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The impact of urban housing prices on labour mobility: evidence from cities in China

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ABSTRACT

Urban development relies heavily on labour, while the change in urban housing prices, in turn, has a crucial impact on labour. Therefore, the regulatory policies of housing prices have become a critical content of urban management worldwide for a long time. Based on the theoretical analysis of urban housing prices and labour mobility, we use fixed-effect panel model with the panel data of 281 cities in China from 2002 to 2018. We study the impact of rising urban housing prices on labour and identify the housing price jump as an instrumental variable in solving the endogenous problem. The results are as follows. First, the increase in urban housing prices has a crowding-out effect on labour mobility. Second, there is a moderating effect on different levels of education, urban construction, and income under the impact of urban housing prices on labour mobility. Third, the heterogeneity of the impact is reflected in the housing price-to-income ratios and industrial structures. These conclusions are supposed to have significant enlightenment for controlling the urban housing prices during high-quality economic growth and guiding labour flow more rationally.

1. Introduction

1.1. Motivation

The modern city is the main space where labourers gather, providing them with housing, employment opportunities, and related social welfare. At the same time, labourers make corresponding choices for their activity space based on internal constraints and external circumstances. Labour mobility has a far-reaching impact on optimising the spatial allocation of resources. It gradually replaces industry as the core element determining the success or failure of regional economic development. Over the past decade, many economies have experienced a phase of rapidly rising

housing prices. The prosperity of the real estate market has also had a specific impact on the local labour market. According to the Organisation for Economic Cooperation and Development (O.E.C.D.), the real value added to the real estate of 27 economies averaged 9.78% from 2002 to 2018. The prosperity of the real estate market and competition of among real estate companies with large-scale strategies have driven the soaring prices.

The rising housing prices increase the actual costs of enterprises and affect the living quality of the labourers. It impacts the agglomeration and diffusion of urban labour, and further changes the local industry clustering and structure. The rising urban housing prices have hindered labour influx and decreased the spatial allocation efficiency of labourers (Hsieh & Moretti, 2019). The housing prices in the U.K. have a distributional effect on labour supply (Disney & Gathergood, 2018). The spatial changes of housing prices in Norway reflect the characteristics in the local labour market (Osland & Thorsen, 2013). Cities with higher housing prices in the Netherlands generally have superior working locations and better urban infrastructural facilities (Garretsen & Marlet, 2017). At the same time, the wealth effect of housing prices will further expand the polarisation of social resource allocation. With the persistently high housing prices, any small change will magnify several times to affect the relevant interest groups. Since China's reform and opening-up, urbanisation has accelerated, and it has brought substantial demographic dividends and a corresponding housing problem. The labour migration in China reflects an outbreak trend. It is outstanding research to improve urban competitiveness and attract high-quality labour through reasonable housing price planning policies. The inflow of high-quality labour can accelerate economic transition and upgrading and achieve high-quality development. In this context, we study the impact of rising housing prices on labour mobility from an actual perspective in China. We further refine the relevant conclusions about the exact impact of urban housing prices on labour mobility under the background of the different social and cultural systems.

1.2. Literature review and contribution

The difference in urban housing prices profoundly affects labour mobility. The most critical macroscopic theory in demography is the 'push–pull' one in the fundamental theory of labour migration. The current research on the impact of urban housing prices on labour mobility falls into two categories. The rise in urban housing prices has a crowding-out effect on labour mobility. There is a spatial interaction between the real estate and housing market (Hincks, 2012). Further research finds that housing value is closely related to fundamental economic variables such as labour (Han et al., 2018; Li & Zhong, 2020). Peng et al. empirically study the positive correlation between housing prices and population migration and find that the impact in the short-term is not as significant as in the long-term (Peng & Tsai, 2019). The housing market seems to form the primary mechanism that slows down the workers' mobility (Hämäläinen & Böckerman, 2004). The rate of population inflowing in high-income areas has decreased because the rising housing prices prevent migrants with low skills (Ganong & Shoag, 2017). Plantinga et al. believe that higher housing costs decrease

the possibility of labourers entering a particular area (Plantinga et al., 2013). The higher housing prices will push the local labourers to the surrounding area with low (Guerrieri et al., 2013; Jeanty et al., 2010). The other one is that the rise in urban housing prices has a clustering effect on labour. Cities with higher housing costs will attract more labourers with more advanced job skills and higher education because they can reap rich rewards in those areas (Moretti, 2013; Zhou et al., 2020). The expected wealth effect of rising housing prices promotes the willingness of workers to live in immigrant areas (Li, Zou, & Mo, 2021; Zang et al., 2015). Rising housing price has a positive wealth effect and a negative lock-in effect on labour migration (Foote, 2016). Although different scholars have different conclusions about the impact of urban housing prices on labour mobility, these conclusions are not contradictory. The impact of housing prices on labour mobility presents an inverted U-shaped relationship (Zhou et al., 2020). The crowding-out effect is reflected on the right side of the inverted U-shaped curve, and the clustering effect is reflected on the curve's left side. Meanwhile, according to the labour market segmentation theory, the labour market is divided into a primary market dominated by mental workers and a secondary market dominated by manual labour. The impact of urban housing prices rising on these two types of labour markets is also significantly different.

