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The Impact of Housing Prices on Regional Innovation Capacity: Evidence from China

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Abstract: Enhancing regional innovation capacity has become a realistic need to promote high-quality economic development. At present, there is no consensus on how housing prices affect regional innovation capacity. Papers in the existing literature frequently regard regional innovation capacity as a "black box". Little consideration has been given to the internal processes of this black box as well as to the mechanisms of housing prices affecting regional innovation capacity. In order to crack this black box, regional innovation can be divided into three stages: innovation input, innovation output, and innovation achievement transformation based on innovation value-chain theory. In this paper, an analytical framework of housing prices affecting regional innovation capacity was constructed using the relevant theories. An empirical test was conducted using Chinese provincial panel data from 2004 to 2019. It was found that housing prices have negative impacts on innovation input, innovation output, and innovation achievement transformation capacity. These three impact paths are influenced by the three mechanisms of real-estate investment, human-capital level, and regional consumption capacity, and the impacts are heterogeneous among different regions in China. These findings contribute to our understanding of the relationship between housing prices and regional innovation capacity and provide useful references for enhancing regional innovation capacity.

Keywords: housing price; regional innovation capacity; innovation value-chain theory

1. Introduction

With the restructuring of the world economy, the development dividend achieved by relying on factors and investments in the past has gradually disappeared. Economic development needs to be changed to an innovation-driven development path. As early as 2017, the 19th CPC National Congress of China proposed that "innovation is the first driving force leading development"; the 20th CPC National Congress of China in 2022 further proposed to "accelerate the implementation of innovation-driven development strategy"; therefore, the improvement of innovation capacity is an inevitable requirement for building a modern economic system in China. In the above context, many scholars have studied innovation capacity at the micro level of enterprises [1,2], at the middle level of industries [3,4], and at the macro level of regions [5,6]. Data from the National Bureau of Statistics show that the average housing price in China, as one of the important local economic development indicators, more than tripled from 2004 to 2019 (The Chinese average sale price of commercial housing in 2004 was 2778 CNY/square meter and reached 9310 CNY/square meter in 2019). In the same period, data from the National Bureau of Statistics show that CPI data rose by less than two times (Chinese CPI in 2004 was 455.8 and reached 669.8 in 2019). Many scholars have focused on the relationship between housing prices and regional innovation capacity but there is no consensus on how housing prices affect regional innovation capacity. Some scholars pointed out that rising housing prices would lead to the concentration of production factors in real-estate-related sectors, resulting in a shortage of production factors in the innovation sector, which, in turn, would

weaken the regional innovation capacity [7]. Other scholars believed that the financing dilemma of enterprise R&D activities would be alleviated by the wealth effect caused by rising housing prices, which, in turn, would enhance the regional innovation capacity [8]. In addition, current studies on housing prices and regional innovation capacity often regard regional innovation capacity as a "black box". Little consideration has been given to the internal processes of this black box, as well as the mechanisms of housing prices affecting regional innovation capacity. In order to break this black box and explore the influence mechanisms of housing prices on regional innovation capacity, based on the innovation value-chain theory, this paper divides regional innovation into three stages: innovation input, innovation output, and innovation achievement transformation. In this paper, an analytical framework of housing prices affecting regional innovation capacity was constructed combined with the relevant theories of real-estate economics and public administration. An empirical test was conducted using Chinese provincial panel data from 2004 to 2019. The study finds that changes in housing prices affect the level of innovation input, innovation output, and the capacity of innovation achievement transformation. These three impacts are influenced by three mechanisms, respectively: the amount of real-estate investment, the level of human capital, and the regional consumption capacity. Based on the above findings, this paper puts forward relevant policy recommendations on housing prices and regional innovation capacity. This paper demonstrates three main innovations. First, based on the innovation value-chain theory, we divide regional innovation into three stages and explore the mechanisms of housing prices affecting regional innovation capacity, unveiling the "black box" of how housing prices affect regional innovation capacity. Second, most of the existing studies in the literature analyzed the relation between housing prices and innovation capacity from the perspective of economics, whereas this paper further introduces relevant theories of public administration based on China's politically centralized and economically decentralized condition, which enhances the reliability of the theoretical analysis. Third, this study proposes differentiated suggestions for improving regional innovation capacity by combining the path and mechanism mentioned above, which provides a useful reference for improving regional innovation capacity, especially in China. Also, other politically centralized and economically decentralized countries or regions, especially where the economy relied on factors and investments in the past, can benefit from this paper through its analysis of the relationship between housing prices and innovation capacity.

The rest of this paper is organized as follows: The second part is a literature review, which examines the existing literature on how housing prices affect regional innovation capacity. The third part of this paper details a theoretical analysis and research hypothesis. Based on the innovation value-chain theory and theories related to real-estate economics and public administration, the analysis framework of how housing prices affect regional innovation capacity is constructed. The fourth part displays our research design, which includes the econometric model, variable descriptions, and data descriptions. The fifth part is the econometric analysis and a discussion of the results, which includes benchmark regression results, mechanism tests, heterogeneity analysis, robustness, and endogenous analysis. The sixth and final part of this paper unveils our conclusions and policy recommendations. Based on our research conclusions, relevant policy recommendations are put forward in order to improve regional innovation capacity.

2. Literature Review

The literature related to this topic mainly focuses on the relationship between housing prices and regional innovation capacity. At present, there is no consensus on how housing prices affect regional innovation capacity. The main viewpoints can be summarized: housing prices have a positive, negative, and two-way impact on regional innovation capacity. The rest of this section will review the above three viewpoints, respectively.

