Market concentration in homebuilding

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We investigate the impact of increasing concentration in local residential construction markets on housing cycle dynamics. We show that the increase in concentration in the past decade has led to greater unit price volatility, less production, and fewer vacant unsold units. Our results imply that the greater concentration has decreased the annual value of new housing production by $144 billion. Because housing is a determinant of the business cycle these findings provide further evidence that the secular decline in competitive intensity in the American economy is altering macroeconomic dynamics[1].

1 Introduction

At the local level the production of housing has 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 may 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.

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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, 2018b). 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 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 (Kusisto, 2017). 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;

[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"

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 instrumental variables regressions 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 practitioners' understanding of industry dynamics as well as the predictions of a theoretical model of housing construction in oligopoly as described in Appendix C. To the best of our knowledge, this study is the first to document this market concentration and its impact on housing market outcomes.

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 different. The annual volume of new housing would be \$144 billion higher (equivalent to or 19% of net private fixed investment or 0.8% of gross domestic product). Approximately 681,000 additional housing units would be in the production pipeline. Housing price volatility would decline by over 50%.

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 the reasons for the market concentration in homebuilding in Section 2.

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

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

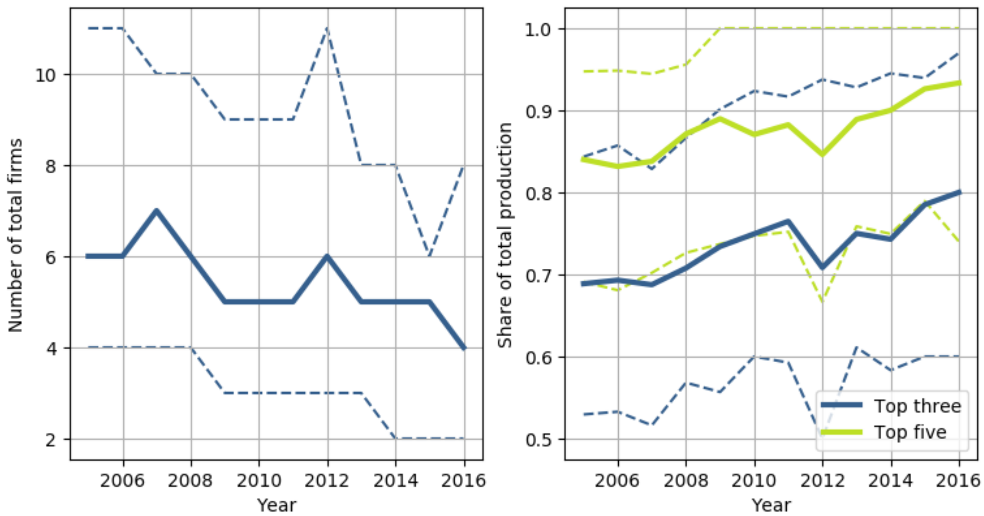

Figure 1: Measures concentration in local housing markets. The left panel shows the umber of firms accounting for 90% of housing construction and the right panel shows the share of production accounted for by largest three and largest five firms in each market. The solid line shows the median market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

market 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),

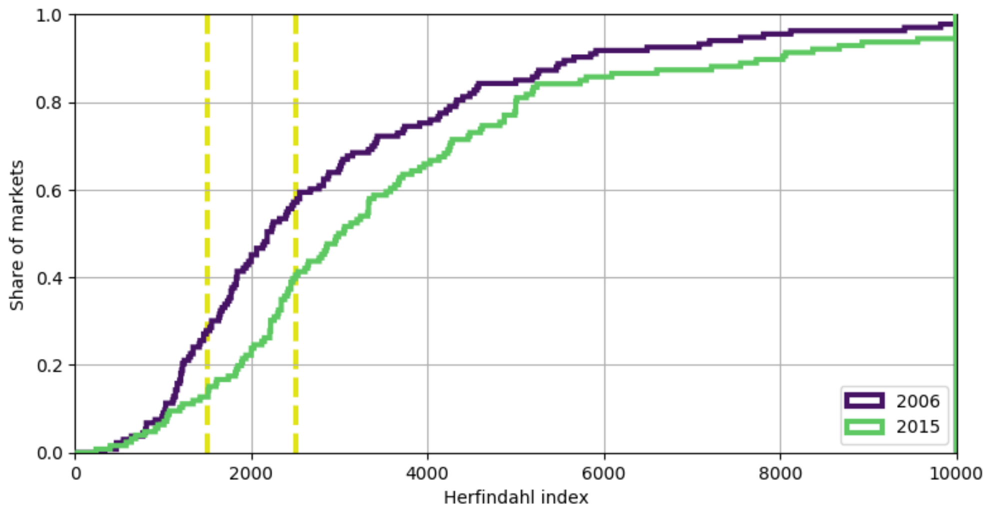

Figure 2: Cumulative distribution of Herfindahl indices for all markets in the sample in 2006 and in 2015. The dashed lines denotes the Federal Trade Commission standard for "moderately concentrated" and "highly concentrated" markets.

and Standard Pacific and Ryland merged to form CalAtlantic in 2015 (Hudson, 2015)[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, the national-scale Pulte Homes 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 dominant 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

[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)

optimistic about their future success following a reduction in local competitive intensity. A subsequent article reports on "major consolidation among homebuilders" and its effects on housing market outcomes (Lahart, 2018). 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.

[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.

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

3 Empirical approach

We use instrumental variable regressions to understand the relationship between competitive intensity and market outcomes. Specifically, we investigate the impact of market concentration on the volume, volatility, and pricing of housing production[7]. For each outcome variable y, we estimate the following specification across firms j, markets m and years t:

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

In Equation 1, $COMP_{mt}$ is a measure of competition intensity and X_{mt} is a vector of covariates. All results include a full set of market, year, and firm fixed effects.

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).

[7]The choice of market outcome variables is disciplined by the theoretical model of housing construction in oligopoly presented in Appendix C.

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.

To understand the variation in local housing markets, we collect median housing price data at the zipcode, place, county, and MSA level U.S. Census Bureau (2016). Within our sample, 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.

Accordingly, the results presented below use places as the unit of analysis throughout. Figure 3 shows the markets included in the sample. Tests presented in Appendix B show that our results are robust to changes in market definition.

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 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.