The impact of urban housing prices on different labourers varies due to the external environments. The decision-making factor of urban education level has the most significant impact on selecting family location (Bayoh et al., 2006). People are willing to afford higher housing prices to obtain better educational resources (Albouy, 2016; Bayer et al., 2007; Muellbauer & Murphy, 2008). Therefore, the proportion of the higher education population increases continually in areas with higher housing prices (Sorens, 2018). This is because the education gap often results in an income gap (Diamond, 2016; Li et al., 2017; Moretti, 2013). If the average duration of education increases by one year, personal income will increase by 11–13% (Liu, 2007). Higher educated labourers usually have access to more income, and their affordability of housing prices will increase accordingly. They are more concerned about the welfare effect of human capital clustering (Haviernikova & Kordos, 2019; Yang & Pan, 2020). The changes in salary, rent, and construction will exacerbate the inequalities among employees from different educational backgrounds, with effect beyond education itself (Diamond, 2016). Urban housing prices is inseparable from natural and artificial facilities (Carruthers & Mulligan, 2012). Urban dwellers are willing to pay higher housing costs for high-quality urban facilities (Carmona et al., 2017; Zheng et al., 2009). While enjoying the dividend of population growth, those developing countries will also face the challenges that municipal infrastructure cannot keep up (Gorelick & Walmsley, 2020; Li et al., 2019). Cities with superior levels of urban construction have significantly higher housing prices (Garretsen & Marlet, 2017). The protection zone in historic blocks led to a rise in housing prices under a specified salary (Waights, 2019). Environmental pollution poses a significant threat to public health that can affect labour migration (Kwakwa et al., 2021; Yang et al., 2021). The housing prices and income trends are driven by aggregate demand, not just by changes in local factors such as productivity or facilities (Gyourko et al., 2013; Jia et al., 2021). The income gap significantly affects the migration decision of labourers, and this

impact is heterogeneous in gender (Zhu, 2002). An equal increase of wage in the labour market will lead labour to move from rural to urban, while the equal increase of housing prices results in labour moving to rural areas (So et al., 2001). Although relevant studies are affluent, there is limited heterogeneity in the impact of urban housing prices on labour mobility. Most generally starts from gender, urban and rural areas, and primary and secondary labour markets. The study subjects are based on the whole country or an individual city. Therefore, it is necessary to study further the impact of urban housing prices on labour mobility.

The main contributions of this paper are as follows. First, we study the impact of housing prices on labour mobility in China's prefecture-level cities and compare the distinction between the short- and long-term impacts. To address the endogeneity problem in this paper, we innovatively construct housing price jump as the instrumental variable. Second, we analyse the moderating effect of urban housing prices on labour mobility. The level of education, urban construction and income can alleviate the crowding-out effect of rising urban housing prices on labour mobility, effectively supplementing existing studies. Third, we analyse the heterogeneity of the impact of urban housing prices on labour mobility. On the one hand, the impact of housing prices on labour mobility is heterogeneous in the housing price-to-income ratio. The intensity of the crowding-out effect of rising housing prices on the labour first strengthens and then weakens with the increase in house price-to-income ratio. On the other hand, the impact of urban housing prices on labour mobility is heterogeneous in different industry structures. The crowding-out effect of rising urban housing prices is weaker for the primary industry and more significant for the tertiary industry.

The remainder of the article is as follows (see Figure 1 for the logical framework).

2. Research design

2.1. Theoretical analysis and research hypothesis

The rise of urban housing prices, mainly commercial housing prices, will have a specific crowding-out effect on labour mobility. Labour mobility is essentially a process of re-selection of living space. According to the labour push–pull theory, the factors that promotes the improvement of living conditions in labour flow is 'pull'. In contrast, the factors that are not conducive to improving living conditions in labour flowing out are 'push'. 'Pull forward and push backward' factors affect labour mobility collectively (Benjamin, 1970). In China, the current restrictions on the free movement of labour are relatively weak, and labour can move and migrate freely across regions. The problem is not the labour barriers but how to actually keep the labour here. According to the labour market segmentation theory, China's secondary labour market currently dominates, and the impact of urban housing prices on labour is shown as a crowding-out effect on the right side of the inverted U-shaped curve. The rapid rise of high housing prices will increase the living cost of labourers without home ownership, reduce the city's attractiveness, and hinder the city's introduction of talents. At the same time, labourers' expectations are linked to urban housing prices. Suppose the rising rate of housing prices is higher than labour's inner expectation or
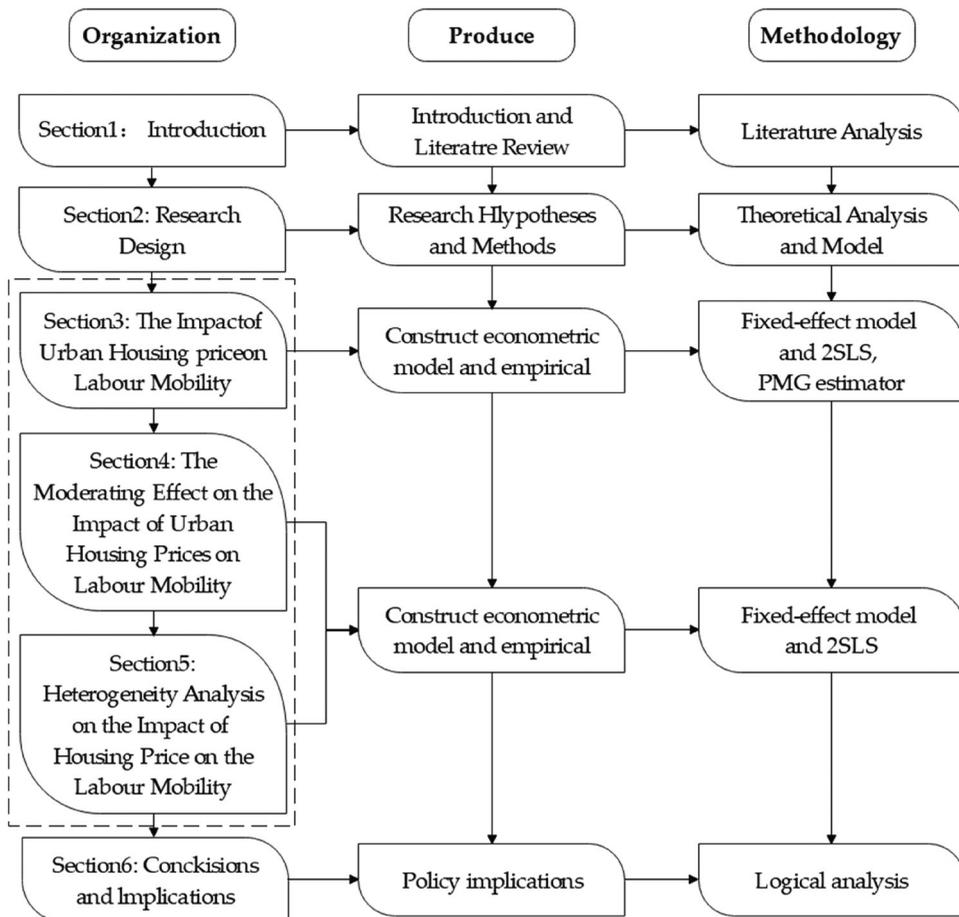
Figure 1. The logical framework of this article.
Source: Authors.