The existing research that states that housing prices have a positive impact on regional innovation capacity mainly believes that the rise in housing prices has a financial mitigation

effect, which then improves the innovation capacity. Yu and Tan found that with the rise in housing prices, enterprises' financing constraints were alleviated, making enterprises' R&D funds more abundant, which improved the innovation capacity of enterprises [9]. Liu believed that for state-owned enterprises, rising housing prices increased their financing capacity, which then prompted these enterprises to increase R&D investment and improved their innovation capacity [10]. Zhang believed that in the context of rising housing prices, real-estate appreciation would enhance urban innovation capacity through the industrial agglomeration effect and knowledge spillover effect [11].

The previous research that states that housing prices have a negative impact on regional innovation capacity mainly believes that the rise in housing prices has a "capital crowding out effect", "factor cost effect", and other effects, thereby weakening the innovation capacity. The rise in housing prices has increased the return on investment of real estate, causing capital in other departments to flow into real-estate sectors and weaken the innovation capacity of enterprises [12,13]. Zhang believed that the rise in housing prices not only affected the innovation capacity of enterprises through the crowding-out effect but also affected household consumption preferences, leading to households' increased real-estate investment and reduced consumption, further forcing enterprise funds to flow to the real-estate industry [14]. Li pointed out, from the perspective of the cost effect, that the rise in housing prices increased the innovation cost of enterprises, forced enterprises to move to areas with low housing prices, and, thus, reduced the innovation capacity of regions with high housing prices [15]. Tao believed that the rise in housing prices led to a reduction in industrial structure upgrading, further weakening the regional innovation capacity [16].

The research that states that housing prices have a two-way impact on regional innovation capacity believes that real estate has dual attributes of investment goods and consumer goods, resulting in housing prices having a two-way impact on innovation capacity. Xu and Zhang constructed a theoretical model, including the "financing mitigation effect" and "capital crowding out effect", from the perspective of enterprise value analysis; they pointed out that housing prices have a two-way impact on innovation capacity [17]. Miao and Wang obtained similar conclusions based on their analysis from the perspective of enterprises [18]. Yu and Zhang thought that the dual attributes of real estate led to a "liquidity effect" and a "crowding effect", which had positive and negative impacts on innovation capacity, respectively, and pointed out that the effect of housing prices on enterprises' innovation capacity in China was dominantly negative [19]. Liu and Shi calculated China's positive effect and the crowding-out effect of housing prices on enterprises' innovation capacity; they found that, compared to the positive effect, the negative effect was dominant in this case also [20].

In summary, there is no consensus on how housing prices affect regional innovation capacity at present and the existing papers frequently regard regional innovation capacity as a "black box". Little consideration has been given to the internal processes of this black box as well as to the mechanisms of housing prices affecting regional innovation capacity. Therefore, based on the innovation value-chain theory, this paper divides regional innovation into three stages: innovation input, innovation output, and innovation achievement transformation. Then, we construct an analytical framework of housing prices affecting innovation capacity in three stages, using the relevant theories of real-estate economics and public administration, such as the Chinese-style decentralization theory. We hope that this analytical framework will help to deepen our understanding of the relationship between housing prices and regional innovation capacity and be a useful reference for enhancing regional innovation capacity.

3. Theoretical Analysis and Research Hypotheses

In order to analyze the process of regional innovation deeply, this paper introduces innovation value-chain theory in order to break the black box of regional innovation capacity. It is worth noting that the current research on innovation can be divided into two levels:

technological innovation and institutional innovation. This paper mainly focuses on technological innovation to study regional innovation capacity. The innovation value-chain (IVC) theory, which originated from Hansen and Birkinshaw, regarded the innovation process as a step-by-step chain structure and applied this idea to promote enterprise innovation [21]. Since then, many scholars have studied and applied the innovation value chain in different industries, different innovation subjects, and different regions [22,23]. The meaning and application scope of innovation value-chain theory have been expanded from the initial microenterprise level to the medium-level industry level and the macroregional level. This paper draws on the views of Hansen and Birkinshaw [21] and refers to the division of regional innovation stages by Yu and Liu [23]; we also divide the regional innovation process into three stages, namely, innovation input stage, innovation output stage, and innovation achievement transformation stage. The innovation input stage refers to the input of production factors to promote the occurrence of innovation activities. The innovation output stage refers to the formation of various innovation achievements based on the occurrence of innovation activities. The innovation achievement transformation stage means those innovation achievements go to the market and realize the innovation value. The following will explore the path and mechanism of housing prices affecting regional innovation capacity based on the above three stages at the theoretical level in order to build an analytical framework.

3.1. Innovation Input Stage

The funds in the innovation input stage mainly derive from enterprises and governments [24,25], so the impact of housing prices on regional innovation input can be analyzed from enterprises and governments, respectively. First, for enterprises, housing prices mainly affect innovation input through the "investment crowding out effect" and "financing mitigation effect". The investment crowding-out effect means that if the investment returns of different departments are significantly diverse, the capital will be reallocated under the premise of limited total capital, resulting in the reduction of capital in departments with lower investment returns. For the real-estate sector and innovation sector, if housing prices rise, the investment return gap between these two sectors will widen. In addition, the investment payoff period of the innovation sector is longer [26], the probability of innovation success is lower [27], and the acceptance of new products in the market is often difficult to predict [28]; so, enterprises usually invest limited funds into the real-estate sector. Enterprises that originally belonged to the innovation sector may invest funds into real-estate projects, resulting in a squeeze of funds from the innovation sector. Therefore, the rise in housing prices has a negative effect on regional innovation input. The financing mitigation effect refers to that which is compared with other types of assets; real estate, as a fixed asset, has financing advantages. In the context of rising housing prices, the ledger assets of enterprises with real estate will appreciate, which will help enterprises obtain external financial support and alleviate the lack of funds for innovation activities. Therefore, the rise in housing prices has a positive effect on regional innovation input. It can be seen that, from the perspective of enterprises, changes in housing prices can affect regional innovation input, but analysis from the perspective of enterprises cannot judge how housing prices affect regional innovation investment.

