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Does Household Registration Matter? Valuing Urban Hukou in China

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Valuing the Urban Hukou in China: Evidence from a Regression Discontinuity Design in Housing Price

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Abstract: This paper explores the demand side of *hukou* (household registration) acquisition in China by estimating the market valuation of urban hukou. According to the provisions in Jinan City's "Acquiring Hukou by Purchasing Houses" policy, this paper uses houses slightly larger than the minimum required floor area as the treatment group, and houses slightly smaller than the minimum required floor area as the control group to perform regression discontinuity design. Empirical results show that residents' willingness to pay for urban hukou in Jinan City was between approximately 90,000 and 126,000 yuan (RMB) in 2017. Our finding is robust to both parametric and nonparametric estimates and different model specifications. We also perform falsification tests by assuming a false policy introduction date and placebo tests based on rental data. Our analysis also offers insights for reform of the hukou system and designs for the provision of public services or welfare.

Keywords: Hukou system; Willingness to pay for hukou; Acquiring hukou by purchasing houses; Regression discontinuity design

JEL classifications: P25, H75, R38, J61

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1. Introduction

The hukou system, which is China's household registration system, is not only the method for population registration, but also the instrument by which a city government grants access to a variety of exclusive rights—most importantly, the right to enjoy certain public services and welfare. The hukou system was established in 1958 to control the influx of rural populations into cities and modernize the development of capital-intensive heavy industries (Lin et al., 1994; Cheng and Selden, 1994). Since then, an urban hukou has conferred access to residential welfare benefits. Substantial public services continue to be closely related to urban hukou, and cannot be enjoyed equally by "floating" populations (i.e., citizens seeking to relocate in an urban area). These services mainly consist of compulsory education for children, registration for local examinations, social insurance subsidies for nonworking individuals,

urban minimum subsistence allowances, affordable housing benefits, etc. (Wu and Zhang, 2010; Tao et al., 2011). From the perspective of individuals who seek urban hukou, the value can be measured as the individual's willingness to pay (WTP) for hukou. From the point of view of hukou suppliers (governments), they must bear the costs of these public services and welfare benefits, such as the construction and operating costs of schools and social security subsidies for nonworking individuals. Furthermore, the relevant analyses on both the demand and supply sides can be of significance for local governments' hukou granting policy design.

Many studies estimate the supply (cost) aspects of granting hukou. China's Research Group of the Ministry of Construction (2006) finds that for every additional individual in an urban population, it is necessary to increase the supporting fees for municipal public facilities. These are 20,000 yuan (RMB) in small cities, 30,000 in medium cities, 60,000 in large cities, and 100,000 in mega cities. The China Development Research Foundation (2010) finds that the average cost of peasant workers' citizenship in China is around 100,000 yuan. In terms of government expenditure for peasant workers' citizenship, based on investigations in Chongqing, Wuhan, Zhengzhou, and Jiaxing, the Research Group of the Development Research Center of the State Council (2011) calculated that the cost was between 77,000 yuan and 85,000 yuan. Qu and Cheng (2013), Zhang and Wu (2013), and Ding and Xu (2014) estimate the costs of granting urban hukou from different perspectives.

This paper fills an important gap by exploring the demand side of hukou granting in China. We aim to estimate the market valuation of urban hukou. To our best knowledge, previous studies have not provided a quantitative method for estimating market willingness to pay for urban hukou. In fact, the "transactions" of hukou have been recorded in China. As mentioned in Lu (2002), in the 1990s, governments in Lai'an and Quanjiao Counties in Chuzhou, Anhui Province, publicly sought investment at a rate of 5,000 yuan for one urban hukou. Within only a few days, the public income of these counties had increased by more than 3 million yuan. *The People's Daily* reported that the Beijing hukou could cost as much as 300,000 yuan on the

black market in 2013.[1]

This paper uses the clause that addresses “acquiring hukou by purchasing houses” in the settlement policies of certain large and medium-sized cities to perform discontinuity regression and empirically estimate the market value of urban hukou. These clauses stipulate the minimum floor area of a house required to apply for local hukou. The basic idea is that assuming the minimum floor area stipulated in the clause is measured in square meters (sq m), any migrant who intends to acquire hukou by purchasing a house must buy one of that size or larger. Otherwise, he or she cannot obtain local hukou or be granted access to the rights and benefits enjoyed by local residents. Therefore, we take houses slightly larger than the minimum required as the treatment group and houses slightly smaller than the minimum as the control group to perform regression discontinuity design.

Our analysis belongs to an active research strand that uses a combination of the hedonic pricing model (HPM) and natural experimental methods to evaluate policy effects or the value of non-market goods or services. Black (1999) uses boundary fixed-effects models to remove the variation in neighborhoods, taxes, school spending, etc., and precisely infers children's parents’ willingness to pay for better school quality. Gibbons et al. (2013) improve the methodology of boundary discontinuity regression by matching and weighting, and find that a one-standard-deviation change in either school average value-added or prior achievement raises prices by around 3%. Andreyeva and Patrick (2017) use the hedonic difference-in-differences model to separate the household’s willingness to pay for a charter school. Chay and Greenstone (2005) exploit the structure of the Clean Air Act to provide new evidence on the capitalization of total suspended particulates in air pollution into housing values. Moreover, a large strand of research focuses on different kinds of non-market goods and services. For example, Pope (2008a) estimates the value of airport noise using data from the housing market; Linden and Rockoff (2008) and Pope (2008b) estimate the value of crime reduction; and Bui and Mayer (2003) and Gayer, Hamilton, and Viscusi (2000) estimate the

[1] “What’s the Value of Hukou in China’s Mega Cities?” in *People's Daily*, Oct.11, 2013.

value of hazardous waste and toxic emissions.

This paper uses specifications for the floor area cutoff point (90 sq m) for housing purchases in Jinan City's urban hukou management policy, and conducts regression discontinuity design to evaluate residents' willingness to pay for urban hukou. Both the parametric estimation and the nonparametric estimation indicate that hukou rights causes the unit price of residential property to rise by about 1,000-1,400 yuan. In other words, residents' willingness to pay for Jinan hukou will be between approximately 90,000 and 126,000 yuan. This method and empirical findings complement research on the cost of citizenization by examining the demand side.

The remainder of the paper is organized as follows. Section 2 presents the hukou-granting policy's (institutional) background and theoretical considerations. Section 3 describes the data, empirical strategy, and summary statistics. In Section 4, we present the empirical results of parametric estimation. Section 5 implements robustness tests, and Section 6 concludes.

