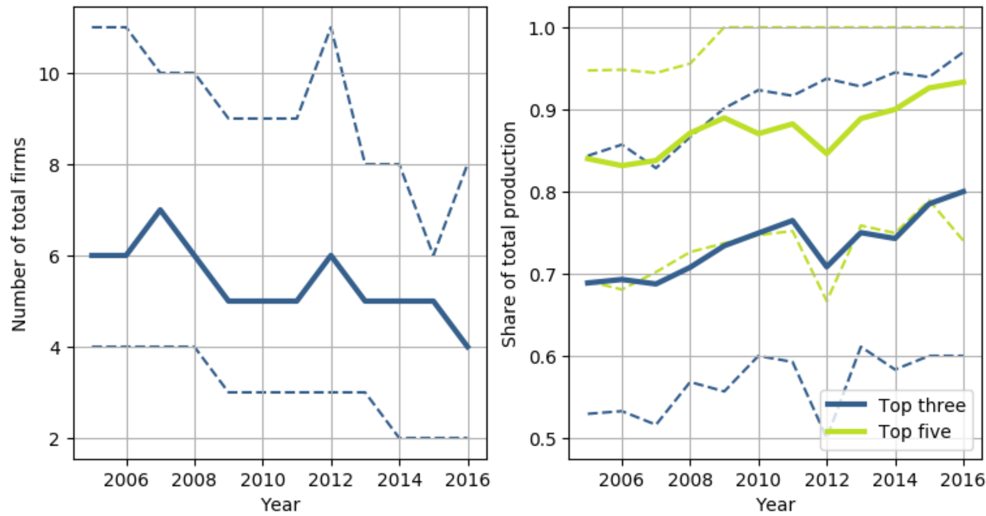

Figure 1: Measures concentration in local housing markets. The left panel shows the umber of firms accounting for 90% of housing construction and the right panel shows the share of production accounted for by largest three and largest five firms in each market. The solid line shows the median market and the dashed lines show the first and third quartiles.

downturn (Thompson, 2009). Highly active firms in our sample which filed for bankruptcy include Caruso Homes (Merle, 2008), Woodside Homes (Beebe, 2012), WCI Communities (Kessler, 2008), and Gemcraft (Mirabella, 2009). Bankruptcy limited 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 use previous years' losses to reduce their tax payments. The measure delivered $2.4 billion in tax refunds in 2009 (Corkery and Drucker, 2009). Academic research found a "substantial" effect on liquidity to a large homebuilder (Graham and Kim, 2009) and media reports indicated that the change was highly beneficial to the largest national firms (Corkery and Drucker, 2009; Barr, 2010).

3. In recent years several large national homebuilders have merged. Pulte Homes and Centex merged in 2009 to create (at the time) the largest homebuilding firm in the country (Clifford, 2009), Tri Pointe merged with Weyerhauser in 2013 (Sorkin, 2013), and Standard Pacific and Ryland merged to form CalAtlantic in 2015 (Hudson, 2015). Large national firms have also

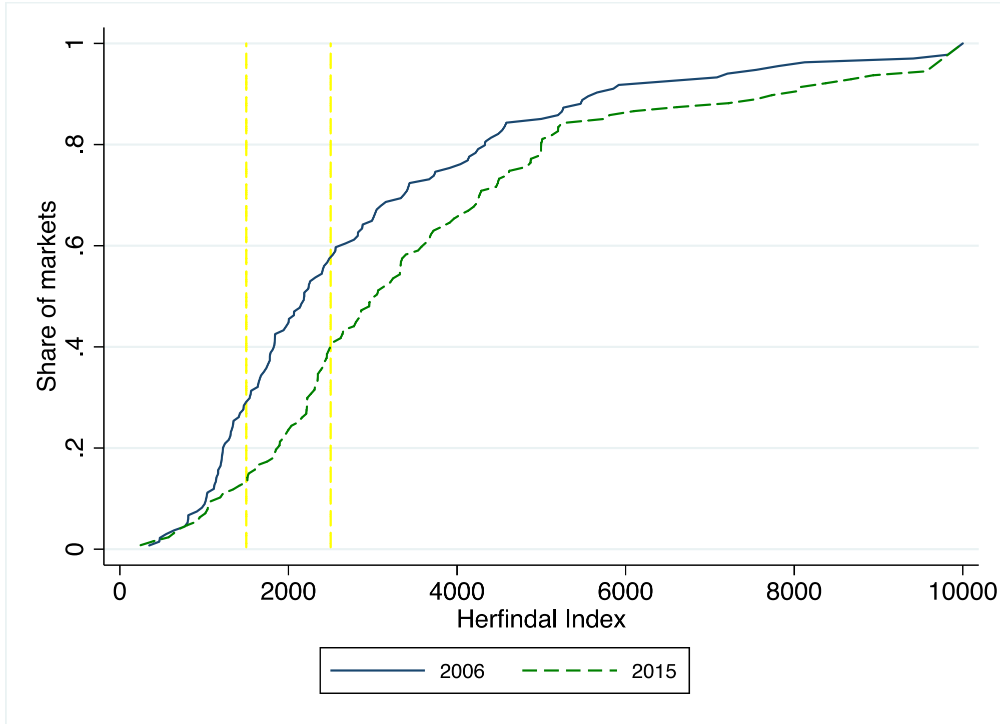

Figure 2: Cumulative distribution of Herfindahl indices for all markets in the sample in 2006 and in 2015. The dashed lines denotes the Federal Trade Commission standard for "moderately concentrated" and "highly concentrated" markets.

purchased many regional firms (Keene Advisors, 2016)[5].

These changes have transformed the competitive environment in new housing production. For example, Elliott Building Group is active in several markets in Pennsylvania and New Jersey in 2005 and 2006 but following bankruptcy in 2007 (Crocker, 2007) it is no longer present in the sample. Conversely, Pulte Homes (a large national builder) significantly increased its construction activity following the introduction of federal stimulus to assume a dominant market share in many Washington DC suburbs and other communities. Taken together, these changes to the competitive environment have favoured the largest firms and contributed to the increase in concentration shown in Figure 1.

Homebuilding firms and other industry participants recognize the advantages of being the dom-

[5]Consolidation has continued after the end of our sample in 2016. Lennar purchased WCI Communities in 2017 (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 (Lane, 2017a). *Builder* magazine describes 2017 as "a mergers and acquisitions juggernaut for home building" (Bousquin, 2017).

inant firm in a concentrated local market. In a Wall Street Journal article titled "Fewer Home Builders Means Happier Home Builders", Lahart (2017) reports that builders are more optimistic about their future success following a reduction in local competitive intensity. When Lennar and CalAtlantic merged, an analyst assessing the benefits of the merger noted that the combined firm would "dominate the housing market" in areas where both firms were active[6] (Builder Magazine M&A, 2017).

In addition to these strategic considerations, larger homebuilding firms benefit from production advantages relative to smaller firms. O'Hollaren (2017) enumerates advantages including economies of scale, the ability to handle design and development in-house, the potential for joint ventures with government and industry, brand name recognition, and financing packages for consumers. Large firms 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 (Martín and Whitlow, 2012; Lahart, 2018). After mergers large national firms have reorganized their production to reflect these advantages (Khouri, 2015; Lane, 2017a). Porter (2003) suggests that larger firms' access to more patient capital through corporate bond markets and greater staff capabilities makes them better equipped to navigate local land use regulation. According to Metcalf (2018), the complexity of local land use regulations constitutes a substantial fixed cost to homebuilders as well as a barrier to entry.

Financial markets provide evidence for the success of large national firms in recent years. From 2010 through 2017, the largest exchange-traded fund based on homebuilder stocks (Google Finance API, 2018a) experienced a cumulative gain of 207%, outpacing even the 140% cumulative gain of the S&P 500 (Google Finance API, 2018b). Even during a historically long market expansion, large national homebuilding firms have outperformed the overall market of publicly traded firms.

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 concen-

[6]However, we are unable to find any evidence that the Department of Justice or the Federal Trade Commission engaged in any regulatory intervention regarding any of theses mergers.

trated among the largest businesses in the industry". Accordingly, the role of high concentration in housing market cycle dynamics merits further investigation.

3 Empirical approach

We investigate the impact of market concentration on the volume, volatility, and pricing of housing production. Our choice of market outcome variables is disciplined by the theoretical model of housing construction in oligopoly presented in Appendix C. For each outcome variable y, we estimate the following specification across markets m and years t:

$$y_{mt} = \beta COMP_{mt} + \gamma X_{mt} + \lambda_m + \mu_t + \varepsilon_{mt} \tag{1}$$

In Equation 1, $COMP_{mt}$ is a measure of competition intensity and X_{mt} is a vector of covariates. We use an instrumental variable to address the endogeneity of competitive intensity. All results throughout this study include a full set of market and year fixed effects λ_m and μ_t and all markets are weighted by population in the 2005–2009 American Community Survey. We report heteroskedasticity-robust standard errors.

3.1 Market definition

We delineate markets for new housing following the Census definition of places. Places include incorporated cities (e.g. Poughkeepsie, NY), towns (e.g. Leesburg, VA), and boroughs (e.g. Norristown, PA) as well as Census-designated places in areas without municipal boundaries (e.g. Columbia, MD). To exclude small markets with limited construction activity, we only include places with a 2015 population of at least $25,000$ (U.S. Census Bureau, 2015a).

Places are a suitable scale for housing markets as they approximately match the spatial range over which consumers search for new housing. Previous literature has used the metropolitan statistical area (MSA) as a unit of analysis. However, an MSA appears to be too large and heterogeneous to behave as a single market. Each MSA is composed of collections of counties and therefore reflect a combination of historical political boundaries and modern economic conditions Rozenfeld et al.

(2011). MSAs contain many local government units — for example, the Washington, DC MSA is comprised of 24 counties or equivalents, several of which are further divided into cities and towns. Moreover, the communities within a MSA vary widely in terms of amenities and resident income — for example, in the Philadelphia MSA, the median household income in Camden, NJ is 36% of the median household income in Levittown, PA (U.S. Census Bureau, 2016). These differences are capitalized into the price of housing — for example, median home values in Ellicott City, MD are more than triple median home values in Baltimore U.S. Census Bureau (2016). This heterogeneity is highly salient to market delineation; price dynamics for expensive and inexpensive housing within the same county can differ sharply (Landvoigt et al., 2015; Liu et al., 2016).

Empirical evidence on search behaviour also suggests that prospective homebuyers' search areas are much smaller in scale than a MSA. Piazzesi et al. (2015) report 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.

Additionally, prices are expected to have high correlations within the relevant markets. We collect median housing price data at the zipcode, place, county, and MSA level from U.S. Census Bureau (2016). Zipcode level prices correlation is the highest within place. The place-level median price explains 65% of the variation in zipcode-level median price whereas the county-level median price explains only 50% of the variation and the MSA-level median price explains only 27% of the variation.

Finally, for all of our empirical results, we perform robustness tests that include the competitive intensity in rings of nearest-neighbour adjacent zipcodes as additional regressors to test if the market conditions outside of our defined markets are affecting market outcomes (see appendix B.6). These tests provide further evidence that our definition of places are a reasonable definition for the salient market for homebuyers and that results are robust to changes in the definition.

