# NIMBYs and Credit Supply

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January 28, 2021

**Abstract**

Communities often impose residential land use regulations affect construction activity and housing supply in local markets. We show more tougher measures significantly increase credit supply. Exploiting the 1947 Interstate Highway plan as an instrument for contemporary land use regulations, we find a 10% increase in the restrictiveness of land use regulation provokes 1) a 5% increase in the probability a mortgage application is approved, 2) a 3% rise in the loan-to-value ratio, 3) a 2% reduction in the probability credit is denied based on collateral values, and 4) 6.6% faster annual house price growth. While regulation that directly affects housing supply has the largest effect, political factors and more detailed project approval regulations that indirectly influence the planning process also matter. The findings are consistent with theories that tie lending to collateral values as stringent land use regulation helps preserve future property values.

Keywords: land use regulation, collateral, credit supply.
JEL codes: G21, G23, R31, R51.

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# 1 Introduction

Homeowners have incentives to restrict building activity in their neighborhood because home equity is often their largest asset. Projects that increase housing supply or create negative externalities may erode property values. Land use is therefore highly regulated in some local housing markets in the United States (US), especially along the East and West coasts where economic activity and demand for housing has grown strongly (Glaeser and Gyourko, 2018). Understanding the economic implications of land use regulation focuses on how these measures influence house prices (Glaeser et al., 2008; Huang and Tang, 2012; Glaeser and Gyourko, 2018), welfare (Turner et al., 2014), and the spatial misallocation of labor (Hsieh and Moretti, 2019).[1] In this paper, we ask a different question: how does land use regulation influence credit supply.

Prior research suggests land use regulation may influence credit supply through two mechanisms: a collateral channel and a liquidation value channel. The collateral channel posits a positive relationship between land use regulation and credit supply. A large literature shows collateral plays a vital role in raising debt finance in markets with information asymmetries. Factors that raise collateral values lower the cost and increase the supply of credit (Gan, 2007; Benmelech and Bergman, 2011; Cerqueiro et al., 2016; Calomiris et al., 2017). Under this view, land use regulations increase credit supply by preserving collateral values through restrictions on the supply of housing and projects with negative externalities that may depress property values. A separate strand of literature shows a lender's willingness to supply credit hinges on the liquidation value of an asset (Shleifer and Vishny, 1992; Benmelech et al., 2005). Liquidation value tends to be higher where an asset is more redeployable and liquid because a lender expects to achieve a higher price in the event of borrower default. In this paradigm, tougher land use regulation reduces an asset's liquidation value by making it less redeployable leading to lower credit supply.

Isolating the equilibrium effect of land use regulation on credit supply poses an econometric challenge due to myriad potential omitted variables. We therefore use an instru-

[1] A related strand of literature quantifies the degree of land use regulation in an area. See, for example, Saiz (2010) Gyourko et al. (2008, 2019), Brueckner et al. (2020), and Brueckner and Singh (2020).

mental variables estimation strategy that exploits the 1947 National System of Interstate Highways (NSIH) plan as an instrument for contemporary land use regulation. Fischel (2004) shows that from the 1970s proximity to Interstate Highways influenced residents' attitudes toward regulating land use. Neighborhoods that are closer to Interstate Highways impose more restrictive land use regulation to prevent industrial firms and their associated negative externalities from locating in the area due to its superior transport links. The location of contemporary Interstate Highways depends to a large extent on the plans drawn up in 1947 on where Highways would be situated (Duranton et al., 2014). However, planners' decisions on the potential location of Interstate Highways in 1947 is plausibly exogenous with respect to credit supply almost 70 years later. We therefore argue the instrument is relevant and meets the exclusion restriction.

Using a large loan-level data set and detailed information on land use regulation across census tracts, we find robust evidence that more restrictive land use regulation provokes a significant increase in credit supply. A 10% increase in land use regulation raises the probability that a loan application is approved by 0.05 and increases the loan-to-value ratio by 3.17%. Subsequent analyses suggest these findings are due to land use regulation preserving collateral values. Increasing the restrictiveness of land use regulation provokes a significant decrease in the probability a lender denies a loan application owing to the collateral.[2] A unique feature of the data set is that we can pin point how different elements of land use regulation influence credit supply. Consistent with the collateral channel, we find that restrictions on the supply of housing have the largest effect on credit supply. However, zoning restrictions, involvement in the planning process by state legislatures, courts, and local political pressure that create frictions that make it difficult to obtain planning approval for a project also matter.

Our paper bridges three distinct strands of literature. The first area of research documents the importance of collateral values in lending. Cerqueiro et al. (2016) show that following a legal change that reduces collateral values lenders tighten credit limits and increase interest rates to existing borrowers. Gan (2007) reports that banks reduce lending

[2]SEE FISCHEL Anecdotal evidence reported by real estate agents and property developers confirms that land use regulation

to borrowers following adverse shocks to the value of collateral.

Prior research provides theoretical and empirical insights into optimal debt policy and liquidation value. Perhaps the most relevant article to our work is Benmelech et al. (2005) who study how zoning regulations affect commercial real estate debt contracts. They argue that zoning regulations capture the redeployability of an asset by determining the potential uses of a property. They find debt contracts for properties with more allowable uses exhibit lower interest rates, larger loan amounts, longer terms to maturities, and fewer creditors consistent with the incomplete contracting view that redeployable assets have higher liquidation values (Shleifer and Vishny, 1992). In contrast, we find more restrictive land use regulations, and zoning specifically, to provoke increases in credit supply. Potential explanations for these divergent results are that we consider only residential rather than commercial properties and the land use regulations we examine cover residential properties. In essence, a property cannot be redeployed for commercial purposes which limits redeployability. More restrictive land use regulation therefore primarily limit building activity and the supply of housing, rather than an asset's purpose.

A voluminous literature speaks to the rise of the NIMBY (not in my back yard) movement. It seeks to understand the consequences of the proliferation of zoning, density restrictions, permitting, and regulation more generally across housing markets (Gyourko and Molloy, 2015). Part of this literature studies how urban development relates to minimum lot size and height restrictions (Glaeser and Ward, 2009; Brueckner et al., 2020), and environmental concerns (Glaeser and Kahn, 2010). Diamond (2016) and Turner et al. (2014) highlight the distorting effects of land use regulation on welfare. Other studies estimate the effect of land use regulation on housing costs (Glaeser and Gyourko, 2018). Our research complements this body of research but extends it to provide novel insights into the credit market effects of residential land use regulation.

The rest of the paper proceeds as follows. Section 2 outlines the hypotheses we test. In Section 3, we describe the data set. Section 4 provides a history of the origin of land use regulation in the US and background information on our instrument while Section 5 details the econometric strategy. We present econometric results and robustness tests in

Sections 6 and 7, respectively. Finally, Section 8 concludes.

# 2 Hypotheses

Land use regulations have potentially contrasting effects on credit supply through their effect on collateral and liquidation values.

## 2.1 Collateral Value

Most theoretical models postulate that the availability of collateral is a binding constraint on external finance. Collateral mitigates information asymmetries and moral hazard, reducing the ex ante risk of debt to a lender (Stulz and Johnson, 1985; Aghion and Bolton, 1992; Hart and Moore, 1998). In credit markets with imperfect information, collateral expands access to, and reduces the cost of debt (Berger and Udell, 1990; John et al., 2003; Jiminez et al., 2006; Benmelech and Bergman, 2009).[3]

Shocks to the value of collateral provoke credit supply responses. Gan (2007) shows that a decline in asset markets that adversely affects the value of collateralizable assets leads banks to reduce lending to existing borrowers and terminate banking relationships. Benmelech and Bergman (2011) find that a firm's bankruptcy depresses incumbent firms' collateral values through two channels: 1) by raising the likelihood of asset fire sales that creates excess supply in the market, and 2) demand for industry assets diminishes as the financially distressed firm cannot raise funds to purchase assets. These factors weaken the balance sheet of incumbents and because collateral plays a vital role in raising debt finance, reduces the availability of credit across the entire industry. When markets are illiquid fire sales erode to a greater extent the value of similar assets held by other market participants.

Cerqueiro et al. (2016) report that following legal changes that reduce the value of an agent's collateral, a bank increases the interest rate on outstanding loans and reduces the total amount of credit available to a borrower. Gilje et al. (2020) find that by increasing

[3] A parallel strand of literature analyzes the relationship between collateral and credit rationing. Where lenders are at an informational disadvantage regarding a borrower's likelihood of default collateral may alleviate credit rationing (Bester, 1985; Besanko and Thakor, 1987).

collateral values, firms that are dependent on asset-based loans mitigate financing frictions that arise during debt renegotiations and are more likely to have credit applications approved.