2. Policy Background and Theoretical Considerations

First, we present the policy's institutional background from the national (central government's) perspective. Several time points are critical:

(1) Under the People's Republic of China Household Registration Regulation system, which was established in 1958, China began to mandate strict restriction and regulation of free relocation by the citizenry. Moreover, the government divided residents into two categories: agricultural hukou and nonagricultural, or urban, hukou. People with agricultural hukou are also called peasants. Because the central government prioritized industrialization, state welfare programs — which were tied to hukou status — heavily favored urban residents; holders of agricultural hukous were unable to access these benefits and were saddled with inferior welfare policies. Conversion of hukou status from agricultural to nonagricultural was highly restricted. With the economic reform and opening in China, the market economy revived in rural areas. Township and village enterprises developed rapidly, and more and more

people with agricultural hukou moved to towns for jobs or business, hoping to change their social status from rural to urban citizenship with nonagricultural hukou.

(2) In October 1984, the State Council issued the "Notice on Peasants Entering Towns and Settling with Local Household Registration" to allow peasants to take their own rations into the rural towns (but not the county towns).

(3) In July 1985, the Ministry of Public Security promulgated the "Provisional Regulations on Urban Population Management," which set the quota for granting nonagricultural status to agricultural residents at 0.02%. However, the quota system generated considerable corruption. At the same time, the government adopted a more open attitude toward the settlement of farmers in cities.

(4) In June 1997, the State Council approved the Ministry of Public Security's "Pilot Scheme for the Reform of the Household Registration System in Small Towns and Opinions on Improving the Rural Household Registration Management System." The opinions clearly stipulated that peasants (and their direct relatives) who found jobs in small cities and towns or bought real estate would be allowed to apply for regular permanent hukou in towns and cities.

(5) In July 1998, the Ministry of Public Security issued the "Guiding Opinions on Solving Several Conspicuous Problems in Current Hukou Management." According to the opinions, newborns could acquire hukou along with their fathers, and the elderly could live with their children. Those who invested in cities, set up businesses, or purchased houses could acquire urban hukou, as long as they had a fixed residence and a legal and stable occupation or source of income, or had lived there for a certain number of years and complied with relevant local government regulations. Their direct relatives were also allowed to acquire urban hukou.

(6) In March 2001, to accelerate the development of urbanization, the State Council approved the "Opinions on Promoting the Reform of the Household Registration System in Small Towns" of the Ministry of Public Security. Today, the government no longer specifies a quota for granting nonagricultural hukou to those who have permanent residence in small cities and towns, and effectively safeguards their legal right to settle in a small town.

From the evolution of the above-mentioned national-level hukou regulations, we can see that

household registration has been linked with the purchase of a house since the second half of the 1990s. Since the turn of the 21st century, with the rapid development of China's real estate market, the persistence of high housing prices and emergence of an asset bubble have prompted local governments to consider their own cases and introduce a number of restrictions on house purchases and mortgage. This has loosened the relationship between household registration and house purchase.

Since the end of the 20th century, in many large and medium-sized cities, household registration—as a mechanism for screening desirable talents and providing exclusive rights to public service consumption—has been tied to the purchase of a house. Tenants, in contrast, do not have equal access to public services such as preschool education, compulsory education, higher education, social security, etc., or only have comparatively weak public service consumption priorities. Clearly, there is a disparity in rights between renters and homeowners.

Furthermore, acquiring hukou in some cities not only necessitates purchasing a house, but one with the minimum floor area required by hukou management regulations: Only buyers who purchase a house of at least the minimum area prescribed can acquire a local hukou. Otherwise, the buyer can only obtain the same citizen rights as tenants. For example, as early as 1996, Shanghai's city government stipulated that the purchase of newly built homes with a floor area of no less than 80 sq m and a value of no less than 400,000 yuan would be eligible for a blue stamped hukou[2]. Another example is Nanjing, where the city government specified a cutoff point for floor area (above 60 sq m) required for acquiring hukou in 2004.

Next, we focus on the evolution of home purchase policies for the hukou management system in Jinan since 2000, as our empirical analysis is based on data from Jinan. According to Wikipedia,[3] "Jinan is the capital of Shandong province in Eastern China. The area of present-day Jinan has played an important role in the history of the region from the earliest

[2] The blue stamped hukou is probationary, and grants the same public rights as local residents with regular hukou. Probationary hukou can be upgraded to regular hukou after three years.

3 See https://en.wikipedia.org/wiki/Jinan.

beginnings of civilization and has evolved into a major national administrative, economic, and transportation hub." Its urban area is 3,304 square kilometers, and its urban population is 4,693,700 (2010). It plays a significant role among large Chinese cities.

Critical time points in Jinan's case are as follows:

(1) In 2001, the "Notice of the People's Government of Jinan Municipality on Reforming the Urban Household Registration System" set the basic requirements for hukou as "a legal fixed residence and a stable occupation and source of income." It stipulated five ways to obtain hukou: home purchase, talent introduction, business investments, a husband or wife seeking to reunite, and rural residents whose farmland had been urbanized. Those who meet one of the above conditions are allowed to acquire hukou in Jinan's urban area. Here we focus on the specific terms of home purchase. The notice stipulates that for domestic residents, the home buyer and his or her spouse and their minor children are allowed to acquire hukous in the home's location if (i) the floor area of a purchased house in Jinan city is no less than 100 sq m, the total housing price is no less than 500,000 yuan, and the buyer obtains a real estate certificate; or (ii) the floor area of the purchased house is no less than 80 sq m, the total price of the house is no less than 250,000 yuan, and the buyer has obtained a real estate certificate and lived in the house for more than three years. The notice also emphasizes that in reforming the household registration system, one of the basic principles is to "require strict control over the entry of low-quality immigration, and to prevent low-level expansion of the urban population and aging of the migrating population." These guiding opinions reflect the local government's strong fiscal motivations in the process of urbanization and citizenization.