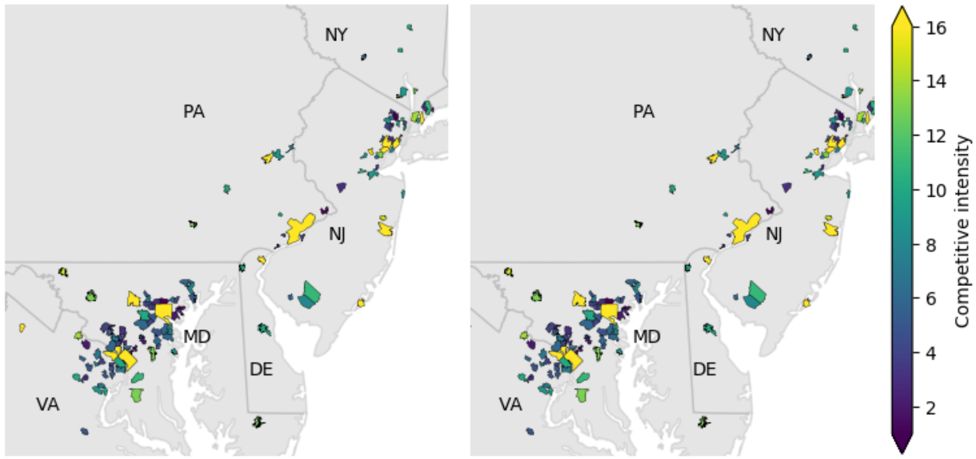

Figure 3: Markets included in the Metrostudy data. The degree of competition shown on this map is the number of firms accounting for 90% of construction. The left panel shows the values in 2006 and the right panel shows the values in 2015.

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. Figure 3 displays the markets included in the sample. As mentioned above we exclude places with less than $25,000$ residents. This leaves 132 markets with a total population of 9.74 million (U.S. Census Bureau, 2015a). Production 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 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[8]. Figures 1 and 3 show this measure for the markets in our sample.

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

3.2.2 Instrumenting for concentration

In Equation 1 it is possible that competition is endogenous to market outcomes — that is, that $\text{cov}\left(COMP_{mt}, \varepsilon_{mtj}\right) \neq 0$. 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[9]. We forecast the construction activity of a national firm j in market m using the activity of firm j in all markets other than m. Appendix A contains implementation details.

This instrument relies on the wide distribution of national firms' residential construction activity across the United States. Accordingly, national firms' production decisions are particularly influenced by the changes to the national environment 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). Moreover, the rationale is similar to the rationale for 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.

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.

As the instrument is increasing in the activity of large national firms, one would expect

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

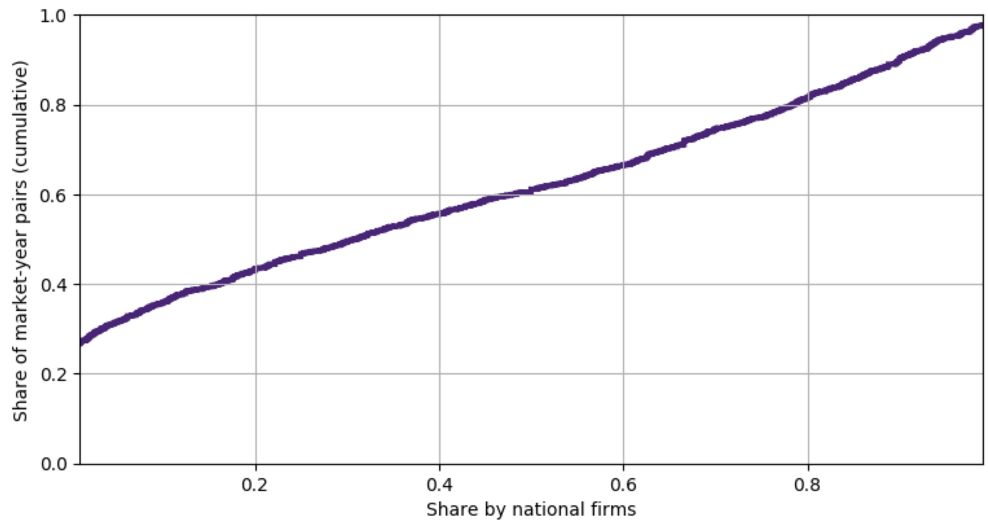

Figure 4: Cumulative distribution of the share of units accounted for by national firms across all market-year pairs.s

negative correlation between the instrument and $COMP_{mt}$. This expectation is correct; 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.

3.3 Measuring demand

To estimate Equation 1, we require a measure of demand for housing in market m at time t. For identification this should be exogenous to conditions in market in m at 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[10] 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 only considering jobs outside the county in which m is located.

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[11]. We use the "overall" index which comprises the total cost of construction including both materials and labour. The data set includes a price index for each three-digit zipcode and a price index for each year. We map these three-digit zipcodes to the markets in our sample and multiply the market index by the year index to obtain a value for each market-year pair.

3.5 Additional covariates

To address the possibility that firms operating at different scales interact differently, in some specifications we control for the share of production by national, regional, and micro-sized homebuilding firms in the same market.

We also include a measure of "established" markets to distinguish markets where most new housing is produced through redevelopment from markets where housing is built on previously undeveloped land. Specifically, we include an indicator variable for whether the market's resale share of total sales falls into the top tercile of all markets in that year.

[10]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. Somewhat shorter commutes are even more common; the majority of workers in Loudoun County, VA commute to a county at least 25 miles away (McKenzie, 2013).

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

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.

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. 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.

