Highly skilled immigrants and local housing prices: Evidence from the H-1B visa lottery

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Abstract

We explore the extent to which the influx of highly skilled immigrants can forecast subsequent local housing prices by exploiting exogenous inflow of highly skilled immigrants to an area through the H-1B visa lottery program. We find that greater exogenous inflow of highly skilled immigrants is associated with higher local housing price appreciation. This positive association between the influx of highly skilled immigrants and housing price appreciation is stronger in areas with faster overall population growth and in areas with inelastic land supply. However, additional analyses show that the inflow of highly skilled workers is not significantly associated with local rent prices.

Keywords: highly skilled immigrants; H-1B visa program; housing; real estate return, housing appreciation

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1. Introduction

The relation between immigration and real estate valuation has long been subject to scrutiny. Understanding the effect of immigration on real estate prices is important for both investors (who seek to understand the role of immigration in real estate investment returns) and policymakers (who seek to understand the role of immigration in household wealth formation and formulation of policies to accommodate the influx of immigrants). However, quantifying the effect of immigration on real estate valuation is often challenging. Besides significant heterogeneity in immigrant populations, the association between immigration and home prices is often confounded by various factors such as economic conditions that attract immigrants, which often independently affect real estate prices. Additionally, there is a paucity of natural experiments which generally limits the ability to credibly use the influx of immigrants to forecast house prices. In this study, we address these challenges by identifying a unique natural experiment – the H-1B visa lottery *winning rate*, an exogenous shock to the influx of a homogenous group (highly educated and skilled immigrants) into an area. In doing so, we quantify the role of immigration in the forecasting of real estate value and provide new evidence on the role of highly skilled immigration on home prices and rent.

It is economically intuitive that overall immigration should be positively related to higher housing prices across metro areas. However, within metros, unskilled and low-income immigrants may drive housing prices lower in some areas (where these immigrants are likely to reside) and higher in other areas – a substitution effect. For that reason, the evidence from the literature on the relation between immigration and housing prices is mixed. For example, Saiz (2003, 2007) documents that the influx of immigrants to metropolitan areas results in an increase in rental prices

in these areas. With respect to house prices, Saiz and Wachter (2011) find that neighborhoods with higher influx of immigrants are associated with lower house prices. Braakmann (2019) shows that in England and Wales, the arrival of immigrants lowers house prices, but only for those with prices lower than the median house price in the region. Daams, Proietti, and Veneri (2019) find similar results using the establishment of asylum seeker reception centers in the Netherlands. In contrast to these findings, Pavlov and Somerville (2020) show that, after the sudden reduction in the number of wealthy immigrants to Canada, house prices declined in areas favored by these immigrants. Bian, Coulson and Sun (2023) also show that immigration increases local house price appreciation in areas with residents that are younger, more educated and less racially biased. The inconsistency in these findings stem, at least in part, from the fact that the differing levels of wealth or earning ability among immigrants are likely to affect housing valuation differently, as well as the inherent difficulty in modelling the endogeneity between housing price appreciation and immigration.

To overcome the challenges that undermine drawing inference from prior work, we exploit a feature of US immigration law – the H-1B visa lottery winning rate – as a natural experiment to provide an exogenous source of variation in the number of highly skilled immigrants into a specific locality. In 1990, Congress created the H-1B visa program which allows foreign-born individuals with at least a bachelor's degree to apply for a visa (i.e., the H-1B visa), which grants the individual the right to work for firms located in the United States. However, since 2008 (with the exception of 2010 and 2013), the number of applicants has exceeded the annual cap allowed under the program. To address this issue, the United States Citizenship and Immigration Services (USCIS) introduced a new lottery system in 2008, which randomly selects 65,000 H-1B visa applications

to process in April of each year. As a result, only about 50% of H-1B visa applications each year are selected by the lottery, with the outcome being randomly determined. This means that the H-1B lottery winning rate provides both *cross-sectional* (in any year the winning rate varies across localities) and *temporal* (within a locality the winning rate varies across years) sources of exogenous variation in the number of highly skilled immigrants into a particular locality.

In addition, the H-1B visa program is designed to supply the US economy with highly skilled workers specifically. These visa recipients are often employed in higher paying occupations such as those related to science, technology, engineering, and mathematics (STEM). Along these lines, a study from the CATO Institute finds that H-1B visa holders' wages are in the 90th percentile of U.S. wages.[1] Therefore, these workers are likely to have the financial ability to purchase a home and increase the local demand for housing. As such we make a directional prediction and hypothesize that exogenous increases in the influx of highly skilled immigrants to a locality will foreshadow an increase in home prices in that area.

Using data from 4,855 3-digit zip code-years from 2014 to 2019, we find evidence of a positive and statistically significant association between highly skilled foreign labor shock and subsequent housing prices at the local level. These results are more pronounced in areas with overall faster population growth and lower land supply elasticity. Economically, our results suggest that a one standard deviation increase in the H-1B lottery winning rate is associated with a 17% increase in excess appreciation in local housing prices in the following year, when compared to the sample mean. These findings suggest that the influx of highly skilled immigrants' ability to

[1] https://www.cato.org/blog/h-1b-wages-surge-top-10-all-wages-us#:~:text=Meanwhile%2C%20according%20to%20the%20Department,8%20percent%20of%20U.S.%20workers.

predict subsequent local housing prices is both statistically significant and economically meaningful. However, we do not find a significant relationship between the H-1B lottery winning rate and local rent prices, which contrasts with the positive relationship between rent prices and general immigration as reported by Saiz (2003, 2007).

One potential critique of our use of the H-1B lottery winning rate to identify exogenous changes in immigrant flow is that, within a particular locality, the average winning rate may vary more significantly through time in areas with fewer H-1B filers than in areas with many filings. This is because in areas with fewer filings, the presence (or lack of) H-1B lottery winners in a particular year could result in unusually large (or small) winning rates, given the smaller base of filings. This could affect our results if the house price dynamics of localities with many filings differed systematically from those with few filings over our sample period in ways that are omitted in our analysis. This issue could be particularly important if our results are mostly driven by localities with fewer filings. However, findings from our analysis discount these possibilities. Our examination of the data shows that there are meaningful variations of the H-1B wining rate in localities in our sample both in the cross-section (i.e., across localities in a given year) and over time (i.e., over years for a particular locality). We observe that even within the localities (3-digit zip codes) that have the largest number of H-1B filings, the year-to-year variation in the winning rate is substantial and economically meaningful. In addition, besides the inclusion of locality fixed effects, we include the number of filings in a locality as a control throughout our analyses. We also find that the relationship between the H-1B winning rate and house prices is most significant in areas with many H1-B fillings. Indeed, in additional (un-tabulated) analyses, we find that our

results remain significant if we exclude the localities where total filings were in the two smallest quintiles over our sample period.

We make several important contributions to the existing literature. First, we enrich the literature that tries to understand how immigration affects local economies by showing that an influx of highly skilled labor is positively associated with house price increases. Second, our study adds to the toolkit available to researchers who study changes in housing prices while potentially alleviating the endogeneity concerns related to unobservable underlying economic conditions. By using an exogenous shock that randomly affects local housing demand, we alleviate such endogeneity concerns. Finally, our findings contribute to the recent debate among policy makers regarding the effect of the H-1B program on local economies in the U.S. Highly skilled immigrants in the U.S. are a crucial part of the driving force for technological advancements and firm performance (Kerr, 2022).[2] This debate has drawn great attention from practitioners and policy makers and has sparked multiple recent academic studies to understand its impact. While most of these studies focus on the labor market impact from the H-1B program, our study of its effects on real estate markets highlights one of the most important real effects of the program on the local economy in the areas where these immigrants live and work.

2. Background and literature review

2.1 The H-1B visa program: A brief overview

[2] For example, a 2017 Harvard Business Review article explained the debate around the H-1B visa (https://hbr.org/2017/05/the-h-1b-visa-debate-explained). A recent Wall Street Journal article in 2022 also illustrates the current discussions on this issue (https://www.wsj.com/articles/us-expand-h1b-visa-program-11667596983).

In the year 1990, to help American firms address a shortage of skilled workers, Congress enacted legislation that offers a working visa under the H-1B visa program to highly skilled immigrant workers.[3] With the H-1B visa program, foreign-born workers with at least a bachelor's degree can apply for working visas (i.e., H-1B visa) to work for firms located in the U.S. The H-1B visa program has gained great popularity and, over time, the number of petitions has far exceeded the maximum allowed each year starting from 2008 (except for 2010 and 2013 when the overall employment rate in the United States was depressed in the aftermath of the financial crisis). To address the allocation issue of available H-1B visas, USCIS introduced a new lottery system in 2008, which randomly selects 65,000 H-1B visa applications to process in April of each year. As a result, only about 50% of H-1B visa applications each year are selected by the lottery to proceed to the next step of the visa application process. Potential employees who submitted their H-1B visa applications but do not win the lottery are required to re-submit their applications the following year or are forced to leave the United States within a defined grace period of 60 days, in most cases.

