

**Examining the Extent to which Talent Housing Policy Acts as a Catalyst for Innovation  
Development in China**

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**Abstract**

Since the beginning of economic reform in 1978, China has entered a rapidly growing period where technology innovation has become the new boosting engine of promoting economic development. With the burgeoning of emerging industries in China, the demand for innovation talents is rising greatly. Due to the great gap between Chinese mega cities and other cities in the field of innovation activities, people who possess these tech and innovative skills tend to concentrate in several mega cities, which intensifies housing affordable issue in these areas. And in return, housing affordability become an obstacle for innovation development. In order to improve the living conditions of talents and optimize the environment for innovation activities, local governments have formulated a variety of talent housing policies.

As an important part of mitigating the housing burden for certain group of people, the purpose of this study is to explore if talent housing policy can affect regional innovation development and what are the impacts. This study incorporated a mixed-methodology research design to first, analyze the development and current situation of talent housing policies, and secondly explore how talent housing policy impact regional innovation activities by running several regression models using quantitative statistics. Finally, policy suggestions have been proposed based on above analysis. The research result illustrates that talent housing policy affects regional innovation development positively and this relationship can inform policy makers, urban planners, and public officials on better implementing housing policy to attract talented people.

## Table of Contents

<b>1</b>	<b>BACKGROUND</b> .....	<b>5</b>
<b>2</b>	<b>LITERATURE REVIEW</b> .....	<b>6</b>
2.1	Research on Housing Affordability .....	7
2.2	Research on Talent Housing Policy .....	10
2.3	Research on Innovation Developments .....	13
<b>3</b>	<b>RESEARCH DESIGN</b> .....	<b>15</b>
3.1	Research Questions .....	15
3.2	Methodology .....	16
<b>4</b>	<b>ANALYSIS ON HOUSING AFFORDABILITY AND DEVELOPMENT OF TALENT HOUSING POLICY</b> .....	<b>17</b>
4.1	Housing Affordability and Innovation Development in China.....	18
4.2	The Development of Talent Housing Policy .....	24
<b>5</b>	<b>QUANTITATIVE ANALYSIS</b> .....	<b>31</b>
5.1	Hypotheses .....	31
5.2	Data Selection .....	32
5.3	Descriptive Statistics.....	35
5.4	Empirical Model .....	39
5.5	Results Analysis .....	46
<b>6</b>	<b>CONCLUSION AND RECOMMENDATIONS</b> .....	<b>47</b>

## Table of Figures

Figure 1 Yuyangli, Huaihai Road, Shanghai, an old housing built in 1917 .....	19
Figure 2 Sales price of commercial housing from 2000 to 2017 .....	21
Figure 3 Scores of talent housing policy in different cities .....	30
Figure 4 The amount of patent application in 2010, 2013 and 2016 .....	36
Table 1 Table of indicators .....	35
Table 2 Descriptive result of the dependent variable.....	37
Table 3 Descriptive result of other variables .....	38
Table 4 Results of Levin, Liu & Chu (LLC) test.....	40
Table 5 Results of Fisher-ADF test .....	41
Table 6 Results of F-test .....	42
Table 7 Results of Hausman test.....	42
Table 8 Fixed effects regression results .....	43
Table 9 Results of empirical analysis .....	48

## **1 Background**

In contemporary society, whoever has an advantage in technological innovation can seize the initiative of transformation and development. As the costs of labor, raw materials and environmental protection continue to rise, the upcoming pressures of China's economic development from resources, energy and ecological environment are further increased. The comparative advantage of China's economy is also changing: the comparative advantage of labor resources is weakened with the slowing down of population growth, but the improvement of population competence in innovation is forming a new comparative advantage. The central government of China has released hundreds of documents to indicate the importance of technology innovation, which has exerted great impacts on policy change of local government.

However, due to the constraints of economic resources, market environment and population size, the imbalance of technology innovation development is a prominent issue. Most of the innovation activities are concentrated in first-tier cities such as Beijing, Shanghai and Shenzhen, where the housing price have long been in a high level, even ranking top positions in international market. The high housing price in these cities has gradually priced out tons of high-tech professionals. According to the Southern Metropolis Daily, only 33.9% of college graduates in 2016 are willing to work in first- and second-tier cities with high housing price, compared with 50.3% in 2014 and 48.4% in 2015, respectively. Moreover, the population inflow rate of most key cities slowed down significantly between 2010 and 2016 according to National Bureau of Statistics. In the Shenzhen Political Consultative Conference in recent years, doers and enterprises have voiced out that housing affordability have forced high tech talents to leave this city.

Major cities in China have been aware of the relationship between high housing price and the losing of talented people. As Chinese proverb saying, only live in peace can work in contentment. Meeting the housing needs of talented people would solve their worries and eliminate part of the obstacles to innovation development. However, given that high housing price can bring huge amount of land revenues to local governments to support the construction of hard infrastructures, local governments are reluctant to lower the market housing price. Therefore, many local governments in China have formulated a series of housing support policies to attract and retain this young professional group, such as providing oversea talents with subsidies on their housing purchases, and building talent apartments for college graduates, which they believe may be a new solution to this double dilemma. For first-tier cities, they are providing housing bonus to retain existing high-tech talents and maintain their superior status. Meanwhile, second-tier cities are trying to compete with those mega cities on attracting talents and gain a foothold in the technology innovation field. Analyzing how housing policies can be used as talent attracting policies to stimulate the innovation potential of talents would contribute to optimizing current policy system and better address the double dilemma.

## **2 Literature Review**

Housing policy and innovation development are the two major topic in this research, which have drawn great attention from scholars. The purpose of this literature review is to examine existing research on housing affordability, talent housing policy, and innovation development. The topic of this research mainly involves three concepts: housing affordability, talent housing policy, and

innovation development. And this part is organized into three major subsections according to the three concepts.

## 2.1 Research on Housing Affordability

Housing affordability, generally describing the relationship between housing expenditure and individual/household income, is an important academic research in almost all societies. However, affordability as a concept is hard to define. A variety of definition have been used in practice (policy and academic), while most of these definitions include components of adequate accommodation and adequate residual income (Robinson, Scobie, & Hallinan, 2006). The measurement of housing affordability, which is built upon the different definitions of this term, varies greatly as well. In general, there are three measurements widely used: outgoings on housing to income ratio, residual income measure, and house price to income ratio (Burke, 2004). In consideration of the accessibility of data and the purpose of the research, these three measurements have their strengths and weaknesses. Despite the difference on measurements, most researches on housing affordability revolve around such issues as tenure choice (Lee, Ho,&Chiu, 2016) or housing opportunity for lower-income groups (Whitehead, 1991). In almost all the countries, housing affordability is most likely hampered by the mismatch between the rise in housing price and the rise of residents' income. Low-income people, as the most vulnerable group in terms of this problem, have attract the most attention from both government and scholars (Tighe, 2010). In most advanced countries, governments have made great efforts and commitment to ensure “decent housing for every household at a cost within their means” (King 2003; Bengtsson 2001). The

establishment of affordable housing system is considered a major solution affordability issues (Rubin, Seneca, & Stotsky, 1990). However, in the condition of exploding rising in housing price, affordability may become a problem which is not exclusive for low income groups (Li, Wu, Dai, Gao & Pan, 2017). Li, Wu, Dai, Gao and Pan (2017) found that housing affordability was also an issue for young university graduates in Guangdong, China, and would be major concern when they deciding their employment location. Moreover, in recent years, lots of the scholars began to focus on doing more in-depth analysis of housing affordability which looks at how people react to the unaffordable housing market. Dodson and Berry (2005) did research on the impact of housing affordability on people's mobility in labor market in Melbourne. In general, housing affordability is always a worldwide trending topic. The research target of housing affordability has been widened to more income groups and the research began to focus a more in-depth analysis.