4.1.1 Production volume

Tables 2 and 3 show regression coefficients where the dependent variables are the volume of housing produced as measured by the logarithm of the dollar value of new housing built and the logarithm of the square feet of housing built. As shown, firms in more concentrated markets produce significantly less housing even with after instrumenting for market concentration. 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. T

4.1.2 Production volatility

Classical models of noncooperative firm strategy under oligopoly (as reviewed in Shapiro (1989)) often predict that a small set of firms will compete on price whereas a larger set

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

Variable	N	Median	Mean	Std. dev	Min	Max
Number of firms producing 90%	22344	12.0	25.08	31.08	1	129
Jobs within fifty miles (millions)	22344	3.54	4.33	2.16	0.15	8.49
Construction cost index	19096	1.94	1.96	0.25	1.38	2.52
National firm share	22344	0.08	0.15	0.18	0.00	1.00
Regional firm share	22344	0.08	0.12	0.13	0.00	1.00
Micro firm share	22344	0.67	0.61	0.25	0.00	1.00
Established markets	12419	0.00	0.25	0.43	0.00	1.00
Total value of housing ($ million)	22343	81.20	183.92	233.10	0.10	1120.00
Production volatility	22313	43.00	108.27	167.55	0.00	998.00
Housing units in pipeline (months)	12858	10.49	23.09	38.74	0.0	667.2
Price volatility (per square foot)	22170	15.93	30.61	54.97	0.08	1364.88
Firms per market-year	1437	10.0	15.55	22.80	1	225
National firms per market-year	1437	2.0	2.32	2.52	0	17
Markets	137					
Years	11					
Firms	8045					

of firms willinstead will 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 proportional change in housing price per square foot $\|p_t - p_{t-1}\| / p_{t-1}$ and the logarithm of the absolute change in the number of housing units as dependent variables. Tables 4 and 5 show the results of these regressions. Higher competitive intensity is associated with greater supply volatility whereas lower competitive intensity is associated with greater price volatility.

4.1.3 Production pipeline

The presence of competitors affects the timing of homebuilders' production decisions. As noted by Mueller (1995), the real estate market cycle is driven by firms competing to build quickly to satisfy unmet demand and gain a first-mover advantage in a growing market:

> In a competitive capitalistic market, developers must speculate and start the

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

	OLS	IV	OLS	IV	OLS	IV
Firms producing 90%	0.064	1.10	0.067	1.36	0.064	1.10
	(0.013)	(0.18)	(0.014)	(0.26)	(0.013)	(0.18)
Jobs within 50 miles	0.79	7.52	0.48	7.22	0.79	7.52
	(0.50)	(1.33)	(0.50)	(1.49)	(0.50)	(1.33)
Construction cost	-0.33	-0.47	-0.26	-0.36	-0.33	-0.47
	(0.034)	(0.049)	(0.034)	(0.050)	(0.034)	(0.049)
Share national firms			1.06	0.72		
			(0.085)	(0.13)		
Share regional firms			0.23	0.23		
			(0.094)	(0.13)		
Share micro firms			0.41	-1.08		
			(0.076)	(0.31)		
Established market					-0.47	
					(0.56)	
Observations	15782	15782	15782	15782	15782	15782
R^2	0.776	0.640	0.781	0.594	0.776	0.640
1^{st} Stage F-statistic		87.567		55.303		87.567
1^{st} Stage p-value		0.000		0.000		0.000

Standard errors in parentheses.

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

Table 3: Regression results where the dependent variable is the logarithm of the total square footage of housing produced.

	OLS	IV	OLS	IV	OLS	IV
Firms producing 90%	0.062	1.05	0.064	1.28	0.062	1.05
	(0.013)	(0.17)	(0.013)	(0.24)	(0.013)	(0.17)
Jobs within 50 miles	0.91	7.25	0.60	6.89	0.91	7.25
	(0.48)	(1.26)	(0.48)	(1.40)	(0.48)	(1.26)
Construction cost	-0.34	-0.47	-0.27	-0.36	-0.34	-0.47
	(0.032)	(0.046)	(0.032)	(0.047)	(0.032)	(0.046)
Share national firms			1.04	0.71		
			(0.081)	(0.13)		
Share regional firms			0.18	0.14		
			(0.090)	(0.12)		
Share micro firms			0.39	-1.01		
			(0.073)	(0.30)		
Established market					-1.39	
					(1.43)	
Observations	15768	15768	15768	15768	15768	15768
R^2	0.761	0.617	0.767	0.572	0.761	0.617
1^{st} Stage F-statistic		87.010		55.169		87.010
1^{st} Stage p-value		0.000		0.000		0.000

Standard errors in parentheses.

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

Table 4: Regression results where the dependent variable is the logarithm of the absolute value of the change in the number of the units of housing produced.

	OLS	IV	OLS	IV	OLS	IV
Firms producing 90%	0.18	1.46	0.20	1.74	0.18	1.46
	(0.034)	(0.38)	(0.035)	(0.52)	(0.034)	(0.38)
Jobs within 50 miles	-1.52	6.79	-2.42	5.69	-1.52	6.79
	(1.27)	(2.81)	(1.26)	(3.04)	(1.27)	(2.81)
Construction cost	-1.04	-1.21	-0.87	-1.00	-1.04	-1.21
	(0.085)	(0.10)	(0.086)	(0.10)	(0.085)	(0.10)
Share national firms			1.90	1.41		
			(0.22)	(0.29)		
Share regional firms			-0.18	-0.25		
			(0.24)	(0.26)		
Share micro firms			0.40	-1.44		
			(0.19)	(0.65)		
Established market					-3.90	
					(1.41)	
Observations	15703	15703	15703	15703	15703	15703
R^2	0.322	0.223	0.334	0.205	0.322	0.223
1^{st} Stage F-statistic		88.280		54.375		88.280
1^{st} Stage p-value		0.000		0.000		0.000

Standard errors in parentheses.

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

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

	OLS	IV	OLS	IV	OLS	IV
Firms producing 90%	-0.11	-3.15	-0.033	-3.78	-0.11	-3.15
	(0.036)	(0.50)	(0.038)	(0.72)	(0.036)	(0.50)
Jobs within 50 miles	-8.69	-28.2	-8.58	-28.0	-8.69	-28.2
	(1.36)	(3.68)	(1.36)	(4.15)	(1.36)	(3.68)
Construction cost	-0.23	0.16	-0.33	-0.049	-0.23	0.16
	(0.092)	(0.14)	(0.092)	(0.14)	(0.092)	(0.14)
Share national firms			-2.06	-1.05		
			(0.23)	(0.38)		
Share regional firms			-0.44	-0.32		
			(0.26)	(0.36)		
Share micro firms			-1.59	2.75		
			(0.21)	(0.88)		
Established market					-11.6	
					(1.48)	
Observations	15763	15763	15763	15763	15763	15763
R^2	0.180	-0.404	0.191	-0.600	0.180	-0.404
1^{st} Stage F-statistic		86.989		55.012		86.989
1^{st} Stage p-value		0.000		0.000		0.000

Standard errors in parentheses.