the tolerable range. Under this scenario, the labourer will become increasingly pessimistic about their future living standard and tend to reselect the employment area. Based on this, we propose the following hypothesis H1:

H1: Urban housing prices have a significant crowding-out effect on labour mobility.

To a certain extent, the level of urban housing prices is affected by several urban development conditions, such as different levels of education, urban construction and income. The better development prospects of cities, the more matched development opportunities for labourers, and more excellent wealth growth space will be reflected in urban housing prices. High housing prices often mean that the area is more affluent in education resources, urban infrastructures and ideal space for wealth growth. The crowding-out effect can be mitigated by labourers' aspirations for a better future and the pursuit of a high-quality of life. Quality educational resources are an effective catalyst for enhancing regional value. Aggregating quality educational resources can help enhance the region's current development and long-term development value. Urban infrastructures can promote high-quality development of China's economy

under the new normal stage and improve urban residents' living quality (Li, Zou, Tan, et al., 2021; Yang et al., 2022). The income level is related to the labourers' wealth accumulation and purchasing power and ref'ects economic affordability. Based on this, we propose the following hypothesis H2:

> H2: The level of education, urban constructions, and income respectively play a moderating role in the impact of urban housing prices on labour mobility.

Labourers always face a different environment of different housing price-to-income ratios and industry structures. The housing price-to-income ratio roughly describes the relationship between the average income and housing price in a city, which can reflect the housing affordability of urban residents. At the same time, this indicator reflects the pressure on the real estate market. If the ratio is too high, it proves that the real estate market has a bubble risk. The difference in price-to-income ratios has also become a consideration for labourers to make decisions in employed cities. Industrial structure impacts the cumulative effect of financial support and technological progress (Yao et al., 2021). Most labourers in the primary industry are local aborigines who have close ties to their regions. Without considering the transformation of the industry structure, the production materials such as land and lakes will hinder their migration. Besides, most labourers in the primary industry live in self-building houses in the suburb, and there is a low demand for commercial housing. The secondary industry, as the core industry, has a strong and rigid demand for labour, and the demand for labour from enterprises is strong. The working skills of labourers in the secondary industry have also been continuously improved, forming a strong 'rigid demand' for urban housing. The labour mobility in the tertiary industry is the largest. They are more concerned about urban development opportunities, living environment and policy dividends than other groups (Su et al., 2021). Therefore, they are more sensitive to changes in urban housing prices. Based on this, we propose the following hypothesis H3:

> H3: The impact of urban housing prices on labour mobility is heterogeneous in various cities with different housing price-to-income ratios or industrial structures.

2.2. Methods

2.2.1. Housing prices and labour mobility

In this article, the benchmark models of the impact of urban housing prices on labour mobility are set as the following model (1) and model (2):

$$Lab_{it} = \alpha_0 + \alpha_1 hp_{it} + \lambda X_{it} + \rho_i + \varepsilon_{it}\# \tag{1}$$

where, the subscript i represents the sample city, the t represents the sample time. The Lab represents labour force, the hp represents urban housing price, the X represents the control variables at the city level, including the economic development level ($pgdp$), the industrial structure upgrading (ind), the postal development level (pos), the green area (gre), the medical treatment (med), the cultural construction (cul),

the employment situation (emp), the living costs (lic) and the natural growth rate (nag).