Accordingly, the results presented below use places as the unit of analysis throughout. Figure 3 shows the markets included in the sample. Under this definition, the majority of our markets

are suburban communities. Despite the highly visible construction in dense urban centres, new housing remains concentrated in the suburbs. In the second half of the twentieth century nearly all growth in urban population and land area occurred in the suburbs (Nechyba and Walsh, 2004). Between 2000 and 2010, the population grew faster in the suburbs than in the city centre in 98 of the hundred largest metropolitan areas (Couture and Handbury, 2017) and Census data suggests that this pattern has continued in large metropolitan areas since 2010 (Frey, 2018). Accordingly, our market definition reflects the real-world geography of new housing construction.

3.2 Measuring competition

We use a novel data set on residential construction to construct a measure of local competitive intensity. To account for potential endogeneity between housing market activity and market concentration we also use this data set to construct an instrumental variable.

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 use data from Metrostudy. Metrostudy monitors residential development and property transactions to identify the firms building and selling individual housing units at a fine level of spatial disaggregation (Metrostudy, 2018). This data set also provides information on attributes of new units including their size and price as well as information on firms' characteristics including the overall scale of their operations. Although this data set is widely used in private industry, to the best of our knowledge this is its first use in the academic literature.

Our sample consists of places in the metropolitan areas centered on Philadelphia, Washington DC, Baltimore, Allentown, PA, Atlantic City, NJ, Dover, DE Salisbury, MD, Trenton, NJ, Winchester, VA, and Vineland, NJ as well as large parts of the New York metropolitan area excluding New York City itself. As mentioned above we exclude places with less than $25,000$ residents. This leaves 137 local housing markets markets with a total population of 9.26 million (U.S. Census Bureau, 2015a). We use data from 2005 through 2016 aggregated to the national level. Production

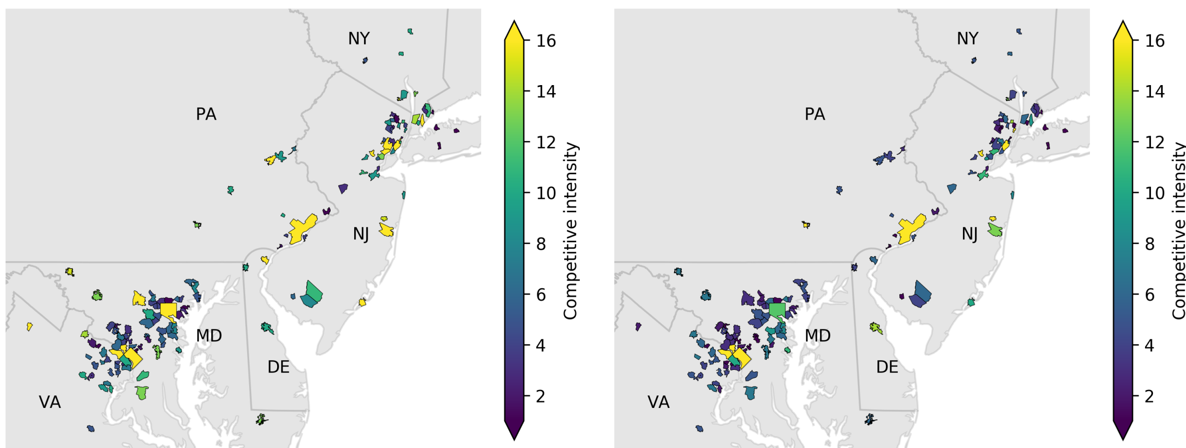

Figure 3: Markets included in the Metrostudy data. The degree of competition shown on this map is the number of firms accounting for 90% of construction. The left panel shows the values in 2006 and the right panel shows the values in 2015.

volume in these markets has followed the national trajectory described in Section 1. The number of housing units produced fell 66% from 2006 through 2011 and then remained low even as the economy recovered — in fact, the number of units declined a further 20% from 2011 through 2016.

We measure competitive intensity by the minimum number of firms building 90% of new housing in a given market-year. This measure excludes small firms building a small number of highly customized luxury housing units and therefore effectively captures the number of active market participants[7]. Figures 1 and 3 show this measure for the markets in our sample.

3.2.2 Instrumenting for concentration

In Equation 1 it is possible that competition is endogenous to market outcomes — that is, that $\operatorname{cov}(COMP_{mt}, \varepsilon_{mtj}) \neq 0$. This endogeneity could arise from local shocks that simultaneously impact competition and housing market outcomes. For example, a change to permit approval policy could affect both the number of active firms and the number of units produced. We construct an instrumental variable to address this concern.

Specifically, we construct an instrument from the predicted behaviour of national firms[8]. We

[7] Our results are robust to the use of the Herfindahl index and other concentration measures.

[8] The Metrostudy data set categorizes each firm as national, regional, local, or micro depending on their total production. The data set includes 87 nationally-active firms.

forecast the construction activity of a national firm j in market m using the activity of that firm j in all markets other than m. This instrument relies on the wide distribution of national firms' residential construction activity across the United States. National firms' production decisions are particularly influenced by the changes to the national environment, factors that are exogenous to local market conditions as described in section 2. This strategy is analogous to the shift-share instrument introduced to the economic literature by Bartik (1991) and Blanchard et al. (1992). Appendix A contains implementation details.

Since the instrument uses a measure of the average growth in activity of a national firms j in all markets other than the focal market m, the instrument is increasing in the activity of the corresponding national firm. As this activity grows, market shares in the focal market are expected to grow. Accordingly, one would expect a negative correlation between the instrument and $COMP_{mt}$. Indeed, the unconditional correlation between the instrument and $COMP_{mt}$ is negative (-0.094) and statistically significant. When reporting results in Section 4.1 we include the first-stage F-statistic throughout. Because our regression specification includes only one endogenous regressor, this is equivalent to the Cragg-Donald statistic described in Cragg and Donald (1993). In every regression reported in this study, we reject the possibility of a weak instrument according to the tests described in Stock and Yogo (2005). We also report the p-value of the coefficient on the instrument in the first stage of the regression.

The national firms whose activity we use to generate the instrument 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 produce housing 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 64% of market-year pairs and account for the majority of construction in 40% of market-year pairs.

The rationale for this instrument is similar to that followed in the instrument for competitive intensity in Atalay et al. (2017): from the point of view of a very large nationally active firm, individual cities are effectively negligible. This assures our exclusion restriction. As required,

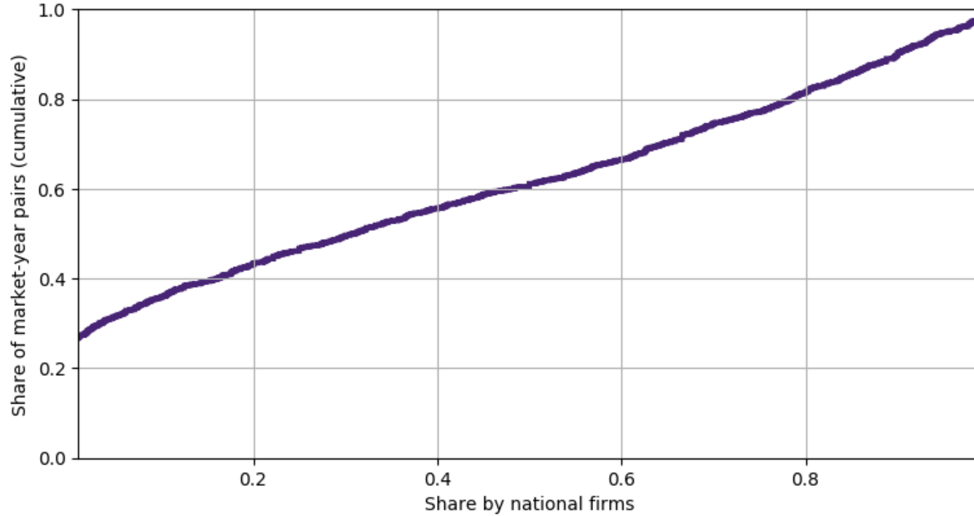

Figure 4: Cumulative distribution of the share of units accounted for by national firms across all market-year pairs.

national firms are present in multiple markets beyond our sample. For example, Pulte Homes is active in 49 metro areas in 25 states, CalAtlantic in 49 metros in 21 states, and NVR in 31 metros in 14 states.

Furthermore, each of the markets in our sample constitutes a small share of the overall national activity of the large national firms. For each national firm j, we compare Metrostudy's measure of national sales volume by firm j to its activity in markets in our sample. We calculate the share of units produced by national firm j in market m in year t relative to its nationwide production in year t. The median of this measure across all (m, t, j) tuples is 0.25% and the mean is 2%. Only (m, t, j) tuples above the 95th percentile of the distribution include situations where a single market comprises 10% of a national firm's activity. The share of overall construction by a national firm in any one market has decreased over time. In 2005 the median share of total construction volume in a single market in our sample for a national firm was 0.32% and the mean was 2.4% whereas in 2016 the median was 0.18% and the mean was 1.1%. Although national firms' overall market share has increased, the growth in their activity has been sufficiently uniform across markets that no market in our sample has become an outsized share of a national firm's overall portfolio.

3.3 Measuring demand

To estimate Equation 1, we require a measure of demand for housing in market m at time t. We use the number of jobs accessible from market m as a measure of demand. Specifically, we calculate the number of jobs within fifty miles[9] of housing market m (Bureau of Labor Statistics, 2017). 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 excluding county m — that is, we only consider jobs outside the county in which m is located. Excluding jobs in market m and all markets with which it shares a county produces a measure of demand which is exogenous to competitive intensity in market in m at t.

3.4 Measuring construction cost

We use data from RSMeans (2016) (as used by Gyourko and Saiz (2006) and others) to account for differences in the cost of construction across markets. The markets for the materials and labour needed for housing construction are larger than any individual place and the factors of housing production are largely mobile across firms and markets. Accordingly, we regard the construction cost as exogenous to local competitive intensity. We use the RSMeans overall index which measures 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 markets in our sample and multiply the market index by the year index to obtain a value for each market-year pair.

4 Results and discussion

We present empirical results that demonstrate the impact of market concentration in homebuilding on housing market outcomes. Then, we conduct a counterfactual exercise to quantify the impact of these changes on the scale of the macroeconomy.

[9] Fifty miles appear to be a salient radius for commuting 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 commute to a county more than fifty miles away. Long commutes within fifty miles are even more common; the majority of workers in Loudoun County, VA commute to a county at least 25 miles away (McKenzie, 2013).