Then, for governments, the relationship between housing prices and regional innovation input can be analyzed based on "economic-political man theory" and "Chinese-style decentralization theory". According to the economic–political man theory [29], local governments have self-interested investment preferences. When local governments face two options of production investment and innovative investment, government officials often choose to invest limited resources into productive projects in order to maximize the economic and political interests during their tenure, while relatively ignoring innovative projects. This means that local governments always pay more attention to production than innovation. Further, the core of the Chinese-style decentralization theory lies in political centralization and economic decentralization. From the perspective of Chinese-style decen-

tralization theory, the current governance model in China is "vertical centralization" (that is, local officials are finally appointed by the central government), which forms a political situation to be responsible for the upper level. But, at the same time, there is a serious information asymmetry between central and local governments [30], meaning that it is difficult for the central government to take effective measures to control the self-interested investment of local governments. Therefore, with the rise in housing prices, the economic and political benefits of local governments' real-estate investments far exceed the innovation investment, meaning that local governments tend to give priority to real-estate investment while ignoring innovative investment, resulting in a reduction in regional innovation input. The above analysis based on "economic-political man theory" and "Chinese-style decentralization theory" can be generalized to other political centralization and economic decentralization countries or regions. Based on the above analysis, this paper proposes Hypotheses 1a and 1b.

Hypothesis 1a: *The rise in housing prices leads to a reduction in regional innovation input.*

Hypothesis 1b: *The increase in real-estate investment strengthens the negative impact of housing prices on regional innovation input.*

3.2. Innovation Output Stage

How housing prices affect regional innovation output can be analyzed from the perspective of factor cost and human capital. From the perspective of factor cost, the rise in housing prices has pushed up the factors' prices that are needed for regional innovation, especially the price of labor and capital, thus pushing up the cost of regional innovation and affecting the output of regional innovation. In terms of labor factors, rising housing prices have increased the cost of living and improved wage requirements and bargaining power [31], further raising the wage level [32]. Thus, the regional innovation cost has been increased, and regional innovation output will be reduced. In terms of capital factors, because real estate has the property attribute, and the rising of housing prices has increased the total value of real estate, this has further improved the mortgage value of real estate. Financial departments, such as banks, prefer to implement relatively loose credit policies for their lending activities with real estate as collateral. At the same time, because innovative behavior has characteristics of lagging and a low success rate, as described above, banks and other financial departments are more inclined to implement relatively strict credit policies on innovation-related lending activities. Therefore, funds will flow to the real-estate industry, which will have a crowding-out effect on regional innovation activities and, thus, have a negative impact on regional innovation output.

From the perspective of human capital, studies have shown that talent is one of the important factors that affect innovation capacity [33]. Therefore, human capital, as the source of innovation output, is the key to improving innovation capacity. Human capital changes with labor flow and labor flow will be affected by housing prices. According to the theory of population migration decision [34], the labor force regards the migration decision as an investment behavior, meaning their migration depends on the relative return of migration income and migration cost. If the benefits of migration are greater than the costs, then they choose to migrate, and vice versa. If the housing prices of a place rise, compared to other areas, the cost of labor migration to this place will increase. On the premise that individual skills remain unchanged, the relative return of labor moving in decreases, while the relative return of moving out of this place increases. Therefore, labor often chooses to move out from this place, resulting in a reduction in human capital here. Then, it reduces the regional innovation capacity and the increase in human capital can weaken this negative effect. The above analysis, based on factor cost and human capital, can be generalized to other countries or regions, especially where the economy relied on factors and investments in the past. Based on the above analysis, this paper proposes Hypotheses 2a and 2b.

Hypothesis 2a: *The rise in housing prices leads to a reduction in regional innovation output.*

Hypothesis 2b: *The improvement of human capital will weaken the negative impact of housing prices on regional innovation output.*

3.3. Innovation Achievement Transformation Stage

How housing prices affect the regional achievement transformation capacity can be analyzed from the characteristics of the achievement transformation stage. At the innovation achievement transformation stage, there are mainly two types of risks: the supply side and the consumer side. On the supply side, the innovation subject will face the risk of whether the achievements can be successfully converted into new products. On the consumer side, it will face the risk of whether the new products will be accepted by the consumer. The following will analyze the impact of housing prices on the regional achievement transformation capacity from the supply side and the consumer side.

On the supply side, the innovation subject produces new products based on research achievements, which need to be tested and developed, and requires factors support, especially a large amount of financial support. With the rise in housing prices, financial departments, such as banks, prefer to implement relatively loose credit policies for their lending activities with real estate as collateral. At the same time, because achievement transformation also has the characteristics of the lagging mentioned above, financial departments prefer to implement relatively strict credit policies for achievement transformation. As a result, the capital factors' prices of innovation-related departments are pulled up. This will affect the capital investment in the achievement transformation stage, thus weakening the regional achievement transformation capacity.

On the consumer side, based on the life-cycle theory, the consumer, as a rational person, will determine their current expenditure based on their total wealth in their life. For consumer-oriented housing buyers, rising housing prices mean that the buyers require more funds, thus inhibiting current consumption [35], resulting in the "housing slave effect" [36]. For investment-oriented housing buyers, rising housing prices mean an increase in investment income. In order to pursue higher investment returns, they will also increase real-estate investment and reduce current consumption [37]. For renters, rising housing prices always result in rents rising, further raising their living costs and inhibiting their current consumption. It can be seen that for consumer-oriented buyers, in terms of investment-oriented buyers and renters, rising housing prices allow more funds to flow to the real-estate sector, which restrains current consumption. In this context, new products with a higher innovation level will not be welcomed, thus weakening the capacity for innovation achievement transformation [38].