### 2.1.1 Housing Affordability in China

Housing affordability is not a problem in China before the economic reform and opening-up in 1978 (Li, Qin, & Wu, 2018). After 1990s, the privatization of housing market has reached a peak which accompanied by economic boom and income inequality expansion. For example, Yang and Chen (2014) found that the top 10 % income category achieved a stunning income growth at 356 % from 1997 to 2011, while the low-income households (the 20–40 % income category) increased their incomes by only 236 % and the lowest 10 % income households increased by a mere 125 % over the same period. With the accelerate of urbanization and increase in income, urban housing demand has experienced exploding growth. Meanwhile, due to the family planning policy, average household size in urban China has decreased from 3.08 in 1997 to 2.88 in 2011, which may



positively contribute to the increase of housing demand (Yang and Chen, 2014). The booming housing market and expanding wealth gap has gradually made housing affordability problem emerge in China, especially in the period after 2000. The rapid upsurge in housing prices since 2003 in most major Chinese cities has spurred housing affordability issues to become one of China's top social concerns (Chen et al. 2010; Yang and Wang 2011). Most research on measuring how severe the housing affordability problem is focused on a city level. First-tier cities such as Beijing and Shanghai have drawn the greatest attention from scholars. Chen et al. (2010) took Shanghai as a case study and found that the ratio of monthly mortgage payments of housing to disposable income was 60% in Shanghai in 2008, which could be considered as very unaffordable level. Beijing has the same situation. The price-to-income ratio in Beijing was 6.7 in 2002 (Lau and Li, 2006), but increased to 18.5 in early 2010 (Wu et al., 2012). Some recent research has extended the scope to more cities. Wu et al. (2016) calculated the price-to-income ratios of 12 major cities, identifying a potential affordability problem in cities including Beijing, Shanghai, Guangzhou, Shenzhen and Hangzhou. Yang and Chen (2014) pointed out that, on average, the price-to-income ratio of 35 large and medium-sized cities from 2005 to 2010 was approximately 8 with significant regional variance. Fang et al. (2016) analyzed 124 cities, the largest sample at that stage, and found that the price-to-income ratio was around 8 or higher in most Chinese cities from 2003 to 2012, suggesting the existence of a substantial burden on housing purchases.

In response to the problem of housing affordability in China, both government and academic institutions focused on the establishment of affordable housing for the poor. In 2011, central government made a commitment to provide 36 million affordable housing units before 2015

(Huang, 2012; National Peoples Congress (NPC), 2011). However, as Yang and Chen indicated in 2014, middle class in big cities also trapped in this issue and they could only stay in the rental market due to homeownership affordability problems while little attention was paid to them. Due to the widen of groups affected by housing affordability issue, this problem has more profound influence on the society. Housing affordability has been found to be a significant factor in determining the mobility of young university graduates after graduating from the city where they went to school (Cui, Geertman & Hooimeijer, 2016). The trade-off of location was usually used by young graduates and medium-income household to deal with unaffordable housing (Ling, 2017). This may eventually affect both labor market mobility as well as the social network of middle class in China, especially in big first-tier cities. Miao (2017) examined how housing affordability affected the mobility of high-tech talents in the labor market of Beijing and in turn, hampered the knowledge economy development. Although housing affordability problem has obviously become an obstacle to the social and economic development in China, little attention was paid to widen and deepen the research into different income groups and relate the affordability issue with other social topics. This research intends to contribute to this aspect of literature by examining the how housing affordability impact the innovation development and how should government address this impact.

## 2.2 Research on Talent Housing Policy

Talent housing policy is a term usually defined and used in Chinese literatures, indicating policies providing housing assistance to talented worker groups (Morrison, 2014). However, it is not a

unique Chinese thing, government in western countries also developed similar housing policy to enhance place competitiveness and attract high quality labor force. As noted in David Harvey's (1989) influential work, introducing new types of urban space for consuming and living is a necessary prerequisite for attracting and retaining highly skilled workers essential to place competitiveness. The lack of available housing, in particular, were seen to be undermining the competitiveness of employers and the long-term socio-economic sustainability of different city-regions (Raco, 2008). Then, government support for targeted worker housing programs arose in the U.S. and England in response to these growing concerns. In the U.S., there were specific programs designed to provide housing assistance targeted at public sector workers, such as teachers, nurse and police officers (Scanlon, 2010). In England, the difficulties that public sector workers experience affording housing, particularly in high-cost locations, provoked a government policy response, coined the 'key worker' problem (Office of Deputy Prime Minister (ODPM), 2004). Central government of England introduced a series of programs, including the Key Worker Living (KWL) program in 2004, which established the categories of public sector workers eligible for key worker housing assistance (ODPM, 2004). However, there were also academics criticizing the KWL program for being divisive, privileging certain public sector workers with housing assistance at the expense of others (Morrison, 2010; Raco, 2008).

As the housing affordability problem becoming severer, improving housing affordability for talented workers considered essential to place competitiveness has become a policy initiative for government in China as well (Chen, 2011; Shenzhen Municipal Government (SMG), 2010a, 2011).

Especially for Chinese local government in big cities, they were under great pressure to enhance its city's economic base and reduce potential skills shortages of their major private sector employers and state-owned enterprises due to the intense inter-city competition (Jessop and Sum, 2007). Shen (2010) therefore argues that cities across China aspire to become 'talent' hubs, with both central and local municipal governments 'working hard to attract skilled labor in order to sustain economic growth. Talent housing policy was produced in China under such condition. Miao (2017) examine how housing policy was used in three science parks (Zhongguancun Park in Beijing, Zhangjiang Park in Shanghai and Optics Valley in Wuhan) to support housing affordability of high-tech talents working in those science parks and thus promote the development of knowledge economy. He discussed to what extent, and how these three SPs have factored in the housing dimension in connection with the knowledge economy, paying particular attention to housing affordability, location (inside the SPs or outside in the wider city-region) and the mode of provision (market or government). Chen (2011) put forward suggestions for improving the implementation effect of Shenzhen's talent housing project from three aspects: implementation mechanism, choice of housing subsidy mode, and construction of affordable housing.

However, some scholars also questioned talent housing policy in China as well. Liu (2012) said that the financial funds of local governments for housing subsidies are fixed. When housing subsidies are given to high-income talents, the funding for others will be reduced, which could result in unfair social distribution. Regarding the doubts above, this thesis insist that the purpose of talent housing policy is giving full play to the function of talents. The impact of talents to local

economic development is enormous, and it can in return contribute to the local government's financial funds, which would not lead to social injustice.

### 2.3 Research on Innovation Developments

Schumpeter (1961) first put forward the word “innovation” in 1921 and defined it as a new combination of production functions, which is to introduce new ideas in economic activities to achieve potential excess profits of production factors. Since then, the academic research on innovation theory has developed rapidly. At the same time, with the rapid development of globalization, the concept of core competency was introduced into urban research (Prahalad, 1990). Many scholars believe that innovation is the core competency of a city, and the urban science and technology innovation system has received wide attention and gradually developed. Yusuf and Nabeshima (2005) explores how government policies and corporate organizations in east Asia can effectively guide and create a good urban environment so that cities can better enhance their innovation capabilities and thus promote rapid economic growth. One of those attributes to successful innovative cities is human capital, which can fuel the growth of urban economies through its effects on a range of skill intensive manufacturing activities, producer services, and most emphatically, the creative industries.

As the latest measure for local governments to attract well-educated people, talent housing policy directly affects the supply of talents in regional production activities, which in turn determines technological innovation and entrepreneurial development status in this region. When scholars study the influencing factors of technological innovation, almost no one has included the talent

housing policy. Most research focus on the theory of human capital, some scholars propose that talent agglomeration and knowledge spillover effects will improve the ability and efficiency of knowledge transformation, and thus promote the development of scientific and technological innovation. Representatives are Drucker (1994), Glaeser (2011), and Gao (2011). Some scholars including While, Jonas, and Gibbs (2004) start from the perspective of public policy arguing that policies of local governments have greatly influenced how talents play their roles in the technological innovation activities. These studies reflect to some extent the internal mechanism of how talent housing policy affect the innovation development and shows the instructive meaning of this thesis to clarify the relationship between talent housing policy and development of innovation activities.

By summarizing the current status of innovation development in China and track the development of talent housing policies, the focus of thesis is to test whether talent housing policy is a significant influencing factor on regional innovation development through empirical analysis. However, it is difficult to quantify the impact of certain policy, and the amount of innovation undertaken in an economy. In terms of assessing the development of innovation activities in certain region, defined by Frascati Manual, research and development (R&D) expenditures is a commonly used metric of innovation activity. It is originally used as the ratio of R&D expenditures to GDP to measure the vitality of innovation activities in OECD countries (Gaillard, 2010). Patents are another indicator that is often used as a measure of technology innovation output (Hu, 2018). Using the patents as an indicator of innovation development, Carrillo, Chatterjee, and Hunt (2007) did research on the relationship between knowledge spillovers and urban technological innovation. They found that

in highly urbanized cities, for every 1% increase in employment density, patent application density increased by 20%. Therefore, it is suggested that there is a knowledge spillover effect in human capital, which will promote the improvement of scientific and technological innovation. McKinsey (2015) published a report that tried to provide a comprehensive assessment of the current state of technology innovation in China. They classified technology innovation into four types: customer focused, efficiency driven, engineering based and science based. And then they calculated China's share of these industries' global output to indicate if China is doing well in a certain type of innovation. Yang (2016) provided another approach on learning innovation in China from the perspective of science achievement using China's share of research papers worldwide.