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

	N	Median	Mean	Std. Dev.	Min.	Max.
Number of firms producing 90%	1581	6	8.6	11.7	1	129
Jobs within 50 miles (millions)	1600	3.5	4.3	2.1	0.1	8.5
Construction cost index	1600	18.9	19.1	2.7	12.9	25.2
Total value ($ million)	1580	29.2	76.2	134.2	0.1	1387.0
Total square footage (thousands)	1546	173.3	378.1	598.7	0.8	7863.3
Units sold	1581	67	158.8	266.9	1	2706
In pipeline	1600	737.5	2801.3	4628.9	0	26203
Ready for sale	1600	3	30.7	88.2	0	1405
Active subdivisions	1600	3.5	8.4	12.9	0	132
Price volatility	1392	15.2	30.8	65.4	0.1	1364.9
Production volatility	1455	3	16.9	50.1	0	878
Firms per market-year	1600	10	15.7	22.7	0	225
National firms per market-year	1581	2	2.4	2.6	0	17
Observations	1600					

4.1 Empirical results

We measure the effect of concentration on market outcomes by estimating regression models of the form specified by Equation 1. The measure of concentration is the logarithm of the number of firms accounting for 90% of production. Throughout, all outcome variables are expressed in logarithms. Accordingly, the coefficient on competitive intensity represents an estimated elasticity. We show OLS estimates as well as estimates with the instrument for competitive intensity discussed in Section 3.2.2. Additional results in Appendix B demonstrate the robustness of our results to changes in sample and specification.

Table 1 shows summary statistics for the data set used in these regressions. Volatility is the absolute change of average price per square foot and number of units for sale. The supply in the pipeline is the total number of units either under construction, used as models for display, or vacant and unsold.

4.1.1 Production volume

Table 2 shows regression coefficients where the dependent variables are the volume of housing produced as measured by the dollar value of new housing built, the square feet of housing built and

Table 2: Regression results for the impact of competition on the volume of housing supplied.

	Total value		Square footage		Units	
	OLS	IV	OLS	IV	OLS	IV
Firms producing 90%	0.17***	0.87***	0.17***	0.91***	0.082**	0.62***
	(0.040)	(0.25)	(0.039)	(0.25)	(0.040)	(0.24)
Jobs within 50 miles	-2.97**	2.71	-2.58*	3.38	-1.04	3.33
	(1.41)	(2.58)	(1.37)	(2.55)	(1.43)	(2.46)
Construction cost	-0.44***	-0.43***	-0.33***	-0.32***	-0.32***	-0.32***
	(0.089)	(0.10)	(0.086)	(0.10)	(0.090)	(0.098)
Observations	927	927	925	925	927	927
R^2	0.572		0.497		0.530	
1st Stage F		27.483		27.390		27.483
1st Stage p-value		0.000		0.000		0.000

Standard errors in parentheses.

All specifications include market and year fixed effects.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

the number of new units sold. As shown, firms in more concentrated markets produce significantly less housing. In the IV specifications the volume of housing is positively although not significantly associated with nearby jobs. Unsurprisingly, the volume of new housing has a robust negative relationship with the cost of production.

Our estimates suggest that in the average market a decline from six firms producing 90% to housing to five firms producing 90% of housing (the change in median from 2006 to 2015) with all else equal would lead to a 58% reduction of the value of housing produced, a 60% reduction of the total square footage, and a 46% reduction of the number of housing units. This result is consistent with the theoretical prediction of production decisions in an oligopolistic market. However, it is difficult to reconcile with models that include a competitive sector of atomistic price-taking construction firms.

4.1.2 Supply in pipeline

The presence of competitors affects the timing of homebuilders' production decisions. As noted by Mueller (1995) and formalized by Grenadier (1996), 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. Interfirm competition generates a rush to build. As the number of market participants increases this can result in overbuilding. Mueller (1995) writes:

> 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.

Table 3 shows regression coefficients where the dependent variables are measures of the housing supply under development:

- The total number of units in the production pipeline — specifically, the total number of units either under construction, used as models for display, or vacant and unsold
- The total number of units ready for sale
- The total number of subdivisions in which homebuilders are active

As shown, the theoretical prediction is borne out. A greater degree of competitive intensity is associated with more units in the pipeline, more finished units ready for sale, and more subdivisions in which homebuilders are active.

4.1.3 Price and production volatility

Classical models of noncooperative firm strategy under oligopoly (as reviewed in Shapiro (1989)) predict that a small set of firms will compete on price whereas a larger set of firms will instead compete on quantity. Accordingly, we expect demand uncertainty to be reflected through price volatility in more concentrated markets but through quantity volatility in more competitive markets. To test this, we investigate the absolute change in housing price per square foot and the

Table 3: Regression results for the impact of competition on the pipeline of housing production.

	In pipeline		Ready for sale		Active subdivisions	
	OLS	IV	OLS	IV	OLS	IV
Firms producing 90%	0.19***	0.40***	0.49***	2.88***	0.42***	1.51***
	(0.020)	(0.10)	(0.093)	(0.63)	(0.033)	(0.26)
Jobs within 50 miles	-7.24***	-6.33***	-13.5**	-2.32	1.91	6.54**
	(1.15)	(1.32)	(5.44)	(8.23)	(1.96)	(3.31)
Construction cost	4.38***	4.68***	-0.12	3.76	3.54***	5.09***
	(0.31)	(0.36)	(1.46)	(2.30)	(0.51)	(0.89)
Observations	690	690	651	651	688	688
R^2	0.642		0.161		0.376	
1st Stage F		25.725		24.683		25.924
1st Stage p-value		0.000		0.000		0.000

Standard errors in parentheses

Firms producing 90% and all dependent variables are introduced in logarithms.

All specifications include market and year fixed effects.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

absolute change in the number of housing units as dependent variables. Table 3 shows the results of these regressions. Higher competitive intensity leads to greater supply volatility and lower price volatility.

4.2 Interpretation of results

The results in Section 4.1 show 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 economically meaningful. As shown in Appendix B these effects are also robust to changes of sample or specification.

Throughout Section 4.1 our results show larger magnitudes for the coefficient on competitive intensity in the IV specifications than in the OLS specifications. As discussed in Section 3.2.2, our instrumental variable relies on the behaviour of large national firms. The growth of large national firms' market power over the sample period (as described in Section 2) motivates this choice of instrument. Accordingly, the identifying variation of the instrument is strongest in markets where

Table 4: Regression results for the impact of competition on price and production volatility. Includes comparison to OLS results with all markets.

	Price volatility		Production volatility	
	OLS	IV	OLS	IV
Firms producing 90%	-0.23**	-3.24***	0.68***	3.84***
	(0.10)	(0.78)	(0.12)	(0.86)
Jobs within 50 miles	-9.32***	-33.5***	4.37	18.4*
	(3.58)	(7.92)	(6.90)	(10.6)
Construction cost	-0.50**	-0.54*	-14.9***	-9.98***
	(0.23)	(0.32)	(1.86)	(2.98)
Observations	924	924	658	658
R^2	0.093		0.298	
1st Stage F		27.390		22.603
1st Stage p-value		0.000		0.000

Standard errors in parentheses.
All specifications include market and year fixed effects.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

large national firms are highly active and the local average treatment effect measured in our IV results ascribes a higher weight to these markets. Moreover, our instrument construction requires the presence of national firms. Therefore, our results in the main body of the paper exclude markets where national firms are not active[10]. We acknowledge that our IV results may be most externally valid in markets where large national firms were highly active.

Our results reflect private industry understanding as reported in the media (Lahart, 2017, 2018), as well as real estate cycle model proposed by Mueller (1995) and widely used as a conceptual model in private industry. These results may also be rationalized by a simple theoretical model of oligopolistic firms choosing the timing of irreversible construction decisions in the context of uncertain future demand as outlined in Appendix C. When many firms are competing to build, they build early to preempt their competitors. This increases total housing production, raises the volatility in the supply of housing, and creates a surplus of unfinished units. Conversely, in a more concentrated market, firms can time their housing production to maximize their profits without

[10] Appendix B includes results that examine the impact of this restriction on our sample. As shown, OLS results are largely unchanged with the larger sample (with the exception of price volatility where the coefficient on competitive intensity loses statistical significance).

fear of pre-emption. This lowers production volumes but increases price volatility as firms with market power can opt to build when demand growth is strongest and charge prices higher above their marginal cost of production.

4.3 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 higher 2006 level. Suppose that, absent the developments discussed in Section 2, 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?

So far, we have used data on local competitive intensity and market outcomes for a set of markets in the northeastern United States using Metrostudy data. We extend our results to the remainder of the country using Zipcode Business Patterns data. Appendix D describes this process.

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. This correlation is robust to the choice of assumptions used to map from Zipcode Business Patterns to market concentration described in Appendix D.

Some caveats apply to the external validity of the counterfactual exercise. 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. The markets in our study appear to be in the middle of the national distribution for housing supply elasticity in Saiz (2010).[11] Thus, these markets may not experience identical dynamics to highly constrained markets or very unconstrained markets. Moreover, our analysis focuses on markets with at least 25,000 residents and therefore excludes small towns and rural areas. As discussed in Section 4.2, our IV estimates derive

[11] Seven of the metropolitan areas in Saiz (2010) have principal cities included in our Metrostudy sample. The supply elasticity rankings for these seven metropolitan areas range from the 27th percentile to the 60th percentile of the national distribution.

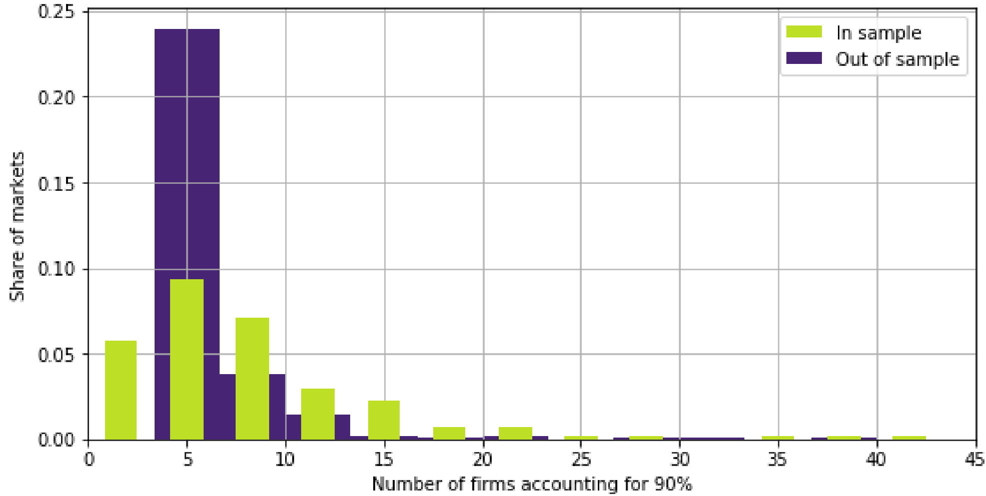

Figure 5: Predicted number of firms accounting for 90% of housing construction in each market in the United States based on 2006. Predicted values obtained from fit to Zipcode Business Patterns data. Narrow green bars show Metrostudy markets and broad blue bars show the rest of the United States.

their identifying variation from the behaviour of large national firms and therefore our estimates are most valid for markets where large national firms are highly active.

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 6.18 to 4.78 — i.e., a decrease of 23%. 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 5 shows how much the 2015 outcomes have changed relative to a baseline where competitive intensity remained at 2006 levels. We calculate 95% confidence intervals from the standard errors of the IV estimates. As shown, the impact is relatively uniform across the distribution of competitive intensity.

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 5 indicate that absent the decrease in competition, the total value of new housing would be approximately $106 billion greater. The $106 billion difference in construction value is equivalent to 3.4% of all private fixed investment in the United States economy in 2015 (Bureau of Economic Analysis, 2017a). Moreover, this is equiva-

Table 5: 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. 95% confidence intervals indicated.