(2) In 2005, the Jinan city government slightly strengthened the conditions for acquiring hukou by purchasing a house. Only an individual who purchases a house with a floor area of no less than 100 sq m in the urban area, acquires a real estate certificate with full payment, actually resides in the purchased house, and is legally employed is eligible to apply for hukou in the location of the house purchased, together with his or her spouse and minor children.[4]

(3) In 2008, to stabilize the economy and boost the recovery of the real estate market

[4] See the "Notice of the People's Government of Jinan Municipality on Printing and Distributing the Interim Measures for Deepening the Household Registration System Reform in Jinan City" (2005).

after the global financial crisis, Jinan's city government relaxed the conditions for home purchase. In November 2008, the General Office of the People's Government of Jinan Municipality released the "Notice on Maintaining the Steady and Healthy Development of the Real Estate Market," which was jointly issued by the Municipal Construction Committee and nine other city government bureaus. This notice stipulates the conditions for hukou granting by home purchase. "In the urban area, hukou will be granted if the homeowner purchases newly built houses with a floor area of 90 sq m or more, and he or she obtains a real estate certificate. With regard to second-hand houses, hukou will be granted if the floor area is over 90 sq m and a real estate certificate has been held for more than two years. ... Each dwelling can enjoy the policy of acquiring hukou by purchasing a house only once within five years."

(4) Since 2009, both central and local governments have mainly focused on controlling housing prices nationwide. More restrictions have been imposed on qualifying house purchases; e.g. a sufficiently long history of paying personal income tax or social security contributions in Jinan. The "Implementation Opinions of the People's Government of Jinan Municipality on Further Deepening the Reform of the Household Registration System" (2017) promulgated in August 2017 abolished quantitative restrictions for acquiring hukou on investment, tax revenue contributions, and the purchase of houses. The threshold requirements on floor area have been cancelled. For ordinary immigrating workers, purchasing a house is still a necessary condition for settling within the city's central urban jurisdictions; however, the city government no longer imposes mandatory requirements for the size of the house. Therefore, floor area requirements for house purchases previous to the reform appear to be a valuable but uncommon case that will enable us to study the value of hukou and the underlying right to enjoy public services and welfare in cities during the evolution of the hukou system in China.

We can further derive a simple theoretical background for the value of hukou, similar to the models for public good provision in the theory of mechanism design. We consider the government's policy concerning floor area requirements for acquiring hukou by purchasing houses as an institutional parameter. A representative individual (without a urban hukou) has a

private valuation (willingness to pay for each sq m) t for the hukou. Let s denote the area of the house and x denote the other (aggregate) characteristics of the house. The Chinese government provides a hukou-granting rule $D(s)=0,\ or\ 1$, where 0 denotes "not granting hukou" and 1 denotes "granting hukou." Such an indicator (binary-valued) function normally takes the form of a step function with a cutoff point s'. If $s \geq s'$, $D(s)=1$, and if $s < s'$, $D(s)=0$. In Jinan's case, the cutoff point is 90 sq m, and the cost function of hukou granting is $C(D(s))$.

Once the granting rule is announced, the individual will generate some best response. Specifically, an individual with private valuation t will choose an area s and other characteristics that the purchase decision is also based on x.[5] Market demand will be a total price function of the area and whether hukou is granted, $P(s,\ D(s),\ x)$, where x represents a vector of housing characteristics—that is, the individual must pay $P(s,\ D(s),\ x)$ to obtain a house with area s depending on whether hukou is granted. The individual must also pay a unit tax, a, based on his or her purchase of the house. The total for purchasing a house with area s will be $(1+a)P(s,\ D(s),\ x)$. The individual has a utility function, $tD(s)+B(s)-(1+a)\ P(s,\ D(s),\ x)$, where $tD(s)$ denotes his or her private valuation for acquiring hukou and the attendant right to enjoy public services and welfare in the city; $B(s,\ x)$ denotes his or her consumption utility of area s and other characteristics x; and $(1+a)\ P(s,\ D(s),\ x)$ denotes his or her total payment for purchasing a house with area s and other characteristics x.

Thus, the best response of the individual to a given granting rule should be $s^*(t)$ and $x^*(t)$ solving max $t\ D(s)\ +B(s)-(1+a)\ P(s,\ D(s),\ x)$ for each t. However, the private valuation

5 Note that the evaluation or purchasing decision in practice may be based on the household level, if the buyer represents a family with more than one person, but not on the individual level.

t is normally unobservable; in addition, both the potential buyer and the government want to identify the market demand function for facilitating their decision-making—for instance, the government must know P so that it can design an optimal hukou access policy.

Therefore, the main task of this paper is to estimate the market demand function P, and therefore the market willingness to pay for acquiring hukou, in terms of the coefficient of D if we focus on the estimated functional form in which P is linear in D. This reflects the market value (pricing) of the house with area s and hukou acquisition. Since D is an indicator function, the difference in P between two values of D can yield the market value of hukou.

It is worth noting that our theoretical considerations and empirical research focus on the market demand driven by actual residential demand and demand for hukou. Since 2016, most local governments, including Jinan's city government, have strengthened control over housing purchases. This has crowded out housing demand driven by investment and speculation. Jinan's city government issued the "Notice of the Jinan City Urban and Rural Construction Committee, the Jinan Housing Security and Housing Management Bureau, and the Jinan Municipal Bureau of Land and Resources on the Implementation of the Housing Restriction Purchase Policy" in 2016, which imposed more restrictions on housing purchases. For instance, any family without Jinan hukou could only purchase one house in Jinan's urban area. This fact enhances the rationale for our focus on the market demand driven by actual residential demand and hukou acquisition.

3. Data, Empirical Strategy, and Summary Statistics

We use listed housing transaction data for Jinan from June 2017 to July 2017 to perform a regression discontinuity design (RDD) and estimate the value of urban hukou in Jinan or marginal willingness to pay for hukou. These data are from the largest second-hand housing trading platform in China, fang.com. From the platform, we collected many characteristics of each house for sale and of the community. We also obtained the rental price dataset for the

same period. Over the one-month period we examined, the housing market, surrounding facilities, and relevant public policies underwent almost no change. Hence, the datasets we use can be viewed as cross-sectional in essence. The housing transaction dataset contains 26,031 observations after trimming to eliminate possibly spurious outliers. The rental dataset contains 11,059 observations after similar data preprocessing.

The hedonic price model (HPM) is the main regression model used in this study. The dependent variable is housing price P per sq m, and the independent variable is X, which represents a series of house and community characteristics; these include total price, floor area, number of rooms, orientation, floor number, decoration, floor area ratio, afforestation rate, building height, supplementary facilities, etc. We pay particular attention to floor area S. According to Jinan city's policy, when the floor area is at least 90 sq m, the buyer is eligible to acquire the local hukou. Otherwise, its buyer only purchases the residential rights to the house and not the additional rights attached to hukou. We present a full list of summary statistics in Table 1 for observations near the cutoff point.