### **3 Research Design**

#### 3.1 Research Questions

The primary goal of this research is to explore the development of talent housing policies in China and whether they can promote regional innovation development. This research wants to answer two key questions:

1. What are the impacts of talent housing policy on regional innovation activities?
2. How to promote regional innovation development through a better adoption of talent housing policy?

By revealing the inner mechanism how housing policies stimulate innovation potential of tech-talents, this thesis aims to raise the attention of local governments to the housing affordability issue for high-tech talents, and then propose effective policy suggestions.

## 3.2 Methodology

This study is based on a mixed-method research design. The first part is a qualitative section aiming to analyze the housing affordability issue talents face and the development status of talent housing policies. The second section is composed of a quantitative analysis to explore how talent housing policy impact regional innovation development. Finally, policy suggestions will be proposed towards optimizing talent housing policy to better stimulate the vitality of innovation activities.

### 3.2.1 Qualitative

The qualitative methods would first explore how severe the affordability issue is for high-tech talents by comparing the housing affordability in China with several developed countries. Major cities such as Beijing, Shanghai and Shenzhen would be select the as representatives to analyze the great impacts brought by the affordability issue on local labor market, and then the impacts on innovation development. Secondly, qualitative section would do background analysis of why there are talent housing policies in China from an empirical perspective and how they have developed now.

### 3.2.2 Quantitative

The basic assumption of this analysis is that the rising of housing price would impede innovation development (Luo, 2016). This test will run two regression models to analyze if talent housing policy can impact the development of innovation industry. Dataset consisting of 112 panel data of 16 major Chinese cities from 2010 to 2016 will be used to conduct the regressions. All of the data will be secondary data and collected from the National Bureau Statistics and regional Economic



Development Analysis Yearbook. From the perspective of talent housing policy, two independent variables are proposed: 1. whether or not talent housing policy was issued in each city; 2. the coverage of talent housing policy in each city. The presence of talent housing policy will be a dummy variable introduced into the model. The coverage of policy will be calculated based on an accumulative score system built in the qualitative analysis section. Based on the results of the quantitative analysis, this research would derive a theoretical explanation for the quantitative results. The inner mechanism of how housing policy impacts regional innovation development will be illustrated explicitly.

Based on the results from both qualitative and quantitative analysis, this research would propose some policy suggestions on how to optimize the current talent housing system and promote innovation development effectively.

#### **4 Analysis on Housing Affordability and Development of Talent Housing Policy**

In the past few decades, with the development of urbanization and problems brought by urbanization such as urban sprawl, rising housing price have continually forced people out of downtown and accelerated displacement in many countries. Housing affordability has become an important social agenda in almost all societies and raised attention from both policy makers and academic scholars. Moreover, the housing affordability is not exclusively a problem for low-income families, it now begins to push young professionals out of mega cities in China. In consideration of the structural transformation of china's economies from labor to capital to

knowledge-intensive industry sectors, housing affordability issue faced by young talents has become an obstacle to the development of innovation economy.

Government involvement in the private market is typically justified by the existence of failures in the private market system (Weimer and Vining 1999). The failure of the invisible hands on solving housing affordability issue has been noticed all over the world. Therefore, talent housing policy has been valued and established in China to both address housing affordability issue and promote economic development. The strong implication here is that an affordable housing price of place can function as a magnet for human capital. This part will first analyze the severity of this issue and then comb through the origin and development of talent housing policy in China.

#### 4.1 Housing Affordability and Innovation Development in China

##### 4.1.1 The Development of Housing Market in China

Technically, the concept of housing affordability did not exist in urban China for 3 decades after the founding of the People's Republic of China in 1949. In the period from 1949-1978, under state socialism, real estate was nationalized and urban housing accommodation was fully controlled and provided by the State through administrative rather than market force while market trading of housing being illegal, which is called welfare housing system. State-owned enterprises and public institutions mainly built and owned dwelling units due to their responsibility on allocating residential units to employees according to their seniority within the organization at a negligible rent. Housing affordability was not worried by residents in this period. However, due to the extremely low rents and rapid population growth (from 57.7 million in 1949 to 172.5 million in

1978), government and state-owned enterprises could not sustain housing provision. Severe housing shortage, dilapidated housing condition and inefficient public provision have featured the real estate in this period. For example, in 1978, the national average per capita living space was only 3.7 square meters for residents in urban areas (Zhang, 1998).

Figure 1 Yuyangli, Huaihai Road, Shanghai, an old housing built in 1917



Sources: photo by Albert Cao (2013).

Since the start of reform and opening up in 1978, housing reform, which change urban housing from being a form of welfare from the State to a type of commodity, began to relieve the central government from the burden of housing provision and facilitate the privatization of housing market.

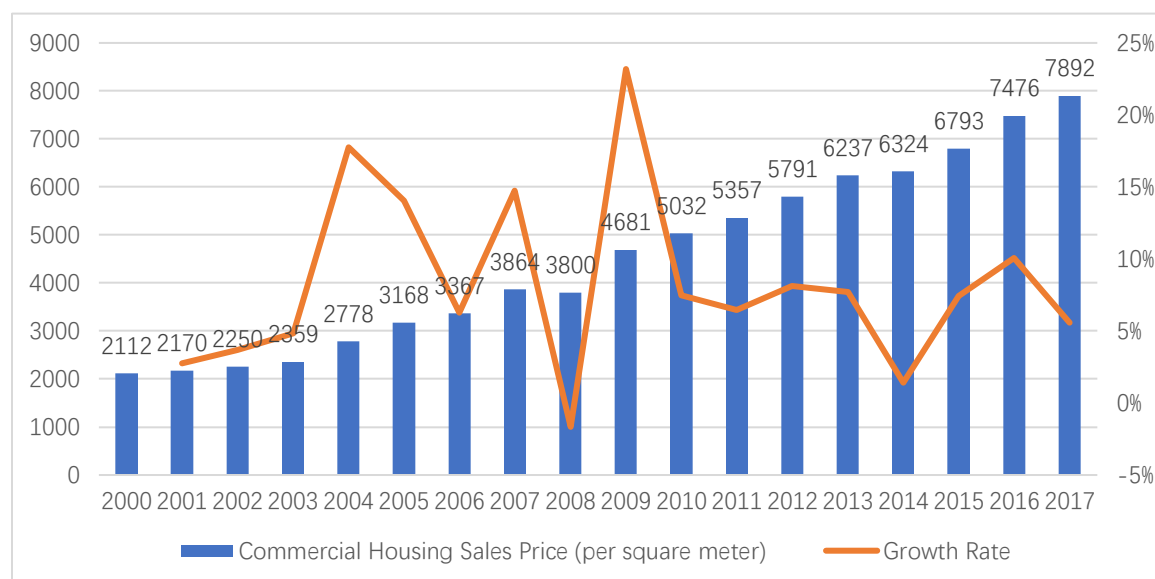
The housing reform was featured with three essential components: first, residential units previously owned by state-owned enterprises or public institutions were sold to the residents living in the units at heavily subsidized prices. Second, housing allocation was terminated and the implicit housing bonus provided for people working in state-owned enterprises or public institutions had been integrated into their salaries. Third, the real estate industry and private housing markets started to develop, in which urban households could purchase or rent their housing at market prices. In 1987, market transaction of state-owned urban land was conducted in Shenzhen, a “Special Economic Zone” set up to experiment with economic reforms and opening-up measures. This housing reform accelerated in the 1990s. And in 1998, the State Council announced the completely abolishment of the welfare-oriented housing distribution and the full privatization of housing market. Since then, the percentage of new housing construction divided by the total housing supply boomed from 30.7% in 1997 to 61.4% in 2003, and then reached a peak of 72.4% in 2007. Due to the unique land revenue system established in China, local government has greatly boosted the explosive development of housing market. Such explosive reform stimulated the potential of land market on promoting infrastructure construction and urbanization process, while triggered the problem of housing affordability in the following years.

#### 4.1.2 Housing Affordability and Innovation Development

Housing affordability is determined by the relationship between housing price and household income and usually measured by the ratio of monthly housing expenditure to monthly household income. At present, 30-years after the housing reform in 1978, the high housing price in China have become an obvious fact. Figure 1 presents the change of average housing price in China from

2000 to 2017. As we can see, there is a clear upward trend in China's housing price. Although affected by the global financial crisis, the first decline in housing price in the past decades showed in 2008, which is a decrease of 1.66%, housing price rose rapidly again with the greatest annual increase rate of 23.2% in 2009. And the price in 2017 was 3.74 times that of 2000. Despite that the State has continuously introduced macro-control policies to curb the rapidly increasing housing price over the years, housing price are still at a high level in recent years.

