

Research On Effectiveness of Low-Carbon Policies on Labor Mobility

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Abstract

The internal and external environment of China's development has undergone profound changes, and the promotion of “dual-carbon” has become an urgent need for cracking the outstanding problems of resource and environmental constraints and realizing sustainable development, while labor mobility can bring “demographic dividend” to the region, which is an important part of realizing the dual-carbon goal. This paper focuses on the low-carbon pilot policies, adopts the panel data of 281 prefecture-level cities from 2005 to 2019, and constructs a multi-period double difference model to investigate the effects of low-carbon policies on labor mobility. The study finds that: low-carbon pilot can significantly promote inter-regional labor inflow, and the above conclusion still holds after a series of robustness tests; mechanism analysis shows that the advancement of industrial structure plays a significant positive moderating role, while government expenditures on finance, science and technology play a mediating role. The research in this paper not only provides a new perspective for the evaluation of the effects of low-carbon policies, but also provides a new basis for city branding to attract labor inflow, and the heterogeneity analysis also provides a theoretical reference for the government to formulate talent policies.

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Keywords: Low-carbon policies, Labor mobility, Multi-period double difference model, Advancement of industrial structure.

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1. Introduction

With the global warming, various environmental problems have gradually attracted widespread attention from all walks of life, people's demand for their own quality of life has become higher and higher, and the "repelling effect" of the environment has made the mobility of labors no longer purely for the purpose of economic gain, and the pulling effect of the quality environment in the city on the labor force has gradually appeared. Therefore, while analyzing the traditional theoretical framework of labor mobility, it is of profound theoretical and practical significance to consider the factors of environmental pilot policies to understand the behavior of labor mobility.

The Seventh National Population Census shows that the total population of China has exceeded 1.4 billion, with the mobile population accounting for about 26.62 percent; compared with the Sixth National Population Census, the mobile population has increased by 69.73 percent, which, to a certain extent, also reflects the growth of labor mobility. On the one hand, the labor force in the broad sense refers to the entire population, so the mobility of population represents the mobility of labor force; on the other hand, statistically, the vast majority of the mobile population are workers within the legal working age range, which shows that the mobile population is mainly dominated by the mobility of labor force. The painful lessons of cities' development and the experience of individual cities' reversal show that, for urban development, the one who gets the population gets the world. Attracting the inflow of labor and giving full play to the "demographic dividend" of cities can help relatively backward cities to produce the "catch-up effect" and effectively reduce the development differences between regions. But what kind of policies can effectively improve the environmental quality and realize the purpose of attracting labor inflow? This paper will start from the city level to explore what kind of policies can promote the labor mobility between cities, and provide some suggestions and enlightenment for the "imbalance" between the development of various cities in China at this stage.

Greenhouse gas is a major source of the global greenhouse effect. Some studies show that cities consume more than 67% of global energy production and produce more than 70% of global carbon emissions (Wang et al., 2017). It can be seen that the city as an important carrier of human production and life, profoundly affecting the global energy consumption and environmental issues, the development of low-carbon cities has become a necessary path for future urban development. Low-carbon city construction has been carried out in full swing in some international metropolises. The London government plans to reduce carbon emissions by establishing a low-carbon energy supply and transportation system; Copenhagen hopes to reduce carbon dioxide emissions to zero by 2025 through a variety of carbon emission reduction and carbon sinks.

At the same time, China's low-carbon city construction has also entered the practical stage, Baoding is China's first "national renewable energy industrialization base", Shanghai has also made certain achievements in building energy efficiency. In

addition, China's low-carbon city pilot policy has so far been carried out in three batches, involving a total of 87 provinces, cities and counties, including 6 low-carbon provinces and 81 low-carbon cities. Among them, there are 24 pilot cities in the east, 18 in the middle and 17 in the west. The location of low-carbon pilot cities is relatively evenly distributed, and there is at least one low-carbon pilot city in 31 provinces, municipalities and autonomous regions in the mainland, which has a wide coverage. So, can the construction of low-carbon cities and the promotion of low-carbon pilot policies attract labor inflow to achieve the dual goals of economic development and environmental improvement? The next part of this paper will sort out the related literature and observe whether previous studies can answer the above question.

2. Literature Review and Commentary

The competition for talent among cities has given rise to the need for research on the impact of policies regimes on labor mobility. In recent years, there are two main aspects of research that are closely related to this paper: on the one hand, there is the literature that studies the influencing factors of labor mobility, and on the other hand, there is the research related to China's pilot policies for low-carbon cities.

2.1 Study on factors influencing labor mobility

Labor mobility is affected by a variety of factors, which have been studied and analyzed in the literature in recent years from various perspective, including the impact of workers' own factors, market-level factors, and government policies factors on labor mobility. First, at the individual level, dissatisfaction with government rules and regulations, work environment, social environment, a shock to the system, age, service, and income significantly influence labor inflow (Rajapakshe, 2021). In addition, air pollution has a negative impact on the net inflow of labor mobility, and the net inflow of labor mobility decreases between 24.9% and 44.7% on average for each unit increase in the health shocks of air pollution(Zhang et al., 2022).Second, at the market-level, the general growth of labor mobility of the population is caused by technological progress, desynchronization of the education sector and the labor market(Tikhonov et al., 2020).High-Speed Rail(HSR) also has a significant effect on promoting the mobility of high-skilled labor, and it provides critical evidence for future infrastructure planning and investment to achieve sustainable and high-quality development(Feng et al., 2023). Third, at the government level, Yang uses panel data for 123 large cities in China from 2000 to 2013 and finds that reforms on the household registration system in cities with a population of less than 2 million can induce labor outflows, while reforms on the household registration system in cities with a population of more than 2 million can effectively attract inflows of labor (Yang, 2017). Some scholars find that the level of regional public services is positively related to labor mobility based on the 2016 Chinese Family Panel Studies data (Wang et al., 2018).

In addition to studying inter-city mobility, some scholars pay attention to the factors influencing the mobility of rural labors, transfer of farmland (Lai et al., 2017) and the use of the Internet (Pan et al., 2022) would drive rural labor migration. It can be seen that in recent years, domestic scholars have studied this area from a variety of perspectives, using different data and models, which has enriched the research system of labor mobility influencing factors, but there are still fewer researches from the perspective of policies. The construction of the research system of the impact of policies is not yet perfect.

2.2 Research progress on pilot policies of low-carbon cities

In the face of the severe situation of global high carbon emissions, research related to the construction of low carbon cities has received more and more attention. In this context, it is of great significance to clarify research progress related to the evaluation of low carbon cities for the development of urban economy as well as for coping with the environmental problems caused by carbon emissions. Scholars have evaluated the performance of low-carbon city pilot policies from the perspectives of pollution reduction, carbon reduction, technological innovation, efficiency improvement, and economic development.