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

> 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 6 shows regression coefficients where the dependent variable is the sum of the number of vacant units, model units[12], and units under construction — that is, the total housing supply in the pipeline. The measure is scaled to the size of the market by expressing the inventory in terms of months of supply at contemporaneous local absorption rates. As shown, the theoretical prediction is borne out; a greater degree of competitive intensity is associated with a larger supply of housing in the construction pipeline.

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 they are also robust to changes to sample or specification.

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

[12]Model units are vacant unsold units used for display purposes for prospective buyers.

Table 6: Regression results where the dependent variable is the months of supply of housing (including under construction, model and finished vacant) at contemporaraneous absorption rates.

	OLS	IV	OLS	IV	OLS	IV
Firms producing 90%	0.18	2.01	0.18	3.16	0.18	2.01
	(0.048)	(0.50)	(0.051)	(0.94)	(0.048)	(0.50)
Jobs within 50 miles	0.089	-6.83	0.42	-10.9	0.089	-6.83
	(3.82)	(5.23)	(3.82)	(7.06)	(3.82)	(5.23)
Construction cost	-7.12	-0.47	-6.90	2.73	-7.12	-0.47
	(0.61)	(1.95)	(0.62)	(3.19)	(0.61)	(1.95)
Share national firms			0.21	1.62		
			(0.29)	(0.64)		
Share regional firms			-0.47	1.75		
			(0.30)	(0.85)		
Share micro firms			-0.11	-1.45		
			(0.24)	(0.57)		
Established market					-17.6	
					(3.30)	
Observations	4379	4379	4379	4379	4379	4379
R^2	0.405	-0.015	0.407	-0.574	0.405	-0.015
1^{st} Stage F-statistic		32.015		15.499		32.015
1^{st} Stage p-value		0.000		0.000		0.000

Standard errors in parentheses.

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

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 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?

This study uses data on local competitive intensity and market outcomes for a set of markets in the northeastern United States. As described in Appendix D we extend our results to the remainder of the country using Zipcode Business Patterns data.

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.

However, while the distribution of competitive intensity in our sample is similar to the distribution in the United States overall, the markets in our sample may differ from other

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

markets in other ways. For example the markets in our study appear to be in the middle of the national distribution for housing supply elasticity[13] and therefore 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. We acknowledge these potential limitations to the external validity of this counterfactual exercise.

Under this set of assumptions, the median number of firms accounting for 90% of production across all markets in the United States from 2006 through 2015 fell from 6.25 to 4.78 — i.e., a decrease of 24%. Weighting the markets by pre-period population (as measured in the 2015 five-year American Community Survey estimates) does not appreciably alter this result. Table 7 shows the predicted impact on markets across the United States at the

[13] Saiz (2010) ranks metropolitan areas according to their housing supply elasticity. Seven of these metropolitan areas 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.

Table 7: 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 25^{th} percentile, median, and 75^{th} percentile of predicted levels of 2006 competition.

	25^{th}	Median	75^{th}
Concentration in 2006	6.22	6.25	6.44
Concentration in 2015	4.63	4.78	5.47
Δ Value of housing supply (%)	38	34	26
Δ Square footage produced (%)	54	48	36
Δ Supply in pipeline (%)	81	71	53
Δ Price volatility (%)	-49	-57	-60

quartiles of the distribution of predicted levels of 2006 competition. All changes in outcome variables are relative to the predicted levels of 2015 competition. 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 7 indicate that absent the decrease in competition, the total value of housing would be on the order of $144 billion greater. The $144 billion difference in construction value is equivalent to 19% of the value of net private fixed investment in the United States economy in 2015 (Bureau of Economic Analysis, 2017a). Moreover, this is equivalent to 0.8% 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 intended for sale started construction and 398,000 new multi-family units intended for sale or rent started construction for a total of 857,000 new units under construction (U.S. Census Bureau, 2017a). Also, in 2015 12% of all housing units in the United States were vacant U.S. Census Bureau (2018a) which yields an estimate of 960,000 housing units under construction or vacant and unsold. Estimates from Table 7 suggest that under this counterfactual level of competitive intensity the number of units in the supply pipeline would increase by approximately 681,000 units.

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.

5 Conclusion

In this study we examine the impact of market concentration on the production of new housing. We document for the first time 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 $144 billion less housing per year. This equivalent to 19% of the value of net private fixed investment in 2015. The reduction in housing construction from the increase in local market concentration has meaningful effects on overall macroeconomic investment.

The empirical results of this study indicate potential future directions for macroprudential policy. Regulators in Hong Kong and Korea have attempted to stem housing speculation by setting loan-to-value limits that reflect the perceived degree of risk in residential mortgages

(Lim et al., 2011); these rules appear to have had a meaningful impact on house price dynamics in Korea (Igan and Kang, 2011). The efficacy of these policy interventions is predicated upon policymakers' ability to identify the potential for price volatility in different markets. Our research indicates that this may be a particularly significant concern in markets with high levels of concentration.

The study also has implications for 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.

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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_{mt}^N 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:

$$\hat{C}_{mtj} = \frac{\sum_{m' \neq m} C_{m'tj}}{\sum_{m' \neq m} C_{m',t-1,j}} C_{m,t-1,j} \tag{A7}$$

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

$$\bar{C}_{mt} = \frac{\sum_{j \in J_{mt}^N} C_{mt,j-1} \hat{C}_{mtj}}{\sum_{j \in J_{mt}^N} C_{mt,j-1}} \tag{A7}$$

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:

$$Z_{mt} = \frac{\bar{C}_{mt}}{\sum_{j \in J_{mt}^N} C_{mt,j-1}} \tag{A7}$$

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 ensure that our results are not driven by 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.1 contains regression results generated with this restricted sample.

2. 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. These excluded markets comprise 9.3% of all observations. Appendix B.2 contains regression results generated with this restricted sample.

3. To ensure that our parameter estimates are representative of the large national firms that have the most latitude for strategic responses, we run the regression with only the observations from national firms. Appendix B.3 contains regression results generated with this restricted sample.

4. As defined in Equation A7, 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 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.4 contains regression results generated with this alternate instrument.

5. 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 nearest-neighbour zipcodes, second-nearest neighbour zipcodes, and third nearest-neighbour zipcodes for each place. Then, we include these competitive intensity measures as additional controls (instrumented as described in Section 3.2.2). Appendix **??** contains regression results generated with these additional controls.

Under each of these alternative specifications, the magnitude and significance of our empirical results remain qualitatively similar.