	25th	Median	75th
Number of firms producing 90% in 2006	6.13	6.18	6.39
Number of firms producing 90% in 2015	4.63	4.78	5.47
Δ Value of housing produced (%)	-22	-20	-13
	$[-32, -10]$	$[-30, -9]$	$[-19, -6]$
Δ Number of units produced (%)	-16	-15	-9
	$[-26, -4]$	$[-25, -4]$	$[-16, -2]$
Δ Price volatility (%)	67	130	146
	$[30, 113]$	$[54, 243]$	$[60, 280]$

lent to 0.6% of 2015 GDP. This is comparable to the scale of the decline in residential investment Leamer (2007) identifies prior to previous recessions.

In 2015, 529,000 new single-family units and 398,000 new multi-family unit started construction for a total of 857,000 new units (U.S. Census Bureau, 2017a). Estimates from Table 5 suggest that if market concentration had remained at 2006 levels then an additional 150,000 units would have been built in 2015.

Finally, our results also suggest that price volatility would be much lower under the counterfactual 2006 levels of market concentration. Data from Zillow suggests that between 2013 and 2017 the average absolute annual change in house prices at the market level was 5.5%. According to our estimates, this would be reduced to approximately 2.4% under 2006 competitive intensity levels.

5 Conclusion

In this study we examine the impact of market concentration on the production of new housing. We document the high and rising market concentration at the level of local housing markets. Our empirical results indicate that a higher degree of concentration in local housing construction markets leads to less housing production, a decreased rush to build more units, and greater volatility in prices. These findings are compatible with stylized results in the literature on real estate cycles and and the literature on oligopoly as well as private industry's understanding of real estate market

dynamics. 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 increase in market concentration from 2006 through 2015 led to the production of $106 billion less housing per year. This equivalent to 3.4% of the value of 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. For example, 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 local policymakers. 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 could influence the level of competitive intensity through permit allocation, our results indicate a novel channel for influencing the supply of new housing.

The production of new housing is an integral component of the growth of cities as well as the macroeconomic cycle. In this study, we demonstrate empirically for the first time the impact of local housing market concentration on housing market dynamics. This research provides a direction for understanding the role of firm behaviour and the scope for policy intervention in the supply of new housing.

References

Albouy, David, Gabriel Ehrlich, and Yingyi Liu, "Housing Demand, Cost-of-Living Inequality, and the Affordability Crisis," Working Paper 22816, National Bureau of Economic Research November 2016.

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.

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.

Benmelech, Efraim, Nittai Bergman, and Hyunseob Kim, "Strong Employers and Weak Employees: How Does Employer Concentration Affect Wages?," Technical Report, National Bureau of Economic Research 2018.

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.

Bousquin, Joe, "The complicated new world of M&A deals in 2017," *Builder*, April 25 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.

Bunten, Devin, "Is the Rent Too High? Aggregate Implications of Local Land-Use Regulation," Technical Report, Federal Reserve Board working paper series 2017.

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

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

Bureau of Labor Statistics, "Quarterly Census of Employment and Wages," 2017.

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

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

Couture, Victor and Jessie Handbury, "Urban revival in America, 2000 to 2010," Technical Report, National Bureau of Economic Research 2017.

Cragg, John G and Stephen G Donald, "Testing identifiability and specification in instrumental variable models," *Econometric Theory*, 1993, *9* (2), 222–240.

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

Fernald, Marcia, ed., "The State of the Nation's Housing," Technical Report, Joint Center for Housing Studies of Harvard University 2017.

Frey, William H., "US population disperses to suburbs, exurbs, rural areas, and "middle of the country" metros," Technical Report, Brookings Institute March 26 2018.

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.

Ganong, Peter and Daniel Shoag, "Why has regional income convergence in the US declined?," *Journal of Urban Economics*, 2017, *102*, 76–90.

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

Glaeser, Edward and Joseph Gyourko, "The economic implications of housing supply," *Journal of Economic Perspectives*, 2018, *32* (1), 3–30.

Goodman, Laurie S, "What is holding back housing?," *Business Economics*, 2018, *53* (2), 79–85.

Google Finance API, "iShares Dow Jones US Home Const. (ETF)," 2018.

_ , "S&P 500 Index," 2018.

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.

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: The intersection of real options and game theory,” *Journal of Applied Corporate Finance*, 2000, *13* (2), 99–107.

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

_ **and Raven Molloy**, “Regulation and Housing Supply,” in “Handbook of Regional and Urban Economics,” Vol. 5, Elsevier, 2015, chapter Chapter 19, pp. 1289–1337.

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.

Keene Advisors, “Major Homebuilding Mergers & Acquisitions Trends,” Technical Report, Keene Advisors, Inc. 2016.

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.

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

_ , "Big Builders Are Remodeling the Housing Market," *Wall Street Journal*, July 13 2018.

Landvoigt, Tim, Monika Piazzesi, and Martin Schneider, "The housing market (s) of San Diego," *American Economic Review*, 2015, *105* (4), 1371–1407.

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.

_ , "Housing really is the business cycle: what survives the lessons of 2008–09?," *Journal of Money, Credit and Banking*, 2015, *47* (S1), 43–50.

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.

McGraw Hill Construction, "Staying Competitive in Today's 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.

Metcalf, Gabriel, "Sand Castles Before the Tide? Affordable Housing in Expensive Cities," *Journal of Economic Perspectives*, 2018, *32* (1), 59–80.

Metrostudy, "Metrostudy Proprietary Housing Data," 2018.

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.

Nechyba, Thomas J and Randall P Walsh, "Urban sprawl," *Journal of economic perspectives*, 2004, *18* (4), 177–200.

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.

Piazzesi, Monika, Martin Schneider, 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.

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.

RSMeans, "RSMeans Online Construction Cost Estimating Data," 2016.

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.

Shapiro, Carl, "Theories of oligopoly behavior," *Handbook of industrial organization*, 1989, *1*, 329–414.

Somerville, C Tsuriel, "The industrial organization of housing supply: Market activity, land supply and the size of homebuilder firms," *Real Estate Economics*, 1999, *27* (4), 669–694.

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

Stock, James H. and Motohiro Yogo, "Testing for weak instruments in linear IV regression," in Donald W. K. Andrews and James H. Stock, eds., *Identification and Inference for Econometric Models: Essays in Honor of Thomas Rothenberg*, Cambridge University Press, 2005, chapter 5.

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

U.S. Census Bureau, "American Community Survey," 2015.

_ , “Zipcode Business Patterns,” 2015.

_ , “American Community Survey,” 2016.

_ , “New Residential Construction,” 2017.

_ , “Value of Construction Put in Place Survey,” 2017.

US Census Bureau, “Housing Starts: Total: New Privately Owned Housing Units Started,” 2018.

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

A Construction of instrument

To explicitly define the instrument, let C_{mtj} be activity of firm j at period t in market m. Also, let J^N_{mt} be the set of national firms active at period t in market m (i.e., the set of national firms with nonzero closings in this market and this year). Then, define $\hat{C}_{mtj}$ as the predicted activity by firm j at period t in market m where the prediction comes from the activities of firm j in all markets other than m:

$$\hat{C}_{mtj} = \frac{\sum_{m' \neq m} C_{m'tj}}{\sum_{m' \neq m} C_{m',t-1,j}} C_{m,t-1,j} \tag{2}$$

Next, for each market, define the market-weighted average over all national firms $\bar{C}_{mt}$:

$$\bar{C}_{mt} = \frac{\sum_{j \in J^N_{mt}} C_{mt,j-1} \hat{C}_{mtj}}{\sum_{j \in J^N_{mt}} C_{mt,j-1}} \tag{3}$$

Finally, to obtain an instrument for the number of firms accounting for 90% of production, normalize by the previous year's total construction by all national firms:

$$Z_{mt} = \frac{\bar{C}_{mt}}{\sum_{j \in J^N_{mt}} C_{mt,j-1}} \tag{4}$$

We use Z_{mt} as an instrument for competitive intensity.

B Tests of robustness

We conduct several tests of robustness to ensure the validity of these empirical results:

1. To address the possibility that concentration in each market year pair is capturing only the particular composition of firms that operate at different scales, we include controls for the share of production by national, regional, and micro-sized homebuilding firms in the market (local is the base category we leave out). Similarly, to take into account the specific unit type portfolio, we also include indicators for the share of residential units in the market that are single-family (attached/multi-family is the base category we leave out). Appendix B.1 contains regression results with these additional controls.

2. To address the possibility that the dynamics of new housing development are different in markets where most new housing is produced through redevelopment and in markets where housing is built on previously undeveloped land, we include a measure of how *established* the market is. Specifically, we include an indicator variable for whether a market's resale share of total sales falls into the top tercile of all markets in that year. Appendix B.2 contains regression results generated with this additional control.

3. To ensure that our results are not driven solely by concentration in markets which may be smaller than the geographic extent of a typical homebuyer's search, we repeat the analysis excluding any market with fewer than forty thousand residents (U.S. Census Bureau, 2015a). These excluded markets comprise 30.1% of all observations. Appendix B.3 contains regression results generated with this restricted sample.

4. Similarly, to ensure that our results are not driven by apparent high concentration in markets with very low volume, we repeat the analysis excluding all market-year pairs with production in the lowest decile of nonzero housing production across all markets in each year. Appendix B.4 contains regression results generated with this restricted sample.

5. As defined in Equation 2, the instrumental variable uses the predicted activity of national firms in market m based on their activity in all markets $-m \neq m$. To account for the

Table B1: Summary statistics for the tests of robustness. The unit of observation in this table is a market-year tuple.

	N	Median	Mean	Std. Dev.	Min.	Max.
National firm share	1600	0.13	0.21	0.23	0	1
Regional firm share	1600	0.10	0.15	0.18	0	1
Micro firm share	1600	0.50	0.52	0.30	0	1
Share of single family units	1581	0.44	0.47	0.33	0	1
Established markets	1597	0.00	0.45	0.50	0	1
Share of resales	1597	0.91	0.88	0.09	0.47	1.00
Observations	1600					

possibility that firms' activity is correlated across nearby markets, we also construct the instrument excluding not only the focal market m but also all other markets spatially adjacent to m. Appendix B.5 contains regression results generated with this alternate instrument.

6. As described in Section 3.1 we use places as our definition of markets. To test whether this definition is reasonable we calculate the competitive intensity in the ring of zipcodes spatially adjacent to each market and we include this competitive intensity measure as an additional control (instrumented as described in Section 3.2.2). Appendix B.6 contains regression results generated with these additional controls.

Table B1 contains summary statistics for the additional variables in these robustness checks. Under each of these alternative specifications, the magnitude and significance of our empirical results remain unchanged.

As discussed in Section 4.2, we are able to construct our instrumental variable only in situations where large national firms are active. Therefore, our results exclude markets where large national firms are inactive. To demonstrate the impact of this change, Section B.7 compares OLS results including the set of markets with no national firms to our baseline OLS and IV results. As shown, with the exception of price volatility, all results remain largely unchanged in magnitude and statistical significance. In the price volatility regression our result is unchanged in sign but decreases in magnitude and statistical significance.