The relationship between credit supply and collateral values is likely to be strong in the housing market, where lenders with a high share of collateralized debt in their portfolios are especially sensitive to future collateral values. A lender's expected payoff depends on future house prices because they determine the liquidation value of housing collateral. Indeed, Favara and Giannetti (2017) show theoretically and empirically that lenders have strong ex post incentives to renegotiate mortgage contracts and avoid borrower default to preserve collateral values. Whereas in a liquid market an asset can be sold rapidly with minimal impact on its price, the illiquidity of the housing market leads imbalances between supply and demand to exert substantial downward pressure on prices (Campbell et al., 2011; Favara and Giannetti, 2017).[4]

Unlike in other asset markets, homeowners and lenders are unable to insure property values against falling asset prices. Land use regulations (LUR) directly limit the supply of housing through zoning restrictions, and indirectly by creating building impediments through political involvement in the planning process by local communities, councils, and state legislatures (Gyourko and Molloy, 2015; Glaeser and Gyourko, 2018). These forces limit changes in future housing supply and preserve the future value of housing collateral. We thus conjecture that more restrictive land use regulations (LUR) increase credit supply.

**Prediction 1.** Land use regulations increase credit supply.

## 2.2 Liquidation Value

An extensive literature argues a lender's willingness to supply credit, and the terms of debt contracts, depends on the liquidation value of an asset. An asset's liquidation value is the amount a creditor expects to receive if they seize the asset following default. Where contracts are incomplete lenders provide more finance the higher the liquidation value, because they receive a larger amount in the case of default.

[4] Falling house prices may move borrowers into negative equity positions triggering default (Campbell and Cocco, 2015), and further price default spirals (Guren and McQuade, 2020).

Liquidation value is a function of an asset's redeployability and illiquidity. Redeployable assets have alternative uses and hence high liquidation values (Williamson, 1988). Where a borrower is unable to repay a debt, the lender can take possession of the assets and easily redeploy them. For example, land can be redeployed for commercial, industrial or residential purposes whereas a steel mill has limited other purposes. Lenders are therefore willing to extend more credit to borrowers where the collateral is redeployable because the liquidation value is high.

An related theoretical literature predicts that optimal debt policy depends on how easily a creditor can liquidate assets (Williamson, 1988; Aghion and Bolton, 1992; Shleifer and Vishny, 1992; Hart and Moore, 1994; Bolton and Scharfstein, 1996). A lender's ability to liquidate an asset depends on the asset's illiquidity: it is easier to attract a buyer for a liquid than an illiquid asset. Shleifer and Vishny (1992) argue the difference between the price an asset attains in a liquidation sale relative to its value in best use. Potential buyers of the asset are other agents in the same market (or industry) as the delinquent borrower. As these agents are also likely to be under financial strain, they are unlikely to raise finance to buy the distressed agent's asset. The liquidation value of an asset is therefore likely to be below its value in best use, and this difference is more pronounced the more illiquid an asset is because there are fewer potential buyers.

In the incomplete contracts paradigm, land use regulations reduce the liquidation value of a property through two channels. First, tougher regulations limit the redeployability of a property. Benmelech et al. (2005) present supportive evidence that zoning restrictions, a subset of land use regulations more generally, lower the redeployability of commercial land. Second, land use regulations make a property more illiquid by reducing the number of potential buyers in the case of default. Together lower redeployability and illiquidity reduce the salability of an asset Benmelech (2009). By lowering a property's liquidation value, land use regulations therefore reduce a lender's ex ante willingness to provide credit.

**Prediction 2.** Land use regulations reduce credit supply.

## 3 Data Description

Our data set merges loan-level information from the Home Mortgage Disclosure Act (HMDA) database, with the Wharton Residential Land Use Regulation Index provided by Gyourko et al. (2019). We use exclusively information from the 2018 HMDA vintage as information on the land use regulation variables are only available for that year.

### 3.1 Dependent Variables

Each observation corresponds to a unique loan application and provides details on the characteristics of the loan, borrower, and lender at the point of origination. We measure credit supply using two approaches. Following Dagher and Sun (2016), we generate *Approved*, a dummy variable equal to 1 if a loan application is approved by the lender, 0 otherwise. Second, we use the loan-to-value (LTV) ratio which is used by Calomiris et al. (2017) to measure credit supply. An advantage of these measures is they obviate the confounding effect of property values. For example, loan amounts may be large because house prices in an area are high making it appear that lenders provide more credit.

### 3.2 Explanatory Variables

For each loan, we observe the borrower's income, ethnicity, race, whether there is a co-applicant, and the property location (census tract). HMDA also provides information on the loan's term to maturity, whether it is a conventional loan (that is, not secured by a government entity such as the Federal Housing Administration, US Department of Veterans Association, or the USDA Rural Housing Service), its GSE conforming status (GSE eligible), whether the loan has first lien status, and the age of the property. Additional information on the characteristics of the neighborhood in which the property is located is available. For example, the MSA level population, the population share of ethnic minorities, average income level (MSA income), the rented share of the housing stock. We also merge in census tract level data on house prices taken from the Federal Housing Finance Agency (FHFA).

### 3.3 Land Use Regulation

In the empirical model, the key independent variables capture the restrictiveness of land use regulations in an area. Measuring the burden of the local regulatory environment presents an empirical hurdle. Gyourko et al. (2019) develop a land use regulation index (LURI) that incorporates subindexes that capture forces that directly limit housing supply (construction caps, building permits, lot sizes) but also political factors that measure the extent of regulatory intervention. The subindexes are the local political pressure index (LPPI), state political involvement index (SPII), court involvement index (CII), local project approval index (LPAI), local zoning approval index (LZAI), local assembly index (LAI), supply restrictions index (SRI), density restrictions index (DRI), open space index (OSI), exactions index (EI), affordable housing index (AHI), and the approval delay index (ADI).

Some of the subindexes capture the extent of various local actors' involvement in the residential development process. A group of the subindexes relate to factors that directly influence the supply of housing in an area through caps on the supply of new housing, density, and zoning restrictions (LZAI, SRI, DRI, OSI). Another set of subindexes measures political burdens. For example, local councils, community pressure, ballot initiatives (LPPI) as well as town hall meeting requirements (LAI) influence the difficulty of obtaining planning approval. State legislatures (SPII) can erect similar barriers with local and state courts (CII) may determine the regulatory burden, density, and zoning. The AHI has potentially important effects on the type and quantity of housing in an area by determining whether developers must include affordable housing in building projects. Finally, the ADI captures the mean time for a decision to be made on residential projects and rezoning requests. Gyourko et al. (2019) use factor analysis to weight each subindex and aggregate the values to produce an overall measure of land use regulation in an area.

The LURI and the subindex variables are available for 2018 at the FIPS Place level. Using a crosswalk, we aggregate the data to the Census tract level and merge the variables with the HMDA data.

### 3.4 Sampling

HMDA is a vast data set that contains approximately 95% of mortgage loan applications. Each observation reports whether the loan is for a home purchase, improvement, or refinancing, and the type of property (a single- or multi-family home). To ensure a homogeneous unit of observation, we restrict the sample to observations of single-family home purchases. Despite the sample screens, this provides a total of 2,630,155 observations.

## 4 The Origins of Land Use Regulation

Homeowners' largest asset is typically the equity in their home. Incomplete insurance markets prevent homeowners from insuring home equity against capital devaluation. This creates strong incentives for homeowners to support land use regulation to maintain the value of their property (McMillen and McDonald, 2002; Fischel, 2004).

Residential zoning and planning regulation developed in two distinct episodes during the twentieth century. Fischel (2004) provides a history of land use regulation and links its development to the invention of new modes of transport and infrastructure. Before 1880 residential, commercial and industrial areas were co-located because most workers walked to their workplace. During the 1880s the introduction of electric streetcars led to the growth of suburbs as workers could live in exclusively residential areas and commute easily to their jobs in downtown areas.[5] The relatively high cost of streetcar tickets disproportionately led richer individuals to migrate to the suburbs.