Further, from the perspective of regional consumption capacity, the negative impact of housing prices on innovation achievement transformation will vary with the regional consumption capacity. When the regional consumption capacity is high, even if residents' funds flow to real estate, the consumption capacity of residents in this region is still high, and the negative effect of housing prices on innovation achievement transformation will be correspondingly weakened. On the contrary, when the regional consumption capacity is low, the rise in housing prices will have a restraining effect on consumption, resulting in a further reduction in regional consumption capacity, and the negative effect of housing prices on innovation achievement transformation will also be correspondingly strengthened. Our analysis, based on the supply side and consumer side, can be generalized to other countries or regions. Based on the above analysis, this paper proposes Hypotheses 3a and 3b.

Hypothesis 3a: *Rising housing prices will reduce the regional innovation transformation capacity.*

Hypothesis 3b: *The increase in regional consumption capacity will weaken the negative impact of housing prices on the regional innovation transformation capacity.*

To sum up, an analysis framework of the impact of housing prices on the regional innovation capacity can be constructed based on the above analysis, as shown in the Figure 1 below. This analysis framework can be generalized to other politically centralized and economically decentralized countries or regions, especially where the economy relied on factors and investments in the past. In this analysis framework, housing prices affect the regional innovation capacity through three paths: innovation input, innovation output, and innovation achievement transformation (Hypothesis 1a, Hypothesis 2a, and Hypothesis 3a, respectively). These three paths are affected by the three mechanisms of real-estate development investment, human capital, and regional consumption capacity (Hypothesis 1b, Hypothesis 2b, and Hypothesis 3b, respectively). The above hypotheses will be empirically tested below with China's data to verify the internal logic of the impact of housing prices on regional innovation capacity.
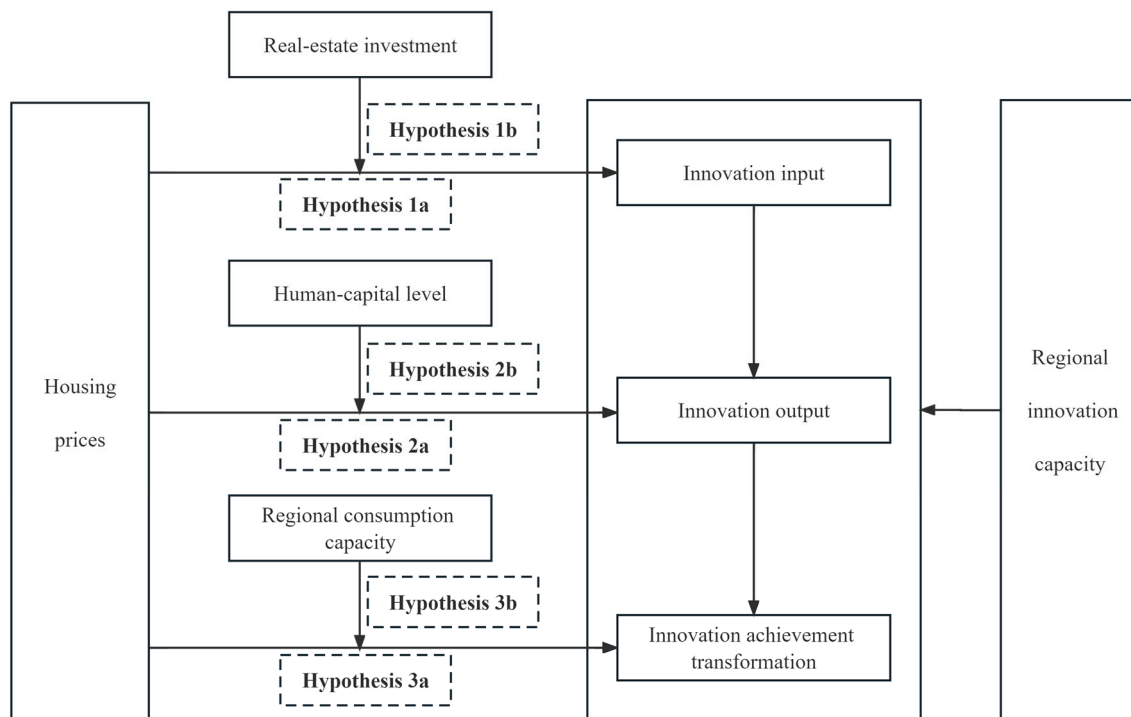

Figure 1. Analytical framework of housing prices affecting regional innovation capacity.

4. Research Design

4.1. Econometrics Model

The benchmark regression models used in this paper are as follows:

$$rdf_{it} = \alpha_0 + \alpha_1 hp_{it} + \alpha_2 X_{it} + \varepsilon_i + \theta_t + \mu_{it} \tag{1}$$

$$perinpapp_{it} = \beta_0 + \beta_1 hp_{it} + \beta_2 X_{it} + \varepsilon_i + \theta_t + \mu_{it} \tag{2}$$

$$newincp_{it} = \gamma_0 + \gamma_1 hp_{it} + \gamma_2 X_{it} + \varepsilon_i + \theta_t + \mu_{it} \tag{3}$$

Formulas (1)–(3) are benchmark regression models of the innovation input stage, innovation output stage, and innovation achievement transformation stage, respectively. In Formula (1), rdf_{it} represents the internal expenditure of research and development funding for year t in region i (hereinafter referred to as "R&D expenditure"), hp_{it} represents the average selling price of commercial housing for year t in region i, X_{it} represents a collection of control variables in the innovation input stage, α are the parameters to be evaluated, ε_i represents the province-fixed effect, θ_t represents the time-fixed effect, and μ_{it} represents the random-error term. In Formula (2), $perinpapp_{it}$ represents the application quantity of invention patent per

capita for year t in region i, hp_{it} has the same meaning as above, X_{it} represents a collection of control variables in the innovation output stage, β are *the* parameters to be evaluated, and ε_i, θ_t, and μ_{it} have the same meaning as above. In Formula (3), $newincp_{it}$ represents the ratio of new product sales revenue to patent quantity, hp_{it} has the same meaning as above, X_{it} represents a collection of control variables in the innovation achievement transformation stage, γ are the parameters to be evaluated, and ε_i, θ_t, and μ_{it} have the same meaning as above. Among them, α_1, β_1, and γ_1 are the estimation parameters we focus on, which represent the impact of housing prices on innovation input, innovation output, and innovation achievement transformation.