In the final regression specification, only the competitive intensity in the nearest-neighbour adjacent zipcodes is statistically significant. The competitive intensity in the second- and third-nearest neighbour zipcodes remains statistically insignificant. This indicates that places are a reasonable definition for the salient market for homebuyers. Insofar as zipcode boundaries do not perfectly match place boundaries, it is unsurprising that competitive intensity in nearest-neighbour zipcodes has a significant impact.

As an additional check on the power of our instrumental variable in a context with many fixed effects we randomly reassign the values of the instrument across observations 400 times. Under this random shuffling, our results should no longer hold. Across all outcome variables this reshuffled placebo instrument generates significance at $p < 0.05$ only 7.8% of the time. This provides additional confidence that our instrument has adequate power.

B.1 Results without low-population markets

Table B1: Regression results where the dependent variable is the logarithm of the total value of housing produced.

	OLS	IV	OLS	IV	OLS	IV
Firms producing 90%	0.029	1.20	0.016	1.62	0.029	1.20
	(0.015)	(0.18)	(0.016)	(0.28)	(0.015)	(0.18)
Jobs within 50 miles	-5.44	6.53	-5.76	7.03	-5.44	6.53
	(0.60)	(1.97)	(0.60)	(2.44)	(0.60)	(1.97)
Construction cost	-0.47	-0.56	-0.39	-0.41	-0.47	-0.56
	(0.036)	(0.050)	(0.036)	(0.056)	(0.036)	(0.050)
Share national firms			0.70	-0.099		
			(0.099)	(0.21)		
Share regional firms			-0.17	-0.22		
			(0.11)	(0.17)		
Share micro firms			0.22	-2.10		
			(0.088)	(0.43)		
Established market					1.08	
					(0.25)	
Observations	11521	11521	11521	11521	11521	11521
R^2	0.773	0.579	0.777	0.465	0.773	0.579
1^{st} Stage F-statistic		95.948		54.514		95.948
1^{st} Stage p-value		0.000		0.000		0.000

Standard errors in parentheses.

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

Table B2: Regression results where the dependent variable is the logarithm of the total square footage of housing produced.

	OLS	IV	OLS	IV	OLS	IV
Firms producing 90%	0.043	1.19	0.026	1.60	0.043	1.19
	(0.014)	(0.17)	(0.015)	(0.27)	(0.014)	(0.17)
Jobs within 50 miles	-4.26	7.48	-4.73	7.83	-4.26	7.48
	(0.56)	(1.88)	(0.55)	(2.34)	(0.56)	(1.88)
Construction cost	-0.46	-0.54	-0.37	-0.39	-0.46	-0.54
	(0.033)	(0.048)	(0.034)	(0.054)	(0.033)	(0.048)
Share national firms			0.58	-0.20		
			(0.092)	(0.20)		
Share regional firms			-0.55	-0.59		
			(0.11)	(0.17)		
Share micro firms			0.067	-2.21		
			(0.082)	(0.41)		
Established market					-3.76	
					(0.59)	
Observations	11516	11516	11516	11516	11516	11516
R^2	0.763	0.538	0.770	0.408	0.763	0.538
1^{st} Stage F-statistic		95.906		54.470		95.906
1^{st} Stage p-value		0.000		0.000		0.000

Standard errors in parentheses.

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

Table B3: Regression results where the dependent variable is the logarithm of the absolute value of the change in the number of the units of housing produced.

	OLS	IV	OLS	IV	OLS	IV
Firms producing 90%	0.39	2.01	0.32	2.40	0.39	2.01
	(0.042)	(0.39)	(0.045)	(0.58)	(0.042)	(0.39)
Jobs within 50 miles	5.14	21.7	4.61	21.2	5.14	21.7
	(1.67)	(4.35)	(1.66)	(4.96)	(1.67)	(4.35)
Construction cost	-1.22	-1.34	-0.99	-1.01	-1.22	-1.34
	(0.099)	(0.11)	(0.10)	(0.11)	(0.099)	(0.11)
Share national firms			2.57	1.54		
			(0.28)	(0.43)		
Share regional firms			0.15	0.094		
			(0.31)	(0.35)		
Share micro firms			1.32	-1.68		
			(0.25)	(0.88)		
Established market					-3.87	
					(0.70)	
Observations	11493	11493	11493	11493	11493	11493
R^2	0.339	0.198	0.353	0.154	0.339	0.198
1^{st} Stage F-statistic		99.243		55.233		99.243
1^{st} Stage p-value		0.000		0.000		0.000

Standard errors in parentheses.

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

Table B4: Regression results where the dependent variable is the months of supply of housing (including under construction, model and finished vacant) at contemporaneous absorption rates.

	OLS	IV	OLS	IV	OLS	IV
Firms producing 90%	0.24	1.49	0.21	1.90	0.24	1.49
	(0.063)	(0.28)	(0.067)	(0.40)	(0.063)	(0.28)
Jobs within 50 miles	11.9	9.60	11.0	8.48	11.9	9.60
	(5.51)	(6.13)	(5.53)	(6.60)	(5.51)	(6.13)
Construction cost	-6.05	-1.25	-5.91	0.79	-6.05	-1.25
	(0.78)	(1.35)	(0.79)	(1.81)	(0.78)	(1.35)
Share national firms			0.67	0.44		
			(0.41)	(0.49)		
Share regional firms			-0.071	-0.38		
			(0.41)	(0.49)		
Share micro firms			0.62	-1.10		
			(0.34)	(0.57)		
Established market					-13.5	
					(3.25)	
Observations	3248	3248	3248	3248	3248	3248
R^2	0.398	0.231	0.402	0.121	0.398	0.231
1^{st} Stage F-statistic		95.703		56.954		95.703
1^{st} Stage p-value		0.000		0.000		0.000

Standard errors in parentheses.

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

Table B5: Regression results where the dependent variable is the logarithm of the absolute value of the change in price per square foot.

