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Land marketization and urban innovation capability: Evidence from China

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ABSTRACT

The economic effect of land marketization reform has been widely discussed, but its effect on urban innovation capability still lacks adequate investigation. Based on urban panel data and micro-industrial enterprise data of China, we investigated how land marketization affects urban innovation capability. Our results demonstrate that land marketization has promoted urban innovation capability, and the effect presents temporal and spatial heterogeneity. The results remain robust when considering different marketization measurement methods and endogenous problems. Mechanism analysis indicates that land marketization promotes urban innovation capability mainly through the financing and selection effects; that is, land marketization eases urban financing constraints and then increases innovation investment (financing effect), while enterprises are forced to innovate to survive in a competitive land market (selection effect). An effective way to stimulate urban innovation capability would be to establish and improve land market competition and market transaction mechanisms. For China, further deepening the market-oriented reform of land factors is the crux of realizing high-quality development.

1. Introduction

Innovation and technological progress are crucial for a country's economy to achieve high-quality and sustainable growth. Increasing innovation capability is globally acknowledged as the most important national strategy (Acemoglu, Akcigit, & Kerr, 2016). As the main platform of economic activities and the center of innovation and entrepreneurship, city and urban regions are endowed with the important mission of leading innovation. To a large extent, technical advances and economic growth are not only the products of forward-looking individuals and enterprises but also the products of cities. Cities and urban regions have thus conceptualized as an "innovation machine," bringing together talents, enterprises, and scientific research institutions. Cities have gradually become the central factor and analysis unit of innovation and economic growth (Florida, Adler, & Mellander, 2017).

As the improvement of urban innovation capability is considered to be the key to development and prosperity, the endogenous driving force of urban innovation is increasingly emphasized, and researchers have explored ways to enhance it. Some have discussed the micro factors affecting innovation from the perspective of enterprises (Ju, Lu, & Yu, 2013; Brunow, Birkeneder, & Rodriguez-Pose, 2018; Liu, 2017; Wu & Li, 2017; Yu, Zhong, & Fan, 2016), while others have focused on the impact of the agglomeration effect, urban scale, knowledge spillover, and urban innovation network on the occurrence probability of innovation activities in view of the theory of economic geography (Bettencourt, Lobo, & Strumsky, 2007; Huber, 2012; Li, Wei, & Wang, 2015). Others have tried to analyze the role of the institutional environment, including policies on industry, finance, foreign trade, education, culture, science, and technology (Florida, 2002; Fu, Pietrobelli, & Soete, 2011; Niebuhr, 2009; Su & Hung, 2009; Zhang, Cooke, & Wu, 2011).

In the above studies, attention has overwhelmingly been paid to enterprises, geography, and policies within the context of advanced economies. In contrast, the role of factor allocation reform in the process of innovation is not fully understood (Friedrich & Nam, 2013; Zhang & Wu, 2019), such as land marketization reform, in developing countries. As Coase asserts, the market is not only an efficient mechanism of resource allocation but also a platform for learning and innovation (Coase & Wang, 2012). Developing countries, especially those with high-intensity government intervention and inferior technological capacity, need to stimulate innovation through market-oriented reform. As the most basic production factor, how land appears in market allocation will affect urban innovation capability is an interesting and significant question for serious investigation. It is worth noting that some studies have preliminarily analyzed total factor productivity (TFP) from the

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perspective of land marketization reform (Lu, Jiang, & Gong, 2020; Xu, Chen, & Zhao, 2018), which provides a basis for understanding the connection between land allocation and urban innovation capability. However, TFP is not completely equivalent to innovation, so accurate conclusions can only be derived after additional investigation. Therefore, this study investigates the role played by land resource allocation reform in promoting urban innovation capability, taking China's land marketization reform as the background.

Currently, various effects of China's urban land marketization have been widely assessed, including promoting land allocation efficiency (Du, Thill, Peiser, & Feng, 2014; Zhu, 2005), capital accumulation (Lin & Yi, 2011), and economic growth (Cao, Feng, & Tao, 2008; Feng, Wei, & Jiang, 2008; Huang, Chen, Yu, & Li, 2013) and widening the urban-rural income gap (Lin & Ho, 2005; Paik, 2014). However, the relevance of land marketization and urban innovation capability has always been absent from investigations. In fact, China's reforms provide a good opportunity to understand the innovation implied by land marketization, because China, as a transitional economy, is striving to innovate to achieve the transition from rapid growth to high-quality development.

Since China's reform and opening up, the urban land supply system has witnessed several major reforms (Ding, 2003). Land allocation has shifted from an uncompensated planned supply to a compensated market-based supply (Lin & Yi, 2011; Liu, Wang, & Zhang, 2020). The marketization of urban land allocation has been an important part of the market-oriented reform of China's economy and has had profound implications for economic development (Xu, Anthony, & Wu, 2009; Xu et al., 2018). After urban land was competitively priced on the open market, there was a sustained and rapid rise in land prices (Yuan, Wei, & Xiao, 2019). From 1999 to 2015, the average price of urban land in China increased 12.25 times (Xu et al., 2018). Land appreciation has generated a staggering amount of land wealth for many cities and has served as the financial base on which they have thrived (Wu, 2019). Urban investments, including innovation activities, have become increasingly dependent on land (Zhao & Song, 2019). Especially in recent years, with the transformation of national strategic directions and performance assessment goals, Chinese local governments have continued to invest more in innovation. The price signals activated by market-oriented land reform have also gradually begun to function. Enterprises have become accustomed to competing in an open land market and using the acquired land to finance themselves (Xu et al., 2018). Land financing has become an important source of funding for enterprises to invest in innovation. Of course, the pressure from rising land prices has, in turn, forced enterprises to think about how to innovate to offset rising land costs. Innovation is thus seen as a key factor for business survival (Rosenbusch, Brinckmann, & Bausch, 2011). These phenomena illustrate the link between land market–oriented reforms and innovation and spur an interest in deeper inquiry.

In this study, based on a large panel dataset of cities and micro enterprises in China, we find that land marketization significantly promotes urban innovation capability through the financing effect and the selection effect. Our findings help to clarify the economic effect of land marketization reform and are important for effectively improving urban innovation capability and pursuing high-quality development.