According to the theoretical analysis mentioned above, the mechanism test of this paper is based on a moderating effect. The mechanism test models are as follows:

$$rdf_{it} = \alpha_0 + \alpha_1 hp_{it} + \alpha_2 X_{it} + \alpha_3 reinv_{it} + \alpha_4 inter1_{it} + \varepsilon_i + \theta_t + \mu_{it} \tag{4}$$

$$perinpapp_{it} = \beta_0 + \beta_1 hp_{it} + \beta_2 X_{it} + \beta_3 perrdp_{it} + \beta_4 inter2_{it} + \varepsilon_i + \theta_t + \mu_{it} \tag{5}$$

$$newincp_{it} = \gamma_0 + \gamma_1 hp_{it} + \gamma_2 X_{it} + \gamma_3 consui + \gamma_4 inter3_{it} + \varepsilon_i + \theta_t + \mu_{it} \tag{6}$$

Formulas (4)–(6) are the mechanism test models of the innovation input stage, innovation output stage, and innovation achievement transformation stage, respectively. In Formula (4), $reinv_{it}$ represents an investment in real-estate development for year t in region i, and $inter1_{it}$ represents the interaction between the average sales price of commercial housing and real-estate development investment for year t in region i. In Formula (5), $perrdp_{it}$ represents human capital for year t in region i; that is, a full-time equivalent of research and development (R&D) personnel per 10,000 people, and $inter2_{it}$ represents the interaction item between the average sales price of commercial housing and the human capital for year t in region i. In Formula (6), $consui_{it}$ represents the regional consumption capacity for year t in region i; that is, the ratio of per capita consumption expenditure to per capita salary, and $inter3_{it}$ represents the interaction between the average sales price of commercial housing and regional consumption capacity for year t in region i. Among them, α_4, β_4, and γ_4 are the estimation parameters that we focus on, representing the impact of real-estate development investment on the relationship between housing prices and innovation input, the impact of human capital on the relationship between housing prices and innovation output, and the impact of regional consumption capacity on the relationship between housing prices and innovation achievement transformation.

4.2. Variable Description

In the three stages of the innovation input stage, innovation output stage, and innovation achievement transformation stage, the dependent variables are R&D funding (*rdf*), quantity of invention patent application per capita (*perinpapp*), and the ratio of new product sales revenue to patent quantity (*newincp*), which represent the innovation input level, innovation output level, and innovation achievement transformation capacity, respectively. In the above three stages, the average selling price of commercial housing is used as the independent variable (*hp*).

In this paper, differentiated control variables are selected according to the characteristics of dependent variables in these three stages. In the innovation input stage, referring to previous studies and combining the characteristics of this stage, this paper selects five control variables: level of economic development (characterized by "GDP per capita", *pergdp*), level of financial development (characterized by "The ratio of total deposits and loans in financial institutions to GDP", *fin*), local fiscal revenue per capita (*revp*), number of scientific and technical personnel (characterized by "number of R&D personnel", *rdp*), and level of intellectual property protection (characterized by "technology market turnover", *tetra*). Among them, economic development is the basis of regional innovation capacity, financial development is the key to easing the constraint of innovation investment, local fiscal revenue per capita determines the level of local support for innovation input, and

R&D personnel and intellectual property protection reflects the environment of regional innovation, which also has an impact on innovation input.

In the innovation output stage, referring to previous studies and combining the characteristics of this stage, four control variables are selected: level of economic development (*pergdp*), per capita financial expenditure on science and technology (*persci*), number of students enrolled in colleges and universities (*stud*), and level of urbanization (characterized by "ratio of urban population to the permanent population at the end of the year", *urate*). Among them, the per capita financial expenditure on science and technology and the number of students enrolled in colleges and universities reflect the degree of regional support for innovation, and the level of urbanization reflects the external conditions of regional innovation output.

In the innovation achievement transformation stage, referring to previous studies and combining the characteristics of this stage, this paper selects five control variables: level of economic development (*pergdp*), industrial structure (characterized by "the ratio of the added value of secondary and tertiary industries to GDP", *industr*), number of students enrolled in colleges and universities (*stud*), infrastructure level (characterized by "road miles per capita", *perroad*), and the degree of industrial prosperity (characterized by "registered unemployment rate", *unem*). Among them, the industrial structure, number of students enrolled in colleges and universities, level of infrastructure, and degree of industrial prosperity will affect the acceptance of new products through the market as well as the innovation achievement transformation capacity.

In terms of the mechanism variables, according to the theoretical analysis mentioned above, we choose investment in real-estate development (*reinv*), human capital (*perrdp*), and regional consumption capacity (*consui*) as the mechanism variables, corresponding to the innovation input stage, innovation output stage, and innovation achievement transformation stage, respectively.