	OLS	IV	OLS	IV	OLS	IV
Firms producing 90%	-0.16	-4.52	-0.098	-6.10	-0.16	-4.52
	(0.045)	(0.59)	(0.049)	(0.98)	(0.045)	(0.59)
Jobs within 50 miles	-12.9	-57.7	-11.6	-59.5	-12.9	-57.7
	(1.80)	(6.61)	(1.78)	(8.41)	(1.80)	(6.61)
Construction cost	-0.27	0.039	-0.57	-0.51	-0.27	0.039
	(0.11)	(0.17)	(0.11)	(0.19)	(0.11)	(0.17)
Share national firms			-2.53	0.47		
			(0.30)	(0.72)		
Share regional firms			0.97	1.17		
			(0.34)	(0.61)		
Share micro firms			-0.76	7.97		
			(0.26)	(1.50)		
Established market					-15.2	
					(1.91)	
Observations	11511	11511	11511	11511	11511	11511
R^2	0.171	-0.943	0.194	-1.599	0.171	-0.943
1^{st} Stage F-statistic		95.863		54.244		95.863
1^{st} Stage p-value		0.000		0.000		0.000

Standard errors in parentheses.

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

B.2 Results without low-production markets

Table B6: Regression results where the dependent variable is the logarithm of the total value of housing produced.

	OLS	IV	OLS	IV	OLS	IV
Firms producing 90%	0.051	1.15	0.046	1.44	0.051	1.15
	(0.013)	(0.18)	(0.014)	(0.27)	(0.013)	(0.18)
Jobs within 50 miles	0.43	7.63	0.16	7.52	0.43	7.63
	(0.48)	(1.35)	(0.48)	(1.57)	(0.48)	(1.35)
Construction cost	-0.32	-0.47	-0.25	-0.37	-0.32	-0.47
	(0.033)	(0.050)	(0.033)	(0.052)	(0.033)	(0.050)
Share national firms			0.99	0.58		
			(0.083)	(0.14)		
Share regional firms			0.23	0.22		
			(0.091)	(0.13)		
Share micro firms			0.45	-1.17		
			(0.074)	(0.33)		
Established market					-0.0071	
					(1.45)	
Observations	15727	15727	15727	15727	15727	15727
R^2	0.785	0.630	0.790	0.568	0.785	0.630
1^{st} Stage F-statistic		85.312		52.567		85.312
1^{st} Stage p-value		0.000		0.000		0.000

Standard errors in parentheses.

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

Table B7: Regression results where the dependent variable is the logarithm of the total square footage of housing produced.

	OLS	IV	OLS	IV	OLS	IV
Firms producing 90%	0.048	1.10	0.042	1.36	0.048	1.10
	(0.012)	(0.18)	(0.013)	(0.25)	(0.012)	(0.18)
Jobs within 50 miles	0.55	7.41	0.28	7.24	0.55	7.41
	(0.46)	(1.28)	(0.46)	(1.48)	(0.46)	(1.28)
Construction cost	-0.33	-0.47	-0.26	-0.37	-0.33	-0.47
	(0.031)	(0.047)	(0.031)	(0.049)	(0.031)	(0.047)
Share national firms			0.98	0.57		
			(0.079)	(0.14)		
Share regional firms			0.17	0.13		
			(0.088)	(0.13)		
Share micro firms			0.44	-1.11		
			(0.071)	(0.31)		
Established market					1.13	
					(0.51)	
Observations	15714	15714	15714	15714	15714	15714
R^2	0.772	0.602	0.777	0.539	0.772	0.602
1^{st} Stage F-statistic		84.764		52.443		84.764
1^{st} Stage p-value		0.000		0.000		0.000

Standard errors in parentheses.

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

Table B8: Regression results where the dependent variable is the logarithm of the absolute value of the change in the number of the units of housing produced.

	OLS	IV	OLS	IV	OLS	IV
Firms producing 90%	0.17	1.49	0.18	1.79	0.17	1.49
	(0.034)	(0.39)	(0.036)	(0.54)	(0.034)	(0.39)
Jobs within 50 miles	-1.70	6.95	-2.69	5.90	-1.70	6.95
	(1.27)	(2.89)	(1.26)	(3.17)	(1.27)	(2.89)
Construction cost	-1.03	-1.22	-0.85	-0.99	-1.03	-1.22
	(0.086)	(0.11)	(0.086)	(0.11)	(0.086)	(0.11)
Share national firms			2.04	1.49		
			(0.22)	(0.30)		
Share regional firms			-0.15	-0.21		
			(0.24)	(0.26)		
Share micro firms			0.45	-1.47		
			(0.20)	(0.67)		
Established market					8.42	
					(3.79)	
Observations	15651	15651	15651	15651	15651	15651
R^2	0.321	0.218	0.334	0.196	0.321	0.218
1^{st} Stage F-statistic		86.219		51.970		86.219
1^{st} Stage p-value		0.000		0.000		0.000

Standard errors in parentheses.

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

Table B9: Regression results where the dependent variable is the months of supply of housing (including under construction, model and finished vacant) at contemporaneous absorption rates.

	OLS	IV	OLS	IV	OLS	IV
Firms producing 90%	0.19	2.06	0.20	3.30	0.19	2.06
	(0.048)	(0.51)	(0.051)	(0.99)	(0.048)	(0.51)
Jobs within 50 miles	0.071	-7.00	0.30	-11.6	0.071	-7.00
	(3.81)	(5.28)	(3.81)	(7.30)	(3.81)	(5.28)
Construction cost	-7.05	-0.23	-6.82	3.26	-7.05	-0.23
	(0.61)	(2.00)	(0.62)	(3.36)	(0.61)	(2.00)
Share national firms			0.37	2.10		
			(0.29)	(0.73)		
Share regional firms			-0.36	2.12		
			(0.30)	(0.93)		
Share micro firms			-0.035	-1.28		
			(0.24)	(0.56)		
Established market					-18.6	
					(3.69)	
Observations	4374	4374	4374	4374	4374	4374
R^2	0.406	-0.031	0.410	-0.651	0.406	-0.031
1^{st} Stage F-statistic		31.336		14.738		31.336
1^{st} Stage p-value		0.000		0.000		0.000

Standard errors in parentheses.

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

Table B10: Regression results where the dependent variable is the logarithm of the absolute value of the change in price per square foot.