Zoning and planning regulation first developed between 1910 and 1930. The invention of the truck during the 1910s reduced the need for heavy industry to locate close to downtown railroad stations and docks. Trucks allowed manufacturing firms to locate in places with low land costs such as residential suburban areas. In addition, the invention of the bus in the 1920s enabled low cost mass transportation meaning that lower income

[5] Cudahy (1990) reports the streetcar network expanded from 3,000 miles of track in 1882 to 22,500 miles in 1902. Fogelson (1990) and Korngold (2001) provide further evidence on the importance of streetcars in spurring the development of residential suburbs. Specifically, suburban developers built parts of the streetcar network and subsidized fares to enhance the attractiveness of living in the suburbs.

individuals were no longer tied to living in the central business district.[6] These forces provoked the introduction of zoning regulation in New York in 1916 which spread to 68 other cities by 1926 and 1,246 municipalities by 1936 (McKenzie, 1933; Toll, 1969; Warner, 1972). Homeowners' demand for land use regulation was to prevent construction of apartment blocks and factories on vacant lots in their neighborhood that could depress house values Fischel (2004).

The second wave of land use regulation took place during the 1970s in response to the creation of interstate highways. Together with the falling costs of commuting via automobiles, the highway network made firms and workers more footloose. Similarly to the 1910-1930 period, interstate highways allowed firms to relocate to suburban areas with lower land costs (Glaeser and Kahn, 2001), exemplified by the creation of industrial parks.[7] Whereas lower income workers previously lived in the central business district to keep commuting costs low, some now had to search for accommodation and employment in suburban areas. Faced by a potential influx of lower income residents and polluting manufacturers, suburban dwellers pushed for the introduction of tougher zoning regulation (Fischel, 2004). This response was most pronounced among areas closer to an interstate highway where firms had a greater incentive to locate because of access to labor and product markets (Duranton et al., 2014).

## 5 Empirical Strategy

Glaeser and Gyourko (2018) highlight the difficulties researchers face in isolating the economic repercussions of land use regulations owing to their time invariant nature and endogeneity concerns. In our setting, policymakers' regulatory preferences may lead to correlations between the restrictiveness of land use regulations and their propensity to regulate credit markets. In this case, credit supply may be lower in areas with tougher land use regulation leading to downward bias in the coefficient estimates.

[6] Fischel (2004) highlights the introduction of automobiles in 1908 did not contribute to these developments. At this time, automobiles were primarily purchased by the middle class and therefore did not make lower-income individuals more footloose.

[7] The rate of automobile ownership increased from 59% of households in 1950 to 82% in 1970 (Fischel, 2004).

To overcome this econometric hurdle we use instrumental variables estimation. In essence, we exploit the historic military plan for the location of interstate highways as an instrument for contemporary land use regulations. In the first stage we estimate

$$LURI_c = \alpha + \beta_1 IH_c + \beta_2 X_c + \varepsilon_c, \tag{1}$$

where $LURI_c$ is the contemporary land use regulation index (in natural logarithms) in census tract $c$; $IH_c$ is the distance (in natural logarithms) between the midpoint of census tract $c$ and the nearest Interstate Highway proposed by the 1947 military plan; $X_c$ is a vector of control variables; $\varepsilon_c$ is the error term.

In the second stage we estimate

$$y_{ilcz} = \gamma + \delta_1 LU\hat{R}I_c + \delta_2 W_{ilcz} + \varphi_{lz} + \epsilon_{ilcz}, \tag{2}$$

where $y_{ilcz}$ is a credit supply variable (either the loan approval dummy variable or the LTV ratio) for loan $i$ originated by lender $l$ in census tract $c$ of zip code $z$; $LU\hat{R}I_c$ is the instrumented land use regulation index from the first stage; $W_{ilcz}$ is a vector of control variables; $\varphi_{lz}$ denotes lender times zip code fixed effects; $\varepsilon_{ilcz}$ is the error term. We cluster the standard errors at the zip code level.

Equation (2) takes steps to eliminate omitted variable. Including lender-zip code fixed effects ensures we compare credit supply decisions taken by the same lender on loan applications for properties within the same 5-digit zip code. This eliminates demand-side determinants of credit supply as well as confounding factors as zip codes are geographically small and economically homogeneous. In addition, the lender-zip code fixed effects ensure a narrow source of identification in (1). Specifically, we compute $\beta$ through comparisons of loans originated by the same lender across census tracts within the same zip code that differ in terms of land use regulations.

### 5.1 Instrument Relevance and Exogeneity

The discussion in Section 4 highlights the importance of Interstate Highways in determining contemporary land use regulations. Areas closer to Interstate Highways are more attractive locations for manufacturing firms because they offer easy access to the road network for shipments. Residents in areas close to Interstate Highways therefore demand tougher land use regulations to prevent firms from locating there and reducing property values due pollution and other negative externalities such as increased congestion.

While the distance to an Interstate Highway is an attractive instrument, a limitation is that it may correlate with other determinants of credit supply. For example, Interstate Highways may increase credit demand in an area because those locations are convenient areas for commuters to live in. In this case, the instrument is correlated with the second stage error term, and estimates of $\delta_2$ are potentially upward biased.

We therefore use the distance between census tract $c$ and the nearest Interstate Highway proposed by the 1947 highway plan as a source of exogenous variation in land use regulation. Duranton et al. (2014) report plans for a national Interstate Highway system were first considered in 1937 by the Roosevelt Administration. After a prolonged effort, a blue print for the location of Interstate Highways was drawn up by the Bureau of Public Roads in 1947. The objective of the plan was to "connect by routes as direct as practicable the principal metropolitan areas, cities and industrial centers, to serve the national defense and to connect suitable border points with routes of continental importance in the Dominion of Canada and the Republic of Mexico" (United States Federal Works Agency, Public Roads Administration, 1947, cited in Michaels (2008)), and historical evidence confirms the 1947 highway plan was drawn according to this mandate (Chandra and Thompson, 2000; Baum-Snow, 2007; Michaels, 2008; Duranton et al., 2014).

[Insert Figure 1] [Insert Figure 2]

Construction of the Interstate Highway system began following enactment of the Federal Aid Highway Act of 1956 and was completed in the 1990s. Figure 1 shows the location of contemporary Interstate Highways largely follows the 1947 plan illustrated in Figure 2), albeit with some deviations. Distance between a census tract and the nearest proposed Interstate Highway in 1947 is therefore relevant in explaining contemporary land use regulations. The 1947 plan is an accurate predictor of highway locations which influence an area's demand for land use regulation. The instrument is also likely to satisfy the exclusion restriction. Specifically, it appears implausible the locations of highways proposed in 1947 were chosen based on credit supply 60 years in the future. Indeed, Duranton et al. (2014) highlight the 1947 plan largely followed the nineteenth century railroad network and the exploration paths of pioneers who settled the US.

## 6 Results

Table 3 presents estimates of equation (2). We begin by presenting OLS estimates. Irrespective of whether we measure credit supply using the approval dummy variable or the LTV ratio, the LURI coefficient is positive and statistically significant. However, the magnitude of the LURI coefficient is relatively small in both columns 1 and 2 of Table 3.

[Insert Table 3]

We therefore move to our preferred instrumental variables approach. Column 3 of Table 3 presents first stage estimates of equation (1). We find distance between a census tract and the nearest Interstate Highway in the NSIH 1947 plan is negatively related with the land use regulation index.[8] The coefficient is precisely estimated and statistically significant at 1%. Increasing distance by 10% reduces the land use regulation index by 0.036%. This finding is consistent with evidence reported by Fischel (2004) that residents of areas closer to Interstate Highways have stronger incentives to restrict land use to prevent firms locating in their neighborhood.

Column 4 of Table 3 presents second stage estimates of equation (2) using the approval dummy variable as the dependent variable. The local average treatment effect (LATE) is considerably larger compared to the estimates obtained using OLS. In this specification a

[8] For brevity we refer to the variable distance to the nearest Interstate Highway in the NSIH 1947 plan as 'distance' henceforth.

10% increase in the LURI index causes a 0.05 increase in the probability a loan application is approved. The coefficient estimate is highly statistically significant. We obtain similar inferences when we measure credit supply using the LTV ratio. In column 5 of Table 3 the LATE is equal to 0.3167 and is significant at 5% when the LTV ratio is the dependent variable in equation (2). This implies a 10% increase in the LURI index increases the LTV ratio by approximately 3.17%. Together these findings are consistent with Prediction 1 that increasing the restrictiveness of land use regulations provokes an increase in credit supply.