As an additional check on the power of our result in a context with many fixed effects, we randomly reassign the values of the instrument across observations one thousand times as a placebo

test. Under this random shuffling, our results should no longer hold. Appendix B.8 contains the results for these placebo tests for the impact on the different dependent variables. As shown, this "placebo" instrument generates a significant effect of concentration (at $p < 0.05$) in 1.6% to 9.8% of all iterations across the various dependent variables with a significant effect in 4.54% of the random shuffling trials across all dependent variables. This provides additional confidence that our instrument has adequate power.

B.1 Results controlling for type of builders and type of units

Table B2: Regression results for the impact of competition on the volume of housing supplied.

	Total Value				Total Sq Feet				Units Sold			
	OLS	IV	OLS	IV	OLS	IV	OLS	IV	OLS	IV	OLS	IV
Firms producing 90%	0.17***	1.07***	0.21***	0.89***	0.16***	1.11***	0.20***	0.93***	0.087**	0.80**	0.17***	0.66***
	(0.043)	(0.34)	(0.041)	(0.25)	(0.042)	(0.34)	(0.039)	(0.25)	(0.043)	(0.32)	(0.040)	(0.23)
Jobs within 50 miles	-3.02**	2.15	-2.34*	3.45	-2.54*	2.87	-2.06	4.08	-1.09	2.96	0.28	4.39*
	(1.42)	(2.60)	(1.40)	(2.63)	(1.37)	(2.58)	(1.36)	(2.61)	(1.44)	(2.45)	(1.37)	(2.42)
Share national firms	0.22	0.22			0.14	0.14			0.037	0.042		
	(0.27)	(0.33)			(0.26)	(0.32)			(0.27)	(0.31)		
Share regional firms	0.20	0.37			-0.093	0.077			-0.077	0.061		
	(0.30)	(0.37)			(0.30)	(0.38)			(0.31)	(0.35)		
Share micro firms	0.16	-0.90*			0.11	-1.00**			-0.046	-0.88*		
	(0.24)	(0.49)			(0.23)	(0.49)			(0.24)	(0.47)		
Share of single family			-0.47***	-0.90***			-0.39***	-0.85***			-0.98***	-1.28***
			(0.11)	(0.20)			(0.10)	(0.20)			(0.11)	(0.18)
Construction cost	-0.43***	-0.47***	-0.46***	-0.48***	-0.32***	-0.36***	-0.35***	-0.37***	-0.32***	-0.35***	-0.37***	-0.38***
	(0.089)	(0.11)	(0.088)	(0.10)	(0.087)	(0.11)	(0.085)	(0.100)	(0.091)	(0.10)	(0.086)	(0.093)
Observations	927	927	927	927	925	925	925	925	927	927	927	927
R^2	0.572		0.581		0.498		0.504		0.530		0.570	
1st Stage F		18.694		28.213		18.666		28.114		18.694		28.213
1st Stage p-value		0.000		0.000		0.000		0.000		0.000		0.000

Standard errors in parentheses.

All specifications include market and year fixed effects.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table B3: Regression results for the impact of competition on the pipeline of housing production.

	In pipeline				Ready for sale				Active subdivisions			
	OLS	IV	OLS	IV	OLS	IV	OLS	IV	OLS	IV	OLS	IV
Firms producing 90%	0.17***	0.39***	0.20***	0.40***	0.47***	3.17***	0.58***	2.77***	0.44***	1.69***	0.45***	1.49***
	(0.020)	(0.11)	(0.020)	(0.099)	(0.098)	(0.75)	(0.091)	(0.58)	(0.035)	(0.31)	(0.033)	(0.24)
Jobs within 50 miles	-6.87***	-6.79***	-7.07***	-6.16***	-13.4**	-10.9	-12.0**	-1.22	0.99	1.45	2.35	7.16**
	(1.16)	(1.26)	(1.15)	(1.31)	(5.55)	(8.21)	(5.28)	(7.75)	(1.99)	(3.37)	(1.93)	(3.20)
Share national firms	0.35***	0.33***			0.96*	0.38			0.37**	0.24		
	(0.11)	(0.12)			(0.53)	(0.80)			(0.18)	(0.31)		
Share regional firms	0.33***	0.29**			1.10*	0.32			0.41*	0.17		
	(0.13)	(0.14)			(0.62)	(0.93)			(0.22)	(0.37)		
Share micro firms	0.40***	0.18			0.91*	-2.00*			0.10	-1.14***		
	(0.098)	(0.15)			(0.49)	(1.07)			(0.17)	(0.42)		
Share of single family			-0.12***	-0.20***			-1.47***	-2.26***			-0.34***	-0.74***
			(0.047)	(0.062)			(0.22)	(0.37)			(0.079)	(0.15)
Construction cost	4.28***	4.72***	4.37***	4.64***	-0.32	5.68**	-0.25	3.16	3.67***	6.13***	3.51***	4.92***
	(0.31)	(0.41)	(0.31)	(0.35)	(1.49)	(2.74)	(1.41)	(2.13)	(0.52)	(1.06)	(0.50)	(0.84)
Observations	690	690	690	690	651	651	651	651	688	688	688	688
R^2	0.651		0.646		0.166		0.214		0.383		0.393	
1st Stage F		21.488		27.262		20.279		26.174		21.454		27.472
1st Stage p-value		0.000		0.000		0.000		0.000		0.000		0.000

Standard errors in parentheses.

All specifications include market and year fixed effects.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table B4: Regression results for the impact of competition on price and production volatility.

	Price volatility				Production volatility			
	OLS	IV	OLS	IV	OLS	IV	OLS	IV
Firms producing 90%	-0.27**	-4.17***	-0.26**	-3.30***	0.74***	4.43***	0.79***	3.70***
	(0.11)	(1.10)	(0.10)	(0.78)	(0.12)	(1.03)	(0.12)	(0.79)
Jobs within 50 miles	-8.78**	-31.0***	-9.69***	-35.4***	1.35	4.50	6.66	20.8**
	(3.57)	(8.33)	(3.60)	(8.17)	(6.99)	(10.8)	(6.75)	(10.1)
Share national firms	-0.48	-0.48			0.37	-0.36		
	(0.68)	(1.05)			(0.65)	(1.02)		
Share regional firms	1.83**	1.13			1.68**	0.67		
	(0.77)	(1.22)			(0.77)	(1.22)		
Share micro firms	0.75	5.35***			-0.14	-3.95***		
	(0.61)	(1.60)			(0.59)	(1.39)		
Share of single familiy			0.28	2.20***			-1.61***	-2.69***
			(0.28)	(0.62)			(0.28)	(0.49)
Construction cost	-0.59***	-0.43	-0.49**	-0.43	-15.0***	-7.18**	-15.1***	-10.8***
	(0.23)	(0.35)	(0.23)	(0.31)	(1.89)	(3.61)	(1.81)	(2.77)
Observations	924	924	924	924	658	658	658	658
R^2	0.110		0.094		0.309		0.332	
1st Stage F		18.666		28.114		18.773		24.132
1st Stage p-value		0.000		0.000		0.000		0.000

Standard errors in parentheses.

All specifications include market and year fixed effects.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

B.2 Results controlling for established markets

Table B5: Regression results for the impact of competition on the volume of housing supplied.

	Total Value				Total Sq Feet				Units Sold			
	OLS	IV	OLS	IV	OLS	IV	OLS	IV	OLS	IV	OLS	IV
Firms producing 90%	0.19***	0.99***	0.18***	0.90***	0.20***	1.04***	0.18***	0.94***	0.12***	0.75***	0.095**	0.63**
	(0.039)	(0.27)	(0.041)	(0.26)	(0.037)	(0.26)	(0.039)	(0.26)	(0.038)	(0.24)	(0.041)	(0.25)
Jobs within 50 miles	-5.91***	0.51	-2.70*	3.40	-5.72***	1.03	-2.37*	4.06	-4.84***	0.22	-0.76	3.84
	(1.40)	(2.69)	(1.43)	(2.75)	(1.34)	(2.66)	(1.39)	(2.72)	(1.36)	(2.47)	(1.45)	(2.62)
Established Market	-0.41***	-0.44***			-0.43***	-0.47***			-0.54***	-0.57***		
	(0.042)	(0.052)			(0.040)	(0.052)			(0.041)	(0.048)		
Share of resales			0.054	0.087*			0.049	0.084*			0.018	0.043
			(0.037)	(0.044)			(0.036)	(0.044)			(0.038)	(0.042)
Construction cost	-0.31***	-0.31***	-0.41***	-0.41***	-0.19**	-0.19*	-0.31***	-0.30***	-0.16*	-0.16	-0.32***	-0.31***
	(0.086)	(0.10)	(0.091)	(0.11)	(0.082)	(0.10)	(0.088)	(0.10)	(0.083)	(0.095)	(0.092)	(0.10)
Observations	916	916	916	916	914	914	914	914	916	916	916	916
R^2	0.612		0.573		0.551		0.497		0.606		0.531	
1st Stage F		25.233		26.154		25.108		26.057		25.233		26.154
1st Stage p-value		0.000		0.000		0.000		0.000		0.000		0.000

Standard errors in parentheses.

All specifications include market and year fixed effects.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table B6: Regression results for the impact of competition on the pipeline of housing production.

	In pipeline				Ready for sale				Active subdivisions			
	OLS	IV	OLS	IV	OLS	IV	OLS	IV	OLS	IV	OLS	IV
Firms producing 90%	0.18***	0.39***	0.19***	0.41***	0.44***	2.77***	0.50***	2.86***	0.41***	1.49***	0.41***	1.51***
	(0.019)	(0.10)	(0.020)	(0.10)	(0.090)	(0.62)	(0.092)	(0.63)	(0.032)	(0.26)	(0.032)	(0.26)
Jobs within 50 miles	-7.13***	-6.28***	-7.37***	-6.45***	-11.9**	-1.51	-10.2*	1.05	2.32	6.73**		7.04**
	(1.14)	(1.30)	(1.16)	(1.33)	(5.24)	(7.95)	(5.43)	(8.23)	(1.90)	(3.25)		(3.32)
Established Market	-0.090***	-0.072***			-0.83***	-0.61***			-0.26***	-0.16**	-0.25***	
	(0.023)	(0.027)			(0.11)	(0.17)			(0.039)	(0.067)	(0.039)	
Share of resales			0.018	0.022			-0.61***	-0.65***			-0.10**	-0.12*
			(0.026)	(0.028)			(0.14)	(0.20)			(0.043)	(0.071)
Construction cost	4.36***	4.66***	4.44***	4.73***	-1.06	2.85	0.69	4.51*	3.29***	4.89***	3.50***	5.21***
	(0.31)	(0.36)	(0.31)	(0.36)	(1.42)	(2.27)	(1.47)	(2.30)	(0.50)	(0.89)	(0.50)	(0.89)
Observations	686	686	686	686	647	647	647	647	684	684	684	684
R^2	0.652		0.645		0.229		0.185		0.413		0.417	
1st Stage F		24.699		25.351		23.643		24.408		24.887		25.557
1st Stage p-value		0.000		0.000		0.000		0.000		0.000		0.000

Standard errors in parentheses.

All specifications include market and year fixed effects.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table B7: Regression results for the impact of competition on price and production volatility.