We will implement the RDD using a parametric estimation method and robustness tests using a nonparametric estimation method. The area S is the running variable in the regression discontinuity design. Let $S_i^{'} = S_i - 90$. We define $D_i = \begin{cases} 1 \; if \;\; S_i \geq 90 \\ 0 \; if \;\; S_i < 90 \end{cases}$; that is, we take houses with area no less than 90 sq m as the treatment group and houses with area less than 90 sq m as the control group.

The basic model of parametric estimation is set as equation (1) below:

$$P_i = \alpha + \beta_0 \cdot D_i + g(S_i^{'}) + \pi^{'} \cdot \mathrm{X}_i + \varepsilon_i, \qquad (1)$$

where D_i is the treatment variable; $g(S_i^{'})$ denotes a polynomial function of running variables S', which may include the linear term and quadratic term of the running variable; and the interaction of these terms and the treatment variable D_i. X_i is the covariate and includes all

house and community characteristics except for area. The coefficient β_0 for treatment assignment represents the marginal impact of the policy at the cutoff point, which is the appreciation of housing prices caused by the hukou-granting policy and represents the estimation of market willingness to pay to acquire hukou. The coefficient π' represents the implicit prices of a set of housing and community characteristics. α is the constant term, and ε_i is a random error term for observation i, which is assumed to be independently and identically distributed. Standard errors in all specifications are heteroscedasticity-robust.

Specifically, we estimate four models:

Model 1 $$P_i = \alpha + \beta_0 \cdot D_i + \beta_1 \cdot S_i^{'} + \pi^{'} \cdot \mathrm{X}_i + \varepsilon_i \quad (2)$$

Model 2 $$P_i = \alpha + \beta_0 \cdot D_i + \beta_1 \cdot S_i^{'} + \beta_2 \cdot D_i \cdot S_i^{'} + \pi^{'} \cdot \mathrm{X}_i + \varepsilon_i \quad (3)$$

Model 3 $$P_i = \alpha + \beta_0 \cdot D_i + \beta_1 \cdot S_i^{'} + \beta_2 S_i^{'2} + \pi^{'} \cdot \mathrm{X}_i + \varepsilon_i \quad (4)$$

Model 4 $$P_i = \alpha + \beta_0 \cdot D_i + \beta_1 \cdot S_i^{'} + \beta_2 S_i^{'2} + \beta_3 \cdot D_i \cdot S_i^{'} + \beta_4 \cdot D_i \cdot S_i^{'2} + \pi^{'} \cdot \mathrm{X}_i + \varepsilon_i \quad (5)$$

Table1: Summary statistics and balance test

	Control group-area ∈ [80,90）			Treatment group-area ∈ [90,100）				
	Obs	Mean	Std.Dev.	Obs	Mean	Std.Dev.	SMD	Variance ratio
House price	3,257	19564	5338	3,936	19838	5093	-0.053	1.099
Area	3,257	84.74	3.014	3,936	94.82	3.1	-3.297	0.945
Rooms	3,257	10.198	4.101	3,936	10.821	4.288	-0.149	0.915
Floor	3,257	2.067	0.736	3,936	1.957	0.739	0.149	0.992
Decoration	3,257	3.489	0.832	3,936	3.548	0.846	-0.070	0.967
Building height	3,257	9.13	6.817	3,936	10.94	7.618	-0.251	0.801
Building age	3,254	17.98	7.158	3,929	15.1	7.181	0.402	0.994
Elevator	3,254	1.269	0.443	3,930	1.372	0.483	-0.222	0.841
Property fee	2,113	0.957	0.844	3,114	1.059	0.829	-0.122	1.037
afforestation rate	2,240	0.331	0.087	2,784	0.365	0.089	-0.386	0.956
FAR	3,091	1.862	0.745	3,741	1.872	0.801	-0.013	0.865
Total building	3,214	36.51	36.12	3,912	34.32	35.51	0.061	1.035
Total houses	3,214	2311	2405	3,912	2446	2983	-0.050	0.650

Notes: House price is the unit price per sq m; Area stands for the floor area of the house; Rooms stands for the number of rooms in the house; Floor=1, 2,3 represent lower, middle, and higher floors, respectively; Decoration=1,2,3,4,5 represent no decoration，simple decoration，medium decoration, good decoration, and luxury decoration, respectively; Elevator=1,2 represents with or without an elevator in the building; FAR stands for Floor Area Ratio.

Table 1 summarizes the statistics for two subsamples that center on the cutoff point with a bandwidth of 10, including effective observations, means, standard errors, etc. The last two columns, respectively, test the balance between the control group and the treatment group from two perspectives: means and standard errors. SMD denotes the standard mean difference between two groups of data. The closer this value approaches 0, the more balanced are the two groups. The variation ratio denotes the variance difference between the two groups. Again, the closer this value approaches 0, the more balanced are the two groups.

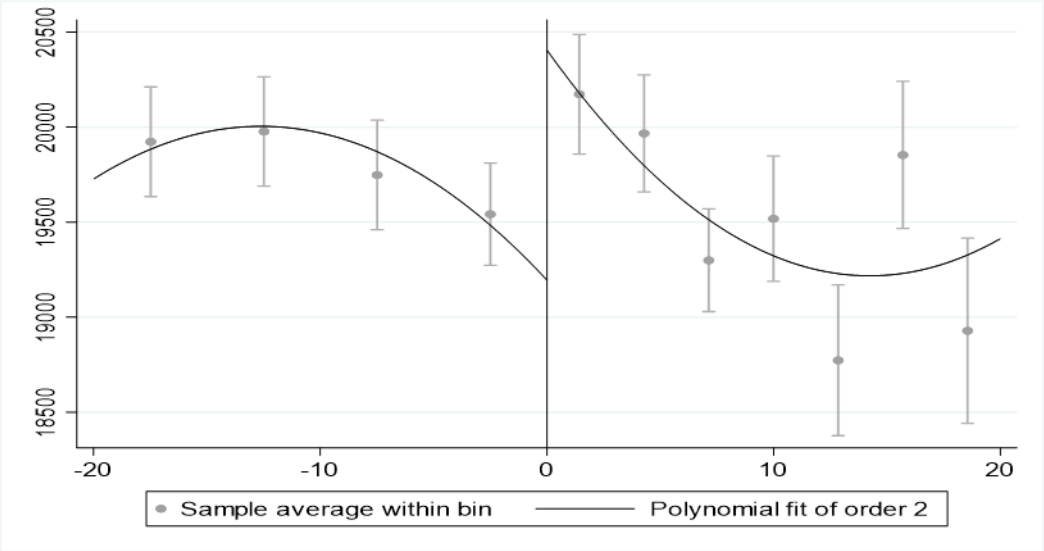

Figure 1: Regression discontinuity (RD) plot: Average Housing Price and Floor Area

Figure 1 depicts the house price bins around floor area of 90 sq m. in the range of ±20 sq m, where we follow the data-driven procedure to select the number of bins[6]. The graph indicates that there is a significant jump in average house price on each side around the cutoff point, and in the first bins closest to the cutoff point; average house price on the right side is almost 1,000 yuan higher than that on the left side.