Compared with the existing literature, the contributions of this study are: (1) the meaning of land marketization reform for innovation is obtained through a combination of theoretical and empirical research, which enhances insights into the economic effects of land marketization. (2) The analytic dimensions of urban innovation issues are expanded based on the new perspective of the factor market, which creates opportunities for deepening factor market reforms to promote high-quality development.

The remainder of this article is organized as follows. Section 2 reviews the institutional background and constructs a theoretical framework. Section 3 introduces the model and the data. Section 4 presents the empirical results. Section 5 analyzes the influence mechanisms, and section 6 summarizes the conclusions and shares policy implications.

2. Institutional background and theoretical framework

Before explaining the analytical framework of this research, we first briefly outline the relevant background of the urban land marketization reform in China.

2.1. Urban land marketization reform in China

Prior to land marketization reform, urban land transactions were banned in China for a long time. State-owned urban land is allocated to socioeconomic units free of charge indefinitely. It is impossible for land to be commercialized in the context of market demise (Ding, 2003). In 1987, Shenzhen took the lead in opening the land market reform and launched the "first deal" of urban land by public auction. In the following year, the provisions allowing the transfer of land use rights were written into the constitution and the Land Management Law, and China's urban land market rose rapidly. The supply of state-owned land changed from free, indefinite, and non-flowing to compensated, limited, and mobile.

In the 1990s, the paid transfer of urban land in China mainly occurred through low-transparency agreements, resulting in serious corruption and land waste (Cai, Henderson, & Zhang, 2013; Tao, Zhang, & Li, 2010). The industrial land market order is more chaotic (Tao, Lu, Su, & Wang, 2009). Economic growth pressured local governments to attract capital with land and transfer industrial land with low, zero, or even negative land prices, resulting in a serious waste of industrial land (Liu et al., 2020).

In the 21st century, China's economic system reform has entered a new stage, once again propelling the reform of land marketization. In 2001, the State Council issued the *Notice on Strengthening the Management of State-Owned Land Assets*, with the aim of "vigorously promoting the tender and auction transfer of state-owned land use rights" and leading the land market-oriented reform into a new stage. The *Regulations on the Transfer of State-Owned Land-Use Right by Tender, Auction, and Listing* that was issued the following year stipulated that commercial, tourism, entertainment, and commercial residential land must be transferred in the form of tender, auction, or listing. This was reinforced in 2004, in a document jointly issued by multiple departments, which added residential and other urban commercial construction land to the list of real estate that could only be transferred through tender, auction, or listing. The focus of urban land marketization reform then shifted to industrial land. *The Circular on Issues Concerned with Strengthening Land Regulation and Control of the State Council* in 2006 further specified that "Industrial land must be transferred through tender, auction, or listing, and the transfer price shall not be lower than the minimum price standard announced."

A series of market-oriented policies have accelerated the growth of

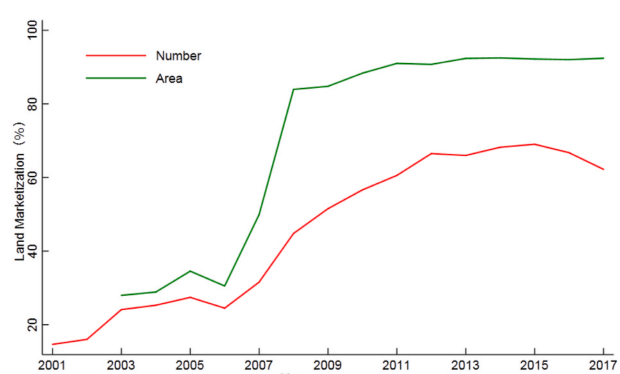

Fig. 1. The dynamics of land marketization level in China, 2001–2017

the land market, which have led to the predominance of tender, auction, and listing for market transfers. As shown in Fig. 1, the land marketization rate measured by the number of transferred cases increased from 15% in 2001 to 62% in 2017, while in terms of area transferred, it increased from 28% in 2003 to 92% in 2017. The level of land marketization rose significantly after 2006 because of market-oriented reforms in industrial land transfer.

As this reform process clearly indicates, land marketization in China has been a gradual top-down reform (Wang, 2014). Although the overall level of marketization is constantly increasing, the land marketization rate is still heterogeneous in different times and regions, which provides a quasi-experimental scenario and rich differentiated data for observing the economic effects of land marketization reform.

The market-oriented land reform has significantly accelerated the realization of land value. At present, the average land price index has risen to three times of what it was 20 years ago. Rising values have directly spawned a boom in land financing, bringing many cities lucrative land wealth. During the period 2000–2020, direct land transaction revenue received by the government increased from 59.6 billion yuan to 8,401.6 billion yuan, and jumped from 9% to a staggering 84% of local revenue. The amount of land mortgage loans has increased from 0.1 trillion yuan in 2000 to 11.31 trillion yuan in 2015. Overall, for every 1% increase in the level of land marketization, the level of urban land financing has increased by 0.77 percentage points (Xu et al., 2018). These funds are playing a decisive role in alleviating the lack of funds for urban development. Without land financing, it is difficult for local governments to undertake large-scale investments in infrastructure, science, and education.

It is estimated that China's infrastructure net capital stock jumped from 869.27 billion yuan in 2000 to 7,512.94 billion yuan in 2016, an eight-fold expansion in 17 years (Zhu & Zhu, 2020). At present, wide highways, well-equipped industrial parks, and high-speed railroads can be seen everywhere. Good infrastructure greatly subsidizes businesses and lowers the threshold for business start-up and production costs (Zhao & Song, 2019). In recent years, new infrastructure investment is developing more rapidly, as represented by 5G network, big data centers, and IoT platforms. China's new infrastructure capital stock was only 69.99 billion yuan in 2003, while this value has increased to 323.17 billion yuan in 2017 (Shang, 2020). These new infrastructure investments have largely accelerated the growth of China's high-technology industries. Moreover, the development of land marketization and the expansion of infrastructure investment have rapidly increased the competitiveness of Chinese companies. For example, at the beginning of the century, there were only 10 Chinese companies on the World Top 500 list, but that number has since grown to 124, ranking first in the world.

