Supply Constraints Are Not Valid Instrumental Variables for Home Prices Because They Are Correlated With Many Demand Factors

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Abstract

Economists sometimes assume that strictly regulated housing markets near mountains and oceans are expensive because they are costly places to build, not because they are nice places with productive firms and workers. U.S. data show this convenient assumption to be false. Housing supply has grown more in supply-constrained markets than elsewhere over recent decades, indicating constraints are correlated with demand growth. Supply constraints are highly correlated with productivity proxies such as historical education levels, immigration, and national employment growth in locally prevalent industries. The correlation between constraints and productivity growth invalidates common uses of constraints as part of instrumental variables for home prices. The relationship between supply constraints and price volatility is much weaker after accounting for observable demand factors.

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1 Introduction

How do local real estate prices affect investment, consumption, or wages, all else equal? A regression of one of these dependent variables on home prices would not provide a reliable answer. Growth in wages and demand for investment and consumption presumably cause home price growth. If any sources of investment or consumption demand are unobservable,

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the regression coefficient on home prices would mix the causal effect of interest with a bias reflecting reverse causation and omitted variables. For example, consider a regression of growth in investment by businesses on home price growth across U.S. metropolitan areas between 1980 and the present. This would involve comparing "Superstar Cities", such as New York and San Francisco, to markets better known for affordability, such as Dayton, Tulsa, and Wichita. The Superstars' amenities, agglomerations of firms in technology and finance, and highly specialized workers seem hard to measure, and likely caused relative growth in both home prices and business investment.

Researchers have turned to physical and regulatory constraints to home building as sources of instrumental variables (IVs) for rent and price growth, recognizing the difficulty of a control variable approach. Finance and labor researchers commonly instrument for price growth with a metropolitan-level measure of housing supply elasticity presented in Saiz (2010). Saiz's elasticity measure is a nonlinear combination of supply constraints, including: land lost to steep slopes and water,[1] historical government expenditure on preventive and regulatory activities, and the 1971 fraction of local Christians that belonged to nontraditional Protestant denominations.[2] Researchers have also studied the relationship between different outcomes and actual regulatory barriers, as measured by Linneman et al. (1990) and Gyourko, Saiz, and Summers (2006). Supply constraints satisfy the "first-stage" requirement for a valid IV: they are correlated with home price growth. Across U.S. metropolitan areas in recent years, housing prices have grown faster where steep slopes, bodies of water, and land use regulations impede construction.

The first stage regression of price growth or volatility on supply constraints may be of independent interest. In the recent home price cycle, the most severe booms and busts were located in markets with historically elastic housing supply. For example, within California, constraints are famously strict along the Pacific Coast, but home price cycles were more pronounced in less-regulated and flatter Central California. This seems difficult to explain under rational expectations.[3]

To solve the identification problem in regressions of consumption, investment, or wages on real estate prices, supply constraints must be uncorrelated with the relevant omitted demand factors. The standard second-stage "exclusion restriction" assumed in the IV studies is that supply constraints are uncorrelated with productivity growth conditional on observable co-

[1]A similar measure is presented in Kolko (2008).

[2]Saiz (2010) reviews studies showing that members of these denominations tend to oppose government intervention into property markets.

[3]Glaeser, Gyourko, and Saiz (2008); Huang and Tang (2012); Paciorek (2013), Davidoff (2013); Nathanson and Zwick (2013), examine this phenomenon. Green, Malpezzi, and Mayo (2005) also consider the empirical relationship between supply constraints and the relationship between price and quantity growth.

variates.[4] Regressions of price volatility on supply constraints are typically informative only if supply constraints are conditionally uncorrelated with the volatility of housing demand.

Both the second-stage IV requirement that supply constraints are uncorrelated with productivity growth and the assumption that constraints are uncorrelated with demand volatility likely imply an assumption that seems much stronger: that supply constraints are uncorrelated with any unobserved housing demand factors. Amenities such as the quality of weather or ocean views seem plausibly uncorrelated with the growth of productivity, and subject to capture with metropolitan area fixed effects in panel settings. However, highly skilled workers appear to sort into naturally and culturally attractive cities, per Gyourko, Mayer, and Sinai (2004). Increasing income inequality should thus have led to a correlation between fixed amenities and income and productivity growth. Changes in the relative supply of amenities such as restaurants and public safety have likely both caused and been caused by the sorting of productive and hence affluent workers into high amenity cities, per Diamond (2013) and Moretti (2013). An instrument for home prices correlated with demand growth, even seemingly through amenity rather than productivity growth is thus suspect. The volatility of demand is presumably correlated with the level or growth of demand.

The remainder of this paper asks whether supply constraints are plausibly uncorrelated with demand growth generally or productivity growth in particular. The list of the most and least elastically supplied U.S. housing markets, presented by Saiz (2010) and reproduced in Table 1 strongly suggests otherwise. This list produces exactly the comparison of Superstar to affordability markets that researchers seek to avoid through the use of IVs.[5]

There are many reasons to expect the seeming gap in amenity and productivity between markets at the extremes of elasticity to extend to the rest of Saiz's data. Some of these are reviewed in Saiz (2010). Theoretically, Proposition 2 states: "Metropolitan areas with low land availability tend to be more productive or to have higher amenities; in the observable distribution of metro areas the covariance between land availability and productivity-amenity shocks is negative." Empirically: "geographically land-constrained areas tended to . . . have

[4]Except possibly through a causal effect of home prices on investment. Diamond (2013), studying sorting by ability into high-amenity cities, states: "The exclusion restriction assumes that land-unavailability and land-use regulation do not . . . impact unobserved changes in local productivity" except through prices. Beaudry, Green, and Sand (2012), in the context of a wage growth regression, assume of the Saiz (2010) elasticity measure: "this is a variable that should be correlated with increases in housing prices but not correlated with city-specific changes in technological knowledge." In the context of business investment, Sraer, Chaney, and Thesmar (2012) require that possibly unlike real estate prices, the instrument is not "correlated with the investment opportunities of land-holding firms." Adelino, Schoar, and Severino (2015) state that their IV estimates will be biased if "supply elasticity is correlated with employment or business creation for reasons other than house price growth."

[5]Whether this problem arises outside of the U.S. is an interesting question, but not salient to most published reseaerch. For example, Vancouver is not as obviously more productive a city than Winnipeg as San Francisco is relative to most unconstrained cities in the U.S.

higher incomes, to be more creative (higher patents per capita), and to have higher leisure amenities (as measured by the number of tourist visits)."

People can move, so if supply-constrained markets are relatively expensive, they should be more pleasant places to live or offer higher wages than other markets. Blanchard and Katz (1992) find, for example, that inter-regional mobility pushes local unemployment rates closer together. However, different households must face different utility and financial incentives to live or remain in particular markets.[6] Supply differences will thus affect the capitalization of given demand shocks into prices and rents, particularly in the short run.