Will the policy discontinuity point generate any abnormal distributions on either side of the discontinuity? Is there any possibility of data manipulation? McCrary's method (2008) is

[6] In figure 1, we specify the integrated mean squared error (IMSE)-optimal evenly spaced method using spacing estimators to select the number of bins. Other specifications such as the IMSE-optimal evenly spaced method using polynomial regression, the IMSE-optimal quantile-spaced method using spacing estimators or polynomial regression, or arbitrarily setting 10 bins on both sides of the cut-point, will lead to the similar quantitative relationship between housing price and floor area.

required to test whether the density function of the running variable (floor area) is continuous on both sides of the discontinuity. As can be seen in Figure 2 (density function), the confidence intervals on the two sides of the discontinuity will overlap greatly, so significant difference in the density function is not present on either side of the discontinuity.

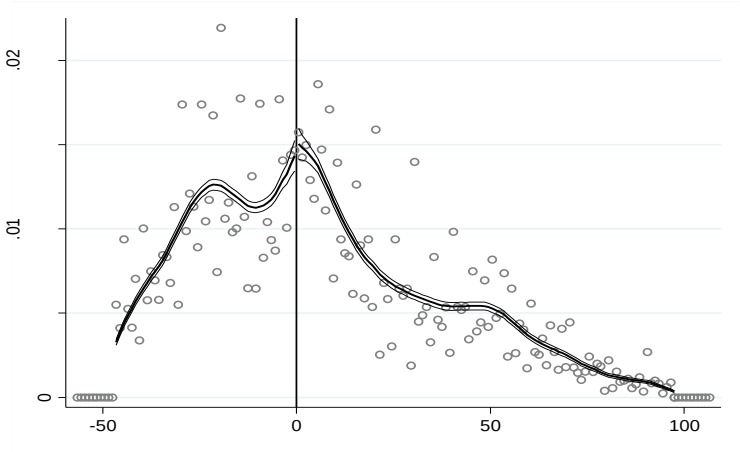

Figure 2: Density function of the running variable (area)

Formally, we use two subsamples, $\{s_i : s_i < \bar{s}\}$ and $\{s_i : s_i \geq \bar{s}\}$, to test the continuity of density function $f(s)$ on the two sides of the discontinuity. The H_0 to be tested is set to be $\lim_{s \uparrow \bar{s}} f(s) = \lim_{s \downarrow \bar{s}} f(s)$. However, estimating the density function on the two sides of the discontinuity will lead to a nonparametric boundary point problem, and further lead to the infeasibility of standard kernel density estimation. To solve this problem, Cattaneo, Jansson, and Ma (2016) designed a new estimator of the density function. Table 2 reports the results of adopting the CJM method to judge the continuity of the density function at the two sides of the density function. A t test and its corresponding P values indicate that H_0 cannot be rejected; that is, we can believe that the density function is continuous on both sides of the discontinuity.

Table 2: Manipulation Test

	Bandwidth		Observations		T Test	
	left	right	left	right	T test	P-value
$T_2(h_1)$	3.504	3.504	1,052	1,485	-0.0530	0.9578
$T_3(h_2)$	11.699	11.699	3,459	4,194	0.6144	0.5390
$T_4(h_3)$	18.726	18.726	5,513	5,761	0.6153	0.5383

Notes: Tp(h) is the manipulation test statistic, where h indicates bandwidth and p indicates the order of the local polynomial used to construct the density point estimator. For density estimation, we assume equal c.d.f. and higher-order derivatives for both subsamples. Optimal bandwidth selection methods are based on asymptotic mean squared error (AMSE) minimization. A triangular kernel function is used to construct the local-polynomial estimator.

4. Empirical Results of Parametric Estimation

The first step in parametric estimation is selecting the functional form. In this section, we will report the regression results of parametric estimations under Models 1-4. In addition, RDD requires selection of a reasonable bandwidth. Considering the size of the sample and the balance of data between the two sides of the cutoff point, we choose 10 sq m as the reference bandwidth in this section; that is, taking ±10 sq m around the cutoff point of 90 sq m of floor area. Furthermore, we choose bandwidths 5 and 20 to conduct robustness tests. In Section 5, we will employ data-driven procedures developed by Calonico, Cattaneo, and Titiunik (2014) to obtainn the optimal bandwidth.

Table 3 reports RD parametric estimations with bandwidths 5, 10, and 20 under the linear model. The first row of Table 3 shows the treatment effect. The second row shows whether the covariable exists. The third row shows the confidence interval of 95%. The fourth row shows P values that represent statistical significance. The last row indicates the number of observed values within each specified bandwidth around the discontinuity.

When the bandwidth is 5 and there are no covariates, the treatment effect of RD is 1,097 yuan—that is, the implicit price of hukou is 1,097 yuan per sq m When the bandwidth increases to 10, the treatment effect of RD without covariates is 717 yuan per sq m. However, after controlling for the main covariates, the treatment effect of RD is 1,051 yuan per sq m.

When the bandwidth increases to 20, results are similar. According to the P values, all of the treatment effects of RD are statistically significant at the 1% level. Moreover, we can find that the models with covariates result in narrower confidence intervals. In other words, the introduction of covariates improves the precision of estimation. Meanwhile, the spans of confidence intervals vary across models with different bandwidths. This implies the importance of optimal bandwidth selection. We will discuss the data-driven optimal bandwidth selection in Section 5.