4.3. Data Description

This paper selected 30 provinces, autonomous regions, and municipalities in China from 2004 to 2019 (excluding Hong Kong, Macao, Taiwan, and the Tibet Autonomous Region) as the research sample. The reason for choosing China's data as the research sample is that China's economy has relied on factors and investments in the past decades, which is very consistent with the above analysis framework. The reason for choosing 2004 to 2019 as the time span is that China's real-estate market reform started in 1998, and in August 2003, the State Council of China issued the "Notice of the State Council on Promoting the Sustainable and Healthy Development of the Real Estate Market", which mentioned that "the real estate industry has a high degree of correlation and strong driving force, and has become a pillar industry of the national economy". This is the first time that China has named the real-estate industry as a pillar industry of the national economy. In addition, the COVID-19 pandemic that occurred at the end of 2019 may have had a significant impact on various socioeconomic indicators in 2020 and subsequent years. Therefore, the period from 2004 to 2019 was selected as the time span of this paper. Data were obtained from the China Research Data Service Platform (CNRDS), GTA Economic and Financial Research Database (CSMAR), and China Science and Technology Statistical Yearbook. Individual missing data were interpolated by using linear interpolation. To eliminate the effects of extreme values, data were winsorized. Meanwhile, in order to reduce the bias caused by heteroscedasticity on the estimation results, natural logarithm processing was performed on nonpercentage-type data. The descriptive statistics for related variables are shown in the following Table 1.

Table 1. Variable descriptive statistics.

Innovation Stage	Variable Type	Variable Name	Obs	Mean	SD	Min	Max
Independent variable		*lnhp*	480	8.46	0.61	7.36	10.33
	Dependent variable	*lnrdf*	480	14.12	1.50	10.32	17.04
		lnpergdp	480	10.40	0.68	8.92	11.91
Innovation input stage	Controlled variables	*fin*	480	2.90	1.11	1.29	8.13
		lnrevp	480	0.34	0.25	0.04	1.36
		lnrdp	480	10.87	1.20	7.82	13.28
		lntetra	480	4.03	1.73	0.50	8.15
	Mechanism variable	*lnreinv*	480	7.14	1.18	4.04	9.39
	Dependent variable	*lnperinpapp*	480	1.20	0.90	0.10	4.10
		lnpergdp	480	10.40	0.68	8.92	11.91
Innovation output stage	Controlled variables	*lnpersci*	480	0.02	0.03	0.00	0.18
		lnstud	480	4.09	0.81	1.65	5.37
		urate	480	0.54	0.14	0.25	0.94
	Mechanism variable	*lnperrdp*	480	2.78	0.79	1.10	4.97
	Dependent variable	*lnnewincp*	480	6.43	0.64	4.42	9.58
		lnpergdp	480	10.40	0.68	8.92	11.91
Innovation achievement transformation stage	Controlled variables	*lnstud*	480	4.09	0.81	1.65	5.37
		industr	480	0.89	0.06	0.70	1.00
		lnperroad	480	3.36	2.19	0.51	14.20
		unem	480	3.48	0.67	1.37	4.60
	Mechanism variable	*consui*	480	0.37	0.06	0.26	0.51

5. Econometrics Analysis and Discussion of Results

5.1. Benchmark Regression Results

Based on Formulas (1)–(3), using the fixed-effect model, a regression analysis was conducted in three different stages and the results are shown in the following Table 2. Column (1) reports the estimated results of the innovation input stage. In this stage, after controlling the corresponding controlled variables, the estimated marginal value of housing prices is significantly negative and significant at the level of 1%. This means that, with the controlled variables constant, and for every 1% increase in housing prices, innovation input decreases by 0.21% on average. Column (2) reports the estimated results of the innovation output stage. In this stage, after controlling the corresponding controlled variables, the estimated marginal value of housing prices is significantly negative and is significant at the level of 1%. This means that, with the controlled variables constant, and for every 1% increase in housing prices, innovation output decreases by 0.48% on average. Column (3) reports the estimated results of the innovation achievement transformation stage. In this stage, after controlling the corresponding controlled variables, the estimated marginal value of housing prices is significantly negative and significant at the level of 1%. This means that, with the controlled variables constant, and for every 1% increase in housing prices, the innovation achievement transformation capacity decreases by 0.91% on average. To sum up, the benchmark regression results verify the three influence paths of Hypothesis 1a, Hypothesis 2a, and Hypothesis 3a.

Table 2. Regression results of housing prices and regional innovation capacity.

	(1) Innovation Input Stage	(2) Innovation Output Stage	(3) Innovation Achievement Transformation Stage
lnhp	−0.21 *** (−3.20)	−0.48 *** (−4.26)	−0.91 *** (−4.18)
Observations	480	480	480
R-squared	0.73	0.22	0.65
Controlled variables	Y	Y	Y
Provincial fixed effect	Y	Y	Y
Year fixed effect	Y	Y	Y

Notes: *** denote statistical significance at the 1% and t-statistics are in parentheses.

5.2. Mechanism Testing

According to Formulas (4)–(6), real-estate development investment, human capital, and regional consumption capacity are introduced as mechanism variables in the innovation input stage, innovation output stage, and innovation achievement transformation stage, respectively. Based on the moderating effect, we verified the effect mechanism of housing prices on regional innovation capacity in three stages, respectively. The results are shown in the following Table 3. Column (1) reports the moderating effect of real-estate development investment on the relationship between housing prices and regional innovation input. The coefficient of *inter1* is significantly negative. This means that the increase in real-estate investment will strengthen the negative relation between housing prices and regional innovation input. Therefore, Hypothesis 1b has been verified. Column (2) reports the moderating effect of human capital on the relation between housing prices and regional innovation output. The coefficient of *inter2* is significantly positive. This means that the increase in human capital will weaken the negative relation between housing prices and regional innovation output. Therefore, Hypothesis 2b has been verified. Column (3) reports the moderating effect of regional consumption capacity on the relation between housing prices and regional innovation achievement transformation. The coefficient of *inter3* is significantly positive. This means that the increase in regional consumption capacity will weaken the negative relation between housing prices and regional innovation transformation capacity. Therefore, Hypothesis 3b has been verified.