	OLS	IV	OLS	IV	OLS	IV
Firms producing 90%	-0.12	-3.24	-0.034	-3.94	-0.12	-3.24
	(0.037)	(0.52)	(0.038)	(0.75)	(0.037)	(0.52)
Jobs within 50 miles	-8.78	-29.1	-8.61	-29.2	-8.78	-29.1
	(1.36)	(3.81)	(1.36)	(4.40)	(1.36)	(3.81)
Construction cost	-0.23	0.19	-0.34	-0.017	-0.23	0.19
	(0.092)	(0.14)	(0.093)	(0.15)	(0.092)	(0.14)
Share national firms			-2.09	-0.89		
			(0.24)	(0.41)		
Share regional firms			-0.43	-0.29		
			(0.26)	(0.37)		
Share micro firms			-1.62	2.96		
			(0.21)	(0.93)		
Established market					-11.5	
					(1.49)	
Observations	15709	15709	15709	15709	15709	15709
R^2	0.180	-0.428	0.191	-0.655	0.180	-0.428
1^{st} Stage F-statistic		84.742		52.290		84.742
1^{st} Stage p-value		0.000		0.000		0.000

Standard errors in parentheses.

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

B.3 Results with large firms only

B.4 Results with adjacent markets removed from the instrument

Table B11: Regression results where the dependent variable is the logarithm of the total value of housing produced.

	OLS	IV	OLS	IV	OLS	IV
Firms producing 90%	0.042	1.21	0.029	1.38	0.042	1.21
	(0.013)	(0.21)	(0.014)	(0.27)	(0.013)	(0.21)
Jobs within 50 miles	1.50	8.88	1.53	8.26	1.50	8.88
	(0.49)	(1.48)	(0.49)	(1.49)	(0.49)	(1.48)
Construction cost	-0.32	-0.51	-0.29	-0.42	-0.32	-0.51
	(0.033)	(0.056)	(0.034)	(0.054)	(0.033)	(0.056)
Share national firms			0.66	0.39		
			(0.087)	(0.13)		
Share regional firms			0.38	0.25		
			(0.094)	(0.13)		
Share micro firms			0.51	-0.99		
			(0.077)	(0.31)		
Established market					-3.19	
					(1.46)	
Observations	14827	14827	14827	14827	14827	14827
R^2	0.793	0.621	0.794	0.588	0.793	0.621
1^{st} Stage F-statistic		67.808		51.306		67.808
1^{st} Stage p-value		0.000		0.000		0.000

Standard errors in parentheses.

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

Table B12: Regression results where the dependent variable is the logarithm of the total square footage of housing produced.

	OLS	IV	OLS	IV	OLS	IV
Firms producing 90%	0.038	1.41	0.026	1.62	0.038	1.41
	(0.013)	(0.22)	(0.013)	(0.29)	(0.013)	(0.22)
Jobs within 50 miles	1.42	9.95	1.40	9.30	1.42	9.95
	(0.47)	(1.55)	(0.47)	(1.59)	(0.47)	(1.55)
Construction cost	-0.33	-0.55	-0.31	-0.46	-0.33	-0.55
	(0.032)	(0.059)	(0.032)	(0.058)	(0.032)	(0.059)
Share national firms			0.56	0.22		
			(0.083)	(0.14)		
Share regional firms			0.21	0.018		
			(0.091)	(0.15)		
Share micro firms			0.41	-1.38		
			(0.074)	(0.34)		
Established market					-2.97	
					(1.40)	
Observations	14817	14817	14817	14817	14817	14817
R^2	0.776	0.498	0.777	0.437	0.776	0.498
1^{st} Stage F-statistic		67.517		51.194		67.517
1^{st} Stage p-value		0.000		0.000		0.000

Standard errors in parentheses.

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

Table B13: Regression results where the dependent variable is the logarithm of the absolute value of the change in the number of the units of housing produced.

	OLS	IV	OLS	IV	OLS	IV
Firms producing 90%	0.27	0.33	0.31	0.20	0.27	0.33
	(0.036)	(0.42)	(0.038)	(0.50)	(0.036)	(0.42)
Jobs within 50 miles	-1.71	-1.33	-2.64	-3.19	-1.71	-1.33
	(1.32)	(2.98)	(1.32)	(2.84)	(1.32)	(2.98)
Construction cost	-1.09	-1.10	-0.90	-0.89	-1.09	-1.10
	(0.090)	(0.11)	(0.091)	(0.10)	(0.090)	(0.11)
Share national firms			2.16	2.18		
			(0.23)	(0.25)		
Share regional firms			0.14	0.15		
			(0.25)	(0.25)		
Share micro firms			0.45	0.57		
			(0.21)	(0.60)		
Established market					8.76	
					(3.96)	
Observations	14783	14783	14783	14783	14783	14783
R^2	0.324	0.324	0.336	0.335	0.324	0.324
1^{st} Stage F-statistic		67.128		51.530		67.128
1^{st} Stage p-value		0.000		0.000		0.000

Standard errors in parentheses.

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

Table B14: Regression results where the dependent variable is the months of supply of housing (including under construction, model and finished vacant) at contemporaneous absorption rates.

	OLS	IV	OLS	IV	OLS	IV
Firms producing 90%	0.23	0.97	0.25	1.20	0.23	0.97
	(0.044)	(0.50)	(0.046)	(0.61)	(0.044)	(0.50)
Jobs within 50 miles	-12.0	-17.6	-11.5	-18.2	-12.0	-17.6
	(3.50)	(5.27)	(3.51)	(5.69)	(3.50)	(5.27)
Construction cost	-7.87	-5.08	-7.68	-4.47	-7.87	-5.08
	(0.55)	(1.96)	(0.55)	(2.13)	(0.55)	(1.96)
Share national firms			0.17	0.61		
			(0.27)	(0.40)		
Share regional firms			-0.33	0.30		
			(0.26)	(0.49)		
Share micro firms			-0.25	-0.70		
			(0.22)	(0.37)		
Established market					64.7	
					(9.60)	
Observations	4030	4030	4030	4030	4030	4030
R^2	0.502	0.427	0.505	0.397	0.502	0.427
1^{st} Stage F-statistic		16.148		13.203		16.148
1^{st} Stage p-value		0.000		0.000		0.000

Standard errors in parentheses.

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

Table B15: Regression results where the dependent variable is the logarithm of the absolute value of the change in price per square foot.