Given the randomness of the H-1B visa lottery process, it is natural that local communities where more applicants win the H-1B visa lottery will have a relatively higher inflow of highly skilled immigrants compared with communities where fewer applicants win the H-1B visa lottery. Thus, in this paper, we use the H-1B visa *winning rate* as an exogenous shock that increases the influx of highly skilled workers in a local area to investigate whether unexpected changes in the number of highly skilled employees in an area affect its real estate valuation.

[3] The Immigration and Nationality Act, section101(a)(15)(H) (https://uscode.house.gov/view.xhtml?req=granuleid:USC-prelim- title8-section1101&num=0&edition=prelim)

2.2 The impact of highly skilled immigrants on firms and local economies

How highly skilled immigrants affect firm performance and decision making is an important question that has drawn attention from policy makers, practitioners, and academics alike (Kerr, 2022). A series of recent papers and published research have tried to shed light on this question by studying the H-1B visa program, which is tailored for highly skilled immigrants in the U.S. For example, Mayda et. al. (2020) study the impact of the lack of H-1B visa among publicly traded firms. They find that H-1B visa shortage leads to reduced employment, sales and profits. Using the winning rate of H-1B visa lottery as exogenous source of variation in the access to highly skilled workers across firms, Dimmock, Huang, and Weisbenner (2022) show that start-up firms with higher lottery winning rates are more likely to receive funding and have successful exits. They also document that the ability to access highly skilled foreign workers leads to better innovation at these start-ups as reflected in the number of patents. Guzman, Tareque, and Wang (2022) show that highly skilled immigrants (i.e., H-1B visa workers) increase the quality of regional start-ups. They further document that this relationship does not exist for unskilled immigrants (i.e., H-2B visa workers). Similar results are also documented in Chen, Hshieh, and Zhang (2021), who show that highly skilled immigrant workers increase the quality of innovation. In addition, they find that losing access to these highly skilled workers leads to worse firm performance, suggesting that these highly skilled foreign workers are difficult to replace.

In addition to highly skilled immigrants' impact on firm innovation and performance, another important aspect of the debate around the H-1B program is how H-1B workers affect local

employment and wages for native-born workers. Although the influx of less skilled immigrant workers may, at least in the short-term, lead to slightly higher unemployment and lower wages among native workers (Card, 2001), the impact that highly skilled workers (i.e., H-1B workers) have on local economy may be vastly different given the nature of the jobs in which these workers are employed. In a recent paper, Bernstein et al. (2020) analyze the impact of immigrants on local labor market by considering the specific nature of the jobs. They show that the influx of immigrants into an area crowds out native workers only in non-tradable jobs (e.g., housekeepers), but this effect does not exist in tradable jobs (e.g., computer programmers). H-1B workers almost all work in sectors that produce tradable goods, suggesting that these immigrant workers are unlikely to crowd out native workers. This conjecture is consistent with empirical findings in Kerr and Lincoln (2010), who demonstrate that more H-1B immigrant workers lead to greater employment and patenting activities in science and engineering, and that H-1B workers do not displace native U.S. workers.

Similarly, Peri, Shih, and Sparber (2015) show that increase in science, technology, engineering, and mathematics (STEM) workers due to the H-1B program is associated with significant wage increase for college-educated native workers. In a more recent study, Glennon (2023) show corroborating evidence to support these conclusions. The author studies U.S. multinational companies' (MNCs) responses to two exogenous shocks that significantly reduced highly skilled immigration. She shows that MNCs respond to these restrictions on highly skilled immigrant labor by offshoring those jobs to their affiliated foreign entities – among the most globalized MNCs hire 0.9 employees abroad for every H-1B visa rejection. Findings from these studies suggest that highly skilled immigrants contribute to the improvements in innovation, firm

performance, and employment opportunities in the companies that hire these workers, and potentially, the areas to which these workers relocate.

2.3 Broader immigration and local real estate markets

All other things equal, the arrival of immigrants into a region naturally increases the demand for housing. However, the impact of immigration on local real estate prices is not straightforward because it is possible that native workers may move out of areas with high influx of immigrants (Filer, 1992; Saiz and Wachter, 2011). Saiz (2003) sheds light on this issue by studying the impact of low-skilled immigrants on local rents. The author uses the Mariel boatlift in the Miami metropolitan area in 1980, which results in a surge of unskilled Cuban nationals, as an exogenous shock to renter population in the region. By comparing rents in Miami with other similar metropolitan areas from 1979 to 1981, he shows that rents in Miami (i.e., the area shocked by influx of unskilled immigrants) increase by 8% to 11% more than the other comparable areas. Saiz (2007) generalizes this finding by showing that this positive association between immigrants and housing rents apply to all major U.S. gateway cities. The study uses data on the number of admitted permanent residents in the U.S. and their self-claimed destination cities as a proxy for the increase in immigrants in metropolitan areas. The results from the study show that the arrival of immigrants is associated with increase in average rent prices.

Despite these findings of the positive association between immigration and local rental prices, the evidence on how immigrants affect local housing prices is not clear. Recent studies suggest that the impact of immigrants on housing values may depend on the properties of the homes and areas. Braakmann (2019) investigates the relationship between immigration and housing prices using data from England and Wales. He shows that the arrival of immigrants in a

region leads to a decrease in housing prices only for those houses with values below the median and has no impact on houses with values above the median. Daams, Proietti, and Veneri (2019) show that the establishment of asylum seeker reception centers (ASRC) across the Netherlands has different impacts on housing prices near the ASRC. Although the presence of ASRC is associated with lower home prices, this relationship only pertains to areas with low population density and high ASRC hosting capacity. House values in cities are not affected by the establishment of ASRC. Saiz and Wachter (2011) study the relationship between immigration and house prices in the U.S. using the census decennial data for the metropolitan areas. They find that neighborhoods with higher growth of immigrants are associated with lower house prices because natives choose to leave these neighborhoods.

In contrast to the findings above, which are pertinent to all areas or areas with lower house values, Pavlov and Somerville (2020) try to understand how wealthy immigrants affect local house prices. They study this issue based on the sudden decrease in wealthy immigrants due to the suspension and closure of the investor immigration program in Canada. Results from their analysis show that decrease in this type of immigrants, who are likely to bring in foreign capital to a local region, significantly reduces housing prices in the neighborhoods with higher prices. A recent study by Bian, Coulson and Sun (2023) addresses some of the inconsistencies in the literature and finds that immigration increases local house price appreciation only in counties where residents are younger, more educated and less racially biased, on average. A few other recent studies investigate the impact of foreign capital on local housing prices and find similar heterogeneity. For example, Li, Shen, and Zhang (2024) show that capital from China contributes to significant increase in U.S. real estate prices, but the effects are more likely to be concentrated in

neighborhoods historically populated by ethnic Chinese. Gorback and Keys (2020) also document this pattern. This impact of foreign demand is not restricted to the U.S., as Badarinza and Ramadorai (2018) show a similar pattern among foreign demand using residential real-estate data from London.

3. Hypotheses

The literature reviewed in section 2 suggests that highly skilled workers contribute to the economic development in the areas where they live, which increases the demand for housing and boosts housing prices. This impact on local housing prices may directly come from highly skilled workers' own demand for housing, or indirectly stem from boosting the wages of the incumbent workers, which stimulates the ability of those already existing workers to demand more housing. Therefore, our first hypothesis is the following:

Hypothesis 1: The unexpected inflow of highly skilled immigrants to an area is associated with subsequent local housing price appreciation.

Given that the inflow of highly skilled immigrants not only increases direct demand for housing but also boosts local economy, we predict that the effect on housing prices from highly skilled immigrant workers will be magnified in areas with thriving economies that are already likely to be experiencing more rapid overall population growth. Therefore, our second hypothesis is the following:

Hypothesis 2: The association between subsequent housing prices and the unexpected inflow of high skilled immigrants should be more pronounced in areas with overall fast population growth.

In similar fashion to our conjecture on overall population growth, businesses in localities with thriving economies are specifically likely to have a growing need for highly skilled workers. Companies in these localities are, therefore, already more likely to file for more H-1B petitions. This implies that the effect on housing prices from highly skilled immigrant workers will be magnified in areas that already have a high underlying demand for skilled workers. Thus, our third hypothesis is the following:

Hypothesis 3: The association between subsequent housing prices and the unexpected inflow of high skilled immigrants should be more pronounced in areas with more H-1B visa petitions.