Figure 2 Sales price of commercial housing from 2000 to 2017



Source: National Bureau of Statistics of China

Moreover, extremely soaring prices were especially apparent in a few first-tier cities, such as Beijing, Shanghai, and Shenzhen, where the absolute number of housing price are extremely high even compared with Hongkong, Tokyo and other international cities. However, the growth rate of household income was far behind the housing price growth (Fang et al., 2016; Wu et al., 2014). The increasing gap between housing price and household income would naturally lead to concern about housing affordability. Although there are different data and multiple measurements used by

scholars on analyzing housing affordability in China, most quantitative researches have concluded that there has been a serious housing affordability problem in urban China now. In order to address this problem, affordable housing system targeting low-income groups has been gradually established in all the cities. However, due to substantial housing burden in first-tier cities, housing affordability problem is serious for young professionals and talents as well.

Affected by the facts that technology innovation activities need long-term investment and there is usually imbalance between input and output, the economic income of talent groups is generally not high, especially for those just graduated and devoted themselves into this industry. Housing problems have become the main obstacle for many talents to anchor themselves in metropolitan cities. Since affordable housing policies mainly targets extremely low-income households, the income level of most of the talents do not qualify them to this standard. They can be called as “Sandwich Class”, who do not meet the requirements for affordable housing, nor can they afford commercial housing in the market. Due to the limited income, some talents can only rent a house far away from their workplace, which greatly increases their commuting time and restricts their living condition. The housing expenditures will obviously bring burdens to talents on both life and spirit levels, which will reduce their productivity and enthusiasm on working and then curb the development of regional innovation industry. Many talents even have to give up their ideal jobs, and have no choice but to leave the big cities they yearn for.

Given the great reliance of innovation development on local talents (Yang, 2011), technicians are the core of high-level technology innovation activities. By 2020, under the instruction of the 13th Five-Year Plan, as the two important indicators of scientific and technological innovation, the

contribution ratio of science and technology development to economic growth should increase from 55.3% in 2015 to 60%, and the ratio of R&D expenditure to GDP should improve from 2.1% in 2015 to 2.5%, which inevitably proposes new requirements and challenges to cities on attracting high-tech labor force. As one of the fastest growing cities in China, both the labor force market and housing market are vibrant in Shanghai in the past 20 years. However, in 2014, about 41.3% of all university graduates in Yangtze River Delta Region worked in Shanghai, and by 2015 the figure fell to 35%. According to the results of a research on the health of white-collar elites in Shanghai released at the end of 2015, among the elites participating in the survey, 46% of them voted for high pressure on purchasing housing. Combing above data, high housing price might partially contribute to the losing of these young talents. In addition to that, according to 2017 China Urban Innovation and Entrepreneurship Environment Evaluation Research conducted by Tsinghua University Science Park, Beijing has ranked as the first with obvious advantage when evaluating talent market for innovation development, indicating that Beijing is the city in China with the most abundant high-tech labor force resources. In 2016, the number of students in college and above in Beijing reached 972,900, and exceeded the sum of the same numbers in the cities of Wuhan and Guangzhou, who ranked as the second and the third in the list. The number of colleges, universities and well-known academic institutions in Beijing also ranked first in all cities in China. In terms of funding, the fiscal expenditure of Beijing local government on science and technology was ¥47.35 billion, which was significantly higher than other cities as well. At this stage, as the technology leader of Chinese cities, Beijing is moving towards building itself as an international city. However, compared with the top three international cities — New York City, London and Tokyo, there are

still significant gaps in talent fostering system and talent investment environment. For example, in New York City, London and Tokyo, the proportion of high-tech industry employees is about 30% while Beijing is only 4.1%. In terms of financial industry and cultural entrepreneurial industry, Beijing also has a gap compared with these cities. In particular, personnel work in financial industry only accounted for 2.32% in Beijing, while New York City and London both have a number above 10%. Beijing, as the city with the greatest potential on innovation development in China, is still lacking of well-educated talents, not to mention other major cities. Therefore, how to mitigate the negative impacts brought by housing affordability problem and attract more high-tech talents are crucial to the innovation development in all major cities in China.

## 4.2 The Development of Talent Housing Policy

### 4.2.1 The Origin of Talent Housing Policy

When realizing the importance of solving housing affordability issue for talent groups to attract and retain them, the formulation of talent housing policies become an inevitable choice for local government in China. Actually, the practice of using housing policy as a way to attract talents is not only emerging in China, but also in some developed countries. For example, facing the shortage of well-qualified teachers in certain community, the Department of Education in some States of the U.S. began to offer housing perks as an incentive to attract great teachers to struggling public schools, including allowing the use of tax credits or mortgage revenue bonds for teachers who commit to serve at least five years in a low-performing school. Moreover, in Germany, housing policy has been integrated into national immigration policies as a way to improve the



competitiveness of Germany on attracting oversea tech talents to work and inhabit in Germany. In the new Germany immigration law, there are three types of talents identified who can enjoy the housing benefits to different extents. The first type is scientists with advanced expertise, who are qualified to enjoy supports from federal government including providing social talent housing directly. The second one is prominent researchers and professors in certain fields, provided with housing benefits from local government on purchasing public talent housing. The last type is experts with special professional experience or public officials working in leadership positions. Their employers, regardless of private companies or public organizations, are required to offer them with enterprise talent housing.

Learning from the experience of other developed countries, beginning in 2007, under the guidance of the State Council, major cities in China have successively issued corresponding talent housing policies, which have given strong support to talent on purchasing housing from multiple levels.

#### 4.2.2 Current Status of Talent Housing Policy in China

Since 2007, when the first talent housing policy was enacted in Guangzhou, the optimizing of talent housing policy has gone through more than ten years. After collecting and organizing relevant policy documents from official websites of different local governments, this research finds that, by 2016, all the 16 cities selected have successively enacted housing policies targeting talents group. Local governments, in response to their social environment, industrial structure and economic development requirements, usually choose different but appropriate approaches to address the housing affordability issue of talent groups. A multi-dimension talent housing system has been developed and gradually established in these 16 cities, including approaches such as rent

subsidies, public-rental housing, and provident funds bonus to reduce the pressure of talents on purchasing residential housings. This research concluded these different approaches into 9 categories as below and established a scoring system based these categories, which will be used in the quantitative part as an indicator of the coverage of talent housing policy measuring how many kinds methods used by a city to support talent on housing purchasing.

#### 1. Provision of free housing

In order to optimize the policy environment, some cities provide free housing for the introduction of both oversea and domestic top talents. For example, the local government of Nanjing has promulgated a housing policy targeting “High-level Talents” in 2013, and divided the talents introduced into five categories, among which the highest level would be provided with a free talent apartment more than 100 square meters for three years. Moreover, the city government of Ningbo has implemented a similar policy for overseas high-level talents, providing them with free housing within 100 square meters for three years.

#### 2. Permanent grants of property

There is a policy in some cities stipulating that high-level talents who have lived in the housing provided by local government for more than a certain period of time will be given preferential support on gaining the property rights of their houses. For instance, since 2013 in Luoyang City, newly cultivated academicians and people selected by the national “Thousand Talents Plan” would be granted housing property rights after five years of work in Luoyang. In 2010, Shenzhen has issued a talent housing project mentioning that for globally outstanding talents and academicians, property rights of the talent apartment they lived in will be given to them

if they have been working in Shenzhen for 10 years. The time limit can be shortened appropriately according to individual outstanding contribution.

### 3. Qualified them for public-rental housing

Public rental housing is usually invested and owned by government and mainly provided for extremely low-income households to rent. To support talents who just graduate from college and has limited deposits, some local governments have lowered the standard requirements for them and qualified them for renting these relatively cheap housing. Wuhan has announced a document in 2015 on encouraging college graduates in employment and entrepreneurship, which qualified newly-employed college students and entrepreneurial talents to rent public rental housing. And in 2011, Chongqing provided public rental housing to all kinds of innovation talents.

### 4. Provision of talent apartment

Some local governments have set part of newly constructed commercial housing as price-fixed housing and talent apartment. Talents who have not yet purchased commercial housing in the local area may apply for the price-fixed housing at a price lower than the market level. The city of Huizhou has built a number of high-end talent apartments as early as 2008, and sold them to senior talents at a limit price. In 2010, Quanzhou City announced that high-level entrepreneurial and innovative talents applying for the first set of housing in the family should be given price priority according to the price of affordable housing.