Table 3: Flexible parametric RD methods：Model1

	Model 1:linear					
	h=5	h=5	h=10	h=10	h=20	h=20
RD treatment effect	1097	863	717	1051	578	1193
Covariates	No	Yes	No	Yes	No	Yes
Parametric 95% CI	[457, 1737]	[281,1144]	[246,1189]	[619,1484]	[232,924]	[873,1152]
Parametric *p*-value	0.001	0.003	0.003	0.000	0.001	0.000
$N_w^- \mid N_w^+$	1846|2238	1726|2127	3257|3936	3056|3726	6341|6304	5949|5980

Notes: (i) All estimates are constructed using linear ordinary least-squares estimators with heteroscedasticity-robust standard errors;(ii) covariates include house characteristics, such as number of rooms, floor area, decoration, elevator, and height and age of building, and community characteristics such as FAR, afforestation rate, total buildings, total houses, etc.; and (iii) $N_w^+ = \sum_1^n 1(\bar{s} \le S_i < \bar{s} + h)$, $N_w^- = \sum_1^n 1(\bar{s} - h \le S_i < \bar{s})$.

A major challenge for parametric regression is setting the functional form to the estimate. If the functional form is correctly specified, the RD estimator will be unbiased in estimating the policy impact at the cutoff point. If the functional form is incorrectly specified, treatment effects will be estimated with bias. For instance, if the true functional form is highly nonlinear, a simple linear model can produce misleading results. To test the robustness found in Table 3, we report respective RD estimating results for the linear interaction model, quadratic model, and quadratic interaction model. Regardless of which functional form is considered, the treatment effect of RD attains both economic significance and statistical significance. For

instance, at bandwidth 10 and controlling for all covariates in the regression equation, the treatment effect of the linear regression estimation is 1,051; of the linear interaction model 1,009; of the quadratic model 1,066; and of the quadratic interaction model 1,381. The treatment effect of RD, therefore, is basically stable in the economic sense—that is, houses with urban hukou (no less than 90 sq m in floor area) cost more than 1,000 yuan (per sq m) more than houses with less than less than 90 sq.m.

Table 4: Flexible parametric RD methods：Model 2

	Model 2:linear interaction					
	h=5	h=5	h=10	h=10	h=20	h=20
RD treatment effect	1134	863	651	1,009	576	1,775
Covariates	No	Yes	No	Yes	No	Yes
Parametric 95% CI	[485, 1783]	[277,1450]	[177,1125]	[576,1443]	[229,923]	[855,1495]
Parametric *p*-value	0.001	0.004	0.007	0.000	0.001	0.000
$N_w^- \mid N_w^+$	1,846|2,238	1,726|2,127	3,257|3,936	3,056|3,726	6,341|6,304	5,949|5,980

Notes: (i) All estimates are constructed using linear ordinary least-squares estimators with heteroscedasticity-robust standard errors; (ii) covariates include house characteristics, such as number of rooms, floor area, decoration, elevator, and height and age of building, and community characteristics such as FAR, afforestation rate, total buildings, total houses, etc.; and (iii) $N_w^+ = \sum_1^n 1(\bar{s} \le S_i < \bar{s} + h)$, $N_w^- = \sum_1^n 1(\bar{s} - h \le S_i < \bar{s})$.

Table 5: Flexible parametric RD methods：Model 3

	Model 3: quadratic					
	h=5	h=5	h=10	h=10	h=20	h=20
RD treatment effect	800	796	645	1,066	528	1,169
Covariates	No	Yes	No	Yes	No	Yes
Parametric 95% CI	[134, 1467]	[191,1401]	[168,1123]	[630,1502]	[183,874]	[850,1487]
Parametric *p*-value	0.019	0.01	0.008	0.000	0.003	0.000
$N_w^- \mid N_w^+$	1,846|2,238	1,726|2,127	3,257|3,936	3,056|3,726	6,341|6,304	5,949|5,980

Notes: (i) All estimates are constructed using linear ordinary least-squares estimators with heteroscedasticity-robust standard errors; (ii) covariates include house characteristics such as number of rooms,

floor area, decoration, elevator, and height and age of building, and community characteristics such as FAR, afforestation rate, total buildings, total houses, etc.; and (iii) $N_w^+ = \sum_1^n 1(\bar{s} \le S_i < \bar{s} + h)$, $N_w^- = \sum_1^n 1(\bar{s} - h \le S_i < \bar{s})$.

Table 6: Flexible parametric RD methods：Model 4

	Model 4: quadratic interaction					
	h=5	h=5	h=10	h=10	h=20	h=20
RD treatment effect	1,705	1,039	1,965	1,381	1,086	1,281
Covariates	No	Yes	No	Yes	No	Yes
Parametric 95% CI	[648, 2763]	[198,1980]	[1248, 2683]	[734,2028]	[571, 1601]	[810,1752]
Parametric *p*-value	0.002	0.03	0.000	0.000	0.000	0.000
$N_w^- \mid N_w^+$	1,846|2,238	1,726|2,127	3,257|3,936	3,056|3,726	6,341|6,304	5,949|5,980

Notes: (i) All estimates are constructed using linear ordinary least-squares estimators with heteroscedasticity-robust standard errors; (ii) covariates include house characteristics, such as number of rooms, floor area, decoration, elevator, and height and age of building, and community characteristics such as FAR, afforestation rate, total buildings, total houses, etc.; and (iii) $N_w^+ = \sum_1^n 1(\bar{s} \le S_i < \bar{s} + h)$, $N_w^- = \sum_1^n 1(\bar{s} - h \le S_i < \bar{s})$.

5. Robustness Testing

Since specific functional forms will affect parametric estimation, we also adopt a nonparametric method to design discontinuity regression as the robustness test. An important feature of nonparametric RD is that bandwidth is not selected arbitrarily, but instead calculated by data properties per se. The MSE-optimal method is frequently used to calculate bandwidth (Imbens and Kalyanaraman, 2012). Its main idea is that one can make a tradeoff between estimation bias and estimation variance. Narrow bandwidth can reduce estimation bias, but the reduction in sample volume will increase estimation variance. The opposite conditions are present in the case with wide bandwidth. Let MSE= Bias^2 + Variance，and then the MSE-minimized bandwidth will be the optimal bandwidth. Based on the above idea, Calonico et al. (2014) further extend this method to include allowing covariate adjustment, heteroscedasticity-robust or cluster-robust variance, etc.