The diagnostic tests confirm that the instrument is strong and an accurate predictor of contemporary land use regulations. As previously remarked, the distance coefficient has the expected sign and is individually significant in the first stage. Moreover, the Kleibergen-Paap F-statistic comfortably exceeds the Stock-Yogo critical value of 10 and is equal to 3,558 and 2,817 in columns 4 and 5, respectively. The considerably larger LURI coefficients obtained using two stage least squares relative to the OLS estimates are therefore unlikely due to a weak instrument problem. Rather, it seems likely the OLS estimates are biased downwards.

Among the control variables in column 4 we find intuitive results. The probability that an application is approved is positively associated with a loan's GSE and first lien status reflecting the greater liquidity of the secondary market for agency loans (Keys et al., 2010,?) and the increased security of the lender's claim to the collateral in case of default, respectively. Approval is more likely in areas with a large population, where a larger share of the population are high income earners, and those with higher property values. In contrast, loans with longer terms to maturity are significantly less likely to be approved, reflecting the greater interest risk to the lender. We find a significant correlation between approval and a borrower's ethnicity, the ethnic minority population share, the share of the housing stock that is rented, and the age of the property. Interestingly, we find no significant link between credit applications per capita and the probability that a loan application is approved. This suggests credit demand does not drive our inferences.

In column 5, we find the LTV ratio is significantly and positively related to the loan term, a borrower's ethnicity, the size of the population living in a census tract, the ethnic minorities' population share, credit applications per capita, and the high income population share. The LTV ratio is significantly lower for GSE loans, reflecting the maximum LTV ratio stipulated by the GSEs. First lien status, property age, and property value are significantly and negatively associated with the LTV ratio. Only the rented share enters insignificantly.

[Insert Table 4]

An advantage of the Gyourko et al. (2019) land use regulation database is that it provides 12 subindexes. This allows us to study the effects of different regulatory aspects on credit supply. We group the subindexes into four broad categories: political interference (LPPI, SPII, LAI), zoning and supply restrictions (LZAI, SRI, DRI, OSI), project approval restrictions (CII, LPAI, ADI), and financial measures (EI, AHI).

Panel A in Table 4 presents estimates of equation (2) using the approval dummy variable as the dependent variable and each index as the main explanatory variable. Consistent with the previous results, the LATE is positive and statistically significant in all but one cell of Panel A. Columns 1 to 3 present estimates using the subindexes that measure the degree of political interference in the planning process. A 10% increase in local political pressure and state political involvement increase the probability of approval by 0.007 and 0.008, respectively. The local assembly index coefficient is considerably smaller at 0.0264. These results imply that local actors (councils, managers, community pressure groups, ballot initiative) and involvement by state legislatures have a larger effect on credit supply compared to whether an area mandates residents have a say in proposed residential projects through town meetings and direct democracy involvement by the local population.

Next, we analyze the effects of factors that influence the supply of housing. Columns 4 to 7 of Table 4 Panel A show that local zoning approval, supply restrictions, density restrictions, and open space requirements all increase the probability a loan is approved. However, supply restrictions has the largest effect with a LATE of 0.1087. In comparison the LATE for local zoning, density restrictions, and open space requirements is 0.0598, 0.0661, and 0.0328, respectively.

In columns 8 to 10 of Panel A, we test how factors that influence whether a project is approved affect loan approvals. A higher degree of involvement by local and state courts through their involvement in determining residential building activities and growth management significantly increases the probability a loan is originated (column 8). We estimate the approval delay index to have one of the largest LATEs in Panel A of Table 4 at 0.1071. This index captures the average review time for a residential project and delays to rezoning requests. Together, these findings suggest that factors that create frictions in the planning and approval process increase credit supply. Interestingly, the evidence in column 9 of Panel A indicates an inverse relationship between the local project approval index and the likelihood of loan approval. Gyourko et al. (2019) highlight this subindex relates to projects that do not require changes to existing zoning regulations, and rather shows how many local entities must approve a project. The negative LATE may therefore capture the fact the LPAI index does not prevent building activity that may threaten collateral values.

The remainder of Panel A present estimates of equation (2) using subindexes that capture financial frictions. Column 11 shows that the probability of loan approval is lower in areas where property developers are required to pay a fee or the allocable share of infrastructure costs. Exactions such as these create a disincentive to house building activity.

Panel B of Table 4 presents the corresponding estimates using the LTV ratio as the dependent variable in (2). The LATEs are quantitatively and qualitatively similar to before. Economically, the supply restrictiveness index and the approval delay index exert the largest effect on credit supply.

The evidence in Table 4 paints a consistent picture. Factors that constrain house building activity either directly by regulating building activity or indirectly by creating frictions that make it more difficult to obtain approval for a project increase credit supply. This helps preserve the value of collateral, leading lenders to originate more credit.

### 6.1 The Collateral Mechanism

The theoretical apparatus that underlies the empirical tests suggests that land use regulations increase credit supply because they preserve collateral values. An advantage of the HMDA data is that it allows us to observe the reasons why a lender denies credit. We can therefore inspect whether more restrictive land use regulation influences credit supply decisions through the collateral channel.

[Insert Table 5]

Table 5 reports estimates of equation (2) using dummy variables that measure the reason why a lender denied a credit application. Column 1 of Table 5 presents the results of a regression in which the dependent variable is denial for collateral reasons. The LURI coefficient is negative and significant at 1%. It implies that a 10% increase in the restrictiveness of land use regulations reduces the probability credit is denied because of collateral concerns by 0.02. This suggests that lenders are more willing to supply credit in areas with higher LURI values because the regulations help guard against erosion of the collateral value.

Next, we investigate whether land use regulations motivate other potential reasons to supply credit. In column 2 of Table 5 we evaluate whether lenders cite a borrower's credit history as a reason for denying credit. The estimates show that land use regulations cause a significant reduction in the likelihood a loan application is denied based on a borrower's credit history. We find similar evidence in column 3 of the table that shows more restrictive land use regulations lower the probability of denial based on the DTI ratio. We also find that increasing the LURI index causes a significant reduction in the probability credit is denied because of unverified information. However, the LATE in column 4 of Table 5 is somewhat smaller relative to the preceding columns and implies a 10% increase in the LURI decreases the probability of denial due to unverified information by 0.004. This suggests lenders are less concerned about information asymmetries among credit applicants in areas with stringent land use regulation or they are able to extract more soft information. A potential explanation for these three results could be the composition of borrowers across areas with different land use regulations. For example, more affluent individuals with better credit records that are less vulnerable to income shocks that compromise their repayment ability may be disproportionately drawn to areas with restrictive land use regulations. We return to this issue below.

The remaining columns of Table 5 study the relationship between land use regulations and other factors motivating denial of credit. However, we find no significant relationship between the LURI and a borrower's employment history, whether the borrower has insufficient cash for the down payment, whether the mortgage application is incomplete, whether mortgage insurance is denied, and other potential reasons.

[Insert Table 6]

Our second test of the collateral value mechanism relies on house price data. If land use regulations preserve the value of collateral, one would anticipate higher house prices and faster price growth in more restricted markets. Table 6 reports estimates of (2) using house prices, returns, and growth rates over various horizons as the dependent variable. Prior research documents positive links between land use regulation and the level of house prices (Huang and Tang, 2012). Consistent with this literature, column 1 in Table 6 shows a 10% in the LURI index leads to a 19.4% increase in the level of house prices.

While these estimates are suggestive about contemporary house price levels, they are silent about long-run prices. We therefore calculate the annual rate of return over the past 3, 5, and 10 years as well as the growth rate of house prices over these intervals. The estimates in columns 2 to 4 of Table 6 indicate that land use regulation provokes significantly faster annual returns in the housing market. We estimate a 10% increase in the LURI provokes a significant 5.21%, 7.42%, and 8.96% increase in the annual rate of return over the past 3, 5, and 10 years, respectively. Using the growth rate of house prices provides similar insights. In columns 5 to 7 of the table we estimate that increasing the LURI by 10% raises the house price growth rate by 6.64%, 10.75%, and 8.80% over the past 3, 5, and 10 years, respectively.

A consistent picture emerges from Table 6. The level and historic rate of house price appreciation are significantly higher in markets with more stringent land use regulation.

In mortgage contracts the property is invariably used as collateral to secure the loan. The evidence indicates the value of this collateral is likely to remain high when restrictive land use measures are in place, suggesting lenders are more willing to extend credit in markets where collateral is less likely to depreciate in future.

## 6.2 Cost of Credit

Collateral also influences the cost of credit (Benmelech and Bergman, 2009). Pledging capital reduces risk to a lender in case of default because it can seize and sell the collateral if a debtor fails to make a loan repayment. Holding all other factors equal, borrowers that pledge more collateral when taking a loan should obtain credit at a lower price.