### 5. Purchase subsidies

There are also subsidies provided for talents on purchasing housing. In 2009, Guangzhou proposed a regulation on giving talents with doctoral degree and technical leaders a one-time purchase subsidy from ¥500,000 to ¥2,000,000. In 2012, Changsha announced to give a subsidy of 20 percent of market price to talents who meet certain criteria on purchasing their first commercial housing. One-time purchase subsidies have become a preferred way for talents on supporting them to purchase real estate due to its simplified and efficient process, while it relies heavily on fiscal revenue of local governments.

#### 6. Rent subsidies

When choosing in which city to have their first job, newly graduated college students would generally consider the rent price of apartment in a city due to their weak payment capability. Therefore, subsidies for rent by government funds can effectively alleviate their short-term housing problems. Wenzhou City in 2013 promulgated a talent housing rental subsidy policy, stipulating that rental housing would be provided by real estate market on market price, while local government would allocate certain amounts of rental subsidies to newly employed college students and other high-level talents. Shenzhen enacted a regulation on providing one-time rental subsidies granted to those who have undergraduate degree or above in 2014. This regulation stipulated that ¥6,000 yuan will be provided for each undergraduate, ¥9,000 yuan for masters, and ¥12,000 for doctors. In 2016, the amount of rental subsidies has been increased by a certain amount, of which talents with doctoral degree can receive ¥30,000 yuan.

#### 7. Discount on housing loan

This approach provides talents discount in housing loan when purchasing market price commercial housings. Local government has established a special funds to support and give the loan bonus to individuals. For example, in 2015, Zhengzhou enacted a talent introduction policy stipulating that if the introduced talents have been working in Zhengzhou for one year and made outstanding contributions to local economy, they can enjoy a 10% discount on their housing loan. According to the “High-level Talent Housing Solutions” formulated by Guangzhou in 2014, outstanding experts who have been certificated as A level would be given special bonus on housing loan to purchase commercial housing.

#### 8. Discount on provident fund loan

In recent years, China’s housing provident fund system has worked well in solving the housing affordability issue for all residents. Policies using provident fund to support talents on housing issue have shown up in many cities as well. In 2013, Luoyang has implemented a plan mentioning that newly introduced talents can be exempted from the six-month pre-deposit requirement when applying for housing provident fund loans. Jinan also stipulated that when college graduates apply for personal housing accumulation fund loans, the maximum amount of loans they can get can be increased by 30%.

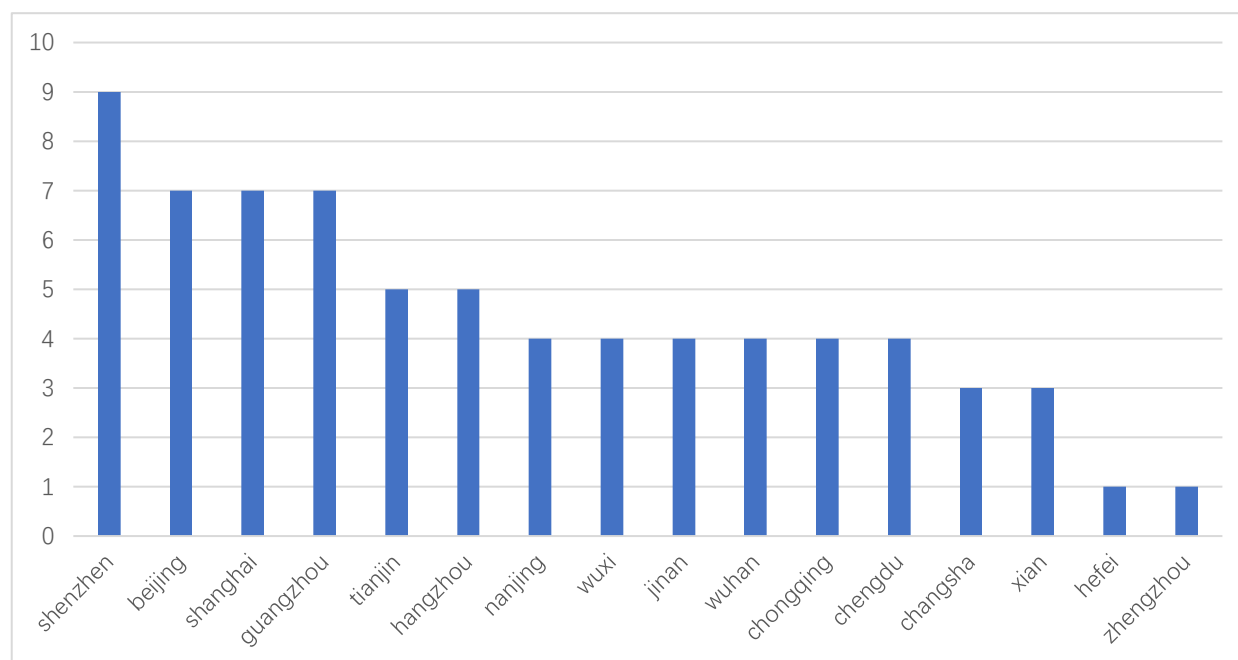
#### 9. Others

There are more other ways of cities in China to provide support to talents on housing issue, including exemption from property-purchasing restrictions, tax deduction and other policies. Chongqing enacted a policy in 2009 for the introduction of high-level indicating that talents who meet the requirements can be exempted from deed tax when purchasing their first

commercial housing. Shanghai adopted some fine-tuning to the housing purchasing restriction for talents work in Shanghai but without *hukou*.

From the categories above, a multi-dimension talent housing system with various supporting approaches has been developed and gradually established in lots of Chinese cities. Based on the scoring system established on the 9 categories, the figure below shows the coverage of talent housing policy in selected 16 cities in 2016. Most of the cities have a score of 4, and Shenzhen has become the city with strongest support for talents on housing purchasing, which has the highest score of 9. Shenzhen, as the fastest growing city in China, it has very advanced policy environment to attract well-educated labor force to devote themselves into the development of Shenzhen. Although all the 16 cities have already enacted talent housing policies in 2016, there are still great gaps between these cities on the coverage of their supports.

Figure 3 Scores of talent housing policy in different cities



Source: National Bureau of Statistics of China

## **5 Quantitative Analysis**

Housing affordability has become an emerging obstacle on regional scientific and technological innovation development. For talented people, their development space may be limited due to excessive housing burden in mega cities such as Beijing, Shanghai and Shenzhen, which have the most prosperous innovation resources. They would have more concerns when devoting themselves into scientific and technological innovation work as well. For private companies or research institutes, they have to eliminate the negative effect of high housing price by increasing the remuneration package, which undoubtedly amplifies the burden on enterprises. For the city, a portion of talented people would be priced out, which will contribute greatly to loss of human capital. And the development of science and technology innovation in the city will naturally be hindered.

### **5.1 Hypotheses**

Most of the existing literatures focus on the relationship between R&D investment and technological innovation output, but they rarely deal with the inhibitory effect of rising house price on regional innovation development. Based on the above analysis, this research proposes the first hypothesis:

H1: there is no relationship between the rising of housing price and regional innovation development.

As the enterprises, the dominant role in science and technology innovation, failed in the allocation of market resources, it is necessary for the government to intervene and formulate specific policies to correct the market failures. The enactment of talent housing policy has become a signal that government is determined create a conducive environment to the growth and development of talents. A good policy environment will give talents a strong sense of yearning and belonging to the city, and drive the arrival of talents who are in line with regional development. At the same time, it also stimulates the enthusiasm of local talents and avoids the loss of existing people. The aggregation effects of human capital in a city will become a driving force for regional science and technology innovation. In order to research if talent housing policies can exert expected impacts on regional innovation development, another two hypotheses are proposed:

H2: there is no relationship between the presence of talent housing policy and regional innovation development.

H3: there is no relationship between the coverage of talent housing policy and regional innovation development.

## 5.2 Data Selection

This research selects 16 large and medium-sized cities in China as samples. most of which have already issued the talent housing policy. In consideration of the continuity, accuracy and availability of data, this analysis selects panel data of 112 observations from 16 large and medium-sized cities in China from 2010 to 2016, and conducts empirical research on the influencing factors of urban innovation development in China.



### 5.2.1 Dependent Variable

The number of independent intellectual property rights owned by a country has been widely used as an important indicator of the level of scientific and technological development (Hu, 2018). Patents, as a form of intellectual property, are used in this research to measure how innovation Chinese cities are. The number of patent applications can reflect the original output of independent innovation activities in enterprises. Although there are some limitations on the use of patent data as innovation output indicators, considering the availability, objectivity and stability of patent data, it is still a fairly reliable measurement on innovation output.