Our first hypothesis is based on the argument that the unexpected inflow of highly skilled immigrant workers due to the H-1B program increases local housing demand because these workers are potential and capable homebuyers who also contribute to the development of the local economy thus raising the wealth of incumbents. With the increased demand for housing, areas with limited housing supply should experience greater increase in prices. Given that it is easier (more difficult) to adjust the supply of housing in areas with more (less) available land for new homes, our fourth hypothesis is the following:

Hypothesis 4: The association between subsequent housing prices and the unexpected inflow of high skilled immigrants should be more pronounced in areas with more limited land supply.

The nature of the H-1B program ensures that immigrant workers granted these visas must be highly skilled and earn competitive wages. Indeed, according to a study by the CATO Institute, H-1B visa holders earn wages equivalent to the 90th percentile of all wage earners in the U.S.[4] Therefore, these immigrants are likely able to purchase a home and are more likely to be home buyers than renters. Therefore, we expect that the relationship between H-1B immigrant workers and rent prices to be ambiguous. Accordingly, our fifth hypothesis is the following:

Hypothesis 5: The unexpected inflow of highly skilled immigrants to an area should be positively associated with subsequent local housing rents, but this association should be weaker than that for purchase prices.

4. Data and methodology

4.1. Data and sample description

In this paper, we exploit the random assignment nature in the H-1B lotteries and use the percentage of H-1B visa applications won by the lottery system by firms in an area in a given year (i.e., *winning rate*) to proxy for exogenous inflows of H-1B workers in local areas. We obtain data related to the H-1B visa program from USCIS through a Freedom of Information Act (FOIA) request. The H-1B visa program data provides firm-year level information on the number of H-1B visa petitions, workplace addresses, the number of H-1B visa petitions selected by the lottery, and the number of H-1B visa petitions accepted/denied during the visa approval process. The main

[4] https://www.cato.org/blog/h-1b-wages-surge-top-10-all-wages-us#:~:text=Meanwhile%2C%20according%20to%20the%20Department,8%20percent%20of%20U.S.%20workers.

variable in this study, the *winning rate*, is computed as a fraction of the petitions won by the lottery and the total number of petitions initially submitted to USCIS, and aggregated by 3-digit zip code level *i* and year *t*:

$$Winning\ Rate_{i,t} = \frac{\#\ of\ H-1\text{B}\ Visa\ Applications\ Won\ by\ Lottery_{i,t}}{Total\ \#\ of\ H-1B\ Visa\ Applications_{i,t}} \quad (1)$$

Additional information on the H-1B visa program such as reported salary and other employee and employer information are collected from the Labor Condition Application (LCA) data which is disclosed by the United States Department of Labor (DOL) every year. We assign a value of zero to 3-digit zip codes that did not record any petitions or for which there were no petitions.

We obtain housing price and rent data from various sources. The House Price Index (HPI) information is obtained from the Federal Housing Finance Agency (FHFA). The FHFA publishes quarterly HPI data by each zip code in the United States. We compute the excess appreciation for a year as the difference between the change of HPI in 3-digit zip code *i* from quarter *q* to quarter *q+4*, adjusted by the change of national HPI from quarter *q* to quarter *q+4* in year *t*.

$$Excess\ Appreciation_{i,q+4} = \left(\frac{HPI_{i,q+4} - HPI_{i,q}}{HPI_{i,q}}\right) - \left(\frac{HPI_{national,q+4} - HPI_{national,q}}{HPI_{national,q}}\right) \quad (2)$$

We collect annual rent data by metropolitan statistical area (MSA) from the U.S. Department of Housing and Urban Development's (HUD's) Office of Policy Development and Research (PD&R), and the change in rent is computed by dividing the difference between the aggregated rent in year *t* in MSA *i* and the aggregated rent in year *t-1* in MSA *i* by the aggregated rent in year *t-1* in MSA

i. Local population data is obtained from the United States Census database, and housing supply (i.e. land elasticity) information is from Saiz's website.[5]

Table 1 shows the summary statistics of our regression sample of 4,855 3-digit zip code-years between January 2014 and December 2019.[6] Panel A in Table 1 shows that on average, the excess appreciation is –0.025, and the average H-1B visa winning rate over this 6-year period is 0.571. Panel A of Table 2 reports the average winning rate by year. The average value gradually decreases over time from 0.66 to 0.48 until 2017, and then gradually increases in 2018 and 2019.

4.2 Cross-sectional and time series variation in the winning rate

Before carrying out empirical analysis, we start by examining the suitability of the winning rate, as defined in (1), for obtaining plausible estimates of the effect of exogenous variation in skilled immigrant flow on house prices. At one extreme, if every application for the H-1B visa was granted, there would be no variation in the winning rate across localities, and a regression of home price appreciation on the winning rate would yield coefficient estimates of zero. Similarly, at another extreme, if the percentage of successful applicants in every locality and every year was exactly the same in the H-1B lottery, there would again be no variation in the winning rate across localities and we would be unable to use the winning rate for identification.

The discussion above suggests that for the winning rate variable to be a useful source of exogenous variation, there must be (random) statistical variation across localities and time. In other words, there must be measurable cross-sectional variation across localities in every year as well as

[5] https://urbaneconomics.mit.edu/research/data

[6] We start our sample from 2014 because prior to that year, and in the aftermath of the great recession, there were several years in which the number of filings fell below the H-1B cap meaning that the winning rate was essentially 100% across all localities. We end in 2019 to avoid the impact of COVID and its immediate aftermath.

time series variation within a locality over the years. If the probability that any applicant will win the lottery is x, then as the number of applicants increases, the law of large numbers and the central limit theorem imply that the winning rate will be normally distributed, with a mean of x and standard deviation σ. The standard deviation will decrease as the number of applicants increases. As such, one potential concern with using the winning rate is that σ may be too small to provide enough variation across and within localities to provide meaningful identification. We thus begin our analysis by investigating this possibility.

We start by examining the mean and standard deviation of the winning rate across localities (3-digit zip codes) in any year in our sample. Panel A of Table 2 shows that, while the mean varies very slightly from year to year (from 0.48 to 0.66), the standard deviation is within a much narrow range of 0.28 – 0.29 every year. This means that the standard deviation across 3-digit zip codes ranges between 42% and 58% of the year's mean. This is economically meaningful and suggests that, across 3-digit zip codes in any particular year, there is substantial cross-sectional variation. For further comparison, it is worth noting that the coefficient of variation[7] of the winning rate is of similar magnitude to those of population, wages, and the absolute number of filings across localities.

Next, we examine the time-series variation within 3-digit zip codes. In other words, how meaningful is the variation in winning rate in any locality, from year to year? We investigate this in several ways. We start by randomly selecting 20 3-digit zip codes from our sample and calculate the mean time-series standard deviation of each of these 3-digit zip codes. We then compute the mean of the time series standard deviation for these 20 localities. The first 10 iterations as reported

[7] Ratio of standard deviation to the mean.

in Panel B of Table 2 show that the mean time-series standard deviation within 3-digit zip codes ranges from 0.21 to 0.29, which is comparable to the annual standard deviation across 3-digit zip codes reported in Panel A. In a further simulation, we randomly select 845 3-digit zip codes (with replacement) and carry out a similar computation, and find that over 1,000 replications, the mean time-series standard deviation is 0.237.[8] Taken together, the simulations in Panel B indicate that, even within 3-digit zip codes, there is economically meaningful variation in the winning rate from year-to-year.

One further concern is that while the average time-series variation across our 3-digit zip codes may be substantial, areas with a high number of applicants (or a high population) may have little to no year-to-year variation in their winning rate. In areas with fewer filings, the presence (or lack of) H-1B lottery winners in a particular year could result in unusually large (or small) winning rates, given the smaller base of filings, which in turn increases the year-to-year variation in winning rates. In contrast, in areas with a higher number of filings, the typical winning rate may not vary meaningfully from year-to-year given that there are simply more individuals with a random chance of winning the lottery. This may have the effect of forcing our identification to rely entirely on 3-digit zip codes with fewer filers.

To determine the extent to which this is the case, we divide our sample into terciles based on the average number of filers over our sample period, with the first tercile having the fewest filers, and the third tercile having the most. For each 3-digit zip code, we calculate the mean time-series standard deviation and then compute the mean of the time-series standard deviation for each tercile. The results which we present in Panel C of Table 2, show, as we intuitively expect, that the

[8] There are 845 unique 3-digit zip codes with data in at least two years in our sample.

time-series variation decreases as the number of filings increases. However, and most pertinent to our study is that even in the tercile with the largest number of filings, the mean time-series standard deviation (0.128) still has an economically meaningful amount of variation from year to year. Assuming a normal distribution, the findings documented in Panel C suggest that the interquartile range (from the 25th to the 75th percentile) variation of the winning rate in the 3-digit zip codes with the largest number of filings is from 0.46 to 0.63.[9] In Panel D, we replicate the analysis from Panel C while dividing localities into terciles based on population rather than number of H-1B filings and find quantitatively and qualitatively similar results.