Table 3. The mechanism of housing prices affecting regional innovation capacity.

	(1) Innovation Input Stage	(2) Innovation Output Stage	(3) Innovation Achievement Transformation Stage
lnhp	−0.21 *** (−3.21)	−0.36 *** (−3.78)	−0.79 *** (−3.59)
inter1	−0.04 *** (−3.15)		
inter2		0.34 *** (8.56)	
inter3			3.91 *** (4.59)
Observations	480	480	480
R-squared	0.74	0.39	0.67
Controlled variables	Y	Y	Y
Provincial fixed effect	Y	Y	Y
Year fixed effect	Y	Y	Y

Notes: *** denote statistical significance at the 1% and t-statistics are in parentheses.

5.3. Heterogeneity Analysis

Based on the above analysis, with reference to the National Bureau of Statistics' regional statistical classification criteria for real-estate sales, the research sample can be divided into three regions, namely the eastern, central, and western regions. The results of the subgroup regressions are shown in the Table 4 below. Due to space limitations, only the significant subgroup regression estimates are reported in the Table 4 below. In the eastern region, the estimated marginal values of the housing price variable in the innovation output stage and innovation achievement transformation stage are significantly negative and both significant at the 1% level. This means that, with the controlled variables constant, and for every 1% increase in housing prices, innovation output and innovation achievement transformation capacity in the eastern region decrease by 0.79% and 0.83%, respectively. Housing prices have no significant impact on innovation input in the eastern region.

Table 4. Heterogeneity analysis of housing prices affecting regional innovation capacity.

	(1) Eastern Region Innovation Output Stage	(2) Eastern Region Innovation Achievement Transformation Stage	(3) Central Region Innovation Output Stage	(4) Western Region Innovation Input Stage
lnhp	−0.79 ***	−0.83 ***	−0.97 ***	−0.25 **
	(−4.53)	(−2.94)	(−3.76)	(−2.51)
Observations	176	176	128	176
R-squared	0.30	0.58	0.51	0.74
Controlled variables	Y	Y	Y	Y
Provincial fixed effect	Y	Y	Y	Y
Year fixed effect	Y	Y	Y	Y

Notes: ***, ** denote statistical significance at the 1%, 5% levels, respectively, and t-statistics are in parentheses.

In the central region, the estimated marginal value of the housing price variable in the innovation output stage is significantly negative and significant at the 1% level. This means that, with the controlled variables constant, and for every 1% increase in housing prices, innovation output in the central region decreases by 0.97%. Housing price has no significant impact on the innovation input and innovation achievement transformation capacity in the central region.

In the western region, the estimated marginal value of the housing price variable in the innovation input stage is significantly negative and significant at the 5% level. This means that, with the controlled variables constant, and for every 1% increase in housing prices, the innovation input in the western region decreases by 0.25%. Housing prices have no significant impact on the innovation output and innovation achievement transformation capacity in the western region. It can be seen that in different regions, the impact of housing prices on regional innovation capacity at different stages has obvious heterogeneity.

5.4. Robustness and Endogeneity Analysis

In order to test the robustness of the regression results, this section takes the approach of replacing the dependent variables for robustness testing. In the innovation input stage, the dependent variable is the logarithm of R&D funding in benchmark regression. Due to the large differences in population size among provinces, the logarithm of R&D expenditure per capita is used as the dependent variable. In the innovation output stage, the dependent variable is the quantity of invention patent applications per capita in benchmark regression. Since innovative behavior and patent applications have a certain probability of failure and failure or success may not be related to the number of people, the application quantity of the invention patent is used as the dependent variable. In the innovation achievement transformation stage, the dependent variable is the ratio of new product sales revenue to patent quantity in benchmark regression. Due to the different levels of economic development among provinces, the ratio of new product sales revenue to GDP is used as the dependent variable.

After adjusting the dependent variables in three stages, the benchmark regression process is repeated, and the results are shown in the Table 5 below. It can be seen that the estimation results, after replacing the dependent variables, are similar to the original regression results. Both show that there are significant negative relations between the housing price and innovation input, innovation output, and innovation achievement transformation capacity. This means that the regression results of housing prices on regional innovation capacity are robust.

Table 5. Robustness analysis of housing prices affecting regional innovation capacity.

	(1) Innovation Input Stage	(2) Innovation Output Stage	(3) Innovation Achievement Transformation Stage
lnhp	−0.18 ***	−0.27 **	−0.09 ***
	(−2.70)	(−1.98)	(−3.22)
Observations	480	480	480
R-squared	0.70	0.30	0.57
Controlled variables	Y	Y	Y
Provincial fixed effect	Y	Y	Y
Year fixed effect	Y	Y	Y

Notes: ***, ** denote statistical significance at the 1%, 5% levels, respectively, and t-statistics are in parentheses.