First, in terms of pollution reduction, some scholars construct a double difference model of region and time to assess the significant positive impact of low-carbon policies' implemented in Europe in recent years on regional air quality (Wolff, 2014), and our scholars confirm that the implementation of low-carbon pilot policies helps to reduce air pollution (Song et al., 2019). Second, in terms of carbon emission reduction, low-carbon pilot policies can significantly reduce the emissions of CO₂ (Huo et al., 2022) and improve carbon emission efficiency (Yu et al., 2021; Wen et al. 2022). Third, in terms of green technological innovation, Ma et al. find that low-carbon city pilot policies can stimulate enterprises to innovate in green technologies, and believe that tax incentives and government subsidies are important financial tools (Ma et al., 2021). Chen et al. find that LCCPS improves local green efficiency by promoting the aggregation of innovative resources (Chen et al., 2022). The fourth is that in terms of efficiency improvement, low-carbon pilot policies can not only improve the green total factor energy efficiency (Gao et al., 2022) and ecological efficiency of cities (Song et al., 2020), but also promote the total factor productivity of local enterprises (Chen et al., 2021). Fifth, in terms of green economic growth, low-carbon city construction significantly and sustainably facilitates green growth (Cheng et al., 2019), and Zhou et al. find that because of the LCCP policy has failed in the central and western regions, overall suppressing China's low-carbon economic transformation (Zhou et al., 2021).

In order to intuitively assess the effects of low-carbon policies, Chen et al. conduct a multi-dimensional assessment, through an evaluation index system of low-carbon cities construction, concluding that the low-carbon pilot has achieved positive effects (Chen et al., 2018), and has laid an important foundation for the advancement of national low-carbon development (Li et al., 2018). Although the

low-carbon pilot policy has been implemented in China for 12 years since it began in 2010, the research on the low-carbon pilot policies has been relatively comprehensive, no scholars have yet assessed the effect of the policies from the perspective of social livelihood, focusing on the dimension of labor mobility.

The above literature combing reveals that: in the relevant studies assessing the policies of low-carbon pilot cities, most of them are based on the panel data of prefecture-level cities in previous years, and the double difference model is applied to solve the endogeneity problem caused by the self-selection of the samples. Previous studies have achieved relatively abundant achievements on the influencing factors of labor mobility, but there is no literature focusing on the effects of low-carbon pilot policies on them. In addition, most scholars have only examined the direct impacts of low-carbon pilot policies on cities, industries and enterprises, and less research has been conducted on their relationship with people in society, but the ideological principle of "people-centeredness" has always been fundamental to the government policies. In view of this, the marginal contribution of this paper may lie in: (i) choosing the data of newer years and examining the effects of the three batches of low-carbon city pilot policy based on the double difference model with multiple time points; (ii) locking the establishment of the low-carbon pilot cities on the "people", exploring the impact of the pilot policies on the activities of social people, and offering new perspectives and new ideas on performance evaluation of the low-carbon pilot policies; (iii) exploring the relationship between low-carbon policies and labor mobility, and conduct an in-depth analysis of labors with different qualities and cities with different locations, so as to provide more targeted advice.

3. Research Mechanisms and Hypothesis Formulation

There are three main reasons why the low-carbon city pilot policies attract labor inflow: firstly, the brand value of a city affects the development of the city to a great extent, and the establishment of a low-carbon city pilot can signal the brand value of the city to the labors, attracting labor inflow. secondly, the industrial structure is not only a regulator of environmental governance, but also make difference on carrying human capital, which plays a vital role between the natural environment and human activities. lastly, the implementation of the low-carbon city pilot policies can promote local governments to take positive initiatives, which indirectly affects the labor mobility. Each of these three aspects will be analyzed in depth below.

First, city branding has a great impact on the competitiveness of cities. The reputation of "Paradise Above, Suzhou and Hangzhou Below" has made Suzhou and Hangzhou city brands, enhancing the attractiveness and competitiveness of Suzhou and Hangzhou, which have ranked among the best in the country in recent years in terms of both resident population and incremental growth. However, some cities have suffered from negative publicity, resulting in damage to their reputation and a significant reduction in their brand value, which is certainly detrimental to the development of the city. It can be seen that enhancing the city's popularity and recognition, giving full play to the city's brand value, and sending positive signals

to labors can attract the inflow of labor and accumulate human capital. At the same time, the low-carbon city pilot policy has received positive responses from governments in China, which have plunged into the construction of national low-carbon pilot cities. From the first batch of low-carbon city pilot policies launched in 2010 to the third batch carried out in 2017, a total of 87 provinces, municipalities and counties across the country have been included in the scope of research, the pilot content is becoming more explicit, and the pilot ideas are becoming clearer. This also sends a signal to labors: the low-carbon city pilot policy is becoming more mature, the low-carbon pilot cities are becoming more representative and exemplary, and the brand effect on labors is becoming more profound. In addition, after being established as a low-carbon city pilot, a low-carbon city pilot kick-off meeting is usually held at the citywide level, to publicize opinion on the pilot work, and to promote and strive for the understanding and support from all sectors of the society for the pilot work, which further brings into play the signaling effect of the city's brand. Based on this, hypothesis 1 is proposed.

Hypothesis 1: *Low-carbon city pilot policies can send signals to labors and attract labors inflow through the branding effect.*

An important entry point for environmental governance is to force the optimization and adjustment of industrial structure. The sustainability of environmental policies effects is the most important purpose of the implementation of a policy, low-carbon city pilot policies adopt a multi-period, multi-approval selection and assessment system, not only for the "pioneering", with the experience of the pilot city for other cities to explore an effective low-carbon governance path, but also in order to take the opportunity to rectify the current production methods of enterprise with high-pollution and high energy-consuming, help them transform into low-carbon, regulate environmental pollution from the root, and make the ecological governance effect of the low-carbon city pilot policy sustainable. This requires the coordination of industrial structure, the adjustment and upgrading of industrial structure can not only improve the efficiency of resource utilization, but also reduce the proportion of polluting industries, and control the emission of greenhouse gases. Moreover, the low-carbon city pilot policies implements the main leadership responsibility system, and the local governments of the pilot cities formulate specific carbon emission targets and low-carbon work implementation programs according to the actual situation of the localities, the carbon emission targets are decomposed to the key enterprises, and the work implementation programs are reported to the National Development and Reform Commission (NDRC), and a top-down supervision mechanism is set up to ensure that the emission reduction targets of the pilot are reached. Under such strict environmental regulation, the sunk and marginal costs of polluting industries entering the market increase, and the green barriers formed by the policies will reduce the polluting industries, clean industries gain a competitive advantage. Therefore, the mandatory environmental control plays the role of survival of the fittest, can inhibit the development of polluting industries, accelerate

the development of clean industries, and promote the optimization and transformation of industrial structure. And the change of industrial structure will inevitably bring about the mobility of labor between sectors, also including the mobility of labor between cities. Therefore, the following hypothesis is proposed.