Strict regulations, steep slopes, proximity to water, and historically large shares of non-traditional Protestants would all be questionable instruments for home prices, even ignoring equilibrium compensation. Hamilton (1975), Fischel (2001), and Ortalo-Magne and Prat (2011) describe theoretically how local politics are likely to lead to a correlation between zoning and housing demand. Saiz (2010) emphasizes that there is no need to impose strict regulations on development where there is little growth pressure, and shows that lagged growth predicts regulation. Wallace (1998) presents evidence in the Seattle metropolitan area that zoning "follows the market." Hilber and Robert-Nicoud (2013) state: "More desirable locations are more developed and, as a consequence of political economy forces, more regulated." Assuming differences in demand pressure are persistent (e.g. San Francisco has been under greater growth pressure than Detroit for a while), regulations adopted in the past are likely to be correlated with housing demand growth in the present.

Mountains and bodies of water are not just constraints on builders, but also amenities, creating "prospect and refuge" in the language of landscape architecture.[7] Natural amenity rationalizes building restrictions, and both taste for amenity and government intervention are correlated with demographic characteristics (education and wealth) likely correlated with both the level and growth of productivity (Kahn (2007), Gyourko, Mayer, and Sinai (2004)).

To see the problem with physical barriers as IVs for price, consider asking how the listing price of a home affects time to sale within greater Los Angeles. Unobserved home quality will cause both a high listing price and a rapid sale, so an instrument is needed for price. One might think to instrument for price with an indicator for whether or not the home has a view of the Pacific Ocean. Identification would require an assumption that the steep slopes, presence of nearby bodies of water, and stricter regulations associated with view homes raise listing prices only through their impact on construction cost, and not because views of the water are desirable. This approach would compare places like Malibu to places like South Los

[6] Aura and Davidoff (2008) show for plausible preference parameters, over horizons long enough to ignore frictional moving costs, supply constraints can explain only a small fraction of differences in price levels across U.S. metropolitan areas.

[7] See Appleton (1975).

Angeles and would likely yield a downward-biased estimate of the causal effect of price: steep slopes and proximity to water are inherently attractive and should increase the speed of sale. Given households' ability to choose neighborhoods, it is also not clear why neighborhood-level construction cost could be passed on to consumers if they were not correlated with amenity or productivity. Averaging slopes and proximity to the ocean at the market level, and then comparing listing prices and time on the market between metropolitan areas like Los Angeles versus metropolitan areas like Topeka is not a clearly superior approach.[8]

The fraction of Christians who were members of nontraditional denominations in the early 1970s is also a questionable IV for price. Based on their geographic concentration in Appalachia and political leanings, some nontraditional Protestant denominations are stereotyped as anti-intellectual and associated with a "culture of poverty."[9] The correlation between cultural openness and productivity may well have grown over time.[10]

Table 1 lists the most and least regulated metropolitan areas' housing price and quantity growth between 1980 and the present. The least elastically supplied cities saw much more price growth, but almost as much quantity growth as the most elastically supplied cities. Section 2 of this paper shows graphically that if supply constraints shift supply curves up or in but are not associated with demand growth, then constraints should be negatively correlated with quantity growth. If supply constraints were uncorrelated with demand growth, they would be valid instruments for price in a regression of log quantity growth on log price growth to be interpreted as an estimate of demand elasticity. In that case, a positive relationship between quantity growth and supply constraints would imply a positive IV estimate for the price elasticity of housing demand. Existing IV studies ignore housing quantity growth.

Section 3 presents correlations across U.S. metropolitan areas between different measures of supply constraints and some demand measures: immigration, education and Bartik (1991)-type national changes to employment in local industries. Section 3 also presents regression estimates of home price and quantity growth and price growth volatility over the 1980-2014 period on supply constraints and correlated demographic factors.

Supply constraints are *positively* associated with housing unit growth and observable demand characteristics, and their relationship with price growth and volatility falls significantly in the presence of demographic and productivity controls. It is not plausible to assume that supply constraints are uncorrelated with unobservable demand factors, and a stretch to

[8]The cross-metropolitan approach would provide a rationalization for passing through construction costs to relatively immobile consumers, but would also introduce the likely evolving correlation between amenity and worker types.

[9]See McCauley (1995) and Ryden (2011) for more nuanced views.

[10]For example, recent legislation granting rights to discriminate on religious grounds in Indiana was presumably designed in part to appeal to fundamentalist Christians, and appears to have risked reducing the number and productivity of firms and workers in Indiana.

assume orthogonality to productivity growth.

To salvage the use of supply constraints as IVs, one might take an interactive approach. If, for some reason, second order terms in common proxies for demand were uncorrelated with demand growth, then supply constraints interacted with demand factors might provide clean variation in home prices even though constraints are correlated with demand. Along similar lines, Sraer, Chaney, and Thesmar (2012) and others exploit the theoretical short-run difference in local price growth generated by the interaction between supply constraints and national demand shocks. Results presented in Section 4 indicate that contrary to the implicit assumption, second order terms are important in demand growth. Neither interest rates nor "Bartik" employment growth approximations can be interacted with supply constraints to form an IV for home prices uncorrelated with demand growth.

Two significant caveats are in order before proceeding. First, correlation with demand growth does not imply Saiz's elasticity or land unavailability measures are biased. Second, even if supply constraints are not valid IVs for home prices as commonly used, some of the papers using this identification approach may still present unbiased results. For example, Sraer, Chaney, and Thesmar (2012) and Adelino, Schoar, and Severino (2015) use clever interactions between home prices and firm characteristics that obviate the need for a price instrument conditional on different assumptions from those evaluated in this paper.

2 Supply Constraints, Quantity Growth, and Demand

If one accepts that supply constraints as commonly used should not be correlated with housing demand growth,[11] then it is interesting to consider their correlation with quantity growth. In Figure, 1 markets A and B have less elastic supply curves than C and D, and markets B and D experience greater demand growth than A and C. Comparing cities of type B to type D, or A to C, can provide information on the effects of price growth on some outcome with demand growth held constant. Comparing type B cities to type C cities, or type A to type D, would be less informative if demand is imperfectly observable. The standard assumption is that supply elasticity is uncorrelated with demand growth, *e.g.*, city pairs of type A vs D are as commonly observed as pairs B vs. C. If instead pairs of type B vs. C dominate the data, supply constraints are correlated with demand growth and fail to solve the identification problem of a correlation between prices and demand growth.

Figure 1 provides a link between quantity growth and the validity of supply constraints as instruments. If inelasticity or supply constraints are uncorrelated with demand growth,

[11] That is, if one suspects unobserved demand growth might be correlated with productivity growth or the volatility of demand growth.

they will be negatively correlated with quantity growth; if supply constraints are positively correlated with demand growth, the correlation between supply constraints and quantity growth is ambiguous. It should thus be necessary but not sufficient for the instrument's validity that supply constraints be negatively correlated with quantity growth conditional on observable variables.[12]

The graphical analysis of Figure 1 applies only when demand is growing. Rising demand is consistent with the fact that 258 out of 261 markets over the years considered in the empirical work below saw positive quantity growth. However, some markets saw declining real prices over the last 35 years. How barriers to growth would affect supply elasticity in the face of a negative change in demand is not clear, since investors can not adjust housing supply downward quickly in response to shrinking demand (as in, e.g., Wheaton (1999)).