	OLS	IV	OLS	IV	OLS	IV
Firms producing 90%	-0.055	-5.26	0.011	-6.02	-0.055	-5.26
	(0.038)	(0.77)	(0.040)	(1.00)	(0.038)	(0.77)
Jobs within 50 miles	-11.8	-44.3	-11.7	-41.6	-11.8	-44.3
	(1.40)	(5.38)	(1.39)	(5.55)	(1.40)	(5.38)
Construction cost	-0.30	0.53	-0.42	0.15	-0.30	0.53
	(0.095)	(0.21)	(0.096)	(0.20)	(0.095)	(0.21)
Share national firms			-2.35	-1.06		
			(0.25)	(0.50)		
Share regional firms			-0.59	0.15		
			(0.27)	(0.52)		
Share micro firms			-1.74	5.03		
			(0.22)	(1.19)		
Established market					35.7	
					(4.18)	
Observations	14812	14812	14812	14812	14812	14812
R^2	0.187	-1.448	0.199	-1.778	0.187	-1.448
1^{st} Stage F-statistic		67.494		51.172		67.494
1^{st} Stage p-value		0.000		0.000		0.000

Standard errors in parentheses.

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

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 $t \in \{1, 2\}$:

$$\begin{aligned} \ell_1 &= \beta_0 + \beta_1 H_1 \\ p_1 &= \alpha_0 + \alpha_1 (Z - H_1) \end{aligned} \tag{C15}$$

$$\begin{aligned} \ell_2 &= \beta_0 + \beta_1 (H_1 + H_2) \\ p_2 &= \alpha_0 + \alpha_1 (2Z - H_1 - H_2) \end{aligned} \tag{C15}$$

In Equations C15 and C15, 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 $t = 2$[14] 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

[14]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.

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 $t = 2$:

$$\begin{aligned} h_1^*\left(m; \tilde{h}_1, \tilde{h}_2\right) &= \frac{1}{2\left(\alpha_1 + \beta_1\right)}\left(K + 1 - \left(\alpha_1 + \beta_1\right) m\tilde{h}_1\right) \\ h_2^*\left(m; \tilde{h}_1, \tilde{h}_2\right) &= \frac{1}{2\left(\alpha_1 + \beta_1\right)}\left(K + 2 - \left(\alpha_1 + \beta_1\right)\left(m\tilde{h}_1 + \left(n - m - 1\right)\tilde{h}_2\right)\right) \end{aligned} \tag{C15}$$

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:

$$\pi_2^*(m) - \pi_1^*(m) = \frac{-1}{4\left(n - m\right)^2\left(n + 1\right)^2\left(m + 1\right)}\left[m\left(-2 - n\right) + 3n + 1 - K - 3n^2\right] \times$$
$$\left[m^2\left(K + 5n + 3\right) + m\left(-5Kn = 2K - 5n^2 + 3n + 2\right) + 2Kn^2 - Kn - K - 3n^2 + 2n + 1\right] \tag{C15}$$

In a mixed-strategy equilibrium, the left-hand side of Equation C15 must be equal to zero. The term in square brackets on the first line of Equation C15 has no root with $m > 0$ under Assumption 1. However, the term in square brackets on the second line of Equation C15 has roots as follows:

$$m^*_\pm = \frac{1}{2\left(K+5n+3\right)}\left[5n^2+\left(5K-3\right)n+2\left(K-1\right)\pm\right.$$
$$\left.\sqrt{\left(5n^2+\left(5K-3\right)n+2\left(K-1\right)\right)^2-4\left(K+5n+3\right)\left(2Kn^2-Kn-K-3n^2+2n+1\right)}\right] \tag{C15}$$

It remains to show that Equation C15 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 C15 is positive.*

Proof. To show that the solution is positive, it is sufficient to show that $\left(K+5n+3\right)\left(2Kn^2-Kn-K-3n^2-2n+1\right)$ is negative. Then, the term under the radical is less than the term outside the radical. Note that this term factors to $\left(K+5n+3\right)\left(n-1\right)\left(2Kn+K-3n-1\right)$. 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 C15, 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 C15 that is used to define m^*_- in Equation C15 and rearrange:

$$\frac{\partial m^*_-}{\partial n} = 1 + \frac{7Kn - 3n + K + 7Km^*_- + 9m^*_-}{5n^2 - 5Kn + 3n + 2K + 2 - 10m^*_- n - 2m^*_- K - 6m^*_-} \tag{C15}$$

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 C15 is positive. Under Assumption 1, the numerator is positive. Rearranging the denominator yields the following condition on m^*_- for the denominator to be positive:

$$m^*_- < \frac{5n^2 + 5Kn + 3n - 2K + 2}{2\left(K + 5n + 3\right)} \tag{C15}$$

This is exactly the condition implied by Lemma 1 for m^*_-. Under Assumption 1, m^* as specified by Equation C15 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 C15 yields the following construction decisions for each firm:

$$\begin{aligned} h_1^* &= \frac{K+1}{(m+2)(\alpha_1+\beta_1)} \\ h_2^* &= \frac{m+2K-4}{(m+2)(\alpha_1+\beta_1)(n-m+1)} \end{aligned} \tag{C15}$$

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

$$\begin{aligned} H_1^* &= \frac{mn}{n-1}\frac{K+1}{(m+2)(\alpha_1+\beta_1)} \\ H_2^* &= \frac{n^2-mn-n}{n-1}\frac{m+2K-4}{(m+2)(\alpha_1+\beta_1)(n-m+1)} \end{aligned} \tag{C15}$$

From Equation C15 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 C15 using $m' = \frac{\partial m}{\partial n}$ for notational clarity:

$$\frac{\partial H_1}{\partial n} = \frac{K+1}{\alpha_1+\beta_1}\frac{2n^2m' - 2nm' - m^2 - 2m}{(m+2)^2(n-1)^2} \tag{C15}$$

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 C15 is also positive. $\square$

According to Equation C15, 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 C15 with probability $\frac{m}{n-1}$ and given the price at $t = 1$ as specified by Equation C15, $\text{SD}(p_1)$ may be written in terms of m as follows:

$$\text{SD}(p_1) = \frac{\alpha_1 (K+1)}{\alpha_1 + \beta_1} \frac{nm(n-m-1)}{(n-1)(m+2)} \tag{C15}$$

Differentiating Equation C15 with respect to n and rearranging yields the following result:

$$\text{sign}\left(\frac{\partial}{\partial n}\text{SD}(p_1)\right) = \text{sign}\left(n(n-1)m'(2n - mn - 3m - 2) + m(m+2)(mn - n + m + 1)\right) \tag{C15}$$

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 $m > \frac{n(n-1)}{n(n+1)}$. $\square$

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.