In addition to promoting infrastructure investment, land financing driven by land marketization is critical to enhancing government investment in innovative development. The marketization of land significantly has contributed to the increase in overall fiscal revenue, thus relaxing the strains on the fiscal budget to a considerable extent. Some studies have also shown that there is significant competitive behavior among local governments in China in terms of spending on science and education (Zhou, Zong, & Chen, 2013). When the marketization of land eases budget constraints, local governments increase their spending on science and education. Data from the National Bureau of Statistics show that local financial expenditures on science and education grew from 170.19 billion yuan to 389.16 billion yuan during the period 2000–2019. R&D investment increased from 104.25 billion yuan in 2001 to 1,567.68 billion yuan in 2016, and its proportion of GDP also doubled. The central government has also further adjusted the expenditure structure of land transfer income in 2011 by directly adding a column for education expenditure, requiring a 10% provision for education funds.

For enterprises, marketization facilitates freer access to land. Entrepreneurs no longer need to go through cumbersome administrative approvals and plan configurations to obtain land, thus greatly stimulating entrepreneurial enthusiasm. Once an enterprise has been established, land is then transformed into the largest collateralizable asset. Corporate financing through land has developed almost simultaneously with the land market reform; especially after the marketization of industrial land in 2006, land financing has become more common among enterprises. Data from the China Land Market Network show that the amount of corporate land mortgage loans was only 2.17 billion yuan in 2006, which skyrocketed to 137 billion yuan in 2017. By 2009, the amount of corporate land mortgage loans reached a staggering 3,640 billion yuan, which has since declined but is still huge (Zhang, Wei, & Ou, 2019). It is evident that the land market has emerged as an important capital market amidst the lagging development of China's stock market, which provides entrepreneurs with confidence in starting their own businesses. As a result, along with the development of the land market and the growth of land mortgages, Chinese startups have witnessed a growth boom, with the number of startups reaching 5.5 million yuan in 2016, growing at a consecutive 2-digit growth ratio and ranking first in the world.

2.2. Theoretical mechanism

As shown in Fig. 2, the market provides a platform for value visualization and competition. Innovation activities require significant capital investment and efficient enterprises. The supply from the market and the demand from innovation match each other, such that innovation seems to be a natural result of market operations. In other words, the market itself carries the innovation gene. As the most important market, the land factor market activates the largest assets and the sharpest land use competition, which greatly spurs innovation activities. Based on the existing literature, we construct a logic for land marketization and urban innovation capability. Financing and selection effects are proposed to substantiate our views. The financing effect suggests that land marketization eases the financing constraints for governments and private enterprises, thus expanding innovation investment. The selection effect suggests that the competition mechanism introduced by land marketization forces enterprises to innovate continuously to survive.

2.2.1. How does land marketization affect urban innovation capability: Financing effect

The market-oriented allocation of land resources will inevitably produce financing effects and directly bring about the expansion of economic capital accumulation. In the absence of a land market and land transactions, land remains a rigid asset that cannot accumulate wealth and generate additional income. As De Soto (2000) found, many developing countries lack capital because they have not yet established a perfect property right recognition and market mechanism for land assets. Before the market-oriented reform in China, land was also allocated in a planned way, resulting in a long-term shortage of capital (Ding, 2003; Liu et al., 2020). However, after the reform of land marketization, land has gradually become the most important financing tool for cities, thus opening up a new avenue for capital creation (Xu et al., 2009).

Local governments are the most direct beneficiaries of land financing (Liu et al., 2020). As the actual landowners, local governments obtain huge amounts of capital through land lease and mortgage financing (Qin, Zhu, & Zhu, 2016), which greatly enhances the government's capacity for fiscal expenditure. According to Liu and Lin (2014), land lease income contributes almost half of local fiscal revenue in China. The increase of fiscal revenue brought about by land marketization has led directly to the expansion of government R&D investment in science and education departments, which is indispensable for improving urban innovation capability (Arqué-Castells, 2012; Acemoglu, Moscona, & Robinson, 2016; Howell, 2017). Government R&D investment directly supports the development of scientific research projects in universities and scientific research institutions (Niosi, 2010), and it also supplements the innovation resources of local enterprises, effectively reducing R&D

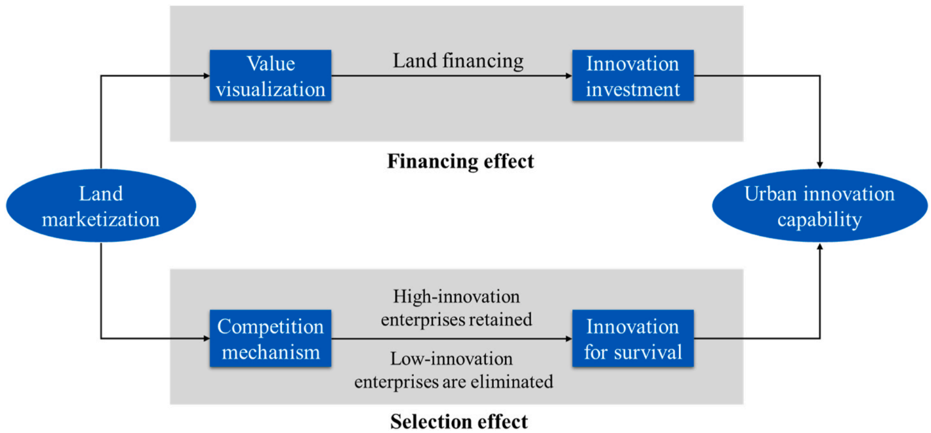

Fig. 2. Theoretical mechanism.

risk for enterprises and thus stimulating their R&D and innovation activities (Czarnitzki, Ebersberger, & Fier, 2007; Lach, 2010). In addition, from the perspective of signaling theory, Feldman and Kelley (2006) claim that government innovation investment is a "good signal" to support innovation, which strengthens the investment confidence of enterprises, guides enterprises to increase R&D investment, and then stimulates enthusiasm for urban innovation.