If supply constraints were uncorrelated with demand growth, then could be used to recover the price elasticity of housing demand. For example, suppose the quantity q of housing units demanded in a metropolitan area has a constant elasticity β with respect to price p. This would suggest a regression in differences:

$$\Delta \ln q_{mt} = \alpha + \beta \Delta \ln p_{mt} + \epsilon_{mt}. \tag{1}$$

OLS estimates of (1) are biased because growth in prices and quantities reflect both supply and demand factors. If supply constraints were uncorrelated with demand growth, though, they would provide an instrument for price. In a bivariate IV regression across markets, we would have:

$$\hat{\beta}_{IV} = \frac{\text{Cov}\left(\text{supply constraints, log quantity growth}\right)}{\text{Cov}\left(\text{supply constraints, log price or rent growth}\right)} \tag{2}$$

With control variables present, the IV estimate of β would have the same formulation as (2), but with the named variables specified as residuals from individually regressing each on observable demand factors. Given a positive covariance between supply constraints and price growth, a positive covariance between constraints and quantity growth would imply a positive estimate for the elasticity of demand. A positive estimate $\hat{\beta}_{IV}$ combined with the familiar positivity of the denominator, and an assumption that housing is not a Giffen, good would imply that supply constraints are not valid instruments and are correlated with omitted demand terms in ϵ.

[12] Saiz (2010) observes, regulations and barriers to growth can be thought of as both inward rotations and upward shifts of supply curves. Conceivably, supply-constrained cities could have greater quantity growth but no greater demand growth if demand elasticity were highly correlated with supply constraints. I am unaware of any studies claiming such a correlation.

3 Empirical Analysis of Supply Constraints and Productivity, Price, and Quantity Growth

We wish to know if commonly used supply constraints are plausibly uncorrelated with unobserved demand factors. Correlations with observable factors may provide a hint. Table 3 lists some correlations among measures of supply constraints and demographic and industrial factors related to productivity growth. These measures are summarized in Table 2. The supply characteristics are: the Gyourko, Saiz, and Summers (2006) measure of the intensity of regulations ("regulations"), Saiz's measure of unavailable land ("unavailable"), and calculated elasticity ("elasticity"), as well as my own calculation of the fraction of Christians in nontraditional Protestant denominations as of 1971 ("Protestant").[13]

"college+" and "immigrant" measure respectively the fraction of the adult population in 1980 that had education greater than or equal to 4 years of college, and that were born outside the U.S. (based on the 1980 IPUMS Census sample). I also calculate a variable "Bartik" (akin to Bartik (1991)) that approximates local demand pressure based on national industrial employment growth. This variable for metropolitan area m is equal to the sum over all industries i of the fraction of those aged between 20 and 65 who live in m who worked in i in 1980, times the national (exclusive of the CBSA in question) percentage change in the number of people aged 20-65 in industry i between the 1980 Census and the 2010-2012 American Community Survey. In light of stylized facts, the high correlation among these variables is unsurprising.

Some regression specifications include geographic controls. A first is for 1980 housing units divided by land area: density is a component of supply elasticity in Saiz (2010). Inspection of the list of "Superstar" cities in Gyourko, Mayer, and Sinai (2004), discussions of American politics (for example Sarah Palin's discussion of "The Real America" and what we might imagine to be its complement) and the geography of home price volatility in the 2000s, suggest that two regions have had notably different demand conditions than others over the past few decades. Inspection of the list of Superstar Cities in Gyourko, Mayer, and Sinai (2004) reveals extreme concentration on the California coast between San Diego and the San Francisco Bay Area and the "Acela Corridor" between Washington, D.C. and New York. The variable "Coastal" includes metropolitan areas with at least one county adjacent to the Pacific Ocean in California, Oregon, or Washington; or stops on the Acela line. The second set of metropolitan areas with presumably distinct demand conditions are

[13] From "Churches and Church Membership in the United States," 1971 edition, available online from The Association of Religion Data Archives. Following Saiz (2010), I define nontraditional denominations as the complement of: Catholic, United Church of Christ, American Baptist, Presbyterian, Methodist, Lutheran, and Episcopal. Shares are based on "adherence" rather than membership.

the "Sand States" of Arizona, California, Florida, and Nevada. Saiz (2010) proposes tourist visits as a measure of amenity. Of the top 10 continental U.S. destinations for tourists from other countries, 9 are Sand or Coastal markets.[14] Davidoff (2013) shows that roughly 2/3 of variation in the magnitude of the 2000s home price cycle across metropolitan areas is explained by an indicator for being in a Sand State. That paper also shows that within U.S. states, the magnitude of the 2000s home price cycle is not related to the Saiz measure of land unavailability.

Table 3 shows that each measure of supply constraints (high regulations and unavailable land, low nontraditional Protestant share and elasticity) is significantly positively correlated with each proxy for demand levels and growth (college, immigrant, Bartik, Sand, and Coastal). The geographic, demographic, and industrial growth potential factors are also highly correlated with each other. These large correlations are inconsistent with the standard identifying claims regarding orthogonality of supply constraints to productivity growth.

Table 4 presents regressions of home price and quantity growth on the composite Saiz elasticity measure in isolation, and then with observable controls present. Home price growth is the log CPI-deflated change in the Freddie Mac Home Price Index (FMHPI), January, 1980 to January, 2014. Quantity change is the log ratio of Census counts of housing units in the 2010-2012 American Community Survey to the 1980 Census estimate. Table 5 repeats the analysis with the dependent variable equal to the standard deviation of one-year (January to January) real home price growth between 1976 and 2014.[15]

Tables 4 and 5 show significant negative unconditional correlations between the Saiz elasticity estimate and home price growth and volatility, consistent with prior work. We also find a significantly negative correlation between supply elasticity and quantity growth; this is not consistent with the Saiz measure acting as a pure supply shifter. Figure 2 plots price and quantity growth for 261 metropolitan areas, with plotting circles proportional to the inverse of elasticity against price and quantity. Even outside of the extremes listed in Table 1, regressions with supply elasticity on the right hand side are prone to compare the type B vs. C cities shown in Figure 1.[16] Measured elasticity does not look like a pure supply shift.

Based on the quantity regression results, IV formula (2) would indicate that demand is upward sloping in price, with or without the demand controls. Unreported IV regressions

[14] Based on Internet resource: "National Travel and Tourism Office Overseas Visitation Estimates for U.S. States, Cities, and Census Regions: 2013" from the U.S. Department of Commerce International Trade Administration. Chicago is the exception.

[15] This volatility measure is almost perfectly correlated (coefficient .95) with the maximal annualized ratio of start-to-peak-to-end cyclicality ratio $\frac{p_{t1}^2/[p_{t0}p_{t2}]}{t2-t1}$ for any three ordered dates $t0, t1, t2$ chosen to maximize the value within a metropolitan area.