Taken together, the results in Table 2 help to allay any concerns about the amount of statistical variation in the winning rate. The results suggest that there is substantial and meaningful variation in the winning rate both across localities in any given year, and within any locality across time.[10] Finally, it is worth noting that the mean winning rate does not differ significantly across terciles constituted either by population or the number of H-1B filings.

4.3. Empirical Specification

As we have discussed, it is inherently challenging to study the relationship between the arrival of highly skilled immigrant workers in an area and its housing price appreciation. There is little data on the exact inflow of highly skilled immigrant into a local area. More importantly, there is a plausible omitted variable issue when studying the association between immigrant inflows and housing prices. Local areas with good living conditions (e.g., low crime rate, desirable amenities,

[9] As shown in Panel C Table 2, the mean for the highest tercile is 0.544 and the average standard deviation is 0.128.
[10] In robustness tests (section 5.4; Table 6) we examine the impact of the winning rate on house prices in separate subsamples of localities with a smaller and larger number of H-1B filings respectively.

etc.) tend to experience housing price increases. At the same time, these desired living conditions make these areas more attractive to highly skilled immigrants who seek to migrate to the United States from outside of the country.

We address these difficulties by using the winning rate in the H-1B lottery program as our measure of shocks to highly skilled immigrant flow into a locality (3-digit zip code). Consider a 3-digit ZIP code area *i* in year *t*. The effect of the immigration shock on house price excess appreciation can be determined by estimating the following:

$$Excess\ Appreciation_{i,t+1} = \alpha + \beta \times \ln \Delta P_{it} + \Gamma \times Controls_{it} + \delta_t + \eta_i + \varepsilon_{i,t} \quad (3)$$

The immigration shock in this context, ΔP_{kt}, can be defined as:

$$\Delta P_{kt} = \frac{\Delta H1B_{it}}{POP_{i0}} \quad (4)$$

where $\Delta H1B_{kt}$ is the number of new H-1B arrivals in area *i* at time *t*. POP_{i0} is the baseline population of the area, set to the population for each area *i* to just prior to the beginning of the sample period (*t = 0*) to avoid cumulative endogeneity in population over the sample period.

If we assume that each locality has an underlying endogenous number of annual H-1B filing applications, denoted $FH1B_{io}$, which is driven by (partly unobservable) local economic and demographic conditions, then, the actual number of H-1B applications in area *i* at time *t* can be expressed as:

$$FH1B_{it} = FH1B_{io} + \epsilon_{it}, \quad \epsilon_{it} \sim N(0, \sigma^2) \quad (5)$$

Let W_{it} denote the exogenous (random) $Winning\ Rate$ in area i in year t. Then the number of new H-1B arrivals is given by:

$$\Delta H1B_{it} = (FH1B_{io} + \epsilon_{it}) \times W_{it} \qquad (6)$$

Substituting (6) into the immigration shock definition, ΔP_{kt}, in (4), we get:

$$\Delta P_{it} = \frac{\Delta H1B_{it}}{POP_{i0}} = \frac{(FH1B_{io} + \epsilon_{it}) \times W_{it}}{POP_{i0}} \qquad (7)$$

Econometrically, this implies that $\ln \Delta P_{it}$ can be written as:

$$\ln \Delta P_{it} = \gamma \times W_{it} + \lambda \times \frac{FH1B_{io}}{POP_{i0}} + \zeta_{it} \qquad (8)$$

Substituting (8) in (3) and noting that second term of (6) will be subsumed in the 3-digit-zip-code fixed effect, our empirical model can then be written as:

$$Excess\ Appreciation_{i,t+1} = \alpha + \beta \times Winning\ Rate_{i,t} + \gamma \times Ln(\#\ Total\ Filings)_{i,t} + \delta_t + \eta_i + \varepsilon_{i,t} \qquad (9)$$

where i represents the 3-digit zip code area and t is the year. δ_t represents year fixed effects, and η_i represents location (3-digit zip code) fixed effects to account for any variations in housing price that are due to certain time periods (e.g., the appreciation in housing prices following the 2008

financial crisis), or specific areas, respectively.[11] We include the total number of filings to account for the possibility that it may be systematically correlated with both house price appreciation and H-1B lottery winning rate.[12]

5. Results

5.1. Baseline findings

We perform our baseline analysis on the association between H-1B lottery winning rates and subsequent house prices using the specification in Eq. (9). We report the findings in Table 3. Column (1) includes only year fixed effects while column (2) includes only location fixed effects. As shown, we find a positive and statistically significant relationship between the H-1B lottery *winning rate* and excess appreciation of housing price in the following year. We include both time and location fixed effects in column (3) and find similar results. The robustness of our results to the inclusion of location fixed effects is especially insightful as it indicates that, within a particular locality, house prices are higher following a higher winning rate than in other years. This suggests that our results persist even if we account for fixed local attributes that are unlikely to change significantly over our sample period including geography, local amenities, and historical (pre-sample-period) immigration patterns

In terms of economic magnitude, findings from our most stringent model (i.e., column (3) with year and location fixed effects) suggest that a one standard deviation increase in H-1B lottery *winning rate* (0.286) is associated with a 0.0043 increase in housing price excess appreciation over

[11] A potential alternative specification is to measure the immigration shock as the number of newly arrived H-1Bs as a percentage of the baseline population and use the winning rate as instrument for that endogenous variable. We discuss this and its implications for our results in Section 5.8. We find that this does not affect our inference.
[12] In un-tabulated analysis, we find that dropping the number of H-1B filings does not change our inference.

the next year. Given that the mean value of excess appreciation is –0.025 during the sample period, the increase of 0.0043 translates to 17.2% of the magnitude of mean housing price excess appreciation. Therefore, our findings show that exogenous increases in the arrival of highly skilled immigrants to an area is associated with a statistically significant and economically meaningful housing price appreciation in that area.[13]

5.2. Additional Controls

Table 3 presents findings from our baseline specification with fixed effects to account for variation that is unique to specific time periods and/or certain locations. It is, however, possible that these fixed effects do not completely capture time-varying factors that may also affect local housing prices. In this subsection, we consider this possibility by including and examining the impact of the following six additional control variables on the inference from our baseline specification.

(i) *Population*: The total population in an area may influence the rate of house price appreciation in a locality. At the same time, population size may itself be a determinant of the number of H-1B filings in that location. Furthermore, the number of filings may subsequently affect the winning rate. To account for this, we include the level of population in the 3-digit ZIP code as a control variable.

[13] There are 875 3-digit zip codes in the U.S. which suggests that, over the six-year period of our sample, we would expect to have 5,250 3-digit-zip-code-year observations. However, as we note in section 4.1, the intersection of our data sources leaves us with 4,855 3-digit-zip-code-year observations. It is possible that that the 395 missing 3-digit-zip code years are not a random selection. To investigate this possibility, we run a simulation with 1,000 iterations in which randomly drop 395 3-digit-zip code years from the full sample of 5,250 3-digit-zip-code-years in each iteration, and run the empirical specification reported in column (3) of Table 4. We find that the mean coefficient on the winning rate from this simulation is 0.0096, with a mean standard error of 0.05, which is quantitatively and qualitatively similar to the results reported in Table 4.

(ii) *Average wage*: Local prevailing wages are likely to be associated with house prices, as areas with higher wages tend to experience higher demand in the housing market. H-1B regulations require employers to pay foreign workers a wage that meets or exceeds the prevailing wage for the position in the area. Given that H-1B applicants are more likely to be drawn to areas with higher wages, local wage levels may affect the volume of H-1B filings. We therefore include the average wage reported on H-1B filings in the locality as a control variable.

(iii) *Change in population*: Shifts in population over time can directly influence house price trends in a given area and may also affect the number of H-1B filings originating from that locality. Accordingly, we include the change in population as a control variable.

(iv) *Unemployment rate*: Housing price dynamics are likely to be influenced by the prevailing unemployment rate in a locality. Likewise, the local employment environment may impact the number of H-1B filings. To control for this, we include the change in the unemployment rate, derived by aggregating county-level annual unemployment data from the U.S. Bureau of Labor Statistics to the 3-digit ZIP code level.

(v) *Gross income*: As with other economic variables discussed above, we expect local income levels to influence house prices. At the same time, H-1B application volumes are likely to be higher in areas with greater income levels. We include as a control the change in average gross income in the area, defined using IRS data as the annual adjusted gross income reported by individuals on their tax returns, averaged at the 3-digit ZIP code level.

(vi) *Graduate Degrees*: The level of educational attainment in a locality plays a key role in housing market dynamics (Beracha, Gilbert, Kjorstad, and Womack, 2018). H-1B eligibility rules explicitly favor applicants with graduate degrees. Moreover, the types of positions for which firms

typically sponsor H-1B visas often require graduate-level education. Such individuals are also more likely to be attracted to regions with high levels of innovation and local amenities (Beracha, He, Wintoki, and Xi, 2023). As a result, the number of graduate degree holders in an area may affect both the number of H-1B filings and the winning rate. We include the change in the percentage of graduate degree holders at the state level as a control, using data from the National Center for Education Statistics.