Table 7 reports estimation results for the treatment effects of RD using the local linear interaction model (p=1) and local quadratic interaction model (p=2) under different bandwidth selection methods.[7] Suppose that left and right bandwidths are identical. For the linear interaction model, the one-side optimal bandwidths are 7.704 and 4.634, which are obtained, respectively, using the MSE and CER bandwidth selector. For the quadratic interaction model, the one-side optimal bandwidths are 14.623 and 8.18, respectively, again using the two bandwidth selectors. To compare with previous results, we also report the results of nonparametric estimation with bandwidth 10. The treatment effects of local linear estimation are, respectively, 1,411, 1,418, and 1,409. These numbers are very close. However, the effects for the local quadratic model are, respectively, 1,402, 1,074, and 925. As for significance, we expect that the treatment effect with bandwidth 10 in the local quadratic model has relatively weak statistical significance, and other estimation results are significant at least at the 5% level. Compared to parametric estimation, although the treatment effects of RD differ slightly in magnitude, the findings are robust in terms of both economics and statistics.

Table 7: Robust bias-corrected local polynomial methods

	Linear Model（p=1）			Quadratic Model（p=2）		
	$h = \hat{h}_{MSE}$	$h = \hat{h}_{CER}$	$h = \hat{h}_{FP}$	$h = \hat{h}_{MSE}$	$h = \hat{h}_{CER}$	$h = \hat{h}_{FP}$
RD treatment effect	1411	1418	1409	1402	1074	925
Robust 95% CI	[718,2104]	[476,2360]	[626,2191]	[688,2188]	[83,2064]	[-176,2025]
Robust *p*-value	0.000	0.003	0.000	0.000	0.034	0.100
$N_w^- \mid N_w^+$	2345|2958	1431|1807	2856|3599	4250|4801	2594|3376	2856|3599
h	7.704	4.634	10	14.623	8.18	10

Notes: (i) Point estimators are constructed using local polynomial estimators with triangular kernel; (ii) "robust p-values" are constructed using bias correction with robust standard errors, as derived in Calonico et al. (2014); (iii) h_{MSE}corresponds to the second-generation data-driven MSE-optimal bandwidth selector proposed in Calonico et al. (2014) and Calonico et al. (2016); h_{CER} corresponds to the coverage error rate (CER) criterion to calculate optimal bandwidth; and $h_{FP} = 10$ to facilitate comparisons with previous parametric estimation; and (iv) $N_w^+ = \sum_1^n 1(\bar{s} \le S_i < \bar{s} + h)$, $N_w^- = \sum_1^n 1(\bar{s} - h \le S_i < \bar{s})$.

We have estimated both parametric and nonparametric models to test the significance of the

7 This section only reports regression results without covariates. When controlling for all covariates, the main findings remain unchanged.

unit price difference that is present around floor area 90 sq m, and have attributed the difference to willingness to pay for hukou. However, is the treatment effect of the above estimations caused solely by the physical property of floor area? To answer this, we explore two strategies to run a falsification test. First, we assume that policy discontinuity occurs at either 70 sq m or 110 sq m, and perform a placebo test. Second, we use rent data to test whether the policy discontinuity at 90 sq m has a significant treatment effect. The rationale is that tenants do not have rights equal to those of homeowners—which allow access to local public services such as education, public health care, etc.—although tenants can still enjoy the residential utility of the house or apartment. If the treatment effect of RD based on rental data does not have statistical significance, or has statistical significance but little economic significance, we can infer that the treatment effect of RD found in the housing price dataset is caused by the difference in citizenship (hukou) rather than by the physical properties of dwellings.

Table 8 reports the results of a placebo test that assumes a policy cutoff point at 70 or 110 sq m. Clearly, regardless of whether the local linear regression model or local quadratic model is used, the treatment effects are statistically insignificant. Primarily, this indicates that the jump in housing price at 90 sq m is caused by the difference in citizenship and not by the physical properties of dwellings.

Table 8: Placebo test—assuming false policy discontinuity

	Linear Model（p=1）		Quadratic Model（p=2）	
False discontinuity	Area=70 sq m	Area=110 sq m	Area=70 sq m	Area=110 sq m
RD treatment effect	879	445	1,202	520
Robust 95% CI	[-824,2582]	[-175,1065]	[-489,2893]	[-300,1339]
Robust *p*-value	0.312	0.160	0.163	0.214
$N_w^- \mid N_w^+$	684|1,148	4,134|2,724	1,686|2,098	4,784|2,951
h	2.921	15.838	5.614	17.956

Notes: (i) Point estimators are constructed using local polynomial estimators with triangular kernel; (ii) “robust p-values” are constructed using bias correction with robust standard errors, as derived in Calonico et al. (2014); (iii) h_{MSE}corresponds to the second-generation

data-driven MSE-optimal bandwidth selector proposed in Calonico et al. (2014) and Calonico et al. (2016); h_{CER} corresponds to the coverage error rate (CER) criterion used to calculate optimal bandwidth; and $h_{FP} = 10$ to facilitate comparisons with previous parametric estimation; and (iv) $N_w^+ = \sum_1^n 1(\bar{s} \le S_i < \bar{s} + h)$, $N_w^- = \sum_1^n 1(\bar{s} - h \le S_i < \bar{s})$.

Furthermore, we still set the cutoff point at 90 sq m, but use the rental data to perform falsification tests. Table 9 reports the results of RDD under the local linear model and local quadratic model. The treatment effect of RD does not have statistical significance, except that the effect of RD under the local linear model with optimal bandwidth 9.378 has some statistical significance at the 5% level. This indicates, once again, that the discontinuity at 90 sq m is caused by the difference in citizenship or hukou and not by the physical properties of dwellings.

Table 9: Placebo Tests on Rent Price

	Linear Model（p=1）			Quadratic Model（p=2）		
	h = $\hat{h}_{MSE}$	h = $\hat{h}_{CER}$	h = $\hat{h}_{FP}$	h = $\hat{h}_{MSE}$	h = $\hat{h}_{CER}$	h = $\hat{h}_{FP}$
Treatment effect	1.564	1.233	1.030	0.996	1.179	-0.096
Robust 95% CI	[0.14,3.00]	[-0.58,3.05]	[-0.89,2.95]	[-0.51,2.50]	[-0.92,3.28]	[-3.22,3.03]
Robust *p*-value	0.032	0.183	0.293	0.194	0.271	0.952
$N_w^- \mid N_w^+$	883|2195	692|1448	887|2206	1714|2983	1230|2531	887|2206
h	9.378	5.887	10	17.068	10.026	10

Notes: (i) Point estimators are constructed using local polynomial estimators with triangular kernel; (ii) "robust p-values" are constructed using bias-correction with robust standard errors, as derived in Calonico et al. (2014); (iii) h_{MSE}corresponds to the second-generation data-driven MSE-optimal bandwidth selector proposed in Calonico et al. (2014) and Calonico et al. (2016); h_{CER} corresponds to the coverage error rate(CER) criterion used to calculate optimal bandwidth; $h_{FP} = 10$ to facilitate comparisons with previous parametric estimation; and (iv) $N_w^+ = \sum_1^n 1(\bar{s} \le S_i < \bar{s} + h)$, $N_w^- = \sum_1^n 1(\bar{s} - h \le S_i < \bar{s})$.