[16] This is the visual counterpart of the unconditional regressions showing supply elasticity to be negatively correlated with both price and quantity growth.

yield the same upward sloping "demand" estimates when FMHPI price growth is replaced with log growth of median rent as calculated by the 1980 Census and the 2009-2011 American Community Survey. Using elasticity as an IV makes the regression bias worse.[17]

In the second specification of Tables 4 and 5, college and immigrant share as of 1980, and predicted employment growth based on 1980 industry shares are added as regression controls. The relationship between supply elasticity and each of price and quantity growth and price volatility is weakened by the presence of controls but remains different from zero at a 1% confidence level in all specifications. That is, the supply instrument appears to affect the dependent variables through correlations with observed demand factors. The third columns add geographic controls (density and Coastal and Sand state dummies); these further attenuate the estimated relationship between elasticity and price and movements. A natural conjecture is that the instrument also affects prices and quantities through unobservable demand factors, too.

Appendix tables 8 through 13 repeat tables 4 and 5, but replacing the Saiz elasticity estimate with alternative measures of supply constraints: the Gyourko, Saiz, and Summers (2006) regulations index, the Saiz unavailable land measure, and the 1971 nontraditional Protestant share. The regression results are broadly consistent across supply constraint measures. A difference is that the regression coefficient in quantity growth regressions on either regulations or unavailable land is indistinguishable from zero instead of significantly positive conditional on covariates. Like the elasticity measure, both unavailable land and regulations have an unconditionally positive relationship with quantity growth. The nontraditional Protestant measure (negatively correlated with Saiz elasticity) has a consistently positive relationship with quantity growth, but is insignificantly associated with price growth conditional on demographic and geographic observables. No specification supports the inference that supply constraints lead to greater price growth only because they reduce construction.

In the case of the Protestant measure, the regressions are confined to a large subset of metropolitan areas that contain counties in which a Brandeis University study (Tighe et al. (2013)) estimates the fraction of the population that is Jewish. The variable "Jewish" is a weighted average across counties with non-missing data within each metropolitan area. The data support two conjectures: (i) Jews are likely to avoid regions in which nontraditional Protestants are concentrated, and (ii) regions with large Jewish population concentrations have enjoyed high price growth in large part due to correlation with education, immigrant share, and Bartik shocks attributable to industry shares. The inclusion of the Jewish fraction (which does not affect the nontraditional Christian share mechanically) as a control is not intended to identify a causal effect, rather to serve as a warning that cultural factors are

[17]OLS regressions yield a small negative coefficient on price growth.

likely correlated with both demand and supply.

4 Interactive Instrumental Variables

Suppose that outcome y_{mt} in market m at date t can be written as a function of home rents, prices, or user cost p_{mt}; observable variables x_{mt}; and unobservable factors ε:

$$y_{mt} = \alpha_m + \alpha_t + \beta p_{mt} + x_{mt}\gamma + \varepsilon_{mt}. \tag{3}$$

Equation (3) is typically estimated in a panel, so that all variables can be purged of metropolitan fixed effects α_m and shared national effects at t, α_t. We suspect that p is correlated with ε conditional on x, α_m and α_t, so OLS estimates of β are biased.

Perhaps recognizing that supply constraints alone are not valid IVs for home prices, economists have proposed two types of interactive IVs. A first panel approach exploits interactions between supply constraints and time-varying demand shocks. Sraer, Chaney, and Thesmar (2012) consider the interaction between supply constraints and real mortgage interest rates. I follow their approach and calculate real mortgage interest rates between 1993 and 2007 as the St. Louis Federal Reserve Bank (FRED) 10-year mortgage interest rate less lagged annual inflation at a monthly frequency. Table 6 presents monthly regressions of log real FMHPI home prices on the real mortgage interest rate, the Saiz elasticity measure, and their interaction. Each specification also includes time and metropolitan area dummy variables and covers the period. The hope is that in more elastically supplied markets, there is a less negative (more positive) effect of rising interest rates on prices, because demand factors like mortgage rates are only capitalized into prices where supply is inelastic. Standard errors are clustered at the CBSA level.[18]

This interactive approach may have an advantage relative to simple IV due to differences between the short- and long-run price elasticities of housing demand. Short-run price increases arising from the interaction of falling real interest rates and supply constraints might not be compensated by rising amenity or productivity. To the extent variation in real interest rates is uncorrelated with the simple passage of time, this IV approach uses oscillations in demand interacted with supply constraints. Specification (1) of Table 6 confirms the result in Sraer, Chaney, and Thesmar (2012) that there is the expected positive interactive effect of supply elasticity times interest rates.

[18]Standard errors are likely understated due to clustering at the level of date. This is not a major problem as we find a sign reversal, and the question of interest is whether the significant positive relationship between interest rates times elasticity and log real home price is robust to modifications in the specification. We find that the result is not robust.

A potentially serious problem with this panel approach is that interest rates have featured a strong negative time trend in recent decades. Thus the interaction of a supply constraint $\times$ real interest rate is highly correlated with supply constraint $\times$ passage of time. We know that the latter is highly correlated with demand growth from Tables 4 and 3. It is thus sensible to control for two types of interactions, when seeking the supply-side causal effect of supply constraints interacted with real mortgage interest rates:

1. Supply constraints interacted with a measure of time: "elasticity $\times$ time."

2. Demand controls from regressions above interacted with real interest rates.

Specification (2) of Table 6 adds elasticity $\times$ time (one month=1/12 unit) to the right hand side along with elasticity times real mortgage interest rate. We find that roughly 75% of the estimated relationship between interest rate times Saiz elasticity found in specification (1) can be attributed to the passage of time times supply elasticity, and we know that this effect is not driven by any negative relationship between supply elasticity and quantity growth. Thus we suspect that roughly three-quarters of the estimated relationship between elasticity and real interest rates has to do with long-term demand trends that themselves likely relate to investment opportunities. Specification (3) adds the interaction of time-invariant metropolitan demand controls with real mortgage rates. This specification recognizes that there might be interactions between demographic and productivity characteristics and interest rate fluctuations that affect home prices. The sign on elasticity times interest rate now becomes negative: that is, conditional on the interaction between supply elasticity and time and the relationship between historical productivity level and growth measures interacted with interest rates, supply constraints are associated with *less* price sensitivity to interest rates. Supply elasticity interacted with interest rates as a price instrument appears to satisfy neither the first-stage nor second-stage requirements of a significant relationship with price or orthogonality to unobserved demand components.