To further investigate the short- and long-term distinction in the impact of labour mobility on urban housing prices, we introduce the P.M.G. estimator. The P.M.G. estimator could provide a good estimate of the coefficients both for short- and long-run relationship (Salim et al., 2020). Nested the model (1) into a general A.R.D.L. framework as follows:

$$Lab_{it} = \mu_i + \sum_{j=1}^{p} \lambda_{ij} Lab_{i,\,t-j} + \sum_{j=0}^{q} \delta'_{ij} hp_{i,\,t-j} + \sum_{j=0}^{q} \vartheta'_{ij} X_{i,\,t-j} + \epsilon_{it} \# \qquad (2)$$

where, λ_{ij} is coefficient of lagged dependent variables; $X_{i,\,t-j}$ is a $(k \times 1)$ vector of control variables and ϑ'_{ij} is a $(k \times 1)$ vector of control coefficients. Model (2) can be further reparametrised into an error-correction form as follows:

$$\Delta Lab_{it} = \mu_i + \emptyset_i \left(Lab_{i,\,t-1} - \delta'_{ij} hp_{it} - \vartheta'_{ij} X_{it} \right) + \sum_{j=1}^{p-1} \lambda^*_{ij} \Delta Lab_{i,\,t-1}$$
$$+ \sum_{j=0}^{q-1} \delta^*_{ij} \Delta hp_{i,\,t-1} + \sum_{j=0}^{q} \vartheta^*_{ij} \Delta X_{i,\,t-1} + \epsilon_{it} \qquad (3)$$

The parameter vector δ'_{ij} and ϑ'_{ij} contains the long-run relationship between labour mobility and urban housing price. The parameter $\emptyset_i$ is the error correction term. It measures the speed of adjustment of Lab_{it} towards its long-run equilibrium value following a change in hp_{it}. If $\emptyset_i$ is 0, then there is no long-run equilibrium relationship between the dependent and independent variables. The parameter vector δ^*_{ij} and ϑ^*_{ij} contains the short-run relationship between labour mobility and urban housing price.

2.2.2. Test for moderating role

The previous analysis shows that there are moderating effects of education level, urban construction level, and income level in the effect on the impact of urban housing prices on labour mobility. To verify these three moderating mechanisms, the model is specifically set as follows.

$$Lab_{it} = \alpha_0 + \alpha_1 hp_{it} + \alpha_2 hp_{it} \times M_{it} + \alpha_3 M_{it} + \lambda X_{it} + \rho_i + \varepsilon_{it} \# \qquad (4)$$

where, the M is moderating role, including education level (edu), urban construction level (urb) and income level (inc). In model (4), the coefficients α_2 reflects the moderating effect.

2.3. Instrumental variable: housing price jump

The bilateral relationship between the variables mainly characterises the endogeneity of the rise in urban housing prices and labour mobility. We refer to the method of Charles et al. (2018) and use the regression discontinuity design (R.D.D.) method that can effectively analyse the causal relationship between urban housing prices and labour mobility. The essence of R.D.D. is to estimate the ordinary least squares (O.L.S.) on both sides of the specific time and detect the changes of the two fitting lines at the discontinuity. The reasons for adopting the R.D.D. to identify the housing

price jump are as follows. First, this paper has the advantage of a large sample size to analyse the housing price jump comprehensively. Second, identifying provincial housing price jump helps to eliminate the impact of a single policy in a city. Third, as a classic policy evaluation model, using R.D.D. to identify the housing price jump can effectively eliminate the endogeneity caused by neglected variables related to time trends, which is not possible with a single structural breakthrough. Fourth, the single structural break will be close to 0, which loses much data to analyse where the house price changes linearly over time. The R.D.D. can get more data on housing price jump to make the estimation more precise.

The housing price jump can estimate the causal relationship between them. The economic logic of this instrumental variable is that the economic fundamentals of a city will not change suddenly in a short period. What's more, short-term structural changes in housing prices mainly from short-term shocks within the real estate market, rather than from traditional fundamentals. Such as speculative investment behaviour in real estate, changes in the adjustable interest rate collateral loans, or the downregulation of the housing loan rate (Chiang, 2020; Di Maggio et al., 2017; Favilukis et al., 2017; Matei, 2020; Mayer, 2011). The housing price jump can be used as an instrumental variable to explain changes in house price due to external shocks that are independent of other economic fundamentals. This type of shock will not affect labour's employment city selection through channels other than housing prices. Therefore, it is a reasonable instrumental variable. The accuracy of the R.D.D. results is affected by the model set, of which the bandwidth is the key. As for the bandwidth selection, the I.K. method is used to calculate the Optimal Bandwidth (Imbens & Kalyanaraman, 2012; Li, Yang, et al., 2021). According to the research of Lee and Lemieux (2010), the following model (9) is constructed:

$$hp_{it} = \lambda_0 + \lambda_1 * Skip_{it} + \lambda_2 * Y_{it} + \varepsilon_{it}$$
$$Skip_{it} = \begin{cases} 1, Y_{it} \geq 0 \\ 0, Y_{it} < 0 \end{cases} \# \tag{9}$$

Among them, the $Skip_{it}$ is the processing variable. That is, the t takes 1 after the housing price jump, otherwise takes the value 0. The Y_{it} is the execution variable, that is, t minus the difference of the time when housing price jump. The ε_{it} is the error term. In the provinces where 281 cities are located divided, the overall housing price jump in different cities within each province is identified.