In addition to direct R&D investment, local government investment in infrastructure construction has also greatly stimulated urban innovation. After the implementation of land marketization reform, urban infrastructure has experienced unconventional growth in China. It is generally believed that this rapid growth is mainly due to the urban income growth brought by land marketization (Zheng, Sun, Wu, & Wu, 2014). Cities with good infrastructure are more likely to attract creative talents (Florida, 2002; Baum-Snow & Pavan, 2012). The gathering of industrial, creative, R&D, and international talents in cities is conducive to creating a good environment for knowledge exchange and innovation (Glaeser, Kallal, Scheinkman, & Shleifer, 1992; Winne & Sels, 2010). As with talent, good infrastructure is also a necessary condition to attract high-quality enterprises. After the investment in heavy assets such as urban infrastructure is covered by the government, enterprises can be set up at low cost and concentrate on production, operation, and R&D (Zhao & Song, 2019). This is particularly evident in China, where cities compete to create a good environment for enterprises.

The financing effect brought about by land marketization also improves the investment capability of enterprises in R&D. The importance of enterprise R&D investment to urban innovation capability has been known (Furman, Porter, & Stern, 2002). However, the level of enterprise R&D investment is largely constrained by their financing ability. Land is generally regarded as the best collateral for enterprise financing, but only in a market-oriented environment can enterprise land property rights held be considered mortgageable enterprise assets. Land marketization reform has made it possible to expand credit and ease financing constraints, which consequently allowed enterprises to invest in R&D. In addition, studies have also shown that rising asset prices can boost the asset value of collateral, thereby enhancing the ability of firms to raise capital (Chaney, Sraer, & Thesmar, 2012; Cvijanović, 2014). In the case of land marketization, competitive pricing promotes a sustained increase in land prices and also expands the collateral value of corporate land, which facilitates enhanced corporate financing and innovative inputs.

Land financing is particularly indispensable in the early stage of innovation. Many innovative enterprises only possess technological innovation in their initial stage and lack capital for further development. They often need land financing to speed up the process of technology transformation and further scale up their industrialization. China's rapid growth in land mortgage financing since 2000 has made a note of this (Lin & Ho, 2005). An investigation from Wu (2019) has indicated that land mortgaging is mainly an enterprise behavior in China, and enterprises assign land rights as collateral to obtain bank loans. Cheng, Zhu, Zhang, and Hu (2020) found that land financing is more widely practiced among enterprises that are more active in R&D. Zhao and Song (2019) found that the capital created by the land market strongly led to the rise of new business models and the explosion of innovative enterprises in China.

2.2.2. *How does land marketization affect urban innovation capability: Selection effect*

The survival of an enterprise is largely determined by its innovation capability (Boyer & Blazy, 2014). Innovation is usually regarded as a process of creative destruction (Schumpeter, 1936): non-innovators are replaced by innovators with higher quality, more innovation, and greater adaptability. The innovation competition among enterprises constantly eliminates the low-innovation enterprises and perpetuates high-innovation enterprises, and this continuous dynamic process of enterprise entry and exit injects power into the development of urban innovation capability. Under a planned economy system, the entry and exit of enterprises are completely determined by administrative instructions. In a market economy, the process of survival of the fittest is the result of market competition. As the most important factor market, land market can function effectively in this selection process. The market allocates land to people or firms with higher marginal production efficiency through the competitive pricing mechanism of "the higher bidder wins" (Xu et al., 2018). Land marketization thus has a selection effect on enterprises, which appears in a lower entry rate and a higher elimination rate for low-innovation enterprises. When low-innovation enterprises are eliminated and an increasing number of high-innovation enterprises are allowed to enter in the process of market selection, the urban innovation capability will gradually improve.

The selection effect appears first in the entry of new enterprises. Unlike obtaining land through agreement or even free of cost, in a competitive land market, enterprises are required to bid against each other to obtain land use rights, resulting in land premiums (Liu et al., 2020; Xu et al., 2018). The price competition introduced by land marketization raises the entry threshold for new enterprises. Only high-innovation fledgling enterprises that can afford competitive land prices are able to become established, while less innovative fledgling enterprises that cannot afford the land cost are blocked (Xi & Mei, 2019). This kind of entrance competition guarantees high quality among newborn enterprises.

Second, the selection effect also appears in the exit process for existing enterprises. In a competitive market environment, land prices always increase with economic development, which leads to the rise in land cost along the whole supply chain of production, logistics, storage, and sales (Cheng et al., 2020). Rising land prices further raise labor costs by raising the cost of living, for example through rapid increases in the price of housing (Lu, Zhang, & Liang, 2015). The overall production cost of enterprises thus always rises faster than land prices. With continuous increases in production costs, only enterprises with high innovation capability can survive with excess profits, and low-innovation enterprises gradually withdraw from the market because of low profits. This elimination mechanism forces existing enterprises to improve productivity through continuous technological innovation to make up for the private cost as much as possible, and enterprises that fail to improve productivity are eliminated (Xi & Mei, 2019). This elimination mechanism ensures that existing enterprises continue to pursue technological progress.

3. Research design

3.1. Model setting

3.1.1. Benchmark regression model

We first investigate the causal relationship between land marketization and urban innovation capability based on panel data from 288 cities in China from 2001 to 2016 (see Appendix A for a detailed list of cities). The benchmark regression model is as follows:

$$lninnov_{it} = C + \alpha_1 land_{it} + \alpha_2 \mathbf{Z}_{it} + u_i + \xi_{it} \tag{1}$$

where *i* is the city, *t* is the time, *lninnov* is the urban innovation capability, and *land* is the level of land marketization. ***Z*** represents a set of control variables that have a significant impact on urban innovation capability: industrial structure, investment intensity, government investment in science and education, financial development, higher education level, and foreign direct investment (FDI). *C* is a constant term, μ is the individual fixed effect, and ξ is a random error term.

3.1.2. Empirical test of the financing effect

The mediating effect model and panel data were used to test the financing effect (Baron & Kenny, 1987). The regression model is as follows:

$$lnfina_{it} = C + \alpha_1 land_{it} + \alpha_2 \mathbf{Z}_{it} + u_i + \xi_{it} \tag{2}$$

$$lninnov_{it} = C + \beta_1 land_{it} + \beta_2 lnfina_{it} + \beta_3 \mathbf{A}_{it} + \beta_4 \mathbf{Z}_{it} + u_i + \xi_{it} \tag{3}$$

where *i* is the city, *t* is the time, *lninnov* is the urban innovation capability, and *land* is the level of land marketization. *lnfina* is the scale of land financing. The scale of land financing includes both revenue from land sales, leasing, and other supply activities of local governments in the primary market and cash flows from land transfers, mortgages, and leasing by governments and enterprises in the secondary market. We sum the above revenues and take the logarithm. ***Z*** represents a set of control variables with a significant impact on the financing scale: industrial structure, investment intensity, and financial development level. ***A*** represents a set of control variables: higher education level, government investment in science and education, and FDI. *C* is a constant term, μ is the individual fixed effect, and ξ is a random error term.