Hypothesis 2: *Low-carbon city pilot policies promote labor mobility by promoting the optimization and upgrading of industrial structure;*

Assume that the returns to scale of clean industries are constant, using the Cobb-Douglas production function:

$$y = X^\alpha L^{1-\alpha}, 0 < \alpha < 1 \tag{1}$$

Where y and L denote the output of the enterprise and labor input respectively, X denotes the cleaning input, and α denotes the elasticity coefficient of labor output. According to the principle of optimal factor combination of manufacturers' profit maximization, it can be deduced that the enterprise's demand for labor is:

$$L = \frac{(1-\alpha)}{\alpha W} pX \tag{2}$$

Using s to denote the subsidy of the low-carbon city pilot policies, and assuming that wages are not affected by the subsidy of the low-carbon city pilot policy, the labor demand function is derived from the subsidy of the low-carbon city pilot policy s to obtain the impact of the low-carbon city pilot policies on labor demand:

$$\frac{dL}{ds} = \frac{(1-\alpha)X}{\alpha W} \frac{dp}{ds} + \frac{(1-\alpha)p}{\alpha W} \frac{dX}{ds} = \frac{(1-\alpha)X}{\alpha W} [1 - \varepsilon_{Xp}] \frac{dp}{ds} \tag{3}$$

Where $\varepsilon_{Xp} = -\frac{p}{X} \frac{dX}{dp}$ represents the price elasticity of demand for cleaning inputs; $\frac{(1-\alpha)X}{\alpha W} \frac{dp}{ds}$ represents the change in the relative prices of labor and cleaning inputs caused by the subsidies of the low-carbon pilot city policies, and thus the change in the demand for labor, reflecting the substitution effect between the two; and $\frac{(1-\alpha)p}{\alpha W} \varepsilon_{Xp} \frac{dp}{ds}$ represents the impact of the subsidies of the low-carbon pilot city policies on the cleaning inputs and the total cost, which is the change in the demand for labor caused by the cost effect. When the price elasticity of demand for cleaning inputs is large, i.e. $\varepsilon_{Xp} > 1$, the cost effect is larger than the substitution effect, making $\frac{dL}{ds} < 0$. The low-carbon city pilot policies aims to limit the amount of polluting inputs from enterprises by providing subsidies to increase the use of cleaning inputs, which leads to an increase in the demand for labor L by firms and thus attracts labor inflow. In view of this, hypothesis 3 is formulated.

Hypothesis 3: *Low-carbon city pilot policies attract labor inflows by increasing fiscal spending.*

In summary, this paper will conduct an empirical analysis to test the reasonableness of the above hypothesis.

4. Empirical Design and Data Description

4.1 Modeling

Using the low-carbon pilot as a quasi-natural experiment, the net effect of this pilot policies is identified by comparing the differences in labor mobility between pilot cities (treatment group) and non-pilot cities (control group) before and after the pilot policy. Referring to the research method of Yao Peng et al., we construct a multi-period double difference model with the time-series difference in the implementation of the low-carbon policies among different cities, and control for the two-way fixed effects of city and year, set up the baseline regression model as follows:

$$labor_{it} = \alpha_1 + \beta_1 did_{it} + \rho_1 X_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (4)$$

Where, $labor_{it}$ is the labor mobility rate of the city i in the year t ; did_{it} represents the dummy variable of the low-carbon pilot policy, if the city i belongs to the low-carbon pilot city in the year t , it will take the value of 1, and vice versa, it will take the value of 0; X_{it} represents the control variables selected in this paper, which are the factors affecting the labor mobility of the city i other than the low-carbon pilot policy, including size of city, wage level, cost of consumption, house-buying pressure, education level, medical level, traffic level, and greening level; μ_i and λ_t denote the city fixed effect and time fixed effect, which control all the city-level factors that do not change over time and time-level characteristics that do not change over regions; ε_{it} is the random perturbation term, and the clustering robust standard error with city as the clustering variable is used. The regression coefficients β_1 of the core explanatory variables did_{it} reflect the net effect of the low-carbon city pilot, reflecting the impact of the low-carbon city pilot on labor mobility, and is expected to be significantly positive at β_1 .

4.2 Sample selection

First, considering that the data of labor mobility will be affected by unpreventable factors after the Covid, this paper selects the sample from 2005-2019, without considering 2020 and beyond. Second, the National Development and Reform Commission (NDRC) launched China's first batch of low-carbon pilot cities in 2010, but because the first batch of pilots included five provinces, the pilot range was too large leading to unsatisfactory implementation results. In 2012, the NDRC identified the second batch of pilot lists with cities as the main pilot objects, involving 28 cities and one province. Then in 2017, it determined that 45 cities,

districts, and counties would carry out the third batch of low-carbon pilots. Therefore, this paper takes prefecture-level cities as the research object, excluding provinces, county-level cities and municipal districts, and takes 68 prefecture-level cities that had been established as low-carbon city pilot as the experimental group, and the remaining 213 prefecture-level cities as the control group, and carries out regression analysis by multi-period double difference method.

The low-carbon city pilot policy includes three batches of pilot provinces and cities, and Wang Ganhua et al. show that the low-carbon pilot policy does not have a significant impact on the inter-provincial level (Wang et al., 2014). Therefore, if a province implements a low-carbon pilot policy and the city under its jurisdiction also implements a low-carbon pilot policy, the time of implementation is set at the time when its prefectural-level city is determined to be a pilot city.

4.3 Data sources

Referring to Yuan Hang et al.'s approach, the indexes of industrial structure rationalization and advancement are used to reflect the industrial structure of each city, which are measured by the Tel index and the industrial structure hierarchy coefficient, respectively (Yuan et al., 2018). The calculation formula is shown in Table 1, where $y_{i,m,t}$ denotes the share of the output value for m industry in GDP for city i at t period, $l_{i,m,t}$ denotes the share of employees for m industry in total employees in i city at t period, and $m = 1,2,3$.

Given that the statistical caliber of the year-end total population in the China City Statistical Yearbook changed during the sample period, the year-end total population in China Real Estate Information-Macroeconomic Database is used as a substitute, and the average sales price of commercial residential is also sourced from the Macroeconomic Database. Other than that, the data of other indicators come from China City Statistical Yearbook, China Urban Construction Statistical Yearbook and the annual statistical bulletin of each city. Considering the matching of samples from different databases, the caliber of "total city" is chosen uniformly in order to make horizontal comparisons of labor mobility between cities.

In order to exclude the bias caused by outliers on the research results, this paper shrinks the continuous variables before and after the 1% level to reduce the influence of extreme values. Some of the missing values are filled in with mean values or based on average growth rates, and cities with more missing values are excluded, including Simao and Xiangfan, which are renamed during the sample period, and finally retain 281 prefecture-level cities during the 15-year period to constitute the panel data. The descriptive statistics of the main variables are shown in Table 1.