[Insert Table 7]

HMDA provides information on the loan's interest rate and the fixed costs the lender charges a borrower for originating a loan. Table 7 presents estimates of how these pricing measures respond to land use regulation. We find that interest rates and the ratio of costs to loan amount are negatively related to the LURI. However, in both columns of the table the coefficient estimates are statistically insignificant.

## 6.3 Liquidation Values

**In progress**. There are two important angles: asset redeployability and liquidity or asset saleability. Use Zillow to calculate 1) the difference between the asking price and price received in an area - this is a measure of the asset's value in its next best use (Shleifer and Vishny, 1992) and is essentially the best measure of the liquidation value, 2) market liquidity - how long are houses listed for sale on Zillow before a sale is completed, transactions per capita or as a ratio to the housing stock, how many page views does a property listing receive (this may be a measure of demand and may be less accurate).

### 6.4 Borrower Composition Channel

**In progress**. Another possibility is that land use regulations induce sorting by borrowers. Only relatively richer people can afford the deposit in an area with a high LURI value. These people are also less likely to default. Examine the characteristics of borrowers and how they are related to the LURI.

## 7 Conclusions

Over the past decade, economists have begun to devote more attention to understanding the consequences of regulations that limit the supply of housing owing to these measures influence on the spatial distribution of economic activity, environmental concerns and welfare. We contribute to this rapidly evolving body of research by providing novel evidence into how land use regulation affects credit markets. Estimations show that lenders are more willing to extend mortgage credit to borrowers in neighborhoods where regulation limits housing supply.

Isolating causality in this literature has proved difficult. To overcome this econometric hurdle, our research design leverages plausibly exogenous variation in land use regulation due to the 1947 national interstate highway plan in the US. Communities residing in areas closer to highways have incentives to demand tougher land use regulation because ease of access to the transport network makes it housing construction more attractive in these locations. Tougher land use regulation offers homeowners a means of preventing building activity that would increase the supply of housing and put downward pressure on asset prices.

Our findings inform recent policy debates in the US and elsewhere. Some commentators question whether the removal of land use regulations would allow high-income metropolitan areas such as the San Francisco Bay Area to contribute more to economic growth if people could more easily find housing there. The cost of zoning measures include lower labor mobility, social inequality, and lower rates of entrepreneurship.

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# Tables

Table 1: Variable Descriptions

| Variables | Description | Source |
|---|---|---|
| LURI | Wharton Regulation Index | Gyurko, Hartley and Krimmel (2019) |
| PPI (Local political pressure index) | Index quantifies how local actors involved in residential building activities. | Gyurko, Hartley and Krimmel (2019) |
| SPII (State political involvement index) | Index quantifies how state legislature involved in residential building activities. | Gyurko, Hartley and Krimmel (2019) |
| CII (Court involvement index) | Sum of local and state courts involvements on residential building activities. | Gyurko, Hartley and Krimmel (2019) |
| LPAI (local project approval index) | Number of entities that have to approve a project before construction began. | Gyurko, Hartley and Krimmel (2019) |
| LZAI (Local zoning approval index) | Number of entities that have to approve a change in zoning code. | Gyurko, Hartley and Krimmel (2019) |
| LAI (local assembly index) | Index asks whether a town meeting is required for approval of a project. | Gyurko, Hartley and Krimmel (2019) |
| SRI (Supply restriction index) | Index measures whether local authorities restricts total number of building permits for different type of homes. | Gyurko, Hartley and Krimmel (2019) |
| DRI (Density restriction index) | Minimum lot size requirement restrictions. | Gyurko, Hartley and Krimmel (2019) |
| PSI (Open space index) | A dummy that takes value 1 if residential estate constructors are required to provide a space for a specific community use. | Gyurko, Hartley and Krimmel (2019) |
| EI (Exactions index) | A dummy that takes value 1 if estate developers have to pay any impact fee; 0 otherwise. | Gyurko, Hartley and Krimmel (2019) |
| AHI (Affordable housing index) | A dummy that takes value 1 if there is affordable housing program in the municipality. | Gyurko, Hartley and Krimmel (2019) |
| ADI (approval delay index) | A measure of permit review time for a project. | Gyurko, Hartley and Krimmel (2019) |
| Approval | A dummy that takes value 1 if loan application is approved; 0 otherwise. | HMDA |
| Loan-to-Value Ratio (LTV) | A ratio obtained by dividing loan amount to property value. | HMDA |
| Distance to Interstate Highway | Mile distance from center point of census tract to closest interstate highway. | Calculated by authors from GIS data from ESRI. |
| GSE Eligibility | A dummy that takes value 1 if conforms to GSE puchase requirements ; 0 otherwise. | HMDA |
| First Lien | A dummy that takes value 1 if if mortgage has first lien on property ; 0 otherwise. | HMDA |
| Non-White | A dummy that takes value 1 if borrower is not white ; 0 otherwise. | HMDA |
| Population | Tract population. | HMDA |
| Applicant's Income | Applicant's annual income. | HMDA |
| Property Value | Value of mortgage property. | HMDA |
| Minority Share | Population percentage of minorities per census tract. | HMDA |
| Preapproval | A dummy that takes value 1 if lender requires preapproval ; 0 otherwise. | HMDA |
| Married | A dummy that takes value 1 if borrower is married ; 0 otherwise. | HMDA |
| Credit Applications | Credit applications per capita in census tract. | HMDA |
| LN (House Price Index) | House Price Index in census tract. | HMDA |
| Loan Amount | Amount of Loan Requested. | HMDA |
| Fixed Loan Costs Share | A ratio obtained by dividing fixed loan cost to total loan amount. | HMDA |
| Interest Rate | Applicant-level mortgage interest rate. | HMDA |
| DTI | Debt to income ratio. | HMDA |
| Succsesful Loan Share | Share of total succesful credit application per census tract. | HMDA |
| House Price Growth (past 3 years) | Growth rate based on 2015 and 2018 house prices per census tract. | FHFA |
| House Price Growth (past 5 years) | Growth rate based on 2013 and 2018 house prices per census tract. | FHFA |

## Table 1 Cont'd: Variable Descriptions

| Variables | Description | Source |
|---|---|---|
| House Price Growth (past 10 years) | Growth rate based on 2008 and 2018 house prices per census tract. | FHFA |
| House Price Std. Dev. (past 3 years) | Standard deviation calculated by using house price index between 2015 and 2018. | FHFA |
| House Price Std. Dev. (past 5 years) | Standard deviation calculated by using house price index between 2013 and 2018. | FHFA |

Table 2: Descriptive Statistics

| Variables | Mean | Std. Dev. | Min | Max | Obs |
|---|---|---|---|---|---|
| Loan Term | 328.1553 | 73.20221 | 1 | 720 | 3724482 |
| LURI | 0.235227 | 0.677175 | -2.35737 | 3.688969 | 3724482 |
| Approval | 0.687199 | 0.463634 | 0 | 1 | 3724482 |
| Loan-to-Value Ratio (LTV) | 0.686466 | 0.299673 | 0.000119 | 5 | 3071453 |
| Distance to Interstate Highway | 4.837647 | 10.23232 | 0.00023 | 141.7398 | 3724482 |
| GSE Eligibility | 0.952714 | 0.212251 | 0 | 1 | 3724482 |
| First Lien | 0.844701 | 0.362189 | 0 | 1 | 3724482 |
| White | 0.332825 | 0.471224 | 0 | 1 | 3724482 |
| Population | 6779.752 | 4234.749 | 17 | 47693 | 3724482 |
| Applicant's Income | 183.7751 | 4863.519 | 5 | 4285106 | 3355414 |
| Property Value | 369451.7 | 1963524 | 5000 | 2.15E+09 | 3071453 |
| Minority Share | 32.19412 | 24.08437 | 0 | 100 | 3724482 |
| Preapproval | 0.020912 | 0.14309 | 0 | 1 | 3724482 |
| Married | 0.483613 | 0.499732 | 0 | 1 | 3724482 |
| Credit Applications | 0.064197 | 0.042219 | 9.83E-05 | 0.71831 | 3724482 |
| LN (House Price Index) | 5.587743 | 0.434868 | 4.100658 | 7.571819 | 3247564 |
| Loan Amount | 226131.2 | 293332.2 | 5000 | 3.45E+08 | 3724482 |
| Fixed Loan Costs Share | 0.023678 | 0.161365 | 0 | 217.6088 | 1967186 |
| Interest Rate | 4.882963 | 18.8904 | 0.001 | 7000 | 2529731 |
| DTI | 36.89096 | 18.102 | 15 | 75 | 1367227 |
| Succsesful Loan Share | 0.496268 | 0.338949 | 0 | 1 | 3724482 |
| House Price Growth (past 3 years) | 0.212899 | 0.120592 | -0.35664 | 1.048532 | 3206365 |
| House Price Growth (past 5 years) | 0.385325 | 0.22973 | -0.29343 | 1.969015 | 3244706 |
| House Price Growth (past 10 years) | 0.1981 | 0.229758 | -0.53222 | 2.434959 | 3239525 |
| House Price Std. Dev. (past 3 years) | 19.62721 | 15.14921 | 0.021212 | 258.1411 | 3315905 |
| House Price Std. Dev. (past 5 years) | 27.13456 | 21.32151 | 0.063637 | 310.6514 | 3393407 |