2.4. Variables description and data sources

This article selected 281 prefecture-level cities in China from 2002 to 2018 as the initial sample considering the data availability. The dependent variable is labour (Lab), represented by the population mobility ratio through the population mobility formula. The population mobility = (resident population – registered population)/resident population. The value is positive if the labour force flows into the city and negative when the labour force flows out of the city. It should be noted that the population mobility may include the mobility of the non-working population, which is larger than labour mobility, but does not constitute a substantive impact. Because

Table 1. Descriptive statistics.

Variables	Item	Summary	Lowest	Lower	Medium	Higher	Highest
N		4777	952	952	952	952	969
Lab	Mean	−1.469	−3.930	−5.840	−5.901	−4.358	12.435
	Sd	15.385	12.833	10.486	10.842	12.058	19.847
hp	Mean	7.997	7.717	7.834	7.921	7.975	8.530
	Sd	0.660	0.507	0.566	0.555	0.606	0.722
pgdp	Mean	15.904	15.178	15.716	15.793	16.076	16.739
	Sd	1.111	0.925	0.876	0.922	1.007	1.169
ind	Mean	86.585	82.265	88.526	84.735	84.854	92.440
	Sd	60.059	10.133	133.333	8.546	7.720	6.151
pos	Mean	4.170	3.903	3.987	4.023	4.072	4.852
	Sd	0.939	0.793	0.782	0.717	0.817	1.171
gre	Mean	36.741	32.001	36.131	36.916	37.892	40.696
	Sd	13.679	10.561	8.863	8.813	8.799	23.339
med	Mean	3.498	3.519	3.449	3.433	3.392	3.696
	Sd	0.480	0.457	0.452	0.443	0.484	0.501
cul	Mean	6.761	6.246	6.531	6.519	6.917	7.575
	Sd	1.176	0.904	0.857	0.979	1.149	1.415
emp	Mean	0.027	0.031	0.030	0.028	0.026	0.021
	Sd	0.026	0.030	0.028	0.025	0.022	0.021
lic	Mean	4.693	4.693	4.693	4.692	4.693	4.693
	Sd	0.043	0.042	0.043	0.043	0.043	0.043
nag	Mean	5.664	5.132	5.208	5.717	6.477	5.784
	Sd	5.254	4.946	6.452	4.867	4.882	4.843
Proportion of labour	Mean	0.581	0.597	0.581	0.592	0.580	0.556
	Sd	0.159	0.157	0.162	0.157	0.158	0.159
edu	Mean	9.614	8.741	9.299	9.521	9.725	10.762
	Sd	1.966	1.784	1.744	1.848	1.870	1.994
urb	Mean	117.436	57.580	76.726	79.192	125.581	245.809
	Sd	168.112	114.005	55.690	60.802	161.166	267.057
inc	Mean	10.268	10.235	10.210	10.227	10.209	10.456
	Sd	0.665	0.662	0.686	0.647	0.640	0.655
Housing price jump	Mean	0.070	0.063	0.068	0.069	0.078	0.072
	Sd	0.079	0.073	0.074	0.075	0.075	0.095

Source: Authors.

the increase in urban housing prices, especially commodity housing prices, creates a certain extrusion effect on labour, the dependent variable is commodity housing prices (hp). Referring to the practices of existing kinds of literature (Shen, 2012), the control variables are: economic development level ($pgdp$), industrial structure upgrading (ind), postal development level (pos), the green area (gre), the medical treatment (med), cultural construction (cul), the employment situation (emp), the living costs (lic) and natural growth rate (nag).

Based on the research objectives, three indicators including education level, urban construction level, and income level, are selected as moderator variables in this article. The education level (edu) is calculated by the per capita local general public budget education expenditure. Since China's higher education resources are mainly public, education has strong external economic benefits and the market will fail in the education sector. The urban construction level (urb), represented by the built-up area of land. The per capita income measures the income level (inc). Data on all variables are obtained from the China Urban Statistical Yearbook, except for house price data, which are obtained from the website of Guoxin Real Estate Information. Table 1 reports the descriptive statistical results of all variables.

Table 2. Panel unit root test.

Variables	LLC test	Breitung test	IPS test	Hadri test
Lab	−5.133*** (−6.290***)	5.932 (5.347)	0.693 (−6.791***)	95.696*** (37.746***)
hp	−22.442*** (−6.493***)	29.038 (3.181)	4.758 (−5.061***)	152.007*** (66.316***)
pgdp	−25.025*** (29.434***')	18.876 (8.583)	−4.699*** (−14.708***)	132.408*** (50.747***)
ind	−17.377*** (−18.579***)	20.652 (8.967)	−7.518*** (−9.577***)	16.053*** (19.037***)
pos	17.127 (−6.432***)	22.819 (4.104)	25.997 (−9.418***)	116.163*** (44.237***)
gre	−15.428*** (−15.450***)	1.952 (−5.713)	−10.696*** (−16.294***)	38.903*** (63.346***)
med	−5.205*** (−3.299***)	12.110 (−4.809***)	8.735 (−16.132***)	116.558*** (16.447***)
cul	22.139*** (46.035***)	−18.123*** (14.562)	3.146 (4.289)	15.058*** (44.736***)
emp	−12.718*** (0.793)	−5.190*** (17.487)	−3.684*** (−10.971***)	77.623*** (19.707***)
lic	−38.1268*** (−30.7668***)	−27.785*** (−26.208***)	−19.920*** (−21.230***)	−1.427 (10.010***)
nag	−10.1268*** (−11.1858***)	−26.365*** (−20.718***)	−22.514*** (−28.685***)	21.740*** (7.672***)
Proportion of labour	−29.804*** (39.938***)	0.412 (−3.807***)	−3.175*** (−14.660***)	53.063*** (20.767***)
edu	9.988 (−69.644***)	−14.826*** (7.207)	5.445 (−16.006***)	69.799*** (14.411***)
urb	−0.004 (−14.306***)	23.754 (−0.196)	15.518 (−10.693***)	73.327*** (16.290***)
inc	−24.255*** (−0.001***)	44.766 (11.037)	1.683 (2.272)	150.782*** (21.806***)
Housing price jump	−17.048*** (−21.009***)	−25.379*** (−15.376***)	−24.704*** (−27.133***)	4.210*** (12.228***)