Table 1: Descriptive statistics results of the main variables

Category	Variable name	Variable Description	Unit of variability	Average value	Minimum value	Maximum value
Explained variable	Labor mobility(labor)	Growth rate of the sum of the number of persons employed in various units at year-end, the number of persons employed in private enterprises and self-employed individuals in urban areas, and the number of registered unemployed persons in urban areas at year-end - natural population growth rate	parts per thousand ratio	-5.102	-20.788	8.688
	Net population mobility (pop)	[Total population at the end of the current year - total population at the end of last year \times (1 + natural population growth rate of the current year)]/ Total population at the end of the current year	parts per thousand ratio	-5.648	-20.738	6.904
	Net growth rate of primary school enrolled students (stu)	Elementary school enrolled students' growth rate - natural population growth rate	parts per thousand ratio	-5.860	-20.727	6.723
Explanatory variable	Dummy variable of low carbon pilot (did)	If a city implements a low-carbon pilot policy, it takes the value of 1 for the current year and subsequent years, otherwise it takes the value of 0.	-	0.076	0	1
Control variable	City size(size)	Arithmetic average of the total population at the end of the current year and the total population at the end of the previous year	10000 persons	436.87	16.99	3409.8
	Wage level (wage)	Average wage of employed staff and workers	10000 yuan/person	0.518	0.046	4.192
	Consumption cost(cost)	Total material consumption per capita	10000 yuan/person	1.561	0.148	7.906
	House-buying Pressure (hous)	Average sales price of commercial residential	10000 yuan/sq.m	0.419	0.092	1.839
	Greening level(gree)	Area of green land per capita	Hectares/10000 persons	16.197	0.752	154.62
	Traffic level (traf)	Number of buses and trolley buses under operation and taxis at year-end per capita	Vehicles /10000 persons	10.824	0.843	65.871
	Education level(educ)	Number of regular institutions of higher education , regular secondary schools and primary schools per capita	Institutions/10000 persons	2.401	0.785	8.047
	Medical level (medi)	Number of beds of hospitals and health centers per capita	Sheets/10000 persons	39.718	12.258	95.325
Other variables	Rationalization of industrial structure(rat)	$\sum_{m=1}^3 y_{i,m,t} \ln(y_{i,m,t} / l_{i,m,t})$	-	0.355	-0.029	228.35
	Advancement of industrial structure(adv)	$\sum_{m=1}^3 y_{i,m,t} \times m$	-	6.428	4.736	7.652
	Government expenditure per capita(gov)	Ratio of local government general budget expenditure to total population at year-end	Ten thousand yuan/person	0.669	0.070	3.422
	Scientific and technological expenditures (sci)	Ratio of local government general budget expenditure for science and technology to total population at year-end	Ten thousand yuan/person	0.013	0.000	0.180

5. Analysis of Empirical Results

5.1 Baseline regression results

Column (1) of Table 2 reports the regression results obtained based on the multi-period double difference model (4). The coefficient of *did* is significantly positive at the 1% level, which confirms the positive effect of the low-carbon city pilot policies on inter-city labor mobility, and that being selected as a low-carbon pilot city can signal the city's branding to labors and attract labor inflows. It may be because being selected as a low-carbon city means that the city will implement a low-carbon economy, including low-carbon production and low-carbon consumption, which makes the city's ecological environment more livable and the residents' sense of well-being stronger, which in turn attracts labor inflow.

Table 2: Baseline regression results

Variable	Labor (1)	Pop (2)	Stu (3)
<i>did</i>	0.938*** (2.73)	0.974*** (3.16)	0.799*** (2.63)
<i>size</i>	-0.018*** (-5.17)	-0.018*** (-4.76)	-0.017*** (-4.73)
<i>wage</i>	-0.370 (-0.87)	-0.692*** (-2.76)	-0.738*** (-2.65)
<i>cost</i>	-0.378* (-1.84)	-0.003 (-0.02)	-0.122 (-0.72)
<i>hous</i>	-2.553*** (-3.11)	-1.855*** (-2.82)	-2.049*** (-3.19)
<i>gree</i>	-0.009 (-0.93)	-0.010 (-1.20)	-0.010 (-1.07)
<i>traf</i>	-0.024 (-0.67)	-0.060** (-1.99)	-0.030 (-1.10)
<i>educ</i>	-0.072 (-0.55)	-0.256** (-1.99)	-0.074 (-0.63)
<i>medi</i>	-0.001 (-0.09)	-0.046*** (-2.71)	0.008 (0.69)
city, time fixed effects	Yes	Yes	Yes
observed value	4,215	4,215	4,215
adjusted R ²	0.169	0.216	0.206

Notes: ① The t-values are in parentheses; ② *, **, *** represent significant at 10%, 5%, and 1% levels, respectively; ③ All regressions use cluster-robust standard errors with city as the clustering variable. The following tables are identical.

Besides, the coefficients of the control variables in the model also deserve attention. Among the eight control variables introduced, only the coefficients of city size and house-buying pressure are significant at the 1% level, indicating that the two significantly affect the mobility of labor between cities in China, and the larger the

city size and the higher the house-buying pressure, the more reluctant labors are to flow into the city. City size within a certain range has a significant positive impact on the wage level of the labor, but the population size is too large, its impact on wages will decline (Yang et al., 2021), which in turn increases the "push" of labor outflow. At the same time, high consumer costs impede labor inflows. On the one hand, as a kind of urban signal, house price can reduce the uncertainty on future income of labors, on the other hand, as the main cost of living greatly compressed the disposable income of labors. Obviously, the results of this paper provide a favorable basis for the dominant resistance of house prices to labor mobility.

5.2 Parallel trend test

Before conducting the analysis with a multi-period double difference model, a parallel trend test needs to be done for the control and treatment groups. If some time-varying characteristic variables of the treatment and control groups are not balanced before the treatment, then the hypothesis may not be right. Drawing on the event study method to analyze the dynamic effects of the low-carbon city pilot policies, if there is no significant difference in labor mobility between pilot and non-pilot cities before the implementation of the policies, it means that the premise of the use of the double difference model is valid, both to satisfy the parallel trend assumption. Referring to the practice of other scholars, set up dummy variables from 5 years before the implementation of the pilot to the year of launch, then 4 years after the launch (Beck et al., 2010), and construct the following model for the parallel trend test:

$$\begin{aligned} labor_{it} = & \alpha + \beta_1 before_5 + \beta_2 before_4 + \beta_3 before_3 + \beta_4 before_2 \\ & + \beta_5 before_1 + \beta_6 current + \beta_7 after_1 + \beta_8 after_2 \\ & + \beta_9 after_3 + \beta_{10} after_4 + \rho X_{it} + \mu_i + \lambda_t + \varepsilon_{it} \end{aligned} \quad (5)$$

$before_1$ to $before_5$ denote the dummy variables from 1 to 5 years before the implementation of the policies; $current$ denotes the dummy variables in the year of the implementation of the policies; $after_1$ to $after_4$ denote the dummy variables from 1 to 4 years after the implementation of the policies. The results show that the coefficients of $before_1$ to $before_5$ are not significant, and the coefficients of $current$ and $after_1$ become significant after the implementation of the low-carbon city pilot policy, which on the one hand indicates that the effect of the low-carbon city pilot policy starts to appear in the year of policy implementation and the first year after; on the other hand, it indicates that the effect of the low-carbon city pilot policy on labor mobility does not have lagging effect, but the persistence is not strong either. In order to make the results of the parallel trend test more intuitive, this paper also uses the plotting method to draw a parallel trend, as shown in Figure 1.