	Price volatility				Production volatility			
	OLS	IV	OLS	IV	OLS	IV	OLS	IV
Firms producing 90%	-0.24**	-3.47***	-0.24**	-3.38***	0.65***	3.75***	0.69***	3.82***
	(0.10)	(0.84)	(0.10)	(0.81)	(0.12)	(0.85)	(0.12)	(0.85)
Jobs within 50 miles	-8.53**	-34.3***	-9.40***	-36.0***	5.67	19.1*	5.60	19.9*
	(3.72)	(8.51)	(3.64)	(8.55)	(6.80)	(10.4)	(6.97)	(10.7)
Established Market	0.072	0.23			-0.68***	-0.44**		
	(0.11)	(0.17)			(0.14)	(0.21)		
Share of resales			-0.098	-0.24*			-0.22	-0.28
			(0.094)	(0.14)			(0.18)	(0.26)
Construction cost	-0.53**	-0.53	-0.56**	-0.58*	-15.6***	-10.7***	-14.6***	-9.79***
	(0.23)	(0.33)	(0.23)	(0.33)	(1.85)	(2.97)	(1.89)	(3.00)
Observations	913	913	913	913	655	655	655	655
R^2	0.097		0.097		0.321		0.298	
1st Stage F		25.108		26.057		22.001		22.572
1st Stage p-value		0.000		0.000		0.000		0.000

Standard errors in parentheses.

All specifications include market and year fixed effects.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

B.3 Results without low-population markets

Table B8: Regression results for the impact of competition on the volume of housing supplied. Markets with population of at least 40,000.

	Total Value		Total Sq Feet		Units Sold	
	OLS	IV	OLS	IV	OLS	IV
Firms producing 90%	0.15***	0.75***	0.15***	0.82***	0.065	0.59**
	(0.050)	(0.28)	(0.047)	(0.28)	(0.050)	(0.28)
Jobs within 50 miles	-5.01***	0.58	-4.32***	1.87	-2.41	2.45
	(1.70)	(3.22)	(1.62)	(3.20)	(1.70)	(3.14)
Construction cost	-0.48***	-0.44***	-0.36***	-0.32***	-0.33***	-0.29**
	(0.10)	(0.12)	(0.099)	(0.12)	(0.10)	(0.12)
Observations	927	927	925	925	927	927
R^2	0.634		0.567		0.612	
1st Stage F		17.646		17.593		17.646
1st Stage p-value		0.000		0.000		0.000

Standard errors in parentheses.

All specifications include market and year fixed effects.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table B9: Regression results for the impact of competition on the pipeline of housing production. Markets with population of at least 40,000.

	In pipeline		Ready for sale		Active subdivisions	
	OLS	IV	OLS	IV	OLS	IV
Firms producing 90%	0.22***	0.44***	0.52***	2.76***	0.50***	1.54***
	(0.024)	(0.11)	(0.13)	(0.71)	(0.047)	(0.30)
Jobs within 50 miles	-8.38***	-7.38***	-16.8**	-5.98	2.02	6.76
	(1.36)	(1.59)	(7.21)	(10.4)	(2.66)	(4.29)
Construction cost	4.21***	4.63***	-0.96	3.36	3.82***	5.79***
	(0.36)	(0.44)	(1.87)	(2.88)	(0.67)	(1.16)
Observations	690	690	651	651	688	688
R^2	0.748		0.206		0.433	
1st Stage F		18.005		18.388		17.977
1st Stage p-value		0.000		0.000		0.000

Standard errors in parentheses.

All specifications include market and year fixed effects.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table B10: Regression results for the impact of competition on price and production volatility. Markets with population of at least 40,000.

	Price volatility		Production volatility	
	OLS	IV	OLS	IV
Firms producing 90%	-0.30**	-3.87***	0.84***	4.12***
	(0.14)	(1.06)	(0.16)	(1.03)
Jobs within 50 miles	-10.4**	-43.4***	3.93	19.0
	(4.73)	(12.0)	(9.28)	(14.3)
Construction cost	-0.76***	-1.00**	-17.2***	-10.9***
	(0.29)	(0.45)	(2.42)	(4.01)
Observations	924	924	658	658
R^2	0.139		0.374	
1st Stage F		17.593		16.620
1st Stage p-value		0.000		0.000

Standard errors in parentheses.

All specifications include market and year fixed effects.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

B.4 Results without low-production markets

Table B11: Regression results for the impact of competition on the volume of housing supplied. Markets with volume larger than the lowest decile each year.

	Total Value		Total Sq Feet		Units Sold	
	OLS	IV	OLS	IV	OLS	IV
Firms producing 90%	0.17***	0.90***	0.17***	0.95***	0.076*	0.62**
	(0.039)	(0.26)	(0.038)	(0.26)	(0.039)	(0.25)
Jobs within 50 miles	-3.41**	2.86	-3.04**	3.65	-1.39	3.32
	(1.38)	(2.74)	(1.33)	(2.72)	(1.38)	(2.57)
Construction cost	-0.42***	-0.44***	-0.31***	-0.33***	-0.31***	-0.32***
	(0.085)	(0.10)	(0.083)	(0.10)	(0.085)	(0.094)
Observations	927	927	925	925	927	927
R^2	0.599		0.526		0.565	
1st Stage F		25.027		24.936		25.027
1st Stage p-value		0.000		0.000		0.000

Standard errors in parentheses.

All specifications include market and year fixed effects.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table B12: Regression results for the impact of competition on the pipeline of housing production. Markets with volume larger than the lowest decile each year.

	In pipeline		Ready for sale		Active subdivisions	
	OLS	IV	OLS	IV	OLS	IV
Firms producing 90%	0.18***	0.38***	0.48***	2.88***	0.43***	1.54***
	(0.019)	(0.10)	(0.094)	(0.65)	(0.034)	(0.26)
Jobs within 50 miles	-7.57***	-6.60***	-14.4***	-2.47	2.01	7.34**
	(1.13)	(1.31)	(5.47)	(8.39)	(1.97)	(3.41)
Construction cost	4.51***	4.78***	-0.030	3.74	3.58***	5.09***
	(0.30)	(0.35)	(1.47)	(2.32)	(0.51)	(0.90)
Observations	690	690	651	651	688	688
R^2	0.657		0.167		0.382	
1st Stage F		24.839		23.473		25.032
1st Stage p-value		0.000		0.000		0.000

Standard errors in parentheses.

All specifications include market and year fixed effects.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table B13: Regression results for the impact of competition on price and production volatility.Impact of competition on price volatility. Markets with volume larger than the lowest decile each year.

	Price volatility		Production volatility	
	OLS	IV	OLS	IV
Firms producing 90%	-0.23**	-3.50***	0.70***	3.83***
	(0.10)	(0.85)	(0.12)	(0.85)
Jobs within 50 miles	-8.54**	-36.5***	4.84	20.1*
	(3.66)	(8.92)	(6.98)	(10.8)
Construction cost	-0.53**	-0.45	-14.9***	-10.2***
	(0.23)	(0.33)	(1.88)	(2.97)
Observations	924	924	658	658
R^2	0.097		0.300	
1st Stage F		24.936		22.863
1st Stage p-value		0.000		0.000

Standard errors in parentheses.

All specifications include market and year fixed effects.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

B.5 Results with adjacent markets removed from the instrument

Table B14: Regression results for the impact of competition on the volume of housing supplied. Instrument calculated without adjacent markets.

	Total Value		Total Sq Feet		Units Sold	
	OLS	IV	OLS	IV	OLS	IV
Firms producing 90%	0.18***	0.84***	0.17***	0.89***	0.091**	0.59**
	(0.041)	(0.24)	(0.040)	(0.24)	(0.041)	(0.23)
Jobs within 50 miles	-2.88**	2.67	-2.54*	3.37	-0.81	3.32
	(1.43)	(2.57)	(1.38)	(2.54)	(1.44)	(2.46)
Construction cost	-0.45***	-0.45***	-0.34***	-0.34***	-0.33***	-0.34***
	(0.089)	(0.10)	(0.086)	(0.10)	(0.090)	(0.097)
Observations	913	913	911	911	913	913
R^2	0.570		0.494		0.530	
1st Stage F		29.656		29.534		29.656
1st Stage p-value		0.000		0.000		0.000

Standard errors in parentheses.

All specifications include market and year fixed effects.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table B15: Regression results for the impact of competition on the pipeline of housing production. Instrument calculated without adjacent markets.

	In pipeline		Ready for sale		Active subdivisions	
	OLS	IV	OLS	IV	OLS	IV
Firms producing 90%	0.19***	0.35***	0.52***	2.24***	0.44***	1.46***
	(0.020)	(0.099)	(0.095)	(0.55)	(0.034)	(0.25)
Jobs within 50 miles	-7.24***	-6.55***	-13.1**	-4.60	2.07	6.64**
	(1.15)	(1.28)	(5.47)	(7.23)	(1.96)	(3.19)
Construction cost	4.49***	4.72***	-0.019	2.91	3.65***	5.16***
	(0.31)	(0.35)	(1.48)	(2.04)	(0.51)	(0.86)
Observations	683	683	644	644	681	681
R^2	0.646		0.164		0.382	
1st Stage F		25.580		24.916		25.693
1st Stage p-value		0.000		0.000		0.000

Standard errors in parentheses.

All specifications include market and year fixed effects.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table B16: Regression results for the impact of competition on price and production volatility. Instrument calculated without adjacent markets.

	Price volatility		Production volatility	
	OLS	IV	OLS	IV
Firms producing 90%	-0.23**	-2.37***	0.68***	3.28***
	(0.10)	(0.66)	(0.12)	(0.79)
Jobs within 50 miles	-9.06**	-26.9***	4.37	16.6*
	(3.63)	(6.94)	(6.93)	(9.79)
Construction cost	-0.50**	-0.49*	-15.0***	-10.8***
	(0.23)	(0.27)	(1.88)	(2.76)
Observations	910	910	652	652
R^2	0.097		0.296	
1st Stage F		29.534		22.570
1st Stage p-value		0.000		0.000

Standard errors in parentheses.

All specifications include market and year fixed effects.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

B.6 Results controlling for concentration in surrounding zipcodes

Table B17: Regression results for the impact of competition on the volume of housing supplied. Includes concentration in surrounding ring of zipcodes.

	Total Value		Total Sq Feet		Units Sold	
	OLS	IV	OLS	IV	OLS	IV
Firms producing 90%	0.17***	0.89***	0.16***	0.93***	0.060	0.65**
	(0.042)	(0.32)	(0.041)	(0.32)	(0.043)	(0.31)
Firms producing 90% in ring	0.098*	0.45	0.12**	0.51	0.17***	0.59
	(0.051)	(1.30)	(0.049)	(1.29)	(0.052)	(1.26)
Jobs within 50 miles	-2.61*	5.39	-1.90	6.61	-0.028	7.35
	(1.48)	(7.28)	(1.42)	(7.22)	(1.49)	(7.08)
Construction cost	-0.48***	-0.49***	-0.36***	-0.38***	-0.35***	-0.36***
	(0.092)	(0.12)	(0.088)	(0.12)	(0.093)	(0.12)
Observations	927	927	925	925	927	927
R^2	0.580	0.381	0.509	0.223	0.541	0.371
1st Stage F		14.554		14.498		14.554
1st Stage p-value		0.000		0.000		0.000

Standard errors in parentheses.