3.1.3. Empirical test of the selection effect

In this paper, the selection effect is examined based on microenterprise data. The largest amount of microenterprise data are from The Chinese industrial enterprises database, published by the National Bureau of Statistics, which reports detailed information on each enterprise's basic information and production and operation status. Referring to Brandt, Biesebroeck, and Zhang (2012), we matched and cleaned the scattered enterprise data, and finally created an unbalanced panel of enterprise-level data containing 4.09 million observations for the years 2001–2014. Unfortunately, the industrial enterprise database lacks indicators to measure enterprise innovation capability. In view of this, we obtained the enterprise patent database from the State Intellectual Property Office of China. We matched the patent database with the industrial enterprise database to obtain a micro enterprise database containing enterprise patent information and used the number of patents to measure enterprise innovation ability.

As explained in the theoretical analysis, the selection effect must be examined from two perspectives: one is the entry of newborn enterprises and the other is the collapse of existing enterprises. In the following, we present the empirical research design for each of the two perspectives.

(1) Newborn enterprise entry. The newborn enterprises in each city were screened in the industrial enterprise database year by year, and the median innovation capability was calculated. For any newborn enterprise, if its innovation capability exceeded the median, the enterprise was identified as a newborn high-innovation enterprise, otherwise it was identified as a newborn low-innovation enterprise. In this way, the entire sample of newborn enterprises was divided into two parts: newborn high-innovation enterprises and newborn low-innovation enterprises. The number of the two types of firms was then aggregated year by year at the city scale to generate two new variables: the number of newborn high-innovation firms (*new_high*) and the number of newborn low-innovation firms (*new_low*). Finally, these two new variables were regressed separately on the degree of land marketization. The regression equation is as follows.

$$new\_high_{it} = C + \alpha_1 land_{it} + \alpha_2 \mathbf{Z}_{it} + u_i + \xi_{it} \tag{4}$$

$$new\_low_{it} = C + \beta_1 land_{it} + \beta_2 \mathbf{Z}_{it} + u_i + \xi_{it} \tag{5}$$

Here, *i* is the city; *t* is the time; *land* is the level of land marketization; *new_high* and *new_low* are the number of newborn high-innovation firms and the number of newborn low-innovation firms, respectively; ***Z*** represents a set of control variables: higher education level, government investment in science and education, and financial development level; *C* is a constant term; μ is the individual fixed effect; and ξ is a random error term.

We focused on the magnitudes of α_1 and β_1, which reveal the different effects of land marketization on newborn high-innovation firms and newborn low-innovation firms, respectively. According to the theoretical analysis, α_1 is expected to be positive while β_1 should be negative, which implies that land marketization promotes the start-up of high-innovation firms while inhibiting the start-up of low-innovation firms.

(2) Existing enterprise elimination. The eliminated enterprises in each city were screened out in the industrial enterprise database year by year, and the median innovation capability was calculated. For any eliminated enterprise, if its innovation capability exceeded the median, the enterprise was identified as an eliminated high-innovation enterprise, otherwise it was identified as an eliminated low-innovation enterprise. In this way, the sample of all eliminated firms was divided into two parts: eliminated high-innovation firms and eliminated low-innovation firms. The number of the two types of firms was then aggregated year by year at the city scale to obtain two new variables: the number of eliminated high-innovation firms (*closed_high*) and the number of eliminated low-innovation firms (*closed_low*). Finally, the two new variables were regressed separately on the degree of land marketization.

$$closed\_high_{it} = C + \theta_1 land_{it} + \theta_2 \mathbf{Z}_{it} + u_i + \xi_{it} \tag{6}$$

$$closed\_low_{it} = C + \gamma_1 land_{it} + \gamma_2 \mathbf{Z}_{it} + u_i + \xi_{it} \tag{7}$$

Here, we were mainly interested in the magnitudes of θ_1 and γ_1, which show how land marketization affects firm survival. Both are expected to be positive, but the absolute value of the latter should be larger than the former, because land marketization has a higher probability of eliminating low-innovation firms than high-innovation firms.

The above two perspectives help to identify the existence of a selection effect, but cannot examine the mediating role of that selection effect. Therefore, we needed to design an additional mediation model. In theoretical terms, if the selection effect exists, the number of high-innovation firms will grow with the rise of land marketization at the city level, which ultimately promotes higher urban innovation capacity. Accordingly, we can use the number of high-innovation firms in a city as a mediating variable to test the mediating role of the selection effect. Based on the above analysis, we constructed a mediation model.

$$high_{it} = C + \alpha_1 land_{it} + \alpha_2 \mathbf{Z}_{it} + u_i + \xi_{it} \tag{8}$$

$$lninnov_{it} = C + \beta_1 land_{it} + \beta_2 high_{it} + \beta_3 \mathbf{A}_{it} + \beta_4 \mathbf{Z}_{it} + u_i + \xi_{it} \tag{9}$$

Here, the mediating variable *high* represents the number of high-innovation firms in city *i* in year *t*. Other variables have the same meaning as above.

3.2. Variables and data sources

3.2.1. Urban innovation capability

Quantifying urban innovation capability (*lninnov*) scientifically is a fundamental task. In this study, the urban innovation index in *China's Urban and Industrial Innovation Report 2017* (Kou & Liu, 2017) was adopted to measure urban innovation capability. The calculation of this innovation index was primarily based on the micro patent data released by the State Intellectual Property Office of China, which included invention, utility model, and design patents, among which invention patents need to meet higher levels of utility, novelty, and inventiveness, while the other two types of patents only need to meet lower levels of utility and novelty. Therefore, compared to utility model and design patents, the value of an invention patent is more representative of innovation capability. The patent holder is also required to pay an annual fee to renew the duration of the patent. In general, the longer the duration of the patent, the greater its value. Referring to Pakes and Schankerman (1984), the report estimates the value of each patent based on its duration and then sums the value of each patent at the city level to obtain the urban innovation index. For comparative purposes, the report normalized the total national patent value in 2001 to 100 and derived the urban innovation index for the period 2001–2016.