In Table 4, we report the results from adding these additional controls to our baseline specification. We continue to observe a statistically significant positive association between shocks to highly skilled immigrant inflow and subsequent excess appreciation in housing price. In addition, the economic magnitudes of the effect of the winning rate on house price appreciation in Table 4 are of a similar order to those reported for our baseline specification in Table 3. These findings suggest that H-1B lottery winning rates forecast housing price excess appreciation beyond what can be forecasted by the additional control variables. Taken together with the findings in Table 3, these results provide support for Hypothesis 1.[14]

5.3. Areas with fast population growth

Our baseline results show that the exogenous arrival of highly skilled immigrants to an area is associated with significant appreciation in local housing prices. Given that the influx of highly skilled immigrants increases direct demand for housing while also boosting the local economy and the wealth of incumbent workers, we predict (Hypotheses 2) that the effect on housing prices from highly skilled immigrant workers will be magnified in economically thriving areas experiencing

[14] We retain these control variables in our subsequent analyses.

rapid population growth. We investigate this hypothesis by dividing our sample into two groups based on whether an area has a population growth that is below (i.e., *slow growth*) or above (i.e., *fast growth*) the median 3-digit zip code area in the U.S. in that year and estimate the impact of the *winning rate* on excess price appreciation in each subsample.

We present the results of these analyses in Table 5. Column (1) shows the findings from the subsample of slow population growth areas, and column (2) shows those for areas with fast population growth, respectively. The results suggest that the association between the influx of highly skilled immigrants and subsequent local housing price appreciation is magnified in localities with fast population growth. We also study this differential effect using an interaction between the H-1B lottery *winning rate* and an indicator variable, *Fast Growth*, which takes a value of one for areas with population growth above the median population growth in the U.S. in that year, and a value of zero otherwise. Column (3) documents the findings. Consistent with results from our subsample analysis, the positive association between H-1B lottery winning rates and local housing price appreciation is more pronounced in areas with fast population growth. Taken together, these findings provide support for our Hypothesis 2.

5.4. Areas with a large number H-1B visa petitions

We next test our Hypothesis 3 that the association between housing price excess appreciation and the influx of highly skilled immigrant workers will be magnified in areas which, owing to their economic dynamism, already have high underlying demands for skilled workers. We follow a similar approach to that taken in Table 5 by first splitting our sample into two groups based on whether an area's number of H-1B petition filings is below the national median in that

year (i.e., *Small # Filing*) or above the national median in that year (i.e., *Large # Filing*), and estimate the impact of the *winning rate* on excess housing price appreciation in each subsample.

We present the results of this analysis in Table 6. Column (1) shows the findings from the subsample of areas with the number of H-1B petitions below the median, and column (2) shows those for areas with the number of H-1B petitions above the median, respectively. As shown, the positive association between H-1B lottery winning rates and subsequent local housing price appreciation is driven mostly by areas with a large number H-1B petitions. We also test Hypothesis 3 using an interaction between the H-1B lottery *winning rate* and population growth. The results, which we present in column (3) of Table 6, support the findings from columns (1) and (2) and show that the association between housing price excess appreciation and the influx of highly skilled immigrant workers is magnified in areas with large numbers of H-1B petitions.

The findings in this subsection also address another possibility: the underlying driver of our findings is the potential volatility of winning rates in localities with relatively fewer H-1B filings. This possibility would raise significant concerns with respect to our use of the winning rate to credibly identify exogenous flows of skilled immigrants. As we note in the Introduction, within a particular locality, the average winning rate may exhibit more temporal variation in areas with fewer H-1B filers than in areas with many filings. This is because in areas with fewer filings, the presence (or lack of) H-1B lottery winners in a particular year could result in unusually large (or small) winning rates, given the smaller base of filings. This could result in a situation in which our identification rests largely on localities with fewer H1-B filings. However, the results in Table 6

suggest that this is not the case. We find that the relationship between the winning rate and house prices is significantly more pronounced in areas with a large number of filings.[15]

5.5. Areas with more limited land supply

Hypothesis 4 considers the impact of land supply. We investigate the impact of available land by using the land elasticity measure developed by Saiz (2010). Areas with lower land supply elasticity typically have less available land for the development of new homes. We carry out this analysis in a similar fashion to that conducted in Tables 5 and 6 by first assigning our sample 3-digit zip-code areas into two subsamples: a *Low Elasticity* group and a *High Elasticity* group based on whether the area's land elasticity measure is below or above the national median, respectively. We then examine the impact of the *winning rate* on excess price appreciation in each subsample.

We present our findings in Table 7. We note that this sample is much smaller than our main sample because the land elasticity measure is not available for all 3-digit zip-code areas. We are able to identify this information for 477 3-digit zip-code areas, which represents 57% of the 3-digit zip code areas of our sample. However, despite the smaller sample, our results suggest that the association between H-1B lottery *winning rate* and subsequent local housing price appreciation is mainly driven by areas with less elastic land supply. The coefficient estimate on *winning rate* is positive and significant in column (1) where the sample contains low land elasticity areas, but not significant in column (2) where the sample contains high land elasticity areas. We find similar results in column (3), where we use our full sample and interact *winning rate* with (the natural log of) land elasticity. The coefficient estimate on the interaction between winning rate and *Ln*

[15] In un-tabulated analysis, we find that the relationship between the H-1B winning rate and house prices remains significantly positive even when restricting our sample to those localities in which the number of filings is in the top quintile of filings across all localities.

(Elasticity) is negative and significant, suggesting that the association between H-1B lottery *winning rate* and local housing price appreciation is more pronounced in areas with less elastic land supply as we predict in Hypothesis 4.

5.6. Highly skilled immigrants and local rents

We next examine the impact of the influx of highly skilled immigrants on rental prices. We test our prediction (Hypothesis 5) that the inflow of highly skilled immigrants to an area has a smaller impact on local housing rents. To do this, we employ Eq. (3) with housing price excess appreciation replaced by the changes in rent in the local area and estimate the effect of the H-1B *winning rate* on the change in rent.

We present our findings in Table 8. In column (1), we examine the association between subsequent changes in the rental prices of two-bedroom units and the H-1B lottery winning rate. As shown, the winning rate is not significantly associated with subsequent changes in rents in two-bedroom units in the local area. It may be argued, however, that H-1B workers, who earn substantially higher wages than other workers in the areas, are more likely to rent bigger homes. Accordingly, in column (2), we examine the association between subsequent changes in the rental prices of four-bedroom units and the H-1B winning rate. As is the case with two-bedroom units, we find no significant association between changes in subsequent four-bedroom rental rates and the winning rate. Therefore, our findings do not support (or contradict) Hypothesis 5 and may suggest that the inflow of highly skilled immigrant workers has an indirect "trickle down" and therefore delayed effect on local rents because, as we conjecture, they are more likely to engage in the market to purchase houses.

5.7. Robustness test: Removing California

One alternative explanation for our results is that they are driven by the state of California, a high population state that has a disproportionate share of H-1B visa petitions. For example, California includes Silicon Valley, an area which over the past several decades has both attracted many high skilled immigrant workers while experiencing significantly high housing price appreciation over our sample period. Indeed, while California accounts for 7.9% of the 3-digit zip codes in our sample, the state accounts for 9.1% of H-1B applications and 9.9% of H-1B lottery winners. To address the concern that California may have a disproportionate impact on our inference, we test the robustness of our results by removing California from our sample when estimating the effect of the winning rate on excess housing price appreciation as specified in equation (3).

We present our results in Table 9. We find that removing California from our sample does not qualitatively or quantitatively change our inference. We continue to find that an unexpected influx of highly skilled immigrants into an area is associated with an increase in local house prices.

5.8. Alternative specification: Winning rate as an instrument in a 2SLS framework

Our primary analysis in this paper is based on the empirical model specified in Equation (3), which uses the $Winning\ Rate$ as a proxy for the exogenous shock to immigrant inflows into a locality. As an alternative specification, one could directly measure the immigration shock as the number of new H-1B arrivals in an area ($\Delta H1B$), expressed as a percentage of the population (POP), and write our empirical specification as:

$$Excess\ Appreciation_{k,t+1} = \alpha + \beta \times \frac{\Delta H1B_{kt}}{POP_{kt}} + \Gamma \times Controls_{k,t} + \delta_t + \eta_k + \varepsilon_{k,t} \qquad (10)$$

However, this direct measure $\Delta H1B_{kt}/POP_{kt}$ is inherently endogenous, since the number of new H-1B arrivals depends on the number of filings.