Lastly, Jinan's city government implemented the reform in its hukou-granting policy in August 2017, after which the article "Acquiring hukou by purchasing houses" was abandoned. Therefore, we can predict that the policy discontinuity will no longer be present at 90 sq m. We use the data for house bidding prices on Fang.com to further test whether this policy effect still exists at 90 sq m.[8] From Tables 10 and 11, we can see that such a treatment effect was not statistically significant after the policy for acquiring hukou by purchasing a house was

8 Data were preprocessed by deleting duplicate observations and abnormal values. We truncated price and area variables with 5% tails. In the end, we have 31,334 effective observations. Our general findings are not affected by whether covariates are present. For simplicity, we only report cases without covariates.

abandoned.

Table 10: Flexible parametric RD method: After the "Acquiring hukou by purchasing houses" policy was abolished

	Linear Model（p=1）			Quadratic Model（p=2）		
	h=5	h=10	h=20	h=5	h=10	h=20
treatment effect	-132	33.69	7.95	-396.5	-170.9	-4.38
95% CI	[-295, 30]	[-30.1,97.6]	[-15.9,31.8]	[-1197.6,404.6]	[-428.8,87.1]	[-99.9,91.1]
P-value	0.11	0.301	0.513	0.332	0.194	0.928
$N_w^- \mid N_w^+$	2,093|2,685	3,753|4,816	7,129|7,921	2,093|2,685	3,753|4,816	7,129|7,921

Notes: (i) All estimates are constructed using linear ordinary least-squares estimators with heteroscedasticity-robust standard errors; (ii) covariates include house characteristics, such as number of rooms, floor, decoration, elevator, and height and age of building, and community characteristics such as FAR, afforestation rate, total buildings, total houses, etc.; and (iii) $N_w^+ = \sum_1^n 1(\bar{s} \le S_i < \bar{s} + h)$, $N_w^- = \sum_1^n 1(\bar{s} - h \le S_i < \bar{s})$.

Table 11: Robust bias-corrected local polynomial method: After the "Acquiring hukou by purchasing houses" policy was abolished

	Linear Model（p=1）			Quadratic Model（p=2）		
	$h = \hat{h}_{MSE}$	$h = \hat{h}_{CER}$	$h = \hat{h}_{FP}$	$h = \hat{h}_{MSE}$	$h = \hat{h}_{CER}$	$h = \hat{h}_{FP}$
Treatment effect	-583.8	-703	-666	-601	-806	-781
Robust 95% CI	[-1170,2.5]	[-1558,151]	[-1352,21]	[-1226,24]	[-1774,162]	[-1882,319]
Robust *p*-value	0.051	0.106	0.057	0.06	0.103	0.164
$N_w^- \mid N_w^+$	2731|3575	1598|2150	3307|4351	4595|5676	2731|3575	3307|4351
h	7.58	4.518	10	13.89	7.689	10

Notes: (i) Point estimators are constructed using local polynomial estimators with triangular kernel; (ii) "robust p-values" are constructed using bias correction with robust standard errors as derived in Calonico et al. (2014); (iii) h_{MSE}corresponds to the second-generation data-driven MSE-optimal bandwidth selector proposed in Calonico et al. (2014) and Calonico et al. (2016); h_{CER} corresponds to the coverage error rate (CER) criterion used to calculate optimal bandwidth; and $h_{FP} = 10$ to facilitate comparisons with previous parametric estimation; and (iv) $N_w^+ = \sum_1^n 1(\bar{s} \le S_i < \bar{s} + h)$, $N_w^- = \sum_1^n 1(\bar{s} - h \le S_i < \bar{s})$.

6. Conclusion

It is well known that the Chinese urban hukou system not only performs population registration functions, but also has economic value. To our best knowledge, this paper is the first to study the market value of urban hukou using the case of acquiring hukou by purchasing a house. Using Jinan's urban hukou access policy as the context for our study, we adopt the RD method and present a way to single out the underlying value of hukou by estimation based on house prices. We show that in 2017, urban hukou rights in Jinan result in a rise in residential unit prices of around 1,000-1400 yuan, and market willingness to pay for Jinan's urban hukou will be between approximately 90,000 and 126,000 yuan.

This study also has policy implications for further analysis of public policies related to hukou reform in China and the provision of public goods. First, this paper complements previous studies of citizenization, which adopt a supply (cost) perspective. In contrast, this paper uses a demand perspective regarding relevant practices. Furthermore, based on this analysis, we are able to consider a local government's fiscal capacity and tax system in designing optimal provision policies for public services and welfare, as well as equality of public rights.

Our study has several potential limitations. First, hukou is an instrument that prevents "floating" individuals from enjoying some aspects of social welfare, because hukou certificates are required for these kinds of services. Though other public goods or services—such as urban infrastructures—are also vital to citizens' welfare, local governments cannot exclude people from consuming them using a hukou requirement, whether they are renters or homeowners, local or foreign. Therefore, the value of hukou actually arises from a set of exclusive public services or welfare. While the right to enjoy non-exclusive public services or welfare may still be capitalized into housing prices, the treatment effect of our RD analysis does not address this aspect.

Second, acquiring hukou now is more complicated due to many factors the local government considers—e.g., local fiscal reforms, China's national goals, or reform of the real estate

market. Chinese cities are reforming their policies for acquisition of hukou by purchasing a house, and many local governments have also adopted a scoring system to comprehensively rate hukou applications. Although hukou acquisition channels are being reformed, hukou persists as a screening mechanism to select desirable applicants. Therefore, economic value of hukou still exists, but perhaps in a more complicated way; researchers may find other experimental opportunities to estimate in the future.

Lastly, further empirical work would be desirable to directly estimate the optimal provision of public services and welfare in the design of hukou-granting rules. Based on this study and previous studies that examine the supply (cost) side of hukou granting, it is now possible to test or estimate the entire process of optimal design of hukou-granting rules.

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