The advantages of adopting the urban innovation index are as follows: First, the calculation of the innovation index is based on innovation output data, which is more reasonable than using innovation input data such as R&D expenditure, number of R&D personnel, and energy input. The index is calculated based on micro patent data rather than macro data, and takes into account the patent value rather than just the number of patents (Castaldi, Frenken, & Los, 2015; Sedgley & Elmslie, 2011; Thompson & Fox-Kean, 2005), which enhances the persuasiveness of the measurement results.

The dynamic change in the urban innovation index is shown in Fig. 3; China's urban innovation capability has achieved exponential growth in the period 2001–2016, and the growth rate was further accelerated after the release of the *National Guideline on the Medium- and Long-Term Program for Science and Technology Development* (2006–2020) in 2006. The regional distribution of innovation behavior is unbalanced, showing significant agglomeration in the eastern region. The innovation index for the eastern region is far ahead, mainly benefiting from the coastal advantage. In 2016, Beijing, Shenzhen, and Shanghai were the top three cities in terms of innovation capability and were in the first echelon of innovation, while other cities followed after a relatively large gap. The fourth to tenth place were Suzhou, Hangzhou, Nanjing, Guangzhou, Chengdu, Wuhan, and Xi'an. Among the top 20 cities, there are 13 in the eastern region, 4 in the central region, and 3 in the western region. Jiangsu Province has the largest number of cities, with three cities, followed by Guangdong, Zhejiang, and Shandong, with two cities each.

3.2.2. Land marketization

The existing literature has substantially explored the measurement of urban land marketization (Liu, Cao, Yan, & Wang, 2016; Qian & Mou, 2012; Wang, Chen, Ye, & Huang, 2007). In most studies, the land marketization level is usually characterized by the share of land transferred by tender, auction, and listing in the total land supply. The proportion is expressed by the number of cases or the area. In this study, the proportion of cases (*land_1*) is used as the basic measurement method, while the area proportion (*land_2*) is applied in the robustness test. The relevant data of land is collected from the *China Land Resources Statistical Yearbook*.

3.2.3. Control variables

The control variables involved in the study are summarized as follows: (1) economic development level (*lnpgdp*), expressed as the natural logarithm of per capita GDP; (2) industrial structure (*indus*), expressed as the share of the output value of the secondary industry in GDP; (3) investment intensity (*invest*), expressed as the ratio of fixed asset investment to GDP; (4) financial development level (*finance*), expressed as the ratio of loan balance of financial institutions to GDP; (5) higher education level (*lncollege*), measured by the number of universities; (6) government investment in science and education (*science*), expressed as the share of science and education expenditure in general budget

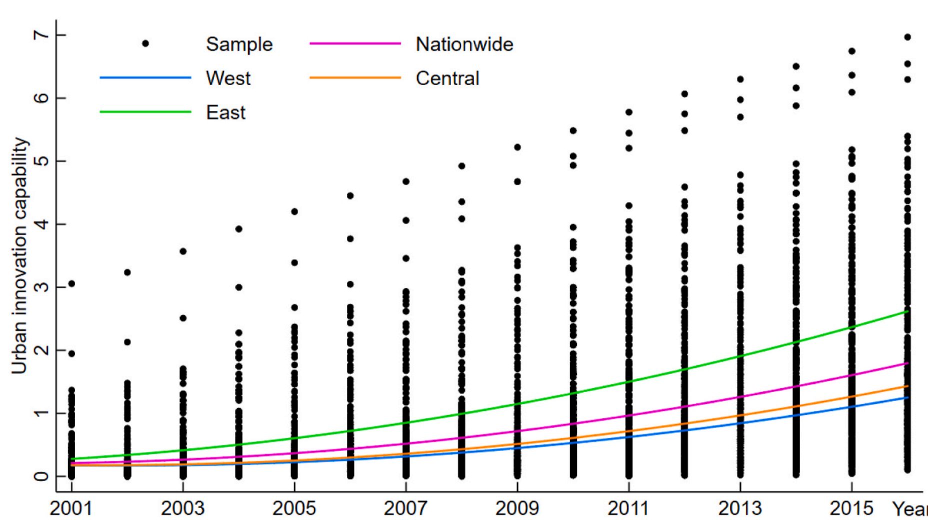

Fig. 3. The dynamics of urban innovation capability in China, 2001–2016

expenditure; and (7) FDI (*lnfdi*), measured by the natural logarithm of FDI. All control variables are at the city and year level. The relevant statistics were obtained from the *China Urban Statistical Yearbook*, *China Regional Economic Statistical Yearbook*, and *China Land Resources Statistical Yearbook*. Descriptive statistics of the variables are presented in Table 1, and the correlation matrix is presented in Appendix B.

4. The impact of land marketization on urban innovation capability

4.1. Benchmark regression results

The sample cities in this study are in different regions, and the individual differences between the cities are significant. The F test showed that the individual effects of the panel data were clear, and it strongly rejected pooled ordinary least squares estimation. The Hausman test indicated that the fixed-effects model was more consistent with the statistical characteristics of the data than the random-effects model. So, our analyses were based on the fixed-effects model. In addition, the VIFs are all much smaller than 10, so there is no multicollinearity problem. Diagnostic tests indicated the presence of groupwise heteroscedasticity and autocorrelation, so clustering robust standard errors were employed to mitigate the resulting bias (clustering robust standard errors were used in all subsequent models).

The benchmark regression results obtained by Eq. (1) are shown in Table 2. The results of model 1 and model 3 indicate that land marketization is positively correlated with urban innovation capability at the 1% significance level. To mitigate the estimation error caused by missing variables, control variables are added in model 2 and model 4. In this case, the impact of land marketization decreases, but it is still significantly positive. For every 1% increase in the level of land marketization, urban innovation capability will increase by 0.679%. The results support our theoretical analysis. The reasons for the rapid improvement of urban innovation capability are undoubtedly complex in China, but these results indicate that market-oriented land reform is an important reason that cannot be ignored. Land and technology factors are not isolated but interrelated, which enhances our understanding of the interaction between different production factors and implies that market-oriented reform should pay attention to the coordination of various factors.