If we again assume (as in Section 4.3) that each locality has an underlying endogenous number of annual H-1B filing applications, denoted $FH1B_{ko}$, which is driven by (partly unobservable) local economic and demographic conditions, then, the actual number of H-1B applications in area k at time t can be expressed as $FH1B_{kt} = FH1B_{ko} + \varepsilon_{kt}, \quad \varepsilon_{kt} \sim N(0, \sigma^2)$. If W_{kt} denotes the exogenous (random) $Winning\ Rate$ in area k in year t, then the number of new H-1B arrivals is given by:

$$\frac{\Delta H1B_{kt}}{POP_{kt}} = \frac{(FH1B_{ko} + \epsilon_{kt}) \times W_{kt}}{POP_{kt}} \qquad (11)$$

Equation (11) illustrates that although the directly computed immigration shock – i.e., the number of H-1B arrivals relative to the baseline population – is endogenous, it can be decomposed into an endogenous component ($FH1B_{ko}$) and an exogenous component (W_{kt}), the random winning rate. This decomposition provides a rationale for using W_{kt} as an instrument for $\Delta H1B_{kt}/POP_{kt}$ in a two-stage least squares (2SLS) estimation. Accordingly, we can estimate (10) using 2SLS, where W_{kt} serves as the instrumental variable in the first stage:

The results of the 2SLS estimation are reported in Table 10. In the first-stage regression, we find that the *Winning Rate* is a strong predictor of the directly measured immigration shock (i.e., $\Delta H1B_{kt}/POP_{kt}$), with an estimated coefficient of 0.126 and a *t*-statistic of 8.18. In the second

stage, we find that this direct immigration shock measure is positively and significantly associated with excess housing price appreciation. These results reinforce the conclusions drawn from our baseline estimation in (9), confirming the robustness of our findings.

6. Conclusion

How immigration affects local economies has been an important topic that practitioners, policymakers, and academic researchers seek to understand. In recent years, the H-1B program for highly skilled immigrants has been oversubscribed such that allocation has been determined by a lottery process. This random allocation provides a unique opportunity to examine the role of immigration in forecasting housing prices by creating exogenous shocks to the influx of a clearly identifiable group of immigrants into a specific locality. In this paper, we shed light on whether and the extent to which the inflow of highly skilled immigrants to an area through this program predicts local housing prices.

Using the H-1B lottery program's winning rates for firms in an area as an exogenous shock to the inflow of highly skilled immigrants, we find a statistically significant positive association between highly skilled immigrant labor shock (i.e., H-1B lottery winning rate) and housing prices in a local area. Economically, our results suggest that a one standard deviation increase in H-1B lottery winning rate is associated with a 17% increase in excess appreciation in local housing prices in the following year, when compared to the sample mean. These findings suggest that highly skilled immigrants' impact on local housing prices is both statistically significant and economically meaningful. In addition, we find that this positive relationship is more pronounced in areas with faster population growth (i.e., higher demand for housing), more H-1B petitions (i.e.,

better economy), and lower land supply elasticity (i.e., limited available land). In addition, we show that, although the inflow of H-1B workers has significant contributions to local housing price appreciation, their presence is not significantly associated with subsequent changes in local rents.

Our findings make several contributions to existing literature. First, we add to the literature that tries to understand how immigration affects local economies. We show that highly skilled labor influx to an area positively affects house prices, an important aspect of local economy. Second, our study adds to the efforts to the broader understanding of the determinants of changes in housing prices while trying to alleviate potential endogeneity concerns. Finally, our findings contribute to the ongoing debate among policy makers regarding the H-1B program. To the best of our knowledge, we are the first to quantify the ability of highly skilled immigrant inflows in forecasting prices in local housing markets.

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Table 1: Sample description

This table reports sample statistics for our regression sample of 4,855 3-digit zip code-years between January 2014 and December 2019 with H-1B visa application winning rates, housing price index (HPI), and population information. Each panel reports the number of observations, means, standard deviations, medians, and inner quartile statistics for our sample. Table A1 in Appendix A provides variable definitions.

Descriptive Statistics – Full Sample

Variable	N	Mean	SD	Pctl(25)	Median	Pctl(75)
Average Winning Rate	4,855	0.571	0.286	0.424	0.571	0.750
Excess Appreciation	4,855	–0.025	0.097	–0.095	–0.040	0.025
Ln(Excess appreciation)	4,855	–0.031	0.096	–0.099	–0.041	0.025
Total Population	4,855	407,371	371,808	163,836	286,313	520,948
Δ Population	4,855	0.004	0.008	–0.001	0.003	0.009
Graduate Degree	4,855	11.868	2.725	9.865	11.305	12.961
Ln(Unemployment Rate)	4,855	1.744	0.250	1.569	1.732	1.927
Ln(Gross Income)	4,855	10.796	0.985	10.053	10.786	11.596
Δ Graduate Degree	4,855	–0.374	0.091	–0.431	–0.389	–0.336
Δ Unemployment Rate	4,855	–0.101	0.076	–0.156	–0.108	–0.054
Δ Gross Income	4,855	0.043	0.078	0.018	0.044	0.067
Ln(# Total Filings)	4,855	2.763	1.873	1.099	2.303	3.829
Ln(Wage)	4,855	11.056	0.312	10.887	11.037	11.183
Ln(Δ Rent 2 Br)	3,120	0.036	0.043	0.009	0.032	0.057
Ln(Δ Rent 4 Br)	3,120	0.036	0.050	0.006	0.031	0.062

Table 2: Randomness of the Main Variable – Winning Rate

This table reports statistics of H-1B visa application winning rates by 3-digit zip code-years between January 2014 and December 2019. Panel A presents descriptive statistics of winning rates by year. Panel B reports the results of bootstrapping simulations on computing standard deviations of randomized 3-digit zip code areas. Panel C presents mean and standard deviation values of winning rates by tercile groups based on the total number of applications, and Panel D presents mean and standard deviation values of winning rates by tercile groups based on the total population. Table A1 in Appendix A provides variable definitions.

Panel A. Average Winning Rate by Year

Year	N	Mean	SD	Pctl(25)	Median	Pctl(75)
2014	835	0.660	0.277	0.528	0.667	0.867
2015	856	0.600	0.278	0.500	0.622	0.750
2016	845	0.532	0.276	0.417	0.531	0.675
2017	851	0.480	0.281	0.333	0.500	0.625
2018	732	0.564	0.294	0.397	0.521	0.755
2019	736	0.592	0.280	0.433	0.565	0.782

Panel B. Bootstrapping the mean of standard deviations by randomized 3-digit zip code

Sample	N	Repetition	Mean
Randomized Sample 1	20	1	0.234
Randomized Sample 2	20	1	0.279
Randomized Sample 3	20	1	0.288
Randomized Sample 4	20	1	0.255
Randomized Sample 5	20	1	0.233
Randomized Sample 6	20	1	0.263
Randomized Sample 7	20	1	0.213
Randomized Sample 8	20	1	0.240
Randomized Sample 9	20	1	0.239
Randomized Sample 10	20	1	0.260
Randomized Sample 11	845	1,000	0.237

Panel C. Mean of standard deviations by tercile groups based on the number of H-1B filings

Tercile	N	Mean	Avg SD by 3-Zip
1 (lowest)	1,631	0.587	0.335
2	1,609	0.581	0.229
3 (highest)	1,615	0.544	0.128
Full Sample	4,855	0.571	0.237

Panel D. Mean of standard deviations by tercile groups based on the total population

Tercile	N	Mean	SD	Avg SD by 3-Zip
1 (lowest)	1,626	0.566	0.360	0.297
2	1,616	0.577	0.288	0.250
3 (highest)	1,613	0.569	0.181	0.151
Full Sample	4,855	0.571	0.286	0.237

Table 3: The effect of winning rate on excess appreciation

This table reports results from regressions measuring the baseline association between accumulated excess appreciation over the next 4 quarters and the H-1B lottery winning rate. The dependent variable is the accumulated value of excess appreciation, which is the difference between the change in housing price index (HPI) in 3-digit zip code *i* from quarter *q* to quarter *q+4* in year *t*, and the change in the national housing price index (HPI) from quarter *q* to quarter *q+4* in year *t*. *Ln (# Total Filings)* is the natural log of the total number of H-1B visa applications submitted in each 3-digit zip code area and year. The sample period is from 2014 to 2019. All other variables are defined in Table A1 in the Appendix. Standard errors are clustered by 3-digit zip code. *t*-statistics are reported in parentheses. *, **, and *** represent statistical significance at the 10%, 5%, and 1% levels, respectively.