Table 3: Credit Supply Estimates

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| Estimator | OLS | | IV-FS | IV-SS | |
| Dependent variable: | Approval | LTV | LURI | Approval | LTV |
| LURI | 0.0161*** | 0.0195** | | 0.5968*** | 0.6312*** |
| | (0.0059) | (0.0076) | | (0.2059) | (0.2368) |
| Loan Term | -0.0402*** | 0.3772*** | -0.0002 | -0.0401*** | 0.3773*** |
| | (0.0010) | (0.0026) | (0.0001) | (0.0010) | (0.0027) |
| GSE | 0.0918*** | -0.4017*** | 0.0025*** | 0.0903*** | -0.4033*** |
| | (0.0016) | (0.0034) | (0.0006) | (0.0017) | (0.0035) |
| First lien | 0.2201*** | 1.3293*** | -0.0002 | 0.2202*** | 1.3294*** |
| | (0.0014) | (0.0032) | (0.0001) | (0.0014) | (0.0032) |
| Minority | -0.0460*** | 0.0210*** | -0.0008*** | -0.0455*** | 0.0215*** |
| | (0.0007) | (0.0008) | (0.0002) | (0.0007) | (0.0009) |
| Population | 0.0084*** | 0.0120*** | -0.0065*** | 0.0124*** | 0.0162*** |
| | (0.0009) | (0.0012) | (0.0020) | (0.0022) | (0.0025) |
| Applicant income | 0.1016*** | 0.1848*** | -0.0001 | 0.1017*** | 0.1849*** |
| | (0.0007) | (0.0010) | (0.0001) | (0.0007) | (0.0010) |
| Property value | -0.0108*** | -0.3140*** | 0.0009* | -0.0113*** | -0.3144*** |
| | (0.0011) | (0.0022) | (0.0005) | (0.0011) | (0.0023) |
| Minority share | -0.0099*** | 0.0045*** | -0.0044*** | -0.0078*** | 0.0067*** |
| | (0.0008) | (0.0010) | (0.0015) | (0.0014) | (0.0016) |
| Preapproval | 0.1080*** | 0.0943*** | 0.0002 | 0.1079*** | 0.0941*** |
| | (0.0021) | (0.0019) | (0.0002) | (0.0021) | (0.0019) |
| Married | 0.0192*** | -0.0135*** | 0.0001 | 0.0192*** | -0.0135*** |
| | (0.0006) | (0.0007) | (0.0001) | (0.0006) | (0.0007) |
| Credit applications | 0.0430*** | 0.0834*** | -0.1242*** | 0.1194*** | 0.1639*** |
| | (0.0129) | (0.0164) | (0.0379) | (0.0388) | (0.0458) |
| Distance to Interstate Highway | | | -0.0033*** | | |
| | | | (0.0008) | | |
| Loan type FE | Yes | Yes | Yes | Yes | Yes |
| Lender * Zip Code FE | Yes | Yes | Yes | Yes | Yes |
| Observations | 2,559,258 | 2,559,258 | 2,559,258 | 2,559,258 | 2,559,258 |
| R-squared | 0.3015 | 0.7317 | 0.8881 | 0.0657 | 0.5573 |
| KP F-stat | - | - | - | 15.299 | 15.299 |

Notes: Columns 1 and 2 report estimates of equation (2) using ordinary least squares. Column 3 reports first stage estimates of (1). Columns 4 and 5 report second stage estimates of (2). Zip codes are measured at the 5-digit level. Variable definitions are provided in Table 1. Standard errors are clustered at the zip code level and the corresponding $t$-statistics are reported in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 4: Subindex Results

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Restriction Type | Political | | | Zoning & Supply | | | | Project Approval | | | Financial | |
| Index | LPPI | SPII | LAI | LZAI | SRI | DRI | OSI | CII | LPAI | ADI | EI | AHI |
| Panel A: Approval | | | | | | | | | | | | |
| Index coefficient | 0.0495*** | 0.0599*** | 0.1470 | 0.0562*** | 0.2690 | 0.2731 | 0.0711** | 0.0579*** | 0.0917** | 0.2657 | 0.0641*** | 0.1136* |
| | (0.0177) | (0.0216) | (0.0925) | (0.0202) | (0.2909) | (0.3638) | (0.0284) | (0.0204) | (0.0430) | (0.2360) | (0.0235) | (0.0585) |
| Control variables | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Lender * 5-digit Zip Code FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 2,559,258 | 2,559,258 | 2,559,258 | 2,559,258 | 2,559,258 | 2,559,258 | 2,559,258 | 2,559,258 | 2,559,258 | 2,559,258 | 2,559,258 | 2,559,258 |
| R-squared | 0.0646 | 0.0641 | 0.0427 | 0.0641 | 0.0047 | -0.0653 | 0.0626 | 0.0647 | 0.0573 | 0.0521 | 0.0647 | 0.0022 |
| KP F-stat | 12.728 | 12.728 | 12.728 | 12.728 | 12.728 | 12.728 | 12.728 | 12.728 | 12.728 | 12.728 | 12.728 | 12.728 |
| Panel B: LTV ratio | | | | | | | | | | | | |
| Index coefficient | 0.0524*** | 0.0633*** | 0.1555 | 0.0595** | 0.2845 | 0.2889 | 0.0753** | 0.0613** | 0.0970** | 0.1202* | 0.0678*** | 0.2811 |
| | (0.0199) | (0.0244) | (0.1009) | (0.0231) | (0.3109) | (0.3830) | (0.0321) | (0.0238) | (0.0471) | (0.0628) | (0.0258) | (0.2554) |
| Control variables | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Lender * 5-digit Zip Code FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 2,559,258 | 2,559,258 | 2,559,258 | 2,559,258 | 2,559,258 | 2,559,258 | 2,559,258 | 2,559,258 | 2,559,258 | 2,559,258 | 2,559,258 | 2,559,258 |
| R-squared | 0.5568 | 0.5566 | 0.5487 | 0.5565 | 0.5348 | 0.5085 | 0.5560 | 0.5568 | 0.5540 | 0.5523 | 0.5569 | 0.5334 |
| KP F-stat | 12.728 | 12.728 | 12.728 | 12.728 | 12.728 | 12.728 | 12.728 | 12.728 | 12.728 | 12.728 | 12.728 | 12.728 |

Notes: This table reports estimates of equation (2) using the subindexes as dependent variables. Index coefficient denotes the subindex's second-stage coefficient estimate. Zip codes are measured at the 5-digit level. Variable definitions are provided in Table 1. Standard errors are clustered at the zip code level and the corresponding $t$-statistics are reported in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 5: Reasons for Denial of Credit