### 5.2.2 Independent Variables

In the test of first hypothesis, which exams the relationship between rising of housing price and innovation development, Sales Price Indices of Residential Buildings from National Bureau of Statistics are used to comprehensively reflect the overall trend and change range of residential housing price. As for talent housing policy, two variables are used to measure the coverage of this policy. A dummy variable taking the value 0 or 1 has been introduced to indicate the presence of talent housing policy in a city. If there are talent housing policies in a certain year, Dum=1; otherwise Dum=0. Another variable is used to measure how supportive talent housing policies can be in a city. Talent housing policies has been classified into 9 categories based on previous research, and the existing of certain category of policy will be scored one point. Taking Beijing as an example, there are three different ways to support talents on purchasing housing in Beijing at 2012, including qualifying talents on buying public housing, providing them with housing subsidies, and giving them home loan discount. In this case, the talent housing policy score of Beijing at 2012

will be three. A higher score represents greater importance attached to talent housing affordability issue by the local government and also greater coverage of talent housing policy. Data collection of the last two variables uses web scraping in Python to excavate policy documents published by local governments of the 16 cities.

### 5.2.3 Control Variables

Including control variables in a regression model can help correctly estimate the effects of variables you interested in on the dependent variable, and thus enhance the validity of the regression model. This research introduces the following factors that may affect the level of scientific and technological innovation as control variables:

1. Research and development (R&D) full-time personnel: represents the number of talents involved in innovation activities;
2. Research and development (R&D) expenditure to GDP ratio: measures the degree of efforts and investment a region put on technology innovation development;
3. Science and technology grants to fiscal expenditures ratio: directly reflects the willingness and ability of local government on supporting science and technology innovation;
4. Education grants to fiscal expenditures ratio: the support from local government on education can promote innovation development greatly;
5. Foreign direct investment: FDI plays a prominent role Chinese technology innovation. It can reflect the impact of outside technology spillover on the innovation development of a region. Fu (2008) found that FDI has significantly positive impacts in patent production;

6. Urbanization rate: the increase of urban population means more labor force and greater free market, both of which can contribute to the development of technology innovation.

Table 1 Table of indicators

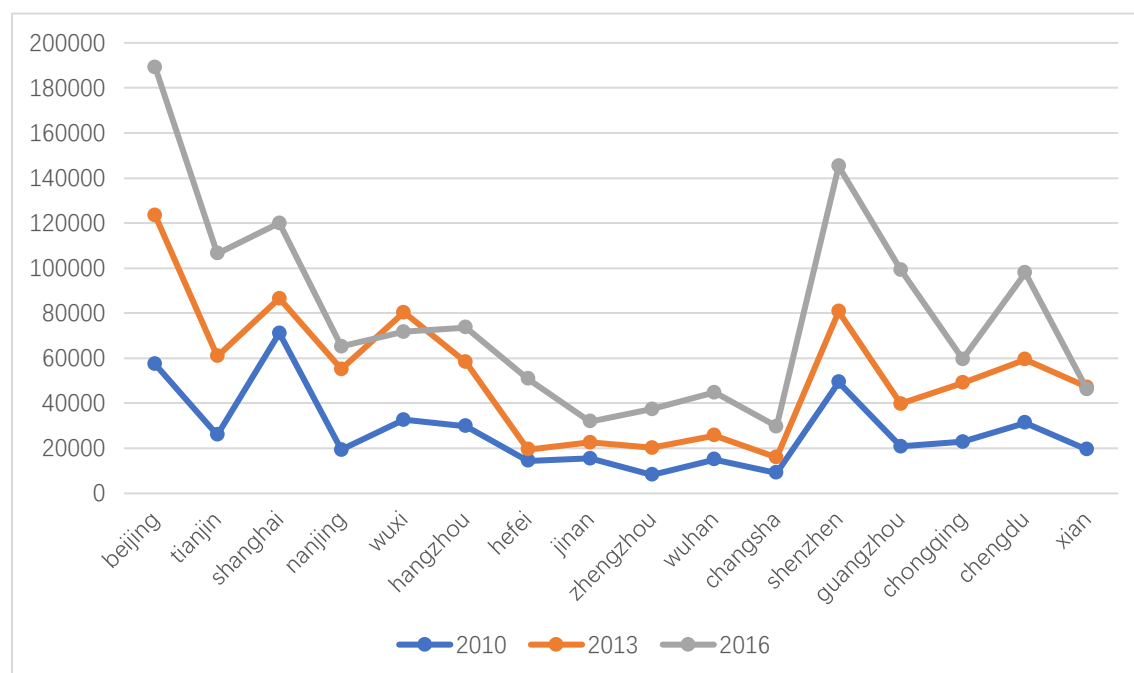
	Indicators	Code
Dependent Variable	Amount of patent applications	Patent
Independent Variables	Sales Price Indices of Residential Buildings	HI
	The presence of talent housing policy	D_policy
	The coverage of talent housing policy	P_score
Control Variables	Research and development (R&D) full-time personnel per capita	RDP
	Research and development (R&D) expenditure to GDP ratio	RDI
	Science and technology grants to fiscal expenditures ratio	Ste
	Education grants to fiscal expenditures ratio	Edu
	Foreign direct investment to GDP ratio	FDI
	Urbanization rate	Urban

### 5.3 Descriptive Statistics

Based on patent data collected in this research, the figure below was drawn to show the great differences and gaps on the amount of patent application between the 16 cities in 2010, 2013 and

2016. Beijing, Shanghai and Shenzhen can be ranked generally as the top 3 in the production of patent application.

Figure 4 The amount of patent application in 2010, 2013 and 2016



Source: National Bureau of Statistics of China

The table below shows the descriptive statistics result of the dependent variable — amount of patent applications. From the column of mean value of the indicator, it can be found that the amount of patent applications increases gradually every year, showing a steadily progress in innovation development. The gap in the number of patent applications is huge and growing fast year by year, which indicates strong imbalance of innovation development in these 16 cities. Moreover, the growing gap may imply that a better basic condition of science and technology innovation can promote greater growth in annual innovation output.

Table 2 Descriptive result of the dependent variable

year	N	mean	sd	min	max
2010	16	27647.13	17711.05	8203	71196
2011	16	36561.44	21852.63	10997	80215
2012	16	44847.44	25233.92	14973	92305
2013	16	52765	29640.03	15956	123336
2014	16	53387.06	30184.8	17763	138111
2015	16	65290.31	35363.12	21999	156312
2016	16	79308.75	44569.86	29758	189129
Total	112	51401.02	33651.52	8203	189129

The table below shows the descriptive statistics results of all the explanatory variables. It can be seen from the mean, minimum and maximum values of various indicators that there are significant differences in the input of technology innovation, education level and market environment in these 16 cities. Actually, the differences between cities can help analyze the factors that contribute to the development of science and technology innovation. According to the statistics, all of the 16 cities have enacted talent housing policies by 2016, and some of them have very diversified policies to support talents on purchasing real estate. Sales Price Indices of Residential Buildings has a mean value of 114 and a maximum value of 225, showing an overall high and still growing housing price in China. The great differences on research and development (R&D) expenditure to GDP ratio and science and technology grants to fiscal expenditures ratio show that technological

innovation is valued differently in the 16 cities. Foreign direct investment reflects the degree of opening up of each city and their ability to attract investment. The significant gap in this indicator implies us the advantageous location of coastal cities on attracting foreign investment and getting benefits from technology spillover. Moreover, China has made great progress in urbanization process in the past 30 years.