	(1) Excess Appreciation	(2) Excess Appreciation	(3) Excess Appreciation
Winning Rate	0.0221***	0.0401***	0.0149***
	(3.95)	(5.82)	(3.46)
Ln (# Total Filings)	0.0122***	–0.0012	0.0072**
	(3.01)	(–0.28)	(2.48)
Constant	–0.0301***	–0.0227***	–0.0190***
	(–4.40)	(–2.91)	(–3.75)
Year FE	Yes	No	Yes
3-digit Zip Code FE	No	Yes	Yes
Adj. R-squared	0.360	0.371	0.716
Observations	5,420	5,380	5,380

Table 4: The effect of winning rate on excess appreciation – Additional controls

This table reports results from regressions measuring the association between accumulated excess appreciation over the next 4 quarters and the H-1B lottery winning rate while including various control variables. The dependent variable is the accumulated value of excess appreciation, which is the difference between the change in housing price index (HPI) in 3-digit zip code *i* from quarter *q* to quarter *q+4* in year *t*, and the change in the national housing price index (HPI) from quarter *q* to quarter *q+4* in year *t*. *Ln (# Total Filings)* is the natural log of the total number of H-1B visa applications submitted in each 3-digit zip code area and year. All other variables are defined in Table A1 in the Appendix. Standard errors are clustered by 3-digit zip code. *t*-statistics are reported in parentheses. *, **, and *** represent statistical significance at the 10%, 5%, and 1% levels, respectively.

	(1) Excess Appreciation	(2) Excess Appreciation	(3) Excess Appreciation
Winning Rate	0.0148***	0.0074*	0.0097***
	(3.08)	(1.81)	(2.59)
Ln (# Total Filings)	–0.0025	0.0073**	0.0052*
	(–0.80)	(2.52)	(1.92)
Ln (Wage)	0.0024	0.0053	–0.0059
	(0.52)	(1.28)	(–1.50)
Ln (Population)	0.0188***	–1.108***	–1.536***
	(6.42)	(–9.04)	(–12.25)
Δ Population	3.865***	1.950***	3.166***
	(13.35)	(5.27)	(8.44)
Δ Unemployment Rate	–0.158***	0.0577***	–0.0848***
	(–7.06)	(2.84)	(–4.60)
Δ Gross Income	0.242***	0.101***	0.119***
	(10.53)	(8.56)	(6.91)
Δ Graduate Degree	–0.137***	0.565***	0.231***
	(–6.22)	(8.66)	(3.75)
Constant	–0.388***	14.04***	19.41***
	(–6.24)	(9.12)	(12.31)
Year FE	Yes	No	Yes
3-digit Zip Code FE	No	Yes	Yes
Adj. R-squared	0.299	0.614	0.664
Observations	4,855	4,813	4,813

Table 5: The effect of winning rate on excess appreciation by population growth

This table reports results from regressions measuring the association between accumulated excess appreciation over the next 4 quarters and the H-1B lottery winning rate by population growth level. The first column uses the sample that has population change below the national median, and the second column uses the sample that has population change above the national median. The third column uses the full sample. The dependent variable is the accumulated value of excess appreciation, which is the difference between the change in housing price index (HPI) in 3-digit zip code *i* from quarter *q* to quarter *q+4* in year *t*, and the change in the national housing price index (HPI) from quarter *q* to quarter *q+4* in year *t*. *Fast growth* in column (3) is an indicator variable taking a value of one if the area experiences a population change above the national median during the fiscal year, and zero otherwise. *Ln (# Total Filings)* is the natural log of the total number of H-1B visa applications submitted in each 3-digit zip code area and year. The sample period is from 2014 to 2019. All other variables are defined in Table A1 in the Appendix. Standard errors are clustered by 3-digit zip code. *t*-statistics are reported in parentheses. *, **, and *** represent statistical significance at the 10%, 5%, and 1% levels, respectively.

	(1) Excess Appreciation (Slow Growth)	(2) Excess Appreciation (Fast Growth)	(3) Excess Appreciation (Full Sample)
Winning Rate	0.0035	0.0232***	0.0075**
	(0.87)	(3.52)	(2.34)
Winning Rate × Δ Population			0.866**
			(2.00)
Δ Population	2.515***	4.212***	2.659***
	(5.04)	(5.69)	(7.15)
Ln (# Total Filings)	–0.0008	0.0151***	0.0054***
	(–0.34)	(3.43)	(2.68)
Ln (Wage)	–0.0063	–0.0087	–0.0060**
	(–1.37)	(–1.30)	(–2.00)
Ln (Population)	–0.985***	–1.758***	–1.520***
	(–4.36)	(–8.13)	(–18.17)
Δ Unemployment Rate	–0.0122	–0.154***	–0.0858***
	(–0.62)	(–4.66)	(–5.95)
Δ Gross Income	0.0542***	0.133***	0.119***
	(2.60)	(5.42)	(7.09)
Δ Graduate Degree	0.203***	0.220**	0.230***
	(2.75)	(2.09)	(4.23)
Constant	12.17***	22.75***	19.20***
	(4.39)	(8.18)	(18.31)
Year FE	Yes	Yes	Yes
3-digit Zip Code FE	Yes	Yes	Yes
Adj. R-squared	0.649	0.639	0.664
Observations	2,302	2,350	4,813

Table 6: The effect of winning rate on excess appreciation by the level of application filings

This table reports results from regressions measuring the association between accumulated excess appreciation over the next 4 quarters and the H-1B lottery winning rate by the level of H-1B visa application filings. The first column uses the sample that experiences the total number of H-1B visa application filings below the national median, and the second column uses the sample that experiences the total number of H-1B visa application filings above the national median. The third column uses the full sample. The dependent variable is the accumulated value of excess appreciation, which is the difference between the change in housing price index (HPI) in 3-digit zip code *i* from quarter *q* to quarter *q+4* in year *t*, and the change in the national housing price index (HPI) from quarter *q* to quarter *q+4* in year *t*. *Large # Filing* in column (3) is an indicator variable taking a value of one if the area has the total number of H-1B visa applications filed above the national median during the fiscal year, and zero otherwise. *Ln (# Total Filings)* is the natural log of the total number of H-1B visa applications submitted in each 3-digit zip code area and year. The sample period is from 2014 to 2019. All other variables are defined in Table A1 in the Appendix. Standard errors are clustered by 3-digit zip code. *t*-statistics are reported in parentheses. *, **, and *** represent statistical significance at the 10%, 5%, and 1% levels, respectively.

	(1) Excess Appreciation (Small # Filing)	(2) Excess Appreciation (Large # Filing)	(3) Excess Appreciation (Full Sample)
Winning Rate	0.0005	0.0208*	0.0047
	(0.12)	(1.65)	(1.23)
Winning Rate × Large # Filing			0.0419***
			(3.56)
Large # Filing			–0.0262***
			(–3.23)
Ln(# Total Filings)	–0.0010	0.0098**	0.0066**
	(–0.21)	(2.12)	(2.16)
Ln(Wage)	–0.0039	–0.0202	–0.0065
	(–0.99)	(–1.42)	(–1.64)
Ln(Population)	–0.888***	–1.757***	–1.511***
	(–6.09)	(–8.87)	(–12.14)
Δ Population	1.611***	4.085***	3.083***
	(4.14)	(6.54)	(8.34)
Δ Unemployment Rate	–0.0413*	–0.106***	–0.0824***
	(–1.68)	(–4.00)	(–4.50)
Δ Gross Income	0.0862***	0.138***	0.117***
	(3.56)	(5.11)	(6.82)
Δ Graduate Degree	0.234***	0.293**	0.237***
	(3.27)	(2.32)	(3.85)
Constant	10.90***	23.19***	19.11***
	(6.13)	(8.94)	(12.21)
Year FE	Yes	Yes	Yes
3-digit Zip Code FE	Yes	Yes	Yes
Adj. R-squared	0.708	0.654	0.665
Observations	2,587	2,129	4,813

Table 7: The effect of winning rate on excess appreciation by land elasticity

This table reports results from regressions measuring the association between accumulated excess appreciation over the next 4 quarters and the H-1B lottery winning rate by MSA-level land elasticity. The first column uses the MSAs with land supply elasticity below the national median, and the second column uses the MSAs with land supply elasticity above the national median. The third column uses the full sample. The dependent variable is the accumulated value of excess appreciation, which is the difference between the change in housing price index (HPI) in 3-digit zip code *i* from quarter *q* to quarter *q+4* in year *t*, and the change in the national housing price index (HPI) from quarter *q* to quarter *q+4* in year *t*. *Low elasticity* is an indicator variable taking a value of one if a MSA area has land supply elasticity below the national median during the fiscal year, and zero otherwise. *Ln (# Total Filings)* is the natural log of the total number of H-1B visa applications submitted in each 3-digit zip code area and year. The sample period is from 2014 to 2019. All other variables are defined in Table A1 in Appendix A. Standard errors are clustered by 3-digit zip code. *t*-statistics are reported in parentheses. *, **, and *** represent statistical significance at the 10%, 5%, and 1% levels, respectively.