Notes: *, **, *** stand for significant levels of 10%, 5% and 1%, respectively, and the values in brackets are T-values. First figures in panel unit root test results are test statistics without trend in test equation and those in the parentheses correspond to test equation with trend.
Source: Authors.

Again, we employ the widely used panel unit root of the Levin-Lin-Chu test, the Breitung Test, the Im-Pesaran-Shin test and the Hadri Lagrange multiplier stationarity test. As shown in Table 2. Because the data set contains both I(0) and I(1) variables, model (3) opts to apply pooled mean group (P.M.G.) for estimation, which is robust to this type of panel data set.

3. Empirical results

3.1. Analysis of the impact of urban housing price on labour mobility

According to the setting models, the parameter estimation results are reported in Table 3. Table 3 reports the fixed-effect model's regression results of the impact of urban housing prices rising on labour mobility. According to the estimation results in columns (1) and (2), the rising urban housing prices have a significant crowding-out effect on labour mobility. Column (3) is the regression results obtained by the 2SLS estimation model. The results obtained by instrumental variables are consistent with the regression results of the fixed-effect model. That is, the urban housing price rising has a crowding-out effect on labour mobility. According to the labour push–pull theory, the crowding-out effect of urban rising housing prices on labour mobility is 'push'. The rise of housing prices can increase the living cost of labourers and decrease their ability to pay. High housing prices will lead to lower life expectancy and a redirection of employment fields. The regression coefficient of the instrumental variable is significantly larger than the O.L.S. estimation, mainly because the instrumental variable solves the endogeneity of homogeneous change of urban housing prices rise and labour mobility. Some unobservable economic factors may cause urban housing prices and labour mobility to change in the same direction. The above conclusion is consistent with hypothesis H1.

Table 3. Housing price and labour mobility.

	(1) Lab	(2) Lab	(3) Lab
hp	−2.886*** (−5.309)	−1.816*** (−4.369)	−10.459*** (−3.574)
pgdp	−2.246*** (−6.994)	0.678** (2.193)	5.268*** (3.357)
ind	0.007** (2.488)	−0.000 (−0.097)	−0.000 (−0.253)
pos	6.278*** (18.968)	0.290 (1.399)	1.130*** (3.216)
gre	0.127*** (9.000)	−0.001 (−0.079)	0.018* (1.741)
med	8.220*** (14.562)	−2.105*** (−4.518)	−0.169 (−0.210)
cul	4.353*** (20.979)	−0.068 (−0.482)	−0.740*** (−2.775)
emp	32.806*** (4.005)	−2.413 (−0.540)	−24.255*** (−2.818)
lic	−10.737** (−2.454)	0.535 (0.256)	8.517** (2.496)
nag	−0.135*** (−3.799)	−0.139*** (−5.915)	−0.177*** (−6.547)
Constant	17.908 (0.894)	7.258 (0.761)	−51.780*** (−2.889)
N	4777	4777	4777
Individual control	NO	YES	YES
R2	0.352	0.041	–
F/Wald	258.927	19.140	28739.90
Results of the first stage			
Instrumental variable	NO	NO	0.385*** (9.76)
F			95.1952

Notes: *, **, *** stand for significant levels of 10%, 5% and 1%, respectively, and the values in brackets are T-values, same as below.
Source: Authors.

There are three specific estimation methods for model (3) of P.M.G., M.G. (mean group) and dynamic fixed effects (D.F.E.). The D.F.E. estimator allows the intercept term to vary between cross-sectional units with a constant slope coefficient. The M.G. estimator accepts the intercept term and slopes to vary between cross-sectional units. However, the P.M.G. estimator lies in between the above two extreme estimators. According to Table 2, the P.M.G. estimator is preferred over the M.G. estimator (Table 4).

The error correction term is significantly negative, indicating that labour mobility is cointegrated with urban housing prices. The coefficient of error correction term implies that in the short run, the annual adjustment deviates from the long-run equilibrium relationship by about 29.7%. The empirical results show that rising housing prices promote labour mobility in the short run, but inhibit it in the long run. The reason may be that workers have a certain lagged response to the fluctuation of house prices. Rising house prices will cause an increasing cost of living for workers, lower savings, and cause labour outflow.

3.2. Robustness test

3.2.1. Robustness test of bootstrap

This section uses Bootstrap to perform re-sampling to obtain more gradual and effective estimators. We use 2000 repeated samplings to obtain the regression coefficients, and the results are reported in Table 5.