An alternative approach offered by Charles, Hurst, and Notowidigdo (2013) is to interact demand growth measures with supply constraints over a long horizon to obtain identification. Let k_m denote a set of demand measures, the first of which is k_m^1 denote a particular measure, and z_m a measure of supply constraints in market m. The first stage regression could be:

$$\ln p_{m2014} - \ln p_{m1980} = a + bk_m^1 z_m + v_1 z_m + v_2 k_m + \epsilon \tag{4}$$

The first interactive demand variable I consider is the Bartik industrial growth instrument. Specification (1) of Table 7 shows in a long-run price growth (1980-2014) regression that there is a significant negative coefficient on the interaction between the Bartik shock and supply elasticity, conditional on both main effects. That is, price growth is more sensitive to local industry shocks where supply is inelastic. Specification (2) of Table 7 recognizes that there might be non-linear productivity effects on price growth. This regression thus includes all three demand controls ("Bartik", "college+", and "immigrant") from Table 4 squared and their pairwise interactions. Since supply elasticity is highly correlated with these demand-side variables, the interaction of elasticity with any of these variables might be spuriously correlated with price growth through a higher order term in demand. Indeed, specification (2) finds three significant second-order demand terms, so that the null hypothesis of joint insignificance is readily rejected. When these higher order demand interactions are incorporated into the regression, the estimated coefficient on the interaction of Bartik and elasticity falls to a level statistically indistinguishable from zero. Specification (3) recognizes that higher order terms in demand could also reflect interactions between elasticity and any demand term, and includes elasticity interacted with each demand term. The results appear impossible to interpret meaningfully. Specifications (4) through (6) of Table 7 replace log price growth with log quantity growth as the dependent variable in equation (4). Conditional only on Bartik industry growth and supply elasticity, there is no significant relationship between their interaction and quantity growth. That is, it is not true that quantity growth among U.S. metropolitan areas has been more sensitive to national industry employment growth where estimated elasticity is greater. Again, we find significant higher order terms in demand controls, and a significant interaction between supply constraints and 1980 immigrant share. Summarizing the results presented in Table 7, there is no empirical support for the statement: "home prices are more sensitive to local industrial potential in inelastically supplied markets only because these markets capitalize demand shocks into prices rather than quantities."

5 Conclusions

Supply constraints are a tempting source of instrumental variables for home prices when omitted variables related to housing demand are a concern. However, all common measures of supply constraints are highly correlated with demand-side factors that themselves are highly correlated with price and quantity growth. All commonly used measures of supply constraints are positively correlated with housing supply growth. These correlations are not surprising, since mountains and oceans are amenities, regulations tend to be imposed in growing markets, and historical cultural antipathy to regulation based on religion is statistically correlated with low education, lack of diversity, and the local predominance of industries that have seen weak growth nationally. Used as an IV for price growth under a generalization of the standard exclusion restriction, supply constraints indicate that housing demand rises with home prices. Unconditional analyses of the relationship between supply constraints and home price volatility thus capture both any causal effect of supply elasticity and the effects of growing (and likely more volatile) demand.

Interacting supply constraints with demand factors to form IVs for price at first glance seems like a way to handle any correlation between supply constraints and omitted demand-side variables. In these specifications, the main effect of constraints can be controlled for. Unfortunately for identification purposes, interacting supply constraints with commonly used demand factors does not solve the problem of a correlation between home price growth and demand growth generally or productivity growth in particular. Interest rates have a time trend that explains most of the correlation between home prices and the instrumental interaction elasticity times interest rates, and we know that the interaction of time and supply constraints are associated with demand growth. The relationship between price growth and interactions between productivity growth proxies and supply constraints are not driven by differential quantity responses to demand shocks, but they are in part driven by higher order effects of demand factors. Consistent with results in Davidoff (2013), most of the differences across metropolitan areas in the volatility of home prices between 1980 and 2014 that seems attributable to supply constraints is explained away by a small number of demographic, productivity, and regional measures.

The analysis above should not be read as a criticism of the Saiz (2010) measures of unavailable land or elasticity *per se*. As Saiz emphasizes, a correlation between supply constraints and demand is to be expected. Supply-side factors could have a use as IVs for home prices in cases where the need for instrumental variables is driven by mechanical correlations or measurement error. Further, in some relevant cases, IVs for home prices might not be necessary. As a general matter, though, if there is a need for price instruments due to omitted demand-side variables, supply constraints do not solve the problem.

A final observation worthy of further exploration is that "Bartik shocks" are evidently highly correlated with supply constraints. They presumably should not be used as instruments for housing demand in regressions with left-hand side variables that may depend on housing supply.

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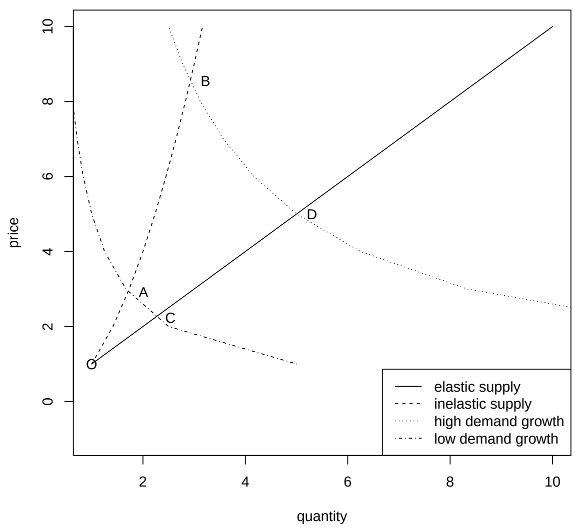
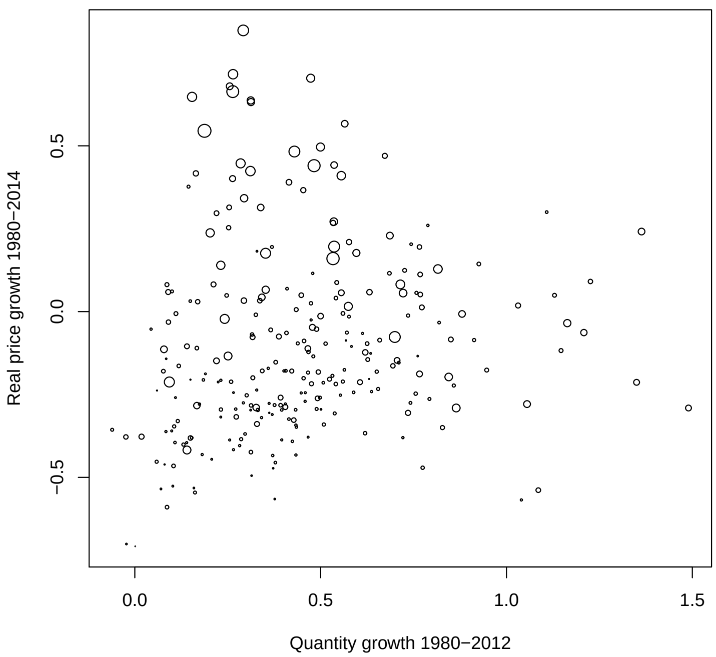
Figure 1: Quantity and price growth in metropolitan areas with different demand growth and supply elasticities



Description: Markets A and B have less elastic supply curves than C and D, and markets B and D experience greater demand growth than A and C.

Interpretation: The standard assumption is that supply elasticity is uncorrelated with demand growth, *e.g.*, city pairs of type A vs D are as commonly observed as pairs B vs. C. In that case we would see a negative empirical correlation between supply constraints and quantity growth.