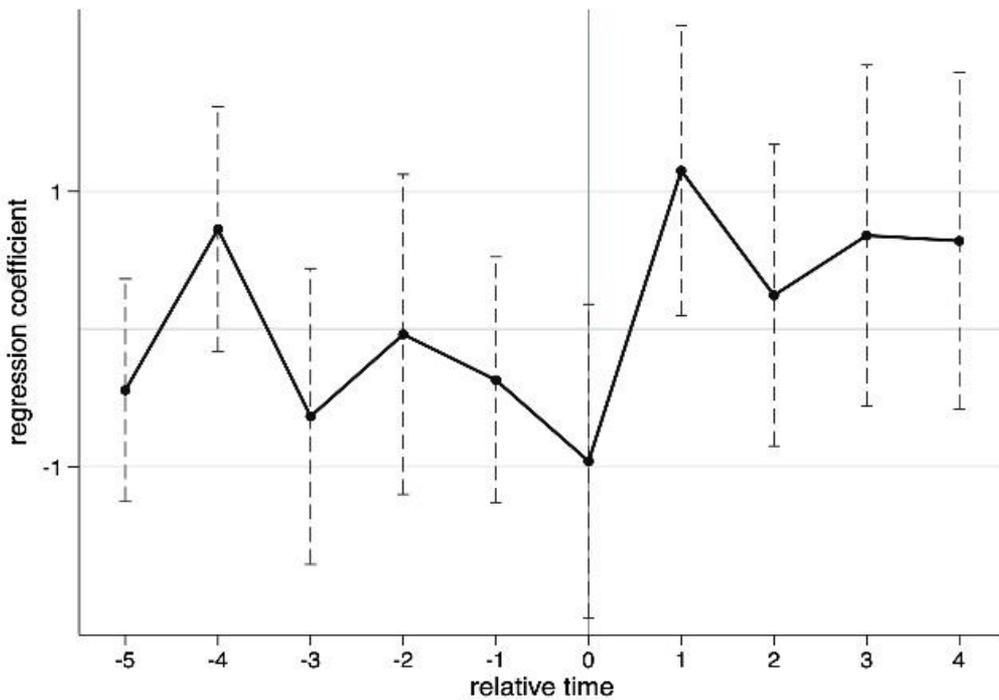


Figure 1: Parallel trend map

The coefficients of the periods before the implementation of the low-carbon city pilot policy are not significant, i.e., the 95% confidence intervals contain 0 values, which indicates that there is no significant difference between the treatment group and the control group before the implementation of the low-carbon city pilot policies, and meets the assumptions of the parallel trend.

5.3 Robustness tests

5.3.1 PSM-DID

In order to fully demonstrate the implementation effect of the low-carbon city pilot policy, the state may at the outset select a group of cities with good natural conditions, resource endowment and economic base as a demonstration, and thus be prioritized to be set up as low-carbon pilot cities, and this selection is not completely random, so there may be a problem of selectivity bias. This paper further reduces the differences between the samples on the basis of the propensity score matching method used to increase the accuracy of the model assessment. City characteristics such as city size, wage level, consumption cost, house-buying pressure, greening level, traffic level, education level, medical level, etc. are selected as matching variables, and the probability of a city being established as a low-carbon pilot city is calculated through the logit model to get the propensity score value, and then one-to-one nearest-neighbor matching is carried out, and 1,365 matched samples are finally obtained, and the matched samples are used to

carry out the same regression analysis. The results show that the results obtained from the double difference method of propensity score matching are basically consistent with those of the benchmark regression. The estimated coefficient of *did* of 0.943 is significant, which is comparable to the estimated coefficient of 0.938 obtained from the baseline regression. This suggests that the low-carbon city pilot policy can significantly promote labor inflow, and also verifies that the baseline regression results are highly robust.

5.3.2 Replacement of explained variables

Drawing on Yang's methodology, this paper uses the growth rate of city labor machinery as a proxy variable for labor inflow (Yang, 2017) to conduct baseline regressions model, which can be used to test the robustness of the above findings by replacing the measure of the explained variables.

Referring to Huang's approach, the labor mobility rate is used to examine the inflow of external labor to the region (Huang, 2010). At the same time, referring to the way of Wu You Meng, the net growth rate of primary school enrolled students is used to measure the level of labor mobility at the household level (Wu, 2020). If the coefficient of *did* remains significant after replacing the explained variables, the conclusion obtained from the baseline regression is robust. As shown in columns (2) and (3) of Table 2, the regression coefficients of the explained variables after replacing them with the net population mobility rate and the net growth rate of primary school enrolled students are both significantly positive at the 1% level, and their significance remains consistent with the results of the baseline regression. It shows that after replacing the explained variables, the effect of the low-carbon pilot policies on labor inflow still exists, which verifies the reliability of the result that the low-carbon city pilot policy can attract labor inflow obtained from the baseline regression.

5.3.3 Changing the sample interval

For the sake of research needs, this paper excludes the five provinces of the first batch of pilots from the variable setting, and divides the experiment and control groups only by the prefecture-level cities that appear in the list. However, such a setting may have an impact on the results, in order to circumvent the bias of sample selection, this paper will regress on the basis of changing the range of sample and observe the changes in the results. Specifically, the first batch of low-carbon pilot cities are first excluded, and the range of time is shortened to 2010-2019, so as to examine the labor mobility status of only 273 prefecture-level cities during this 10-year period. Then, drawing on Zhu Jinhe's approach, provincial capital cities and first- and second-tier cities, and sub-provincial cities and municipalities are excluded separately (Zhu et al., 2021), the regression analysis is conducted again, the results are shown in Table 3. The direction and significance of the regression results are consistent with the baseline regression, indicating that the above conclusions are robust.

Table 3: Changing the range of sample

Variable	Considering only the last two batches of pilots (1)	Excluding of provincial capitals and first- and second-tier cities (2)	Excluding sub-provincial cities and municipalities (3)
<i>did</i>	0.767**	1.419***	1.026***
	(2.19)	(3.64)	(2.78)
Control	Yes	Yes	Yes
City, time fixed effects	Yes	Yes	Yes
Observed value	2,730	3,510	3,930
Adjusted R ²	0.193	0.174	0.167

The respective regression coefficients are also worthy of our attention, and the estimated coefficient of *did* and their significance obtained when considering only the last two pilot batches are both lower than the baseline regression. It further suggests that the implementation of the low-carbon pilot policies in batches does have a significant impact on labor inflow, but as the number of pilot batches increases, the marginal effect brought by the implementation of the pilot may become less and less, and there is still room for the policies effect to play a role. The coefficients of *did* after excluding provincial capitals and first- and second-tier cities, and excluding sub-provincial cities and municipalities are all significantly positive, but both coefficients have increased compared with the baseline regression, which implies that provincial capitals, first- and second-tier cities, sub-provincial cities and municipalities are not more attractive to labor mobility than ordinary cities when they are established as pilot cities. And the estimated coefficients after excluding sub-provincial cities and municipalities are smaller than the coefficient values after excluding provincial capitals and first- and second-tier cities, suggesting that provincial capitals and first- and second-tier cities established as pilot cities are less attractive to labors than sub-provincials and municipalities.

5.3.4 Reverse causality test

Since policies shocks are generally exogenous to the experimental subjects, there is no problem of reverse causality using the double difference method in most cases, but this should not be based on subjective judgments, and empirical analysis should also be conducted to test the possibility that the cities where labors choose to inflow are more likely to be established as pilot cities. Taking the second batch of pilots as

an example, the NDRC issued a notice in April 2012 requesting localities to prepare declaration materials, and identified 29 cities and provinces as the second batch of low-carbon pilots in China in November 2012, and it took nearly a year for this batch of pilots to be carried out. If there is a problem of reverse causality between low-carbon pilot policies and labor mobility, then the inflow of labor at least a year ago would have incentivized cities to participate in the declaration of low-carbon pilots until they were established. In view of this, this paper constructs a baseline regression model with labor mobility rate lagged by 1 and 2 periods respectively as the explanatory variables and low-carbon pilot policies as the explained variable. The results are shown in Table 4, where the estimated coefficients of labor mobility rate lagged by 1 and 2 periods are insignificant, which indicates that the inflow of labor does not have a significant impact on the selection of the pilot cities, and there is no reverse causality problem.