There may be an endogenous issue between housing prices and regional innovation capacity. Housing prices have an impact on regional innovation capacity but regional innovation capacity may also affect housing prices [39–41]. Scholars mostly adopted instrumental variables and lagging first-order housing prices as independent variables to alleviate the endogenous problem. In terms of instrumental variables, scholars use the construction land transfer area per capita as an instrumental variable for housing prices to alleviate endogenous issues between housing price and urban innovation capacity [42,43]. But, as one of the production factors, the supply and price of land resources, especially industrial land supply and price, often has an impact on firms' innovation capacity and, thus, on regional innovation capacity [44,45]. So, the construction land transfer area per capita is not the ideal instrumental variable in this study. Xia uses the degree of fiscal decentralization as an instrumental variable for housing prices to alleviate endogenous issues between housing prices and industrial agglomeration [46]. But, some studies show a strong relationship between the degree of fiscal decentralization and regional innovation [47,48]. It can be seen that the degree of fiscal decentralization is also not the ideal instrumental variable in this study. The fundamental reason why the above instrumental variables are not ideal is that the regional innovation capacity is a systematic issue. The triple helix theory, quadruple helix theory, and regional innovation ecosystem theory all believe that regional innovation capacity involves many subjects, such as enterprises, government, research institutions, and the public, which make it difficult to find ideal instrumental variables that are completely exogenous in research on regional innovation capacity. Therefore, this paper refers to the ideas of scholars such as Dahlberg et al. and Zhang [49,50], selects lagging first-order housing price as the independent variable, and repeats the benchmark regression process for endogenous analysis. The reason for choosing lagging first-order housing prices as the independent variable is that regional innovation capacity will not affect lagging first-order housing prices, meaning endogenous issues can be avoided. The Table 6 show the estimation results after using lagging first-order housing prices (*L.lnhp*) as the independent variable are similar to the results of the benchmark regression. There are significant negative relations between lagging first-order housing price and innovation input, innovation output, and innovation achievement transformation capacity. It can be concluded that the above findings still exist after considering the potential endogenous issue.

Table 6. Endogenous analysis of housing prices affecting regional innovation capacity.

	(1) Innovation Input Stage	(2) Innovation Output Stage	(3) Innovation Achievement Transformation Stage
L.lnhp	−0.1669 ***	−0.4185 ***	−0.7795 ***
	(−2.59)	(−3.82)	(−3.51)
Observations	450	450	450
R-squared	0.75	0.21	0.67
Controlled variables	Y	Y	Y
Provincial fixed effect	Y	Y	Y
Year fixed effect	Y	Y	Y

Notes: *** statistical significance at the 1% levels, and t-statistics are in parentheses.

6. Conclusions and Policy Recommendations

6.1. Research Findings

Based on the innovation value-chain theory, combined with theories related to real-estate economics and public administration, this paper constructs an analysis framework and proposes three paths for housing prices affecting regional innovation capacity and three mechanisms. An empirical test is conducted by using Chinese provincial panel data from 2004 to 2019. The study shows that, first, rising housing prices lead to a decrease in regional innovation inputs and an increase in the amount of real-estate investment strengthens this negative relation. Second, rising housing prices lead to a decrease in regional innovation output, while an increase in the level of human capital weakens this negative relation. Third, rising housing prices lead to a decrease in regional innovation transformation capacity, while an increase in regional consumption capacity will weaken this negative relation. Fourth, the impact of housing prices on regional innovation capacity at different stages is heterogeneous in China. This paper cracks the "black box" of how housing prices affect regional innovation capacity from a multidisciplinary perspective and further explores its internal mechanism, deepening the understanding of housing prices and regional innovation capacity. This paper can provide a reference for other politically centralized and economically decentralized countries or regions, especially where the economy has relied on factors and investments in the past.

6.2. Policy Recommendations

Based on the above findings, this paper proposes the following policy recommendations:

1. According to the characteristics of different innovation stages, a reduction in the regional innovation capacity caused by the rise in housing prices should be avoided. This study has shown that rising housing prices have a negative effect on different innovation stages, and these negative effects vary among regions in China. For the eastern region in China, it is recommended that we focus on the innovation output stage and innovation achievement transformation stage, taking various approaches to reasonably control housing prices according to local conditions to prevent rising housing prices from weakening regional innovation output and innovation achievement transformation capacity. For the central region in China, it is recommended to focus on the innovation output stage to prevent rising housing prices from weakening regional innovation output. For the western region in China, it is recommended to focus on the innovation input stage to prevent rising housing prices from weakening regional innovation input;

2. In order to avoid excessive real-estate investment affecting regional innovation input, it is suggested to strengthen the top-level institutional design and curb or even reverse local governments' self-interested investment preference, especially real-estate investment. The above findings suggest that an increase in real-estate investment reinforces the negative relation between rising housing prices and regional innovation input, while the self-interest investment preference of local governments leads to a preference for real-estate investment. Therefore, it is recommended to strengthen the top-level institutional design, such as strengthening the horizontal supervision of local governments and public supervision, so as to effectively curb the self-interest investment preference of local governments. At the same time, measures, such as expectation management, should be taken to avoid excessive real-estate investment, thus avoiding real-estate investment strengthening the negative relation between rising housing prices and regional innovation input;

3. To weaken the negative relationship between housing prices and regional innovation output, it is recommended that local governments pay more attention to human capital and adopt measures to attract and retain talent. The above findings suggest that an increase in human capital weakens the negative relation between rising housing prices and innovation output. From the perspective of migration cost, it is suggested that local governments should simplify talent migration procedures, adopt multilevel housing security methods, guarantee talents' housing needs, and reduce the cost of living for talents, thus weakening the negative relation between rising housing prices and regional innovation output;

4. In order to weaken the negative relation between housing prices and regional innovation transformation capacity, measures, such as promoting consumption, are suggested to enhance regional consumption capacity. The above findings find that an increase in regional consumption capacity will weaken the negative relation between rising housing prices and innovation achievement transformation capacity. It is suggested that local governments should take measures, such as issuing coupons, consumption subsidies, and tax relief for specific people and specific commodity categories, to reduce consumer pressure and enhance consumer willingness. At the same time, in order to promote the long-term consumption level, it is suggested that local governments guide market players to actively improve the quality of products and services which can attract consumers with better products and services. This can help stimulate people's long-term consumption enthusiasm, so as to achieve the purpose of improving residents' consumption willingness and weaken the negative relation between housing prices and achievement transformation capacity.

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