Table 3 Descriptive result of other variables

Variable	Obs	Mean	Std.Dev.	Min	Max
Housing Price	112	114.089	21.261	93.3	225.8
The presence of talent housing policy	112	.812	.392	0	1
The coverage of talent housing policy	112	2.866	2.099	0	9
R&D personnel	112	6.948	3.168	1.40	16.43
R&D investment	112	.025	.014	.006	.058
Science and technology grants	112	.035	.019	.002	.118
Education grants	112	.148	.03	.067	.246
Foreign direct investment	112	.038	.018	.01	.117
Urbanization rate	112	.727	.141	.37	1

## 5.4 Empirical Model

Wei, Wu and Lyu (2010) have built up an innovative production function model based on the endogenous growth model created by Romer (1990):

$$Y_{i,t+1} = \delta_{i,t}(x_{i,t}, y_{i,t}, z_{i,t}) H_{i,t} A_{i,t}$$

In this model,  $Y_{i,t+1}$  is innovation output of a certain region.  $H_{i,t}$  represents innovation input, and  $A_{i,t}$  quantifies existing innovation bases. Drawing on this model, this research integrates this model with panel data collected, and proposes two empirical models to test the two hypotheses. The enactment of talent housing policy would exert impacts on the number of personnel worked in research and development. Therefore, the products of talent housing policy variables and RDP have been introduced into this model. Moreover, considering that there is almost no lag effect on innovation investment and patent applications, the two models in this research have been established as below:

- 1) To test if there is a relationship between the presence of talent housing policy and regional innovation development, model 1 will be:

$$\begin{aligned} \text{LnPatent}_{i,t} = & \beta_0 + \beta_1 \text{HI}_{i,t} + \beta_2 \text{D\_policy}_{i,t} + \beta_3 \text{D\_policy}_{i,t} * \text{LnRDP}_{i,t} + \\ & \Sigma(\gamma \text{Control\_Variable}_{i,t}) + \varepsilon_{i,t} \end{aligned}$$

- 2) To test if there is a relationship between the coverage of talent housing policy and regional innovation development, the model 2 will be:

$$\begin{aligned} \text{LnPatent}_{i,t} = & \beta_0 + \beta_1 \text{HI}_{i,t} + \beta_2 \text{P\_number}_{i,t} + \beta_3 \text{P\_number}_{i,t} * \text{LnRDP}_{i,t} + \\ & \Sigma(\gamma \text{Control\_Variable}_{i,t}) + \varepsilon_{i,t} \end{aligned}$$

In these two models,  $i$  represents different cities, and  $t$  represents time period.  $\beta_0$  to  $\beta_3$  and  $\gamma$  are the coefficients of the models, and  $\varepsilon_{i,t}$  is the error term. In order to reduce the impacts of possible outliers and extreme values, logarithm transformation has been applied to several variables including the dependent variable —the number of patent applications.

#### 5.4.1 The establishment of regression model

In order to avoid the spurious regression results brought by non-stationary data series and ensure the validity of this research, it is necessary to conduct panel unit-root and stationarity test before regression analysis. In this part, Levin, Lin & Chu (LLC) and Fisher-ADF methods are used to perform both common unit root test and individual unit root test. And  $D\_policy$  as a dummy variable, unit-root test cannot be performed on it.

Table 4 Results of Levin, Liu & Chu (LLC) test

	Variable	P-value	Result
LLC (Null: Unit root (assumes common unit root process))	Inpatent	0.0000	stationary
	lnhi	0.0000	stationary
	p_score	0.0000	stationary
	lnrdp	0.0000	stationary
	rdi	0.0000	stationary
	ste	0.0000	stationary
	edu	0.0000	stationary
	lnfdi	0.0001	stationary



	urban	0.0000	stationary
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Table 5 Results of Fisher-ADF test

	Variable	P-value	Result
Fisher-ADF Null: Unit root (assumes individual unit root process)	lnpatent	0.0000	stationary
	lnhi	0.0006	stationary
	p_score	0.0000	stationary
	lnrdp	0.0001	stationary
	rdi	0.0003	stationary
	ste	0.0000	stationary
	edu	0.007	stationary
	lnfdi	0.0003	stationary
	urban	0.002	stationary

In the table above, both LLC test and Fisher-ADF test assume that there is the presence of unit-root. The results show that all the p-values of are lower than 0.05, which rejects the null hypothesis and indicates the stationarity of sample data.

There are three techniques can be used to analyze panel data, including pooled regression model, fixed effects regression model, and random effects regression model. F-test and Hausman test should be conducted to decide which model is the best for this analysis. The null hypothesis behind F-test is that the preferred model is pooled regression model compared with fixed-effects. And the

Hausman test, which assumes that random effects technique is better, is used to decide between fixed and random effects. Based on below test results, fixed-effects regression model should be used for both of the empirical models in this research. Moreover, in consideration of the multicollinearity issue, stepwise regression was conducted in this part as well. The variance inflation factor of all the variables above are smaller than 10, indicating no presence of multicollinearity problem in the model.

Table 6 Results of F-test

	Model	P-value	Result
F-test	Model 1	0.0000	Fixed-effects
	Model 2	0.0000	Fixed-effects

Table 7 Results of Hausman test

	Model	P-value	Result
Hausman test	Model 1	0.0105	Fixed-effects
	Model 2	0.0002	Fixed-effects

#### 5.4.2 Regression Results

This research uses xtreg command in Stata to analyze the impacts of talent housing policy on regional innovation development. Regression results are shown below:

Table 8 Fixed effects regression results

	Variables	Model 1	Model 2
Housing price	lnhi	-0.532*** (3.524)	-0.667*** (2.568)
The presence of talent housing policy	d_policy	0.947** (0.351)	
The products of talent housing policy variables and RDP	dpolicylnrdp	-0.387 (-0.719)	
The coverage of talent housing policy	p_score		0.132** (1.753)
The products of talent housing policy variables and RDP	p_scorelnrdp		0.365 (-1.347)
R&D personnel per capita	lnrdp	0.493*** (3.335)	0.418** (7.692)
R&D investment per capita	rdi	11.792** (16.713)	12.882*** (16.517)
Science and technology grants	ste	6.756*** (2.937)	9.824** (2.931)
Education grants	edu	2.506 (0.997)	2.834 (0.981)
Foreign direct investment per capita	lnfdi	0.027* (0.039)	0.034** (0.098)
Urbanization rate	urban	8.618*** (0.727)	8.575*** (0.893)
	F Statistic-	35.01***	43.68***
	Observations	112	112
	R-squared	0.581	0.614

	Number of cityid	16	16
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Notes: t-statistics in parentheses, \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$

Seen from the above table, both of the two models have a F-value at the 0.01 significance level, and a R-squared above 60 percent, which indicates the models have high significance level and great fitting degree.

In both of the two models, housing price (lnhi) has a negative regression coefficient with a significance level of 0.01, which rejected the first hypothesis (H1) and indicated that the development of science and technology innovation is negatively correlated with housing price, and the rise in housing price will inhibit the development of technological innovation in the city. In the first model, the dummy variable (d\_policy) representing the existing of talent housing policy in a city has a positive coefficient with a significance level of 0.05. The result rejected our second hypothesis (H2) that there is no relationship between the presence of talent housing policy and regional innovation development and supported the original purpose of local government on using talent housing policy to attract more tech people and promote innovation development. In the second model, the coverage of talent housing policy (p\_score) has a positive coefficient at the 0.05 significance level, which means it has positive impact on innovation development as well.

For the control variables, the investment in research and development (rdi) and full-time personnel working in research and development (lnrdp) both have positive coefficients with a significance level of 0.01, indicating great positive impacts they exerted on the development of technology innovation. These relationships are easily to understand because the money and labor force devoted into one field can be taken as the most direct and decisive factors for the outputs.

Coefficients of science and technology grants from local government (ste) in both of the models are positive at the 0.05 significance level, which shows clearly the positive impacts of fiscal supports from local government on innovation development. Local government, as an important role who has the power to interfere with free market, its investment and support are crucial to the development of innovation in a city. In model 1 and model 2, foreign direct investment (Infdi) has positive coefficients with a significance level of 0.1 and 0.05, respectively. Foreign direct investment, which reflects the impact of outside technology spillover on the innovation development of a region, still has great impacts on innovation development in China. The result is consistent with the arguments from Fu (2008). Moreover, the results of urbanization rate (urban) in both of the models are worth attention. The positive coefficients with a significant level of 0.01 indicates the great positive impacts of urbanization process on innovation development. Compared with rural area, capitals and talents are tend to concentrate in urban area due to advantageous location, convenient transportation and affluent cultural resources. And capitals and talents devoted to technology research are the most direct and decisive factors for promoting innovation development, which has been proved and illustrated above. Taking Shenzhen as an example, from the descriptive statistics results above, there is one city — Shenzhen, of which the urbanization rate has reached 100%. Actually, the Pearl River Delta region with Shenzhen as its center is already one of the most mature metropolitan area in China. The establishment of urban agglomerations, with inner logistics network, labor force flow, capital flow, information and technology exchange, has connected the cities in the Pearl River Delta tightly and promoted their technology development greatly.

However, some of the explanatory variables are not proved to have significant impacts on innovation development. First, the products of talent housing policy variables and RDP (dpolicylnrdp and pscorelnrdp), which have been introduced into this model considering that the enactment of talent housing policy would exert impacts on the number of personnel worked in research and development, are statistically nonsignificant. In addition to that, although education grants from local government (edu) has positive coefficients of 2.506 and 2.834 respectively in both of the regression model 1 and model 2, the results are not statistically significant, which is beyond our expectation.