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| Dependent variable: | Collateral | Credit history | DTI | Unverified info | Employment history | Insufficient cash | Incomplete application | Mortgage insurance | Other |
| LURI | -0.2364*** | -0.2426** | -0.2286** | -0.0317 | 0.0131 | -0.0265 | 0.0293 | -0.0010 | -0.0166 |
| | (0.0896) | (0.1060) | (0.1091) | (0.0270) | (0.0135) | (0.0210) | (0.0398) | (0.0022) | (0.0422) |
| Loan Term | 0.0167*** | 0.0210*** | 0.0160*** | -0.0005*** | 0.0004*** | 0.0014*** | -0.0024*** | 0.0000 | -0.0005 |
| | (0.0004) | (0.0006) | (0.0007) | (0.0002) | (0.0001) | (0.0001) | (0.0003) | (0.0000) | (0.0003) |
| GSE | -0.0175*** | -0.0105*** | -0.0623*** | -0.0010*** | -0.0016*** | -0.0050*** | -0.0036*** | -0.0000 | -0.0082*** |
| | (0.0008) | (0.0008) | (0.0012) | (0.0004) | (0.0002) | (0.0003) | (0.0005) | (0.0000) | (0.0005) |
| First Lien | -0.0536*** | -0.0996*** | -0.1282*** | 0.0017*** | 0.0003*** | -0.0001 | 0.0046*** | 0.0000*** | -0.0103*** |
| | (0.0006) | (0.0010) | (0.0009) | (0.0002) | (0.0001) | (0.0002) | (0.0002) | (0.0000) | (0.0004) |
| Minority | 0.0035*** | 0.0162*** | 0.0246*** | 0.0019*** | 0.0006*** | 0.0009*** | 0.0033*** | 0.0000 | 0.0041*** |
| | (0.0003) | (0.0005) | (0.0006) | (0.0002) | (0.0001) | (0.0001) | (0.0002) | (0.0000) | (0.0003) |
| Population | -0.0038*** | -0.0042*** | -0.0032*** | -0.0008*** | 0.0001 | -0.0000 | -0.0009** | -0.0000 | -0.0014*** |
| | (0.0009) | (0.0011) | (0.0011) | (0.0003) | (0.0001) | (0.0002) | (0.0004) | (0.0000) | (0.0004) |
| Applicant income | 0.0206*** | -0.0010** | -0.1327*** | 0.0005*** | -0.0015*** | 0.0003*** | 0.0012*** | 0.0000 | -0.0013*** |
| | (0.0003) | (0.0004) | (0.0007) | (0.0001) | (0.0001) | (0.0001) | (0.0002) | (0.0000) | (0.0002) |
| Property value | -0.0385*** | -0.0326*** | 0.0802*** | 0.0007*** | 0.0001 | -0.0013*** | 0.0005** | -0.0000** | -0.0031*** |
| | (0.0005) | (0.0006) | (0.0008) | (0.0002) | (0.0001) | (0.0001) | (0.0003) | (0.0000) | (0.0003) |
| Minority share | -0.0020*** | 0.0058*** | 0.0037*** | 0.0003 | 0.0002* | 0.0002* | 0.0007** | -0.0000 | 0.0008*** |
| | (0.0006) | (0.0007) | (0.0007) | (0.0002) | (0.0001) | (0.0001) | (0.0003) | (0.0000) | (0.0003) |
| Preapproval | -0.0224*** | -0.0137*** | -0.0450*** | -0.0071*** | -0.0029*** | -0.0038*** | -0.0223*** | -0.0001*** | -0.0244*** |
| | (0.0006) | (0.0007) | (0.0011) | (0.0003) | (0.0002) | (0.0002) | (0.0007) | (0.0000) | (0.0007) |
| Married | -0.0078*** | -0.0045*** | 0.0006 | -0.0023*** | 0.0002*** | -0.0008*** | -0.0034*** | 0.0000 | -0.0031*** |
| | (0.0003) | (0.0003) | (0.0004) | (0.0001) | (0.0001) | (0.0001) | (0.0002) | (0.0000) | (0.0002) |
| Credit applications | -0.0217 | -0.0794*** | -0.0437** | -0.0023 | 0.0004 | 0.0014 | 0.0031 | -0.0000 | -0.0180*** |
| | (0.0167) | (0.0188) | (0.0208) | (0.0045) | (0.0021) | (0.0032) | (0.0067) | (0.0003) | (0.0067) |
| Control variables | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Lender * 5-digit zip Code FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 2,559,258 | 2,559,258 | 2,559,258 | 2,559,258 | 2,559,258 | 2,559,258 | 2,559,258 | 2,559,258 | 2,559,258 |
| R-squared | 0.0138 | 0.0234 | 0.0782 | 0.0002 | 0.0003 | 0.0002 | 0.0020 | -0.0000 | 0.0041 |
| KP F-stat | 15.299 | 15.299 | 15.299 | 15.299 | 15.299 | 15.299 | 15.299 | 15.299 | 15.299 |

Notes: This table reports estimates of equation (2) using the denial reason variables as dependent variables. Zip codes are measured at the 5-digit level. Variable definitions are provided in Table 1. Standard errors are clustered at the zip code level and the corresponding $t$-statistics are reported in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 6: Housing Price Dynamics

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| House price | Level | Annual Return (ln) | | | Growth Rate (%) | | | Volatility ($\sigma$) | |
| Dependent Variable: | HPI | HPI (3 Years) | HPI (5 Years) | HPI (10 Years) | HPI (3 Years) | HPI (5 Years) | HPI (10 Years) | HPI (3 Years) | HPI (5 Years) |
| LURI | 1.9357* | 0.5205* | 0.7420** | 0.8964** | 0.6614* | 1.0748** | 0.8795* | 4.1841* | 5.2628** |
| | (1.1250) | (0.2957) | (0.3437) | (0.3960) | (0.3673) | (0.5099) | (0.4831) | (2.4674) | (2.1270) |
| Loan term | 0.0024*** | -0.0002 | -0.0002 | 0.0004** | -0.0002 | -0.0003 | 0.0004** | -0.0003 | 0.0005 |
| | (0.0005) | (0.0001) | (0.0001) | (0.0002) | (0.0001) | (0.0002) | (0.0002) | (0.0011) | (0.0009) |
| GSE | -0.0024 | 0.0036*** | 0.0055*** | 0.0045*** | 0.0040*** | 0.0074*** | 0.0056*** | 0.0098 | 0.0083 |
| | (0.0033) | (0.0008) | (0.0010) | (0.0011) | (0.0010) | (0.0014) | (0.0013) | (0.0073) | (0.0065) |
| First lien | -0.0021*** | 0.0005*** | 0.0008*** | 0.0000 | 0.0006*** | 0.0011*** | 0.0001 | 0.0022* | 0.0006 |
| | (0.0006) | (0.0001) | (0.0002) | (0.0002) | (0.0002) | (0.0002) | (0.0002) | (0.0012) | (0.0010) |
| Minority | -0.0092*** | 0.0002 | -0.0000 | -0.0008*** | 0.0004 | 0.0001 | -0.0011*** | -0.0071*** | -0.0088*** |
| | (0.0010) | (0.0002) | (0.0003) | (0.0003) | (0.0003) | (0.0004) | (0.0004) | (0.0021) | (0.0018) |
| Population | 0.0941*** | -0.0069*** | -0.0097*** | -0.0047 | -0.0096*** | -0.0153*** | -0.0101** | 0.0342 | 0.0345* |
| | (0.0104) | (0.0023) | (0.0030) | (0.0036) | (0.0029) | (0.0045) | (0.0045) | (0.0214) | (0.0196) |
| Applicant income | 0.0010 | -0.0043*** | -0.0056*** | -0.0029*** | -0.0055*** | -0.0085*** | -0.0043*** | -0.0226*** | -0.0213*** |
| | (0.0008) | (0.0002) | (0.0003) | (0.0003) | (0.0003) | (0.0004) | (0.0004) | (0.0018) | (0.0016) |
| Minority share | -0.1173*** | 0.0202*** | 0.0273*** | 0.0118*** | 0.0263*** | 0.0422*** | 0.0191*** | -0.0069 | -0.0239* |
| | (0.0073) | (0.0019) | (0.0021) | (0.0025) | (0.0023) | (0.0031) | (0.0030) | (0.0148) | (0.0133) |
| Preapproval | -0.0015 | -0.0003 | -0.0004 | -0.0001 | -0.0003 | -0.0008* | -0.0001 | -0.0023 | -0.0019 |
| | (0.0010) | (0.0003) | (0.0003) | (0.0003) | (0.0003) | (0.0004) | (0.0004) | (0.0022) | (0.0018) |
| Married | 0.0018*** | 0.0000 | 0.0001 | -0.0001 | 0.0000 | 0.0001 | -0.0003 | 0.0014 | 0.0017** |
| | (0.0004) | (0.0001) | (0.0001) | (0.0002) | (0.0001) | (0.0002) | (0.0002) | (0.0010) | (0.0009) |
| Credit applications | -0.2257 | -0.1400** | -0.1816*** | -0.3043*** | -0.1919** | -0.3129*** | -0.4977*** | -1.1408*** | -0.7772** |
| | (0.2135) | (0.0595) | (0.0606) | (0.0876) | (0.0752) | (0.0935) | (0.1173) | (0.4170) | (0.3849) |
| Loan type FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Lender * 5-digit zip Code FE | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 2,751,810 | 2,717,080 | 2,749,374 | 2,744,956 | 2,717,080 | 2,749,374 | 2,744,956 | 2,810,761 | 2,878,014 |
| KP F-stat | 14.691 | 12.413 | 13.926 | 14.856 | 12.413 | 13.926 | 14.856 | 14.707 | 15.089 |