3.2.2. Robustness test of adjusted variables

We conduct the robustness analysis by altering the dependent variables in this part. The dependent variable labour is alternated by the proportion of urban unit employees in the total urban population. The regression results are reported in Table 6.

The results in Table 6 are still the same as the above results. That is, the conclusions are still robust. It suggests that the conclusions drawn in this article remain unchanged when the indicator measurement method changes. The conclusions are still valid when using similar data.

4. The moderating effect on the impact of urban housing prices on labour mobility

4.1. The moderating effect of education level

The regression results are reported in Table 7. Here we mainly focus on the cross-term coefficients between housing prices and education level.

Table 7 shows that education can alleviate the crowding-out effect of rising house prices on labour mobility. The empirical result verifies that the education level has a moderating effect on the impact of urban housing prices on labour mobility. In other words, the labourers are willing to undertake higher housing prices to have better educational resources. Generally, more educated labourers can earn higher income, thus offsetting the crowding-out effect caused by higher housing prices. Cities with

Table 4. Housing price and labour mobility.

	PMG estimation	MG estimation	DFE estimation
Long-run coefficients			
hp	4.649*** (11.392)	12.378 (0.507)	0.240 (0.204)
Control variable	YES	YES	YES
Short-run coefficients			
Error − correction	−0.297*** (−14.069)	−0.754*** (−18.787)	−0.352*** (−9.619)
Δhp	−1.599** (−2.517)	0.899 (0.902)	−1.505*** (−2.745)
Control variable	Yes	Yes	Yes
Constant	15.024*** (11.375)	61.775 (1.273)	12.311*** (3.012)

Source: Authors.

Table 5. Results of robustness test of bootstrap.

	(1) OLS	(2) 2SLS
hp	−1.816** (−2.572)	−10.459*** (−3.184)
Control variable	YES	YES
Instrumental variable	NO	YES
Constant	7.258 (0.584)	−51.780** (−2.404)
N	4777	4777
Individual control	YES	YES
R2	0.041	–
Wald	163.64	88365.21

Source: Authors.

Table 6. Results of robustness test of adjusted variables.

	(1) OLS	(2) 2SLS
hp	−0.087*** (−9.505)	−0.470*** (−6.483)
Control variable	YES	YES
Instrumental variable	NO	0.385***
		(−6.483)
Constant	1.486*** (7.088)	−0.507 (9.76)
N	4777	4777
Individual control	YES	YES
R2	0.147	–
F/Wald	77.562	2315.89

Source: Authors.

Table 7. Estimations of the moderating effect of education level.

	(1) OLS	(2) 2SLS
hp	−10.564*** (−13.269)	−19.569*** (−4.013)
hp × edu	0.918*** (12.801)	1.613*** (4.262)
edu	−7.078*** (−12.670)	−12.462*** (−4.254)
Control variable	YES	YES
Constant	61.256*** (5.793)	74.978*** (4.110)
N	4777	4777
Individual control	YES	YES
R2	0.075	–
F/Wald	30.187	31765.04
Results of the first stage		
Instrumental variable	NO	0.226*** (10.88)
F		118.46

Source: Authors.

abundant education resources can reduce the likelihood of local labourers' outflow. With more education, labourers can improve their ability to pay housing prices.

4.2. The moderating effect of urban construction level

The regression results are reported in Table 8. Here we mainly focus on the cross-term coefficients of housing prices and the urban construction level.

According to Table 8, the urban construction level can alleviate the crowding-out effect of rising housing prices on labour mobility. The empirical result verifies that the urban construction level has a moderating effect on the impact of urban housing prices on labour mobility. With the improvement of urban construction, labourers are willing to bear higher housing prices for high-quality living needs. When the urban is better built, labourers can enjoy more social welfare and offset the crowding-out effect.

4.3. The moderating effect of income level

The regression results are reported in Table 9. Here we mainly focus on the cross-term coefficients of housing prices and income levels.

Table 8. Estimations of the moderating effect of urban construction level.

	(1) OLS	(2) 2SLS
hp	−2.588*** (−6.256)	−10.392*** (−3.658)
hp × urb	0.009*** (10.726)	0.011*** (9.409)
urb	−0.068*** (−9.400)	−0.088*** (−8.619)
Control variable	YES	YES
Constant	17.180* (1.827)	−34.326** (−2.075)
N	4777	4777
Individual control	YES	YES
R2	0.074	–
F/Wald	29.864	30373.92
Results of the first stage		
Instrumental variable	NO	0.386*** (9.92)
F		98.458

Source: Authors.

Table 9. Estimations of the moderating effect of urban income level.

	(1) OLS	(2) 2SLS
hp	−30.430*** (−13.239)	−28.964*** (−3.669)
hp × inc	2.803*** (12.852)	2.667*** (3.632)
inc	−21.222*** (−12.798)	−20.240*** (−3.804)
Control variable	YES	YES
Constant	227.229*** (11.664)	202.640*** (3.566)
N	4777	4777
Individual control	YES	YES
R2	0.075	–
F/Wald	30.435	32689.08
Results of the first stage		
Instrumental variable	NO	0.134*** (19.69)
F		387.81

Source: Authors.