## 5.5 Results Analysis

In this quantitative analysis, panel data of from 16 large and medium-sized cities in China from 2010 to 2016 are collected to analyze the relationship between talent housing policies and innovation development. The empirical analysis indicates that the rising of housing price will inhibit innovation development, while the presence of talent housing policies and how they support talent on purchasing housing are two of the important factors promoting innovation development in Chinese cities.

Hypothesis 1: there is no relationship between the rising of housing price and regional innovation development.

This research rejected this hypothesis by indicating that the rising of housing price will exert negative influence on regional innovation development, which is accordance to the basic assumption of this research. Lots of well-talented people will leave the city if they cannot afford

the exorbitant housing price. And as proved above, the number of people devoted to technology innovation research has great impacts on the innovation outputs.

Hypothesis 2: there is no relationship between the presence of talent housing policy and regional innovation development.

The results from empirical model rejected this hypothesis and present a positive correlation between the presence of talent housing policy and regional innovation development. Specifically, the enactment of talent housing policy shows the attention from local government to housing affordability issue, which is a welcome signal to talent people who want to come to this city.

Hypothesis 3: there is no relationship between the coverage of talent housing policy and regional innovation development.

The third hypothesis is rejected by the regression results as well. Strong coverage of talent housing policy means diversified and advanced support ways from local government given to talent people, which has great positive impacts on innovation development of a city. Well-design policy would reduce the burden of talent on purchasing home much more effectively.

## **6 Conclusion and Recommendations**

China's economy has entered a new phase emphasizing the importance of science and technology innovation on national development. High-tech talents, considering their great contribution to the innovation development, have been increasingly valued by most of large cities in China. All major cities are committed to reducing the barriers to the inflow of talents and introducing policies to attract and retain talents. Under the contradictions between high housing price and the need for

high-tech talents in big cities, talent housing policies formulated by local governments has received great attention and expectation. This research defines talent housing policy as a branch of affordable housing policy and starts from the development of affordable housing policies in both China and other developed countries. The study of affordable housing policy can help explain the reason and background of the appearance of talent housing policy. Then, this research studies current talent housing policies and concluded them into 9 categories. Based on previous qualitative analysis, hypotheses between housing price, talent housing policy and regional innovation development have been put forward and studied. Panel data of 16 major cities from 2010 to 2016 have been used in fixed-effects regression model to conduct the empirical test of the hypotheses.

Final results are showed as below:

Table 9 Results of empirical analysis

Variables	Innovation development (Number of patent application)
Housing price	Negative
The presence of talent housing policy	Positive
The coverage of talent housing policy	Positive
Research and development (R&D) full-time personnel	Positive
Research and development (R&D) expenditure to GDP ratio	Positive



Science and technology grants to fiscal expenditures ratio	Positive
Education grants to fiscal expenditures ratio	Not statistically significant
Foreign direct investment	Positive
Urbanization rate	Positive

Seen from the results above, the rising of housing price has negative impacts on the amount of patent application, which indicated that high housing price would curb the development of science and technology innovation greatly. Both the presence and coverage of talent housing policy can exert positive impacts on promoting innovation development, showing the necessity of talent housing policy in Chinese cities. For the control variables, the investment in research and development and full-time personnel working in research and development both have great positive impacts on the development of technology innovation. These relationships are easily to understand because the money and labor force devoted into one field can be taken as the most direct and decisive factors for the outputs. Moreover, financial support from local government is proved to be necessary as well. Local government, as an important role who has the power to interfere with free market, its investment and support are crucial to the development of innovation in a city. Foreign direct investment, which reflects the impact of outside technology spillover on the innovation development of a region, still has great impacts on innovation development in China. The result is consistent with the arguments from Fu (2008). In addition to that, the urbanization process in China has gone through many decades and have great positive on Chinese innovation

development. Compared with rural area, capitals and talents are tend to concentrate in urban area due to advantageous location, convenient transportation and affluent cultural resources. And capitals and talents devoted to technology research are the most direct and decisive factors for promoting innovation development, which has been proved and illustrated above.

### *Recommendations*

Seen from the income to price ratio, current housing price in China are at extremely high level. Even some talent groups are facing problems on the right to adequate housing, which would bring them great pressures and worries when devoting themselves into innovation activities. For the city, the lack of talent vitality would directly affect technological innovation development, and in turn affect economic growth and social stability. The purpose of the talent housing policy is to solve the housing problem of high-tech talents and to enable talents to exert their full potential on promoting local technological innovation. Combined with the status quo and empirical conclusions, this research puts forward the following suggestions for local government:

1. Control the rapid growth of housing price in metropolitan cities.

Seen from both theoretical and empirical proof, housing price has significantly restraining effects on the development of science and technology innovation. Therefore, control the rapid growth of housing price and make it stable at an appropriate level are important issue.

Since 2016, more than 20 cities in China have successively enacted different real estate market regulations, showing the great attention of local governments drawn on the rising of housing price. This research provides following suggestions on stabilizing housing price.

First, land use efficiency should be improved to increase the supply of urban residential

units. The acceleration of coarse-grained urbanization process in China has led to inefficient use of land and the scarcity of urban land resources. Vacant and unused urban spaces can be revitalized through infill projects and urban renewal projects to increase the land stock and meet the growing residential needs. Moreover, adjustment can be made to housing type structure. The increase of small-to-medium sized units can accommodate more families and also reduce the price pressure. Second, local government should focus on the suppression of speculative activities in housing market by using differentiated loan interest rates, tax rates, and property-purchasing restrictions.

2. Promote the development of talent housing policy.

Talent is a crucial boosting factor in the development of scientific and technological innovation. It is necessary to formulate effective talent housing strategies to attract key talents and fully release their skills and potentials. This research finds that the talent housing policy plays an important role in promoting innovation development. Therefore, local governments can continually focus on advancing the policy approaches to support talents on purchasing housing. Experience from developed countries are worth learning, such as the use of public private partnership in the U.S. on providing affordable housing, the housing savings loan in Germany, and central provident funds in Singapore.

3. Formulate locality-based talent housing policy.

Realized the great impact talent housing policies can bring on attracting talents and promoting economic development, some local governments are blindly following trends when enacting policies, which led to the phenomena that the high-level talents introduced

into one city are not the talents really needed for local society. Local governments have put tons of efforts on attracting them while they can bring limited effects on regional economic development. There are various types and levels of tech-talents whose contribution to the localities is different. Local governments should formulate policies according to the actual development level and environment of the region. Otherwise, it will only bring greater population pressure to cities with insufficient environmental carrying capacity. This research suggests that before the introduction of talents, local governments should clarify the targeted group according to local development level and give preferential treatments to urgently needed talents, such as priority in applying for talent housing, and greater subsidies for housing purchases. When optimizing the structure of talent housing policies, local government should fully consider the differences of talent groups on family size, income level and work place and provide talents with various options. This will not only improve the efficiency of talent housing policy, but also shows the respect and inclusivity of the city and better meet the housing needs of targeted people.

4. Comprehensively consider all factors when promoting technology innovation.

There are many factors can contribute to the development of innovation activities. In the empirical analysis of this research, most of the control variables are proved to have great impacts. Local government should comprehensively consider all aspects of factors and maximize the combined impacts. First, R&D investment directly affects technological innovation output. Since 2013, the ratio of R&D expenditure to GDP in China has exceeded a threshold of 2%, but the gaps between cities are extremely large. Moreover, the

distribution of R&D personnel is imbalanced as well. In future of urban innovation-driven development, R&D expenditure and personnel investment are still the most crucial factors. Secondly, although government technology grants can support the R&D activities and reduce risks of R&D institutions, sometimes the use of these government grants are not efficient. In order to prevent the waste of technology funding, local government should impose supervision on science institutions and strictly hunt down the misappropriation use of funds. Finally, local government can formulate relevant policies to promote scientific and technological innovation by improving informatization level, and accelerating urbanization process.

5. Build up positive talents-competition mechanism among cities.

When planning and formulating talents introduction policies, local governments should rationally consider the competition and cooperation between cities. According to 2017 China Urban Innovation and Entrepreneurship Environment Evaluation Research conducted by Tsinghua University Science Park, most of the cities ranked as the top 100 innovative cities belong to certain megalopolis. It can also be seen that the internal connection among cities would become closer with the higher stage of urban megalopolis development. Closer connection then can bring greater innovation resources spillover from the central cities, and create more favorable innovation environment for all the cities within this area. Therefore, local governments should appropriately allocate talent resources and share resources. In consideration of common interests of the whole megalopolis, cities

should build up an innovative collaboration network across cities to achieve large-scale alliances.

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