All specifications include market and year fixed effects.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table B18: Impact of competition on oversupply. Includes concentration in surrounding ring of zipcodes.

	In pipeline		Ready for sale		Active subdivisions	
	OLS	IV	OLS	IV	OLS	IV
Firms producing 90%	0.19***	0.50***	0.48***	3.15***	0.43***	1.66***
	(0.018)	(0.14)	(0.096)	(0.86)	(0.034)	(0.33)
Firms producing 90% in ring	0.040*	-0.54	0.17	-3.38	0.012	-1.26
	(0.023)	(0.67)	(0.12)	(5.10)	(0.044)	(1.69)
Jobs within 50 miles	-7.94***	-10.8**	-13.5**	-27.2	1.66	-2.18
	(1.06)	(4.97)	(5.59)	(37.6)	(2.02)	(12.5)
Construction cost	3.87***	3.93***	-0.53	1.09	3.59***	4.60***
	(0.29)	(0.63)	(1.52)	(4.75)	(0.53)	(1.52)
Observations	690	690	651	651	688	688
R^2	0.688	0.310	0.167	-1.649	0.383	-1.300
1st Stage F		12.442		12.098		12.519
1st Stage p-value		0.000		0.000		0.000

Standard errors in parentheses

All specifications include market and year fixed effects.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table B19: Regression results for the impact of competition on price and production volatility. Includes concentration in surrounding ring of zipcodes.

	Price volatility		Production volatility	
	OLS	IV	OLS	IV
Firms producing 90%	-0.23**	-3.85***	0.72***	4.50***
	(0.11)	(1.07)	(0.12)	(1.26)
Firms producing 90% in ring	-0.0060	2.76	-0.21	-5.48
	(0.13)	(4.31)	(0.15)	(6.20)
Jobs within 50 miles	-9.46**	-20.5	1.14	-20.4
	(3.81)	(24.2)	(7.01)	(45.3)
Construction cost	-0.49**	-0.55	-16.9***	-15.0**
	(0.24)	(0.40)	(1.92)	(6.01)
Observations	924	924	658	658
R^2	0.093	-1.242	0.320	-1.651
1st Stage F		14.498		11.062
1st Stage p-value		0.000		0.000

Standard errors in parentheses.

All specifications include market and year fixed effects.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

B.7 Comparing OLS and IV results

Table B20: Regression results for the impact of competition on the volume of housing supplied. Includes comparison to OLS results with all markets.

	Total Value			Total Sq Feet			Units Sold		
	OLS	OLS	IV	OLS	OLS	IV	OLS	OLS	IV
Firms producing 90%	0.34***	0.17***	0.87***	0.28***	0.17***	0.91***	0.23***	0.082**	0.62***
	(0.036)	(0.040)	(0.25)	(0.036)	(0.039)	(0.25)	(0.037)	(0.040)	(0.24)
Jobs within 50 miles	-6.29***	-2.97**	2.71	-5.20***	-2.58*	3.38	-4.66***	-1.04	3.33
	(1.35)	(1.41)	(2.58)	(1.32)	(1.37)	(2.55)	(1.36)	(1.43)	(2.46)
Construction cost	-0.22***	-0.44***	-0.43***	-0.19***	-0.33***	-0.32***	-0.14*	-0.32***	-0.32***
	(0.075)	(0.089)	(0.10)	(0.073)	(0.086)	(0.10)	(0.075)	(0.090)	(0.098)
Observations	1580	927	927	1546	925	925	1581	927	927
R^2	0.487	0.572		0.410	0.497		0.441	0.530	
1st Stage F			27.483			27.390			27.483
1st Stage p-value			0.000			0.000			0.000

Standard errors in parentheses.

All specifications include market and year fixed effects.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table B21: Regression results for the impact of competition on the pipeline of housing production. Includes comparison to OLS results with all markets.

	In pipeline			Ready for sale			Active subdivisions		
	OLS	OLS	IV	OLS	OLS	IV	OLS	OLS	IV
Firms producing 90%	0.16***	0.19***	0.40***	0.43***	0.49***	2.88***	0.32***	0.42***	1.51***
	(0.026)	(0.020)	(0.10)	(0.081)	(0.093)	(0.63)	(0.029)	(0.033)	(0.26)
Jobs within 50 miles	-13.4***	-7.24***	-6.33***	-21.3***	-13.5**	-2.32	-3.33*	1.91	6.54**
	(1.56)	(1.15)	(1.32)	(4.83)	(5.44)	(8.23)	(1.77)	(1.96)	(3.31)
Construction cost	4.23***	4.38***	4.68***	0.82	-0.12	3.76	2.91***	3.54***	5.09***
	(0.40)	(0.31)	(0.36)	(1.25)	(1.46)	(2.30)	(0.45)	(0.51)	(0.89)
Observations	1078	690	690	921	651	651	1038	688	688
R^2	0.481	0.642		0.181	0.161		0.258	0.376	
1st Stage F			25.725			24.683			25.924
1st Stage p-value			0.000			0.000			0.000

Standard errors in parentheses.

All specifications include market and year fixed effects.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table B22: Regression results for the impact of competition on price and production volatility.

	Price volatility			Production volatility		
	OLS	OLS	IV	OLS	OLS	IV
Firms producing 90%	-0.075	-0.23**	-3.24***	0.43***	0.68***	3.84***
	(0.074)	(0.10)	(0.78)	(0.096)	(0.12)	(0.86)
Jobs within 50 miles	-5.07*	-9.32***	-33.5***	10.6*	4.37	18.4*
	(2.78)	(3.58)	(7.92)	(5.87)	(6.90)	(10.6)
Construction cost	-0.28	-0.50**	-0.54*	-11.1***	-14.9***	-9.98***
	(0.18)	(0.23)	(0.32)	(1.52)	(1.86)	(2.98)
Observations	1392	924	924	880	658	658
R^2	0.047	0.093		0.244	0.298	
1st Stage F			27.390			22.603
1st Stage p-value			0.000			0.000

Standard errors in parentheses.

All specifications include market and year fixed effects.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

B.8 Placebo tests

Table B23: Results of placebo test for statistical significance of outcome variable under random reassignment of instrument values. Results generated from one thousand random reassignments of instrument across market-year pairs.

Dependent variable	% iterations $p < 0.05$
Total value	3.0%
Square footage	2.3%
Units	1.6%
In pipeline	5.0%
Ready for sale	3.8%
Active subdivisions	9.8%
Price volatility	3.5%
Price volatility	7.3%

C Theoretical model

This model illustrates the strategic behaviour of firms competing to provide housing in a market with an upward-sloping supply curve for land and a downward-sloping demand curve for housing. It provides a comparative static examination of how market outcomes vary with the number of active firms.

The model focuses on forward-looking firms' production decisions. Specifically, the environment consists of n symmetric firms producing housing over two periods. Firms make a single irreversible decision to build at either $t = 1$ or at $t = 2$. Firms use a Leontieff production technology to combine one unit of land and one unit of materials to produce one unit of housing. Each firm purchases land on a spot market subject to an upward-sloping supply curve at unit price ℓ, combine the land with materials at exogenous unit cost c to produce housing, and sell the housing at unit price p subject to a downward sloping demand curve. That is, conditional on choosing to build at t, the firm seeks to maximize $(p_t - c - \ell_t)\, h$ taking into account its own impact on p_t and ℓ_t.

Because housing is highly durable and land supply is fixed, both land and housing prices at $t = 2$ are affected by decisions at $t = 1$. Let H_t be the total volume of housing built by firms building at period t. Then, the land price ℓ_t and house price p_t are as follows for $t \in \{1, 2\}$:

$$\begin{aligned} \ell_1 &= \beta_0 + \beta_1 H_1 \\ p_1 &= \alpha_0 + \alpha_1 (Z - H_1) \end{aligned} \tag{C23}$$

$$\begin{aligned} \ell_2 &= \beta_0 + \beta_1 (H_1 + H_2) \\ p_2 &= \alpha_0 + \alpha_1 (2Z - H_1 - H_2) \end{aligned} \tag{C23}$$

In Equations C23 and C23, the price of housing includes an exogenous demand shifter. Its value grows over time from Z to $2Z$. Each firm takes into account its own impact on the supply curve for land and on the demand curve for housing. Accordingly, each firm faces a tradeoff between building at $t = 1$ and $t = 2$. At $t = 1$ land is more plentiful and housing stock which could compete with

the firm's output has not yet been built. Conversely at $t = 2$ the demand for housing is higher.

While the model environment comprises only two periods, it captures the intuition of pre-emption and volume decisions by forward-looking homebuilding firms. At any point, firms are effectively in period $t = 1$ facing a given land supply and housing demand curve and deciding whether to build immediately or to wait for the realization of demand growth.

Before proceeding, it is helpful to introduce a normalization convention and some new notation that will clarify expressions later in the text. Specifically, we normalize $\alpha_1 Z \equiv 1$ and let $K = \alpha_0 + \beta_0 - c$. As well, the following parametric restriction will become necessary to ensure positive construction in equilibrium:

Assumption 1. *The supply curve for land, the cost of construction, and the demand curve for housing satisfy* $K > \frac{3}{2}$.

Qualitatively, this assumption ensures that the construction cost c is not so high relative to the cost of land and the price of housing that firms are unable to generate positive profits.

The solution concept in this model is a symmetric mixed-strategy weak perfect Bayesian equilibrium. The focal firm has beliefs regarding whether the other firms will build at $t = 1$ or at $t = 2$. Specifically, the focal firm believes that a number $m \in [0, n-1]$ of the other firms will build at $t = 1$ and the other $n - m - 1$ firms will build at $t = 2$[12] In equilibrium, these beliefs will be consistent with the other firms' actions. We seek a mixed strategy equilibrium; the firm will have a nonzero probability of building at $t = 1$ and a nonzero probability of building at $t = 2$.

For a given focal firm, let $\tilde{h}_1$ and $\tilde{h}_2$ be the number of units built of each of the other firms conditional on building at $t = 1$ and $t = 2$. Then, let $h_1^*\left(m; \tilde{h}_1, \tilde{h}_2\right)$ and $h_2^*\left(m; \tilde{h}_1, \tilde{h}_2\right)$ be the best responses of the focal firm. Taking first-order conditions and rearranging yields the following best responses conditional on building at $t = 1$ and at $t = 2$:

$$
\begin{aligned}
h_1^*\left(m; \tilde{h}_1, \tilde{h}_2\right) &= \frac{1}{2\left(\alpha_1 + \beta_1\right)} \left(K + 1 - \left(\alpha_1 + \beta_1\right) m \tilde{h}_1\right) \\
h_2^*\left(m; \tilde{h}_1, \tilde{h}_2\right) &= \frac{1}{2\left(\alpha_1 + \beta_1\right)} \left(K + 2 - \left(\alpha_1 + \beta_1\right) \left(m \tilde{h}_1 + \left(n - m - 1\right) \tilde{h}_2\right)\right) \qquad \text{(C23)}
\end{aligned}
$$

[12]Throughout, we consider only the $n > 1$ case. If $n = 1$, in equilibrium the monopolist firm will always wait until the second period to build.