Figure 2: Log price and quantity growth 1980-2012 (Census quantity) and 2014 (real FMHPI price).



Description: Plotting circles are inversely proportional to Saiz (2010) elasticity estimates.
Interpretation: Supply constraints are not negatively correlated with housing quantity growth. Per Figure 1 they appear to be associated with both supply inelasticity and demand growth.

Table 1: Least elastically supplied (least to most) and most elastically (most to least) supplied large metropolitan areas (from Saiz (2010)).

Least Elastic Supply			Most Elastic Supply		
Name	Δ log q	Δ log p	Name	Δ log q	Δ log p
Miami, FL	0.4	0.16	Wichita, KS	0.37	-0.47
Los Angeles-Long Beach, CA	0.19	0.55	Fort Wayne, IN	0.31	-0.49
Fort Lauderdale, FL	0.51	0.16	Indianapolis, IN	0.46	-0.24
San Francisco, CA	0.17	0.66	Dayton-Springfield, OH	0.17	-0.41
San Diego, CA	0.48	0.44	McAllen-Edinburg-Mission, TX	1.04	-0.57
Oakland, CA	0.35	0.66	Omaha, NE-IA	0.4	-0.18
Salt Lake City-Ogden, UT	0.59	0.01	Tulsa, OK	0.37	-0.43
Ventura, CA	0.43	0.48	Oklahoma City, OK	0.42	-0.39
New York, NY	0.15	0.65	Kansas City, MO-KS	0.4	-0.3
San Jose, CA	0.29	0.85	Greensboro-Winston-Salem-High Point, NC	0.55	-0.22

Description: Δ log p is estimated from Freddie Mac's home price index, January, 1980 to January, 2014. Quantity growth is based on housing unit counts between the 1980 U.S. Census and the 2010-2012 American Community Survey. Housing units are aggregated to the metropolitan area level. Home price growth is a simple average across counties where CBSA and Saiz (2010) metropolitan boundaries differ.
Interpretation: The most supply-constrained markets are better known for amenity and productivity than the least constrained. The gap in price growth between the two sets of cities is much greater than the gap in quantity growth.

Table 2: Summary Statistics.

Variable	Obs	Mean	Std. Dev.	Min	Max
1980 Fraction college+	261	0.059	0.023	0.03	0.19
"Bartik" Industry shock 1980-2012	261	1.527	0.117	1.183	1.813
Gyourko, Saiz, and Summers (2006) Regulations	261	-0.104	0.823	-1.765	4.312
Saiz (2010) elasticity	261	2.537	1.442	0.627	12.148
1971 Nontraditional Protestant share	261	0.513	0.244	0.036	0.987
1980 Population density (normalized)	261	0.49	2.183	0.002	33.441
Sand State	261	0.172	0.378	0	1
"Coastal" metro	261	0.107	0.31	0	1
Saiz (2010) unavailable land	261	0.255	0.209	0.005	0.86
1980 Immigrant population share	261	0.043	0.045	0.007	0.28
Tighe et al. (2013) Jewish share	170	0.01	.01	0.0002	0.08
Housing units 1980 Census	261	244,407	497,293	23,889	4,465,480
Housing Units 2010-2012 ACS	261	369,153	659,774	29,521	5,209,068
Log real FMHPI price growth 1/1980-2/2104	261	-0.101	0.284	-0.708	0.848
Std. dev. of 1-year CPI-deflated FMHPI growth	261	5.714	2.436	2.656	13.956

Description: Unit of observation is a metropolitan area (CBSA), as defined by Freddie Mac for their FMHPI.

Table 3: Correlations between different measures of supply constraints and factors likely associated with productivity growth

	Sand	Coastal	1980 % college+	Bartik	1980 %Immigrant
Unavailable Land	0.40	0.35	0.15	0.31	0.34
Gyourko *et al* regulations	0.31	0.40	0.33	0.38	0.35
Protestant	-0.15	-0.37	-0.22	-0.21	-0.41
Saiz elasticity	-0.35	-0.34	-0.23	-0.31	-0.37
Sand	1.00	0.24	0.15	0.46	0.54
Coastal	0.24	1.00	0.36	0.27	0.39
1980 % college+:	0.15	0.36	1.00	0.66	0.32
Bartik	0.46	0.27	0.66	1.00	0.42
1980 % Immigrant	0.54	0.39	0.32	0.42	1.00

Description: The first four rows are common measures of supply constraints; constraints are increasing in Unavailable Land and Gyourko *et al* regulations and decreasing in the nontraditional Protestant share and elasticity. Sand and Coastal markets appear to have enjoyed greater demand growth and volatility than other markets. The last three rows are demand-side measures related to productivity levels and growth.

Interpretation: Each supply constraint measure is highly correlated with each measure of demand growth.

Table 4: Regressions of price growth and quantity growth on Saiz (2010) elasticity measure and covariates.

Dependent Variable: Price growth			
	(1)	(2)	(3)
constant	0.1611**	-0.425*	-0.5144**
	(0.0304)	(0.2249)	(0.2126)
elasticity	-0.1032**	-0.0774**	-0.0594**
	(0.0104)	(0.0102)	(0.0093)
college+		3.91**	2.449**
		(0.7785)	(0.7403)
immigrant		0.603*	-0.2018
		(0.3452)	(0.3511)
Bartik		0.1728	0.2499
		(0.162)	(0.1559)
density			0.007
			(0.0059)
Coastal			0.3764**
			(0.045)
Sand			0.0173
			(0.0428)
Adj. R-sq.	0.27	0.42	0.55
degrees.freedom	259	256	253

Dependent Variable: Log Quantity Growth			
	(1)	(2)	(3)
constant	0.5582**	-0.9766**	-0.637**
	(0.0338)	(0.2615)	(0.2664)
elasticity	-0.0438**	-0.0228*	-0.0294**
	(0.0116)	(0.0119)	(0.0116)
high educ		-3.0394**	-1.2887
		(0.9053)	(0.9274)
immigrant		0.48	0.5579
		(0.4014)	(0.4399)
Bartik		1.0742**	0.7976**
		(0.1884)	(0.1953)
density			-0.0124*
			(0.0074)
Coastal			-0.2352**
			(0.0564)
Sand			0.1402**
			(0.0536)
Adj. R-sq.	0.05	0.17	0.26
degrees.freedom	259	256	253

Description: Top panel: dependent variable is log FMHPI home price growth 1980 to 2014, Bottom panel: dependent variable is log quantity (Census count of units) growth 1980 to 2012. Unit of observation is a metropolitan area. * Signficant at 5%, ** at 1%.
Interpretation: Saiz (2010) elasticity is negatively correlated with quantity growth, and its negative relationship to price growth is driven in part by observable demand factors.