Table 4: Results of reverse causality test

Variable	Lagging by one period (1)	Lagging by two period (2)
l^*_labor	0.002	0.001
	(1.56)	(0.81)
Control variable	Yes	Yes
City, time fixed effects	Yes	Yes
Observed value	3,934	3,653
Adjusted R^2	0.254	0.249

5.3.5 Exclusion of other city policies

In order to exclude the interference caused by other pilot policies on the effects of low-carbon pilot policies, with reference to scholars' study (Shi et al., 2019); (Lu et al., 2020); (Zhu et al., 2021), the three pilot policies of national smart city, innovative city and civilized city are introduced into the regression model to investigate the net effect of low-carbon pilot policies on labor mobility. The regression model is constructed as follows.

$$labor_{it} = \alpha + \beta did_{it} + \gamma_1 zh_{it} + \gamma_2 cx_{it} + \gamma_3 wm_{it} + \gamma_4 X_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (6)$$

Among them, did_{it} represents the low-carbon pilot policies dummy variable; zh_{it} , cx_{it} and wm_{it} represent the interaction terms of the policies and time dummy variables of smart cities, innovative cities, civilized cities and low-carbon cities, respectively, indicating the common impacts on labor mobility generated by each of them and low-carbon cities. Taking national smart cities as an example, the policies dummy variable of both national smart cities and low-carbon cities is set to

1, and the remaining cities are all assigned to 0. The time dummy variable of the year after the first batch of smart cities is assigned to 1, and the current year and the year before it is set to 0, so that the interaction term of the two is incorporated into the model, and the same for the related dummy variables of innovative and civilized cities, and the final results are obtained as shown in Table 5.

Table 5: Impact results of the test excluding other city policies

Variable	Smart city policies (1)	Innovative city policies (2)	Civilized city policies (3)	Three city policies (4)
did	0.966** (2.52)	0.835** (2.48)	0.919*** (2.69)	0.913** (2.40)
zh	-0.048 (-0.13)			-0.151 (-0.41)
cx		0.587 (1.51)		0.566 (1.48)
wm			0.518 (1.28)	0.309 (0.77)
Control variable	Yes	Yes	Yes	Yes
City, time fixed	Yes	Yes	Yes	Yes
Observed value	4,215	4,215	4,215	4,215
Adjusted R ²	0.169	0.170	0.170	0.170

The results show that the low-carbon pilot policy not only does not depend on other city policies to attract labor inflow, but is the only pilot policies among these four city policies that can significantly attract labor inflow. Specifically, the low-carbon pilot policy is significant at more than 5% level in all four models, and the policies effect is positive, indicating that the low-carbon city has the effect of attracting labor inflow as the brand of the city, while the brand effect when working together with other pilot policies is not significant, and the influence of other city policies can be excluded, the baseline regression results are robust.

5.3.6 Counterfactual tests

As a result of the above tests, the impact of the national smart city, innovative city and civilized city pilot policies can basically be ruled out, but there is still the possibility of interference from other policies or unobservable factors other than the three pilot policies mentioned above. In view of this, in order to verify that the results of the baseline regression are robust, it is also necessary to conduct a counterfactual test, i.e., to examine the impact of the dummy variable *did* on labor mobility when no low-carbon pilot work is carried out. Referring to Yuan Hang's approach, the implementation of the pilot policies is advanced by 1 year, 2 years and 3 years respectively (Yuan et al., 2018). If the result is not significant, it means that the low-carbon policies that has not yet been implemented will not have an

impact on labor mobility, and at the same time, it also means that there is no other systematic error between the control group and the experimental group, and the conclusion drawn from the baseline regression model is still reliable.

Table 6: Results of counterfactual tests

Variable	1 year in advance (1)	2 years in advance (2)	3 years in advance (3)
did_*	0.421	0.207	0.145
	(1.14)	(0.60)	(0.49)
Control variable	Yes	Yes	Yes
City, time fixed effects	Yes	Yes	Yes
Observed value	4,215	4,215	4,215
Adjusted R ²	0.168	0.167	0.167

Table 6 show that none of the regressions are significant, which suggests that the absence of a low-carbon pilot policies does not have an impact on inter-city labor mobility and that other policies or unobservable stochastic factors are not a cause of labor mobility, further confirming the robustness of the results of the baseline regressions.

6. Mechanism Testing

Considering that the impact of low-carbon pilot policies on labors is not necessarily direct, and may indirectly affect the mobility behavior of labors through a variety of channels, this paper will analyze the mechanism of the impact of low-carbon pilot policies on labor mobility.

Firstly, the regulating role of industrial structure is considered to explore the moderating effect of industrial structure in the process of the influence of low-carbon pilot policies on labor mobility, and the model is constructed as follows:

$$labor_{it} = \alpha + \beta_1 did_{it} + \beta_2 W + \beta_3 did_{it} \times W^* + \rho X_{it} + \mu_i + \lambda_t + \varepsilon_{it} \quad (7)$$

Among them, W represents the moderating variables, including rationalization of industrial structure (rat) and advancement of industrial structure (adv); W^* represents the moderating variables after centering, and the centering treatment has no effect on the test results of the moderating effect, but the centering treatment is not only to avoid the problem of covariance, but more importantly, it can ensure that the coefficients of the interaction terms are meaningful and easy to understand the results; $did_{it} \times W^*$ represents the coefficients of cross-multiplier terms of the core explanatory variables and the moderating variables, reflecting the extent to which the moderating variables influence the main effects; the other variables are consistent with the above.

The results are shown in Table 7. The coefficients of the cross-multiplier terms of the advancement of industrial structure and the explanatory variables are significantly positive, and the coefficients of the core explanatory variables are also significantly positive, which suggests that the advancement of industrial structure strengthens the impact of the pilot policies of the low-carbon city on the labor mobility, i.e., the advancement of industrial structure plays a significant positive moderating role in the relationship between the impact of the low-carbon city pilot policies and the labor mobility. The above empirical results can be interpreted as the degree of influence of the pilot policies on labor inflow in low-carbon cities will be affected by the industrial structure, the more advancement of the industrial structure of the city, the greater the influence of the pilot policies on labor inflow in low-carbon cities, and Hypothesis 2 can be partially verified.

Table 7: Test results of influence mechanism of industrial structure

Variable	Labor (1)	Labor (2)
did	0.902***	0.928***
	(2.69)	(2.70)
rat	0.012***	
	(3.40)	
adv		-0.483
		(-1.30)
did*rat	-1.821	
	(-0.90)	
did*adv		2.143*
		(1.94)
control variable	Yes	Yes
city, time fixed effects	Yes	Yes
observed value	4,215	4,215
adjusted R ²	0.170	0.171

In order to continue to explore the channels of influence of low-carbon city pilot policy on labor mobility, the following model is constructed to further explore the influence mechanism of low-carbon city pilot policy on labor mobility.

$$M = \alpha_2 + \beta_2 did_{it} + \rho_2 X_{it} + \mu_i + \lambda_t + \varepsilon_{it} \tag{8}$$

$$labor_{it} = \alpha_3 + \beta_3 did_{it} + \gamma_3 M + \rho_3 X_{it} + \mu_i + \lambda_t + \varepsilon_{it} \tag{9}$$

M represents the mediating variables, i.e., government expenditure per capita (gov), scientific and technological expenditures per capita (sci), and other variables are consistent with the above. The results are shown in Table 8.