As we are interested in a mixed-strategy equilibrium, we seek a situation where firms are indifferent between building at $t = 1$ and at $t = 2$. Imposing symmetry on the decisions of the focal firm and the other firms and rearranging yields the following expression for the difference in optimal profits $\pi_1^* (m)$ and $\pi_2^* (m)$ between construction at $t = 1$ and $t = 2$ as a function of m:

$$\pi_2^* (m) - \pi_1^* (m) = \frac{-1}{4 (n-m)^2 (n+1)^2 (m+1)} \left[m (-2-n) + 3n + 1 - K - 3n^2 \right] \times$$
$$\left[m^2 (K + 5n + 3) + m \left(-5Kn = 2K - 5n^2 + 3n + 2 \right) + 2Kn^2 - Kn - K - 3n^2 + 2n + 1 \right] \quad \text{(C23)}$$

In a mixed-strategy equilibrium, the left-hand side of Equation C23 must be equal to zero. The term in square brackets on the first line of Equation C23 has no root with $m > 0$ under Assumption 1. However, the term in square brackets on the second line of Equation C23 has roots as follows:

$$m_\pm^* = \frac{1}{2 (K + 5n + 3)} \left[5n^2 + (5K - 3) n + 2 (K - 1) \pm \right.$$
$$\left. \sqrt{(5n^2 + (5K-3) n + 2 (K-1))^2 - 4 (K + 5n + 3) (2Kn^2 - Kn - K - 3n^2 + 2n + 1)} \right] \quad \text{(C23)}$$

It remains to show that Equation C23 describes a valid equilibrium belief — that is, a belief which is supported by a mixed-strategy equilibrium. The solution with the positive sign gives $m_+^* > n$ which is not a valid equilibrium belief. The following lemma will begin to establish that m_-^* does constitute a valid equilibrium belief.

Lemma 1. *The solution m_-^* to Equation C23 is positive.*

Proof. To show that the solution is positive, it is sufficient to show that $(K + 5n + 3) \left(2Kn^2 - Kn - K - 3n^2 - 2n + 1 \right)$ is negative. Then, the term under the radical is less than the term outside the radical. Note that this term factors to $(K + 5n + 3) (n - 1) (2Kn + K - 3n - 1)$. Under Assumption Under Assumption 1 and given that $n \geq 1$, this expression is strictly positive. □

The following lemma establishes the large-n behaviour of m_-^*:

Lemma 2. *As n grows large, $\frac{m_-^*}{n}$ is bounded above by $\frac{1}{2}$.*

Proof. From Equation C23, it is clear that m^*_- is always bounded above by $\frac{5n^2+(5K-3)n+2(K-1)}{2(K+5n+3)}$. Dividing by n and taking the limit for arbitrarily large n yields the desired result. ☐

In the large-n limit, half the firms are building at $t = 1$ and half are building at $t = 2$. This fraction arises from the growth in the demand shifter from Z to $2Z$. Uneven growth would give a different limit but the intuition would remain unchanged. The following proposition establishes that m^*_- is monotonically increasing in n:

Proposition 1. *The equilibrium beliefs about the number of firms building in the first period m^*_- increases with n sufficiently quickly that $\frac{m*_-}{n}$ is increasing in n.*

Proof. Differentiate the term on the second line of Equation C23 that is used to define m^*_- in Equation C23 and rearrange:

$$\frac{\partial m^*_-}{\partial n} = 1 + \frac{7Kn - 3n + K + 7Km^*_- + 9m^*_-}{5n^2 - 5Kn + 3n + 2K + 2 - 10m^*_- n - 2m^*_- K - 6m^*_-} \tag{C23}$$

From the chain rule, the sign of $\frac{\partial\left(m^*_-/n\right)}{\partial n}$ is the same as the sign of $\frac{\partial m^*_-}{\partial n} - \frac{m^*_-}{n}$. Accordingly, to show that the latter is positive, it remains only to show that the fraction in Equation C23 is positive. Under Assumption 1, the numerator is positive. Rearranging the denominator yields the following condition on m^*_- for the denominator to be positive:

$$m^*_- < \frac{5n^2 + 5Kn + 3n - 2K + 2}{2\left(K + 5n + 3\right)} \tag{C23}$$

This is exactly the condition implied by Lemma 1 for m^*_-. Under Assumption 1, m^* as specified by Equation C23 satisfies this restriction. This completes the proof. ☐

This proposition corresponds to a "rush" to build at $t = 1$. Although demand will be higher at $t = 2$ (and a monopolist would choose to build at $t = 2$), firms believe that their competitors will build at $t = 1$. If their competitors build at $t = 1$, the remaining land will be more expensive and the demand will be lower at $t = 2$. Accordingly, firms shift production to $t = 1$ with positive probability. In equilibrium, these beliefs are self-fulfilling. While the model represents a significant

abstraction from reality, this result captures the real-world rush to purchase land, build housing, and capture market share.

From Proposition1, the following existence result follows directly:

Proposition 2. *For any number of firms $n > 1$ a mixed-strategy equilibrium characterized by $m^*_- \in (0, n-1)$ exists.*

Proof. From Lemma 1 and 2, $\frac{m^*_-}{n}$ ranges from zero to $\frac{1}{2}$ in the large n limit. From Proposition 1, $\frac{m^*_-}{n}$ is continuously increasing in n. Therefore, by the intermediate value theorem, at any n the value of $\frac{m^*_-}{n}$ lies between zero and $\frac{1}{2}$ — i.e., $m^* \in (0, n-1)$. □

For the remainder of the discussion we will consider the equilibrium generated by belief m^*_-. For legibility we suppress the superscript and subscript and denote this belief by m. Imposing symmetry on Equation C23 yields the following construction decisions for each firm:

$$\begin{aligned} h_1^* &= \frac{K+1}{(m+2)(\alpha_1+\beta_1)} \\ h_2^* &= \frac{m+2K-4}{(m+2)(\alpha_1+\beta_1)(n-m+1)} \end{aligned} \tag{C23}$$

This implies that the equilibrium aggregate production of housing in each period is as follows:

$$\begin{aligned} H_1^* &= \frac{mn}{n-1}\frac{K+1}{(m+2)(\alpha_1+\beta_1)} \\ H_2^* &= \frac{n^2-mn-n}{n-1}\frac{m+2K-4}{(m+2)(\alpha_1+\beta_1)(n-m+1)} \end{aligned} \tag{C23}$$

From Equation C23 we can derive an additional theoretical result:

Proposition 3. *The total volume built at $t = 1$ is increasing in n.*

Proof. Differentiate H_1 as specified in Equation C23 using $m' = \frac{\partial m}{\partial n}$ for notational clarity:

$$\frac{\partial H_1}{\partial n} = \frac{K+1}{\alpha_1+\beta_1}\frac{2n^2m' - 2nm' - m^2 - 2m}{(m+2)^2(n-1)^2} \tag{C23}$$

It remains to show that $2n^2m' - 2nm' - m^2 - 2m$ is positive. To see this, note that Lemma 1 shows that $m' > 1$ and Lemma 2 and Proposition 2 show that $m \leq \frac{n}{2}$. From this, it follows that

$2n^2m' - 2nm' - m^2 - 2m \geq 2n(n-1)$ for $n > 1$. Since this term is positive, the expression on the right-hand side of Equation C23 is also positive. □

According to Equation C23, the volume of construction by each firm at $t = 1$ is decreasing in n. However, according to Proposition 3, the rush to build shown in Proposition 1 is sufficiently large that increasing the number of firms increases the total volume of construction at $t = 1$. This result may seem unsurprising in light of Proposition 1 but it is worth emphasizing that this result would not arise in a marketplace of atomistic price-taking firms.

This discussion has focused on *ex ante* price and construction decisions. However, insofar as each firm is playing its mixed strategy independently, the *ex post* outcome varies with the realization of the n firms' mixed strategies. The following proposition demonstrates that an increase in the number of firms leads to a lower dispersion in *ex post* outcomes:

Proposition 4. *Assume m satisfies the restriction $\frac{2}{n^2+3} > \frac{m}{n(n-1)} > \frac{1}{n(n+1)}$. Then, the ex post price volatility at $t = 1$ is decreasing in n.*

Proof. Let $\text{SD}(p_1)$ denote the *ex post* standard deviation in the realization of p_1. Since n firms are each building the quantity h_1 specified by Equation C23 with probability $\frac{m}{n-1}$ and given the price at $t = 1$ as specified by Equation C23, $\text{SD}(p_1)$ may be written in terms of m as follows:

$$\text{SD}(p_1) = \frac{\alpha_1 (K+1)}{\alpha_1 + \beta_1} \frac{nm(n-m-1)}{(n-1)(m+2)} \tag{C23}$$

Differentiating Equation C23 with respect to n and rearranging yields the following result:

$$\text{sign}\left(\frac{\partial}{\partial n}\text{SD}(p_1)\right) = \text{sign}\left(n(n-1)m'(2n - mn - 3m - 2) + m(m+2)(mn - n + m + 1)\right) \tag{C23}$$

The term $(2n - mn - 3m - 2)$ is positive when $m < \frac{2n(n-1)}{n^2+3}$ and the term $(mn - n + m + 1)$ is positive when $m > \frac{n(n-1)}{n(n+1)}$. □

Remark 1. It is worth noting that the interval described by the two bounds in Proposition 4 is not empty. To see this, note that $\frac{2}{n^2+3} - \frac{1}{n^2+n} = \frac{(n+3)(n-1)}{n(n+1)(n^2+3)}$ which is positive for $n > 1$

Qualitatively, this proposition shows that the dispersion of prices decrease as more firms enter the market. The conditions in the proposition are sufficient, but not necessary. The upper bound on n excludes situations where the number of firms is so large that the market is close to the competitive limit and the dominant effect of an additional firm is the reduction in production by each firm. The lower bound on n excludes situations where the probability of any firm building at $t = 1$ is sufficiently low that the effective price is very close to $1 + \alpha_0$ and the volatility is very close to zero; any marginal increase in competition would raise the volatility.

D Construction of counterfactual

We adopt the following process to infer competitive intensity for the rest of the country using the Zipcode Business Patterns data set (U.S. Census Bureau, 2015b) which provides information on zipcode-level employment in residential construction for 2012 through 2015:

1. We aggregate Zipcode Business Patterns data to the markets in our sample using GIS software.
2. We generate a measure of the implied concentration in the Zipcode Business Patterns data by assuming that production increases linearly with the number of employees.
3. For the subsample of years and markets for which we have Metrostudy data we estimate a mapping from the implied concentration from Zipcode Business Patterns to the measured concentration from Metrostudy using a flexible polynomial specification.
4. We use the mapping generated in Steps 2 and 3 to predict the level of competitive intensity in 2015 for all markets in the United States.
5. For the markets in the Metrostudy data, we estimate a mapping between 2006 and 2015 level of concentration using a flexible polynomial specification.
6. We use the result of Step 4 and mapping generated in Step 5 to predict the level of competitive intensity in 2006 for all markets in the United States.
7. For each outcome variable we use the coefficients in the second column of the tables presented above to estimate the impact of changes in competitive intensity under a counterfactual scenario market competitive intensity in 2015 held at 2006 levels.