According to Table 9, income level can alleviate the crowding-out effect of rising urban housing prices on labour mobility. The empirical result verifies that the income level has a moderating effect on the impact of urban housing prices on labour mobility. The income level is directly related to the labourers' affordability to housing prices. As the income level increases, the affordability increases too. At the same time, the living standard of labourers increases due to higher income levels, while housing prices reflect the level of social development to a certain extent. High-income labourers can accept higher housing prices.

Based on the above conclusions, hypothesis H2 is accepted.

5. Heterogeneity analysis of the impact of housing price on the labour mobility

5.1. Heterogeneity analysis based on the housing price-to-income ratio differences

The housing price-to-income ratio roughly reflects the relationship between urban income and housing price, suggesting the affordability of urban residents and the pressure of the real estate market. We sort the total samples according to the different levels of housing price-to-income ratio into five groups. To analyse the impact of rising urban housing prices on labour mobility under different levels of housing price-to-income ratio. The estimated results are reported in Table 10.

Table 10 reports the impact of urban housing prices on labour mobility. The research indicates an inverted U-shaped curve between the intensity of the crowding-out effect of urban housing prices on labour and the housing price-to-income ratio. The main reasons may be as follows. First, the real estate market bubble is relatively tiny in cities with relatively low housing price-to-income ratio, and the labourers' housing affordability is relatively high. Second, cities with higher housing price-income ratio are generally the first-tier or super first-tier cities in China. They always have rich education resources, leading urban construction levels, broader employment opportunities, good job prospects, and strong attractiveness to labour. At this point, despite the huge real estate bubble, the attractiveness of urban infrastructure to the labour largely mitigates the crowding-out effect of housing prices on the labour. Third, cities of the middle group are often too choosy to fulfil labourers' wishes. In the embarrassing situation, labourers are sensitive to changes in urban housing prices.

Table 10. Heterogeneity based on the housing price-to-income ratio differences.

	(1) Lowest	(2) Lower	(3) Medium	(4) Higher	(5) Highest
hp	−1.264 (−1.007)	−2.037** (−2.148)	−2.583*** (−3.027)	−2.507*** (−2.911)	−0.170 (−0.217)
Control variable	YES	YES	YES	YES	YES
Constant	40.442 (1.509)	48.496** (2.270)	18.810 (1.108)	1.049 (0.057)	−24.021 (−1.317)
N	952	952	952	952	969
Individual control	YES	YES	YES	YES	YES
R2	0.092	0.191	0.195	0.139	0.081
F	8.931	20.958	21.470	14.333	7.983

Source: Authors.

Table 11. Heterogeneity based on the industrial structure differences.

	(1) Primary industry	(2) Secondary industry	(3) Tertiary industry
hp	−0.095*** (−13.445)	−0.418*** (−6.697)	−0.513*** (−8.312)
Control variable	YES	YES	YES
Constant	1.353*** (8.372)	6.053*** (4.232)	8.321*** (5.876)
N	4777	4777	4777
Individual control	YES	YES	YES
R2	0.303	0.517	0.516
F	194.853	481.123	479.177

Source: Authors.

5.2. Heterogeneity analysis based on the industrial structure differences

The industrial structure is the main component of the socio-economic system. The historical development sequence of social production activities can be divided into three parts. We analyse the heterogeneity of rising urban housing prices on labour mobility in different industry structures. The estimated results are reported in Table 11.

Table 11 reports the impact of urban housing prices on labour mobility and heterogeneity in different industry structures. The impact of rising urban housing prices on labour intensity is lower in the primary industry and higher in the tertiary industry. It shows that urban housing prices have different labour crowding-out effect intensity in different industrial structures. The majority of the primary industry labourers who own their own homes have a low demand for commercial housing. The tertiary industry labourers are more flexible in their choice of space, have greater population mobility, and are more sensitive to changes in housing prices than those who are secondary industry labourers.

Based on the above analysis, the last hypothesis, H3 is accepted too.

6. Conclusions and implications

On the basis of the existing theories and literature, we empirically test the impact of rising urban housing prices on labour mobility and its moderating effect. In addition, we further examine whether this effect is heterogeneous across cities with different housing price-to-income ratio and industrial structure. This article addresses endogeneity using a panel model with fixed-effect model based on 2002–2018 panel data in 281 cities in China and identifies housing price jumps as instrumental variables.

First, the rising urban housing prices has a significant crowding-out effect on labour mobility. Considering that both urban housing prices and labour mobility reflect the upward trend of the economy. The endogeneity is solved by constructing instrumental variables to identify the housing prices increase in the provinces where the sample cities are located.

Second, the three variables of education level, urban construction level, and income level respectively play moderating effect of urban housing prices on labour mobility. The improvement of the three variables can alleviate the crowding-out effect. When labourers make employment decisions, the influence of urban 'comfort' characteristics

such as education resources, urban construction level and income level becomes increasingly significant.

Third, the heterogeneity of the impact of urban housing prices on labour mobility is reflected in both housing price-to-income ratio and the industry structure. On the one hand, the research indicates an inverted U-shaped curve between the intensity of the crowding-out effect of urban housing prices on labour and the housing price-to-income ratio. On the other hand, rising urban housing prices on labour intensity are lower in the primary industry and higher in the tertiary industry. At present, few studies have been conducted from the perspective of housing price-to-income ratio. Therefore, it is essential to formulate a scientific and sound management policy based on different housing price-to-income ratio and industry structure.

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