Notes: This table reports estimates of equation (2) using the housing price variables as the dependent variable. Zip codes are measured at the 5-digit level. Variable definitions are provided in Table 1. Standard errors are clustered at the zip code level and the corresponding $t$-statistics are reported in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

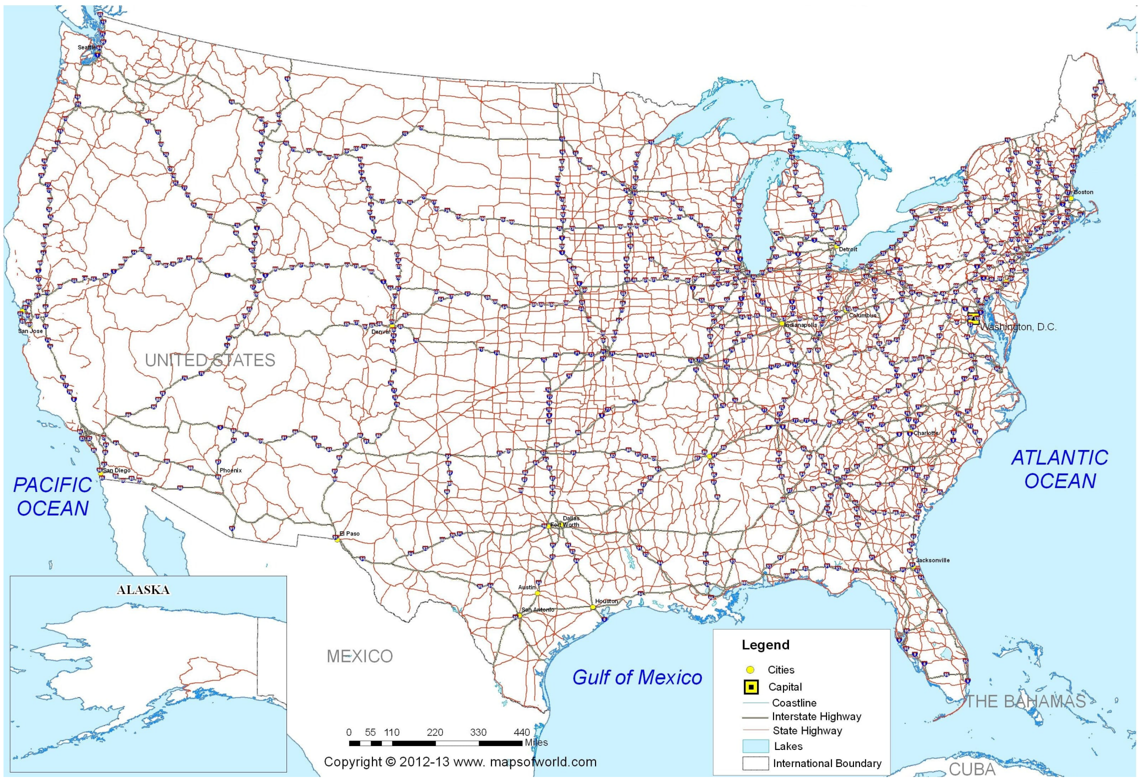
Table 7: Cost of Credit

| | 1 | 2 |
|---|---|---|
| Dependent variable | Interest rate | Total cost |
| LURI | -0.0874 | -0.1679 |
| | (0.0689) | (0.3185) |
| Loan Term | 0.0746*** | 0.2526*** |
| | (0.0012) | (0.0041) |
| GSE | 0.0175*** | -0.1313*** |
| | (0.0009) | (0.0042) |
| First lien | -0.1514*** | 2.2129*** |
| | (0.0016) | (0.0119) |
| Minority | -0.0024*** | -0.0017 |
| | (0.0004) | (0.0017) |
| Population | -0.0007 | 0.0011 |
| | (0.0007) | (0.0033) |
| Applicant income | 0.0028*** | 0.0451*** |
| | (0.0004) | (0.0014) |
| Property value | -0.0459*** | 0.2041*** |
| | (0.0006) | (0.0024) |
| Minority share | 0.0008* | 0.0044** |
| | (0.0005) | (0.0021) |
| Preapproval | -0.0052*** | 0.0545*** |
| | (0.0014) | (0.0044) |
| Married | -0.0008** | 0.0054*** |
| | (0.0003) | (0.0013) |
| Credit applications | -0.0322*** | -0.0217 |
| | (0.0117) | (0.0481) |
| Loan type FE | Yes | Yes |
| Lender * 5-gidit zip Code FE | Yes | Yes |
| Observations | 2,000,500 | 1,532,161 |
| KP F-stat | 15.469 | 14.944 |

Notes: This table reports estimates of equation (2) using the interest rates and the ratio of fixed costs to loan amount as the dependent variable. Zip codes are measured at the 5-digit level. Variable definitions are provided in Table 1. Standard errors are clustered at the zip code level and the corresponding $t$-statistics are reported in parentheses. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

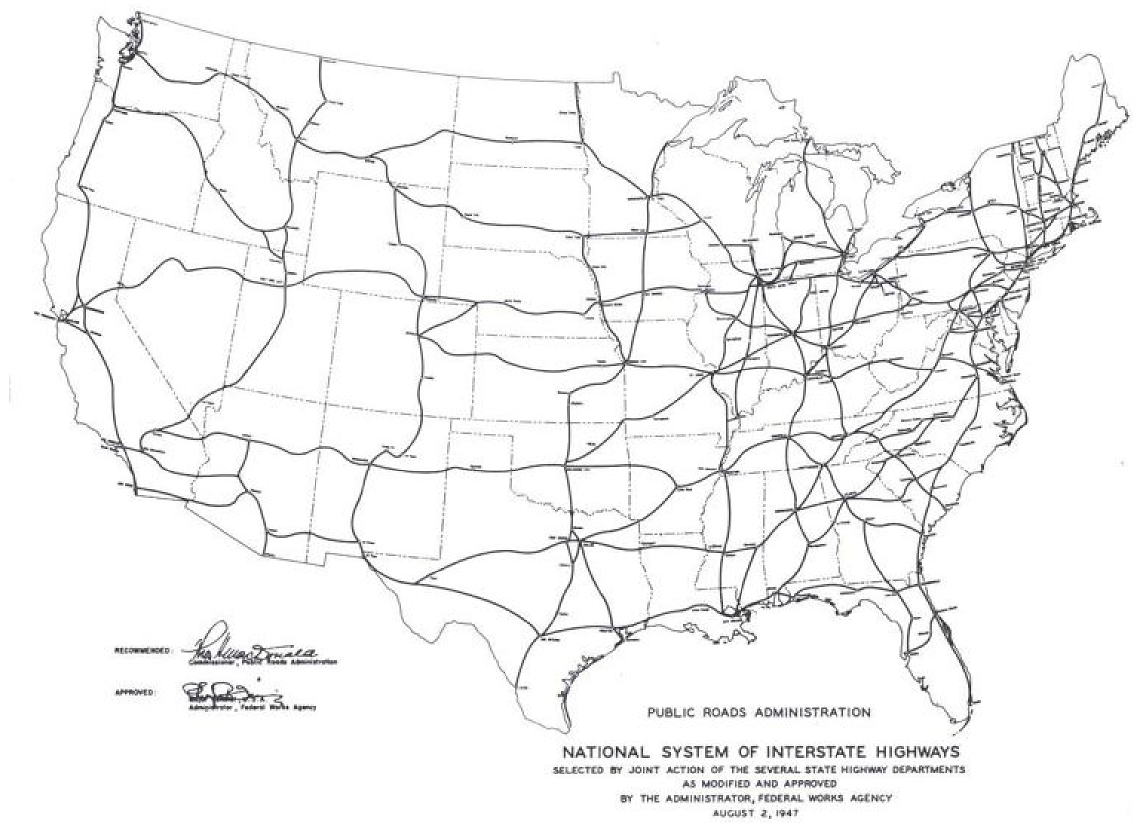
# Figures

Figure 1: The 2018 Interstate Highways System




Notes: This figure shows the location of Interstate Highways in 2018.

Figure 2: The 1947 National System of Interstate Highways Plan




Notes: This figure shows the proposed location of Interstate Highways by the 1947 highway plan. Source: United States House of Representatives (1947)