Table 5: Price volatility and Saiz (2010) elasticity

	(1)	(2)	(3)
constant	7.8385**	-4.5601**	1.5375
	(0.2661)	(1.8048)	(1.5104)
elasticity	-0.8372**	-0.4854**	-0.3022**
	(0.0912)	(0.0818)	(0.0659)
high educ		-20.2535**	-7.1208
		(6.2484)	(5.2589)
immigrant		20.5477**	6.4241**
		(2.7706)	(2.4942)
Bartik		7.7418**	2.8443**
		(1.3001)	(1.1077)
density			-0.0152
			(0.0422)
Coastal			1.3181**
			(0.3196)
Sand			3.5469**
			(0.3041)
Adj. R-sq.	0.24	0.49	0.69
degrees.freedom	259	256	253

Description: Dependent variable: Standard Deviation of 1-year Real FMHPI Growth 1980-2014. Unit of observation is a metropolitan area.

Interpretation: Most of the relationship between supply elasticity and the standard deviation of real price growth disappears conditional on a few demand measures.

Table 6: Panel regression (monthly) of real FMHPI home price index on real mortgage rates interacted with supply elasticity and other demand factors.

	(1)	(2)	(3)
constant	3.5583**	44.6003**	48.8916**
	(0.1223)	(6.4483)	(6.4599)
elasticity × mtg	0.0307**	0.0071**	-0.0059**
	(0.0051)	(0.0015)	(0.0021)
elasticity × date		-0.0066**	-0.0066**
		(0.001)	(0.001)
college+ × mtg			0.3661*
			(0.1937)
Bartik × mtg			-0.2997**
			(0.0398)
immigrant × mtg			-0.6041**
			(0.1589)
Adj. R-sq.	0.84	0.85	0.87
degrees.freedom	46,279	46,278	46,275

Description: Unit of observation is a metropolitan area × month. All specifications include month and CBSA fixed effects. Standard errors are clustered at the CBSA level.

Interpretation: Most of the first-stage relationship between the interaction of supply elasticity and real mortgage rates is attributable to the interaction between supply constraints and time elapsed. From earlier results we know that this is in part reflects demand growth. Conditional on interactions between demand factors and mortgage rates, prices rise *less* sharply with falling interest rates in inelastically supplied markets.

Table 7: Regressions of log real home price growth 1980-2014 and log quantity growth 1980-2012 on demand factors and their interaction with estimated supply elasticity

	(1)	(2)	(3)	(4)	(5)	(6)
		Price growth			Quantity Growth	
constant	-1.5926**	-1.85	0.0876	-0.6911	7.9908**	6.0178*
	(0.3865)	(2.4432)	(2.6122)	(0.4384)	(2.8042)	(3.0003)
elasticity	0.1544	-0.0036	-0.2242	0.0028	-0.0973	0.1132
	(0.1427)	(0.1441)	(0.197)	(0.1619)	(0.1654)	(0.2263)
Bartik	1.1153**	2.3297	-0.006	0.7869**	-10.9329**	-8.5494*
	(0.2489)	(3.4885)	(3.6536)	(0.2823)	(4.0041)	(4.1964)
Bartik× elasticity	-0.1578*	-0.0387	0.1429	-0.0184	0.0438	-0.1301
	(0.0941)	(0.0961)	(0.1458)	(0.1067)	(0.1103)	(0.1674)
Bartik× Bartik		-0.8401	-0.2199		3.9345**	3.2968*
		(1.2675)	(1.2946)		(1.4548)	(1.4869)
college+		-9.9462	-12.1123		14.3619	18.5289
		(14.8407)	(15.6792)		(17.034)	(18.0085)
college+ × college+		-63.5866**	-60.8772**		29.1354	27.2795
		(21.819)	(21.9606)		(25.0434)	(25.2232)
college+ × Bartik		11.3977	13.9916		-9.4364	-13.2085
		(10.7023)	(11.0275)		(12.2839)	(12.6657)
immigrant		4.0318	13.8606		-16.7528	-29.4054*
		(9.8876)	(11.9936)		(11.3488)	(13.7754)
Bartik ×immigrant		-4.2241	-8.0317		13.5585	18.8875*
		(7.1842)	(8.056)		(8.2459)	(9.2528)
college+ ×immigrant		97.7254**	68.6754**		-125.627**	-95.1967**
		(23.9779)	(27.3463)		(27.5215)	(31.4089)
immigrant ×immigrant		-13.5513**	-13.9726**		16.6778**	17.0707**
		(4.6368)	(4.6148)		(5.322)	(5.3004)
college+ ×elasticity			-0.4834			0.3719
			(0.5172)			(0.5941)
elasticity ×immigrant			-1.0817*			1.2713*
			(0.5263)			(0.6045)
Adj. R-sq.	0.36	0.51	0.51	0.13	0.32	0.32
degrees.freedom	257	249	247	257	249	247

Description Unit of observation is a metropolitan area.

Interpretation: National growth in local industries ("Bartik") are capitalized into prices to a greater extent in less elastically supplied metropolitan areas. This effect becomes indistinguishable from zero once one accounts for higher-order terms in demand factors.

A Appendix: Regressions of unit growth and price growth and volatility on other proxies for supply constraints

Table 8: Supply constraint measure: Gyourko, Saiz, and Summers (2006) regulations.

Dependent Variable: Log Price Growth

	(1)	(2)	(3)
constant	-0.0811**	-0.549**	-0.5881**
	(0.0149)	(0.2226)	(0.2144)
regulations	0.1886**	0.1343**	0.0961**
	(0.018)	(0.0183)	(0.0169)
college+		3.4565**	2.2677**
		(0.7877)	(0.7532)
immigrant		0.7465*	-0.1331
		(0.3432)	(0.3557)
Bartik		0.1481	0.2089
		(0.1636)	(0.159)
density			0.0094
			(0.006)
Coastal			0.3634**
			(0.0464)
Sand			0.0371
			(0.0431)
Adj. R-sq.	0.3	0.41	0.54
degrees.freedom	259	256	253

Dependent Variable: Log Quantity Growth

	(1)	(2)	(3)
constant	0.4526**	-1.0938**	-0.7221**
	(0.0171)	(0.259)	(0.2671)
regulations	0.0524**	0.0087	0.0245
	(0.0206)	(0.0213)	(0.0211)
college+		-3.0309**	-1.3068
		(0.9165)	(0.9386)
immigrant		0.6539	0.6332
		(0.3993)	(0.4433)
Bartik		1.1085**	0.8019**
		(0.1903)	(0.1982)
density			-0.0112
			(0.0075)
Coastal			-0.2257**
			(0.0578)
Sand			0.1559**
			(0.0537)
Adj. R-sq.	0.02	0.16	0.24
degrees.freedom	259	256	253

Description: Top panel: dependent variable is log FMHPI home price growth 1980 to 2014, Bottom panel: dependent variable is log quantity (Census count of units) growth 1980 to 2012. Unit of observation is a metropolitan area.

Interpretation: Gyourko, Saiz, and Summers (2006) regulations are positively correlated with quantity growth, and their relationship to price growth is driven in part by observable demand factors.