As can be seen from the results in columns (1) and (3) of the table below, the marginal effect of the low-carbon city pilot policy on government expenditures per capita is significantly positive, as well as on scientific and technological expenditures per capita, indicating that the enactment of the low-carbon city pilot policy does indeed have a boosting effect on the government's related fiscal expenditures.

In addition, the coefficients of the core explanatory variables and the mediating variable M in the model (9), i.e., the direct effect of the core explanatory variables and the indirect effect of the mediating variables, are both significant, indicating that the government expenditure per capita and scientific and technological expenditure per capita both play the role of mediating mechanism in the impact of the low-carbon city pilot policies on labor mobility. In other words, the low-carbon city pilot policy can not only exert the brand effect of the city to directly pull the labor inflow, but also play a mediating effect through the financial, scientific and technological expenditures on the labor mobility and act as a "bridge" to produce an indirect effect.

Table 8: Test results of the mediating effect

Variable	Government expenditure per capita		Scientific and technological expenditures per capita technology	
	Gov (1)	Labor (2)	Sci (3)	Labor (3)
did	0.070**	0.882**	0.004*	1.018***
	(2.16)	(2.58)	(1.77)	(3.06)
M		0.807*		-22.088***
		(1.71)		(-2.95)
control variable	Yes	Yes	Yes	Yes
city, time fixed effects	Yes	Yes	Yes	Yes
observed value	4,215	4,215	4,215	4,215
adjusted R ²	0.874	0.170	0.656	0.173

Further, the column (1) in table 8 demonstrates the mediating effect of government expenditure per capita in the impact of low-carbon pilot policies on labor mobility, the coefficients of models (8) and (9) are significantly positive, and the coefficients $\beta_2\gamma_3$ are the same sign as β_3 , which indicates that the government expenditure per capita has a part of the mediating effect in the whole impact, and this part of the

mediating effect will depend on the magnitude of $\beta_2\gamma_3/\beta_1$, which is about 6%, that is to say, government expenditure per capita plays an indirect effect of about 6% in the mediating effect on attracting labor inflow of the low-carbon city pilot policy. However, for the mediating effect of scientific and technological expenditures per capita in the above process shown in columns (3) and (4), although the coefficients are all significant, the coefficients of $\beta_2\gamma_3$ and β_3 are different, which means that scientific and technological expenditures per capita have a masking effect in the above process (Fan, 2016), and the magnitude of the masking effect is $-\beta_2\gamma_3/\beta_3$, which is about 7%, i.e. the scientific and technological expenditures per capita plays an inhibiting effect of about 7% in the above influence process.

The possible reason for this is that, while the low-carbon city pilot policies attract the labors inflow, the nationwide implementation of the pilot policies has greatly mobilized local governments to invest in science and technology in the hope of promoting the construction of low-carbon pilots and projects, etc., which requires the input of a large number of human resources. Not only do we need high-qualified labors to devote themselves to the research and development or management of low-carbon technologies, but we also need low-qualified labors to produce and use low-carbon related products. However, the regulation of the environment by the low-carbon city pilot policies may cause the production and operation costs of industries to rise and to lay off labors, and the first to bear the brunt is the low-qualified labors, who will choose to flow out of the city if they feel that their working and living environments have become very difficult; or due to the changes in the economic structure brought by the implementation of the low-carbon city pilot policies, which will result in structural unemployment, and the low-qualified labors are not easy to change their work skills, their labor is easier to be replaced by new technology and new products, theoretically easier to flow. In all these cases, the government's initial intention of increasing investment in science and technology is good, but the "invisible hand" of the market may inadvertently promote the outflow of labor, especially low-qualified labors, which in turn creates a masking effect.

7. Expanding the Analysis

In order to further verify the reasonableness of the above inference, this paper will analyze the differences in labors and explore whether the impact of the low-carbon city pilot policy on labor mobility varies according to the qualified level of labors. Besides, the low-carbon city pilot policy is an important part of China's strategy to cope with climate change, selecting regions with different types, development stages and resource endowments to carry out the pilot program. Therefore, whether other qualities of cities also affect the effect of the pilot policies on labor mobility also needs to be further verified. First of all, this paper defines workers in technology-intensive industries as high-qualified labors and workers in other industries as low-qualified labors, measures the quality level of a city's labors by the ratio of the sum of workers in high-tech, education and health industries to the

number of workers in the three industries, and arranges them in the order of magnitude, then uses the median as the boundary to classify labors into two categories, high-qualified labors and low-qualified labors, and the interaction term between the dummy variable of labor quality and the city pilot is constructed and included in the model for regression:

$$labor_{it} = \alpha_1 + \beta_1 did_{it} \times qual_{-}^* + \mu_i + \lambda_t + \varepsilon_{it} \quad (10)$$

Among them, $qual_{-}^*$ is a dummy variable reflecting the quality of labors, divided into two categories: $qual_h$ (dummy variable for high-qualified labors) and $qual_l$ (dummy variable for low-qualified labors). When examining the influence degree of the low-carbon city pilot policy on the inflow of high-qualified labors, $qual_h = 1$ and $qual_l = 0$ are set; when examining the influence degree of the low-carbon city pilot policy on the inflow of low-qualified labors, $qual_h = 0$ and $qual_l = 1$ are set; and the other variables are consistent with the baseline regression model. The results show that the low-carbon city pilot policy has a significant attraction to the inflow of high-qualified labor (the regression coefficient is 1.095**), while the promotion of low-qualified labor is not obvious (the regression coefficient is 0.399). This may be due to the fact that the brand signals of low-carbon pilot cities are more easily received by high-qualified labors, and that high-qualified labors are more concerned about the livability of their working and living places than low-qualified labors, so high-qualified labors are more willing to flow into a city when it sends the brand signaling effect to the outside world.

Second, the different qualities of the cities themselves also affect the attraction effect of the low-carbon city pilot policy on labor mobility. Referring to Zhu Jinhe's approach, the administrative level of cities is divided into provincial capital cities and other prefecture-level cities respectively (Zhu et al., 2021), which are cross-multiplied with the dummy variables of low-carbon city pilot policy and included in the regression model:

$$labor_{it} = \alpha_2 + \beta_2 did_{it} \times grad_{-}^* + \mu_i + \lambda_t + \varepsilon_{it} \quad (11)$$

Among them, $grad_{-}^*$ is a dummy variable for the administrative level of the city, which is divided into two categories: $grad_c$ (a dummy variable for provincial capital cities) and $grad_o$ (a dummy variable for other ordinary prefecture-level cities); $did_{it} \times grad_{-}^*$ represents the interaction term between the initial characteristics of the city and the dummy variable for the low-carbon city pilot policy, with the same method of assigning the value as above, and whose coefficients reflect the impact of the establishment of different administrative levels of the city as a low-carbon city pilot on the labor mobility; the other variables are consistent with the baseline regression model. The results in columns (1) and (2) of Table 9 show that the implementation of the low-carbon city pilot policies in provincial capital cities does not have a significant attraction to labor inflow, but

the impact on labor mobility is significantly positive when an ordinary prefecture-level city is established as a low-carbon city pilot. This may be due to the fact that the marginal effect of the signals sent by provincial capital cities to labors is not as strong as that of ordinary cities. On the one hand, the higher administrative level of a city means that the city tends to be subject to more policies constraints, which indirectly raises the threshold of labor inflow into the city, and the benefits that labors get from flowing into provincial capital cities are not as much as those that can be gained from flowing into ordinary cities; on the other hand, the ordinary cities tend to be more in need of human capital accumulation, and the talent attraction policies introduced to this end are more attractive to some labors, so these labors will choose to flow to ordinary cities in order to obtain more marginal benefits.