	(1) Excess Appreciation (Low Elasticity)	(2) Excess Appreciation (High Elasticity)	(3) Excess Appreciation (Full Sample)
Winning Rate	0.0176*	0.0026	0.0528**
	(1.83)	(0.42)	(2.30)
Winning Rate × Ln (Elasticity)			–0.0344**
			(–2.01)
Ln (Elasticity)			–0.0131
			(–0.72)
Ln (# Total Filings)	0.0204***	–0.0031	0.0103***
	(3.58)	(–0.80)	(2.74)
Ln (Wage)	0.0150	–0.0044	–0.0001
	(1.38)	(–0.58)	(–0.01)
Ln (Population)	–2.310***	–1.327***	–1.880***
	(–7.79)	(–7.66)	(–11.33)
Δ Population	4.893***	2.601***	3.804***
	(4.86)	(4.39)	(5.94)
Δ Unemployment Rate	–0.136***	–0.0257	–0.0757***
	(–3.42)	(–0.93)	(–3.01)
Δ Gross Income	0.144***	0.0330	0.0937***
	(3.83)	(1.15)	(3.68)
Δ Graduate Degree	0.476***	0.144	0.267***
	(2.99)	(1.39)	(2.93)
Constant	29.72***	16.86***	24.08***
	(7.79)	(7.75)	(11.43)
Year FE	Yes	Yes	Yes
3-digit Zip Code FE	Yes	Yes	Yes
Adj. R-squared	0.691	0.666	0.675
Observations	1,091	1,041	2,146

Table 8: The effect of winning rate on change in rent

This table reports results from regressions measuring the association between change in rent over the following year and the H-1B lottery winning rate. The dependent variable is the natural log of the change in rent, which is computed as the difference between rent in year *t+1* and *t* in a given Metropolitan Statistical Area (MSA) and divided by rent in year t. *Ln (# Total Filings)* is the natural log of the total number of H-1B visa applications submitted in each 3-digit zip code area and year. The sample period is from 2014 to 2019. All other variables are defined in Table A1 in Appendix A. Standard errors are clustered by 3-digit zip code. *t*-statistics are reported in parentheses. *, **, and *** represent statistical significance at the 10%, 5%, and 1% levels, respectively.

	(1) Ln (ΔRent 2 Br)	(2) Ln (ΔRent 4 Br)
Winning Rate	–0.0019	–0.0046
	(–0.49)	(–1.00)
Ln (# Total Filings)	–0.0008	–0.0023
	(–0.51)	(–1.24)
Ln (Wage)	0.0055	0.0060
	(1.39)	(1.24)
Ln (Population)	0.266***	0.218***
	(4.74)	(3.35)
Δ Population	0.0546	–0.0164
	(0.23)	(–0.06)
Δ Unemployment Rate	–0.0007	–0.0134
	(–0.05)	(–0.80)
Δ Gross Income	–0.0068	–0.0231
	(–0.44)	(–1.32)
Δ Graduate Degree	–0.0396	–0.0293
	(–0.68)	(–0.44)
Constant	–3.439***	–2.826***
	(–4.79)	(–3.39)
Year FE	Yes	Yes
3-digit Zip Code FE	Yes	Yes
Adj. R-squared	0.163	0.113
Observations	3,055	3,055

Table 9: The effect of winning rate on excess appreciation without California

This table reports results from regressions measuring the association between accumulated excess appreciation over the next 4 quarters and the H-1B lottery winning rate while excluding California. The dependent variable is the accumulated value of excess appreciation, which is the difference between the change in housing price index (HPI) in 3-digit zip code *i* from quarter *q* to quarter *q+4* in year *t*, and the change in the national housing price index (HPI) from quarter *q* to quarter *q+4* in year *t*. *Ln (# Total Filings)* is the natural log of the total number of H-1B visa applications submitted in each 3-digit zip code area and year. The sample period is from 2014 to 2019. All other variables are defined in Table A1 in Appendix A. Standard errors are clustered by 3-digit zip code. *t*-statistics are reported in parentheses. *, **, and *** represent statistical significance at the 10%, 5%, and 1% levels, respectively.

	Excess Appreciation
Winning Rate	0.0080**
	(2.19)
Ln (# Total Filings)	0.0020
	(0.82)
Ln (Wage)	–0.0028
	(–0.73)
Ln (Population)	–1.434***
	(–11.69)
Δ Population	2.124***
	(6.59)
Δ Unemployment Rate	–0.0576***
	(–3.08)
Δ Gross Income	0.1000***
	(5.93)
Δ Graduate Degree	0.127**
	(2.26)
Constant	17.99***
	(11.72)
Year FE	Yes
3-digit Zip Code FE	Yes
Adj. R-squared	0.705
Observations	4,449

Table 10: Robustness Tests

This table reports results from regressions measuring the association between accumulated excess appreciation and the H-1B lottery winning rate using a two stage least squares (2SLS) instrumental variable (IV) regression. The dependent variable in the first column (which serves as the first stage of the IV regression) is the total number of H-1B filings scaled by the population in year *t*. The second column reports results from the second stage IV regression where the dependent variable is the accumulated value of excess appreciation. *Ln (# Total Filings)* is the natural log of the total number of H-1B visa applications submitted in each 3-digit zip code area and year. The sample period is from 2014 to 2019. All variables are defined in Table A1 in Appendix A. Standard errors are clustered by 3-digit zip code. *t*-statistics are reported in parentheses. *, **, and *** represent statistical significance at the 10%, 5%, and 1% levels, respectively.

	(1) Δ Winning Number/Population (First Stage)	(2) Excess Appreciation (Second Stage)
Winning Rate	0.126***	
	(8.18)	
Instrumented (ΔWinning number/Population)		0.126***
		(3.13)
Ln (# Total Filings)	0.206***	–0.0184**
	(10.65)	(–2.21)
Ln (Wage)	–0.0253	–0.00416
	(–1.07)	(–0.75)
Δ Population	3.686**	1.135**
	(2.05)	(2.32)
Δ Unemployment Rate	–0.0685	–0.100***
	(–0.99)	(–4.48)
Δ Gross Income	–0.187	0.109***
	(–1.40)	(5.39)
Δ Graduate Degree	–0.584*	0.344***
	(–1.91)	(4.05)
Constant	–0.320	0.161**
	(–1.28)	(2.42)
Year FE	Yes	Yes
3-digit Zip Code FE	Yes	Yes
Adj. R-squared	0.871	0.625
Observations	3,520	3,520

Table A1: Variable Definitions

Variable	Definition
Winning Rate	The fraction of the number of H-1B visa applications that won initial screening lottery and the total number of H-1B visa applications submitted in a given year.
Excess Appreciation	The accumulated excess appreciation of the next 4 quarters. The excess appreciation in each quarter is the difference between the change in housing price index (HPI) in 3-digit zip code *i* from quarter *t* to quarter *t+4*, and this change in the national housing price index (HPI) from quarter t to quarter *t+4*. $$Excess\ Appreciation_{i,t+n} = \left(\frac{HPI_{i,t+n} - HPI_{i,t}}{HPI_{i,t}}\right) - \left(\frac{HPI_{national,t+n} - HPI_{national,t}}{HPI_{national,t}}\right)$$
HPI	House Price Index (HPI) is published by the Federal Housing Finance Agency (FHFA). The FHFA HPI data document quarterly HPI for each zip code in the United States.
Δ Population	The annual change in population in each 3-digit zip code area and quarter t.
Ln(# Filings)	The natural log of the total number of H-1B visa applications submitted each year.
Ln(Wage)	The natural log of prevailing wages on H-1B visa application submitted by employers.
Fast Growth	Indicator variable taking a value of one if the area experiences a population change above the national median during the fiscal year, and zero otherwise.
Large # Filing	Indicator variable taking a value of one if the area has the total number of H-1B visa applications filed above the national median during the fiscal year, and zero otherwise.
Δ Graduate Degree	The annual change in population with at least a graduate degree in each 3-digit zip code area and quarter t.
Δ Unemployment Rate	The annual change in unemployment rates in each 3-digit zip code area and quarter t.
Δ Gross Income	The annual change in adjusted gross income reported to IRS in each 3-digit zip code area and quarter t.

ΔH1B$_{kt}$/Pop$_{kt}$	Change of the number of winning applications (= The number of total H1-B filings × winning rate) scaled by the population in year t at the 3-digit zip code level, and the value is multiplied by 1,000 to facilitate the interpretation of regression coefficients.
Ln(ΔRent 2 Br)	$\Delta Rent\ 2\ Br_{i,t} = \left(\frac{Rent\ 2\ Br_{i,t+1} - Rent\ 2\ Br_{i,t}}{Rent\ 2\ Br_{i,t}}\right)$
Ln(ΔRent 4 Br)	$\Delta Rent\ 4\ Br_{i,t} = \left(\frac{Rent\ 4\ Br_{i,t+1} - Rent\ 4\ Br_{i,t}}{Rent\ 4\ Br_{i,t}}\right)$