Table 9: Price volatility and Gyourko, Saiz, and Summers (2006) regulations

	(1)	(2)	(3)
constant	5.8683**	-5.212**	1.4121
	(0.1318)	(1.7683)	(1.4843)
regulations	1.485**	0.891**	0.6066**
	(0.1592)	(0.1457)	(0.1172)
college+		-23.322**	-8.4093
		(6.2584)	(5.2153)
immigrant		21.2419**	6.5618**
		(2.7267)	(2.463)
Bartik		7.5219**	2.5101*
		(1.2996)	(1.1012)
density			-0.0031
			(0.0417)
Coastal			1.1712**
			(0.3212)
Sand			3.6174**
			(0.2985)
Adj. R-sq.	0.25	0.49	0.7
degrees.freedom	259	256	253

Description: Dependent variable: Standard Deviation of 1-year Real FMHPI Growth 1980-2014. Unit of observation is a metropolitan area.

Interpretation: Most of the relationship between the intensity of regulation and the standard deviation of real price growth disappears conditional on a few demand measures.

Table 10: Supply constraint measure: Saiz (2010) unavailable land.

Dependent Variable: Log Price Growth

	(1)	(2)	(3)
constant	-0.2886**	-0.6007**	-0.6675**
	(0.0234)	(0.2108)	(0.2031)
Unavailable land	0.7355**	0.6099**	0.4823**
	(0.0711)	(0.0676)	(0.0634)
college+		4.71**	3.127**
		(0.7535)	(0.7234)
immigrant		0.5769*	-0.1661
		(0.3305)	(0.3405)
Bartik		0.0271	0.146
		(0.1584)	(0.1529)
density			0.0114*
			(0.0058)
Coastal			0.3409**
			(0.0445)
Sand			0.0053
			(0.0417)
Adj. R-sq.	0.29	0.46	0.58
degrees.freedom	259	256	253

Dependent Variable: Log Quantity Growth

	(1)	(2)	(3)
constant	0.4102**	-1.1461**	-0.784**
	(0.027)	(0.2559)	(0.2648)
Unavailable land	0.1448*	-0.0606	-0.0403
	(0.0817)	(0.082)	(0.0826)
college+		-3.0542**	-1.2779
		(0.9145)	(0.9433)
immigrant		0.7644*	0.6941
		(0.4011)	(0.444)
Bartik		1.1501**	0.8418**
		(0.1923)	(0.1994)
density			-0.0113
			(0.0075)
Coastal			-0.2015**
			(0.0581)
Sand			0.1669**
			(0.0544)
Adj. R-sq.	0.01	0.16	0.24
degrees.freedom	259	256	253

Description: Top panel: dependent variable is log FMHPI home price growth 1980 to 2014, Bottom panel: dependent variable is log quantity (Census count of units) growth 1980 to 2012. Unit of observation is a metropolitan area.

Interpretation: Unavailable land as measured by Saiz (2010) is positively correlated with quantity growth, and its relationship to price growth is driven in part by observable demand factors.

Table 11: Price volatility and Saiz (2010) land unavailability

	(1)	(2)	(3)
constant	4.1652**	-5.7714**	0.6516
	(0.2041)	(1.735)	(1.4888)
Unavailable land	6.0648**	3.6049**	2.0314**
	(0.6189)	(0.5561)	(0.4645)
college+		-15.4656**	-4.1638
		(6.2011)	(5.303)
immigrant		20.6538**	6.7842**
		(2.7198)	(2.4962)
Bartik		6.9375**	2.4601*
		(1.304)	(1.1207)
density			0.0055
			(0.0423)
Coastal			1.2152**
			(0.3266)
Sand			3.5354**
			(0.306)
Adj. R-sq.	0.27	0.5	0.69
degrees.freedom	259	256	253

Description: Dependent variable: Standard Deviation of 1-year Real FMHPI Growth 1980-2014. Unit of observation is a metropolitan area.

Interpretation: Most of the relationship between unavailable land and the standard deviation of real price growth disappears conditional on a few demand measures.

Table 12: Supply constraint measure: 1971 nontraditional Protestant share of Christians.

Dependent Variable: Log Price Growth

	(1)	(2)	(3)
constant	0.151**	-0.6412*	-0.4401
	(0.0474)	(0.288)	(0.2791)
Protestant	-0.4524**	-0.1803*	-0.0646
	(0.0847)	(0.0829)	(0.0729)
college+		3.7316**	2.9301**
		(0.9632)	(0.8931)
immigrant		0.4065	-0.3579
		(0.4383)	(0.4103)
Bartik		0.2153	0.0685
		(0.2085)	(0.2024)
Jewish		0.0629**	0.0359*
		(0.0191)	(0.0185)
density			0.006
			(0.007)
Coastal			0.3829**
			(0.0521)
Sand			0.1086*
			(0.0493)
Adj. R-sq.	0.14	0.39	0.56
degrees.freedom	168	164	161

Dependent Variable: Log Quantity Growth

	(1)	(2)	(3)
constant	0.3227**	-1.5658**	-1.1382**
	(0.049)	(0.3017)	(0.3339)
Protestant	0.3141**	0.4673**	0.4057**
	(0.0875)	(0.0868)	(0.0872)
college+		-3.0461**	-1.8985*
		(1.009)	(1.0682)
immigrant		1.8026**	1.4827**
		(0.4591)	(0.4907)
Bartik		1.2584**	0.9483**
		(0.2184)	(0.2421)
Jewish		-0.0324	-0.012
		(0.02)	(0.0221)
density			-0.0084
			(0.0083)
Coastal			-0.1342*
			(0.0623)
Sand			0.1353*
			(0.0589)
Adj. R-sq.	0.07	0.32	0.35
degrees.freedom	168	164	161

Description: Top panel: dependent variable is log FMHPI home price growth 1980 to 2014, Bottom panel: log Census count of units growth 1980 to 2012. Unit of observation is a metropolitan area.

Interpretation: The 1971 nontraditional Protestant share of Christians is negatively correlated with regulation and price growth, and positively correlated with quantity growth. The negative relationship with price disappears conditional on demand and cultural factors.

Table 13: Price volatility and nontraditional Protestant share of Christians

	(1)	(2)	(3)
constant	8.109**	-9.2307**	1.3064
	(0.4156)	(2.4062)	(1.9597)
Protestant	-4.1445**	-2.026**	-2.0678**
	(0.7422)	(0.6926)	(0.512)
college+		-23.9679**	-8.2712
		(8.0482)	(6.2696)
immigrant		16.6288**	2.135
		(3.6619)	(2.8801)
Bartik		10.915**	3.2544*
		(1.7424)	(1.4206)
Jewish		0.0564	0.0729
		(0.1595)	(0.1296)
density			-0.0158
			(0.0488)
Coastal			1.2176**
			(0.3657)
Sand			3.8831**
			(0.3459)
Adj. R-sq.	0.15	0.45	0.72
degrees.freedom	168	164	161

Description: Dependent variable: Standard Deviation of 1-year Real FMHPI Growth 1980-2014. Unit of observation is a metropolitan area with at least one county covered by Brandeis Jewish population data.

Interpretation: Approximately half of the relationship between the nontraditional Protestant share of Christians and the standard deviation of real price growth disappears conditional on a few demand measures.