In addition, differences in geographic location often represent differences in transportation conditions, openness, resource endowment and development strategies within the city, so it continues to consider whether the geographic location of the city causes differences in the effect of the low-carbon pilot policies on labor mobility. First, this paper divides China's cities into three regions: eastern, central, and western cities, according to the regional divisions used in the Fourth National Economic Census Bulletin, and generates regional dummy variables, which are then regressed in groups.

Table 9: Results of city heterogeneity analysis

Variable	Provincial capital cities (1)	Ordinary prefecture-level cities (2)	Eastern cities (3)	Central cities (4)	Western cities (5)	Northern cities (6)	Southern cities (7)
did	-0.099 (-0.16)	1.199*** (3.05)	1.601* (2.69)	0.600 (1.01)	0.336 (0.56)	1.210** (2.35)	0.762* (1.77)
control variable	Yes	Yes	Yes	Yes	Yes	Yes	Yes
city, time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
observed value	390	3,825	1,485	1,485	1,245	1,965	2,250
adjusted R ²	0.242	0.170	0.199	0.274	0.139	0.245	0.151

The obtained results are shown in columns (3), (4) and (5) of Table 9. The effect of the low-carbon pilot policy on labor mobility in the eastern cities is significantly positive, while the effect in the central and western cities is not significant. This may be due to the fact that the industrial structure in the central and western regions as a whole favors heavy industry and the development of tertiary industry is relatively slow (Zhu et al., 2021). The tertiary sector is more labor-absorbing than the secondary sector (Chen et al., 2020). This also makes the cities in the central and western regions to implement low-carbon pilot policies to attract labor force is not as effective as the eastern region; Moreover, the eastern region is better than the

central and western regions in the supply of exclusive public services such as education and medical care, as well as in the employment opportunities and wage levels brought by the economic development. In addition, the "Matthew effect" of labor mobility makes the lack of labor in the underdeveloped areas of the central and western regions more and more serious, and it is easy to form a vicious circle. To sum up, the implementation of low-carbon city pilot policy in the eastern region will bring more obvious effects.

However, it is incomplete to consider only the division of Eastern, Central and Western, so this paper also refers to Li Erling's approach, classifies 15 provinces and municipalities in Northeast, Northwest, and North China (including Henan and Shandong) as the northern region, and the remaining 16 provinces and municipalities are classified as the southern region (Li et al., 2002), continues to group regression to conduct the heterogeneity test. The results, as shown in columns (6) and (7) of Table 9, show that the effect of low-carbon city pilot policy on labor mobility is significantly positive in both northern and southern cities, but the effect in northern cities is much larger than that in southern cities.

On the one hand, since the reform and opening up, China's southern and northern regional economic differences have gradually narrowed (Li et al., 2002), and the national regional economic differences have mainly unfolded in the east and west, which makes the policies effects between the north and the south converge, and the overall consistency is significantly stronger than the east and the west distribution; on the other hand, in the process of China's reform and development, the overall level of the economy between the north and the south regions has been changing from weak in the south and strong in the north to strong in the south and weak in the north, and the economic center has shifted south. This means that for labors, the marginal gains from flowing into southern cities are not as great as those from going to northern cities, so the implementation of low-carbon city pilot policy in the north will have a more pronounced effect on labor inflow than in the south.

8. Main Conclusions and Policies Recommendations

This paper takes the low-carbon city pilot policies as a quasi-natural experiment, adopts panel data of 281 prefecture-level cities across China from 2005-2019, applies the multi-period double difference model to assess the policies effect of the low-carbon city pilot policies on labor mobility, uses the moderating effect model to explore the influence of industrial structure on the effect of the policies, and uses the mediation model to explore the government's fiscal expenditure in the effect of policies. The results find that: (1) the brand value of low-carbon pilot cities has a signaling effect, which can enhance the city's popularity and attract labor inflow, and the low-carbon city pilot policies can transmit signals to labors independently of other pilot policies, which has a significant attraction effect on labor; (2) the low-carbon city pilot policies not only strengthen the effect of policy on attracting labor inflow by promoting the green transformation of industrial structure, but also guide the government to increase the fiscal expenditure, which has a significant effect on

labor inflow; (3) Low-carbon city pilot policies have a stronger effect on attracting high-quality labors; (4) The impact of low-carbon pilot policies on labor inflow varies among cities in different regions. In response to the above conclusions, this paper puts forward the following policies recommendations:

- Firstly, fully recognizing the importance of the value of city branding for city development, government should focus on enhancing the visibility of cities and building city brands, give full play to the signal effect of low-carbon city pilot policies, guide cities to attract the labor inflow, weaken the imbalance on development between cities, let labors move between cities, especially high-qualified labors, then gradually form a modern city system that conforms to China's national conditions and the laws of economic development, break down the shortcomings of mechanism that impede the social mobility of labors, optimize the allocation of human resources, and promote economic and social development;
- Secondly, it actively guides cities to carry out green transformation and upgrading of industrial structure, and greatly exerts the regulating effect of industrial structure in the impact of low-carbon city pilot policy on labor inflow. By promoting the green and advanced transformation of the city's industrial structure, the city's ability to absorb labor is enhanced. From the perspective of labors, the transformation of industrial structure solves the employment problem of some labors, while from the perspective of cities, the green upgrading of industrial structure enhances the positive externality and continuity of low-carbon city pilot policies, and improves the quality of the environment while further attracting the inflow of labors and accumulating human capital;
- Thirdly, attention should be paid to the financial support preferences of the labor mobility, and the mobility of population should be fully mobilized through increased financial expenditures, especially on science and technology. The government should vigorously cultivate green innovative talents, optimize the policy and give full play to the clustering effect of talents. The high-qualified labors' preference for expenditures on science and technology will lead high-qualified labors to continue to enter the labor market and obtain jobs, which not only guarantees the improvement of the quality of the labor stock, but also fully releases the demographic dividend of the city.
- Fourthly, the mobility of labors to developed regions should be encouraged and supported to strengthen the polarization effect of talent in the central and western regions, and to attract and stabilize high-qualified talents. At the same time, cities in the central and western regions should focus on creating conditions that can attract and gather talents, gradually forming talent concentration, and upgrading the level of human capital in cities from point to surface. Giving full play to the technological spillover and radiation-driven role of the eastern cities to the neighboring cities, the experience exchange on low-carbon models between cities should be encouraged, so as to achieve the purpose of interactive exchanges, mutual reference and common progress.

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