Table 1
Variable measures and descriptive statistics.

Variable	Meaning	Measurement	Mean	Std. Dev.
lninnov	Urban innovation capability	Total patent value (logarithm)	0.792	1.020
land_1	Land marketization	Amount of land supplied by market/Total amount of land supplied	0.404	0.243
land_2	Land marketization	Land area supplied by market/Total land supply area (logarithm)	0.408	0.250
lnfina	Scale of land financing	The scale of financing in the primary market of land + The scale of financing in the secondary market of land (logarithm)	11.899	1.938
lnpgdp	Economic development level	Per capita GDP (logarithm)	9.920	0.883
indus	Industrial structure	Secondary production output/GDP	47.713	11.102
invest	Investment intensity	Fixed asset investment/ GDP	0.595	0.292
finance	Financial development level	Loan balance of financial institutions/GDP	0.811	0.490
lncollege	Higher education level	Number of colleges and universities (logarithm)	1.271	1.092
science	government investment in science and education	Science and education expenditure/Total fiscal expenditure	19.801	4.703
lnfdi	Foreign investment level	Foreign direct investment (logarithm)	9.405	1.987

Table 2
Benchmark regression results.

Model number	Model 1	Model 2	Model 3	Model 4
Model Setup	Random-effects	Random-effects	Fixed-effects	Fixed-effects
land_1	1.356***	0.601***	1.382***	0.679***
	(0.088)	(0.079)	(0.089)	(0.080)
indus		−0.018***		−0.031***
		(0.004)		(0.005)
science		0.036***		0.044***
		(0.006)		(0.007)
invest		0.710***		1.060***
		(0.093)		(0.102)
finance		0.474***		0.402***
		(0.116)		(0.118)
lncollege		0.430***		0.350***
		(0.037)		(0.057)
lnfdi		0.143***		0.095***
		(0.018)		(0.018)
_cons	0.245***	−1.944***	0.234***	−1.132***
	(0.037)	(0.243)	(0.036)	(0.278)
VIF	1.00	1.42	1.00	1.42
Heteroscedasticity (P-Value)	–	–	0.00	0.00
Autocorrelation (P-Value)	0.00	0.00	0.00	0.00
Hausman (P-Value)	0.00	0.00	0.00	0.00
F-statistic/Wald-statistic	239.87	695.63	242.45	65.39
R^2 (Within)	0.212	0.477	0.212	0.494
Observations	4608	3702	4608	3702

Note: ***, **, and * are significant at the 1%, 5%, and 10% level, respectively, and the brackets are the standard error of the coefficients.

The regression results for the control variables were as follows: (1) Industrial structure is significantly negatively correlated with urban innovation capability, indicating that a high proportion of secondary industry does not mean stronger innovation capability. On the contrary, the extensive industrial model relying on large-scale factor inputs may not be conducive to urban innovation capability. (2) The coefficient of government investment in science and education is significantly positive, indicating that urban innovation capability is promoted because investment in science and education has increased scientific research output and human capital. (3) Investment intensity is significantly positively correlated with urban innovation capability, indicating that good infrastructure is helpful for the agglomeration and circulation of innovation factors. (4) Financial development significantly promotes urban innovation, indicating that investment in innovation activities is promoted by reducing financing constraints. (5) The impact of higher education level is significantly positive, implying the importance of human capital cultivation for innovation. (6) The coefficient for FDI is significantly positive, which indicates that the introduction of new technology and improvement of human capital brought by FDI have a positive effect on urban innovation capability. The above observations regarding the control variables are all consistent with the theoretical expectations. Owing to space constraints, control variables are not reported below.

4.2. Heterogeneity analysis

The average effect of land marketization on urban innovation capability was identified in the previous section. Here, we further investigate the differentiation effect under conditions of heterogeneity. We focus on heterogeneity from the spatial and temporal perspectives, and the same settings as the benchmark model are adopted.

The natural, economic, and social conditions in cities of different levels differ greatly in China, leading to heterogeneity in economic laws. In this study, the effect of land marketization on urban innovation capability may differ in different cities, it is necessary to divide the 288 sample cities into different levels for analysis. According to the *City Commercial Charm Ranking 2016* published by *Yi Magazine*, the first-tier and the new first-tier are classified as high-level cities, and the others are classified as low- and medium-level cities. We constructed an interaction term *land_1*city*, where *city* is a dummy variable for city type (1 for high-level cities and 0 for low- and medium-level cities). The regression results are presented in model 1 of Table 3. The coefficients of *land_1* and *land_1*city* are both significantly positive, indicating that the positive effect of land marketization on urban innovation capacity is heterogeneous at the city level, and the effect is stronger in high-level cities.

There are also significant differences between the eastern regions and the midwestern inland regions in China. Considering this heterogeneity, the eastern and midwestern regions are divided for comparative analysis. We proposed a regional dummy variable *region* (*region* = 1 for the East and *region* = 0 for the Midwest) and combined it with the land marketization variable to form an interaction term *land_1*region*. Model 2 in Table 3 shows that the coefficients of *land_1* and *land_1*region* are both significantly positive, implying that the promotion of urban innovation by land marketization is stronger in the eastern region than in the midwest. Heterogeneity in cities and regions is linked, as most high-level cities are concentrated in the eastern region in China.

Since 2006, the focus of urban land market-oriented reform has shifted to industrial land. The new policy required that industrial land must be transferred in a more market-based way, which enhances the urban land marketization level. Therefore, we divided the whole period into two phases, with 2006 as the node, to investigate the temporal heterogeneity. In view of this, a time dummy variable *time* (*time* = 0 before 2006 and *time* = 1 after 2006) was proposed. Model 5 in Table 3 shows that both *land_1* and *land_1*time* coefficients are significantly positive, which indicates that the contribution of land marketization to urban innovation capacity is stronger after 2006. It suggests that the market-based allocation of industrial land is particularly critical for the cultivation of urban innovation capability, because innovation activities are now more concentrated in the industrial field in China, and the marketization of industrial land has obviously accelerated industrial technology innovation.

4.3. Robustness test

We conducted a robustness test to see whether the results are still stable under different conditions (The results are summarized in Appendix C). We primarily considered the following situations.

Table 3
Heterogeneity analysis.

Model number	Model 1	Model 2	Model 3
land_1	0.540*** (0.079)	0.246*** (0.080)	0.217** (0.094)
*land_1*city*	2.324*** (0.292)		
*land_1*region*		0.835*** (0.147)	
*land_1*time*			0.497*** (0.083)
Control variable	YES	YES	YES
VIF	1.44	1.49	2.00
Heteroscedasticity (P-Value)	0.00	0.00	0.00
Autocorrelation (P-Value)	0.00	0.00	0.00
F-statistic/Wald-statistic	83.39	63.64	66.73
R^2 (Within)	0.523	0.509	0.504
Observations	3702	3702	3702

Note: ***, **, and * are significant at the 1%, 5%, and 10% level, respectively, and the brackets are the standard error of the coefficients.

(1) The land marketization effect on urban innovation capability may not be immediate, but may instead be lagged. In the robustness test of model 1, we therefore set the land marketization to lag 1 year as the main explanatory variable for a reassessment. The results indicate that the lag term for land marketization level is still positively correlated with urban innovation capability, implying that the impact is stable and lasting. The reliability of the original conclusion is thus further supported.
(2) We used different measurement methods for land marketization—namely, the share of the land area transferred by tender, auction, and listing in the total land supply area. The results of model 2 show that the impact of land marketization on urban innovation capability is still significantly positive under different measurement methods, which indicates that the conclusion remains stable with the change of measurement methods—that is, the original conclusion is robust.
(3) Replacement of dependent variable measures. Three types of indicators have commonly been used in the literature to measure urban innovation capacity: TFP (total factor productivity) (Hall, 1988; Klette, 1999; Klette & Griliches, 1996), R&D investment (R&D expenditure), and patents (Aghion, Bloom, Blundell, Griffith, & Howitt, 2005; Griliches, 1990). In modern economies, most innovation is the result of conscious investment, so R&D expenditure is a reasonable indicator of innovation. However, in China, there are two main problems in using R&D expenditure: the poor availability of data and the fact that R&D expenditures are often misreported. We therefore stopped using R&D expenditure as a proxy variable for urban innovation capacity. Based on the above considerations, in the robustness test, we instead substituted TFP to measure urban innovation capacity. Referring to Battese and Coelli (1992), the SFA method was applied for the measurement of TFP. Model 3 shows that changing the urban innovation capacity measure does not affect the original findings. The regression results continue to show that the development of land marketization significantly contributes to the improvement of urban innovation capacity.
(4) In China, urban administrative level is related to resource allocation. Municipalities and provincial capitals with high political status occupy an advantage in the allocation of innovation resources, which may challenge the robustness of the results. We therefore performed a reassessment based on the samples excluding provincial capitals and municipalities (model 4). The results show that the coefficient of land marketization is still significantly positive, and the original conclusion that land marketization promotes urban innovation capability is still supported.
(5) Consideration of endogeneity issues. Endogeneity here may be related to three aspects. The first is reverse causality—cities with strong innovation capability tend to implement market-oriented reform and adopt market mechanisms to allocate land resources. The second is caused by measurement errors in land marketization level. The third is caused by the omission of variables that could affect urban innovation capability. To alleviate endogeneity issues as much as possible, the number of land illegal

cases[1] and the second-order lag of land marketization[2] were adopted as instrumental variables and were tested using the two-stage least-squares (2SLS) method (model 5). The results show that the positive relationship between land marketization and urban innovation capacity remains significant.

5. The influence mechanism of land marketization on urban innovation capability

The above has revealed the causal relationship between land marketization and urban innovation ability, and it is worth further exploring its mechanism. In this section, we test the financing effect and selection effect.

5.1. Financing effect

The regression results for the financing effect obtained by Eqs. (2) and (3) are shown in Table 4. Model 1 shows that land marketization significantly promotes the financing scale, while model 2 shows that the financing scale significantly promotes urban innovation capability, which indicates that the financing effect is indeed an important channel for land marketization to promote urban innovation capability. The intermediary effect of land marketization through the financing effect is about 0.304 (= 1.573 * 0.193), which accounts for 40% (= 0.304/(0.304 + 0.457)) of the total effect. In model 3 and model 4, we changed the measurement method of land marketization, and the financing effect remained significant. Similar to our findings, Xu et al. (2018) also confirmed that the expansion of the urban financing scale is related to land marketization.

Table 4
Financing effect.

Model number	Model 1	Model 2	Model 3	Model 4
Dependent variable	*lnfina*	*lninnov*	*lnfina*	*lninnov*
land_1	1.573*** (0.126)	0.457*** (0.068)		
land_2			1.152*** (0.084)	0.096* (0.050)
lnfina		0.193*** (0.019)		0.233*** (0.021)
Control variable	YES	YES	YES	YES
VIF	1.07	1.78	1.05	1.83
Heteroscedasticity (P-Value)	0.00	0.00	0.00	0.00
Autocorrelation (P-Value)	0.00	0.00	0.00	0.00
F-statistic/Wald-statistic	296.16	64.60	304.38	61.45
R^2 (Within)	0.472	0.540	0.455	0.489
Observations	3966	3702	3966	3704

Note: ***, **, and * are significant at the 1%, 5%, and 10% level, respectively, and the brackets are the standard error of the coefficients.

We also examined the spatial heterogeneity of the financing effects. We were particularly interested in the heterogeneity of financing effects at the city and region level. In this paper, we designed an interaction term model that includes city dummy variables (*city*) and region dummy variables (*region*). The dummy variable is equal to 1 for high-level cities and eastern regions, otherwise it is 0. The results are summarized in Table 5. The coefficients of the land marketization variables and the interaction term are significantly positive, indicating that the financing effect of land marketization is stronger in high-level cities and eastern regions. As a result of population agglomeration, greater land appreciation leads to stronger land financing capacity in high-level cities and eastern regions. This significant difference in the financing effect may thus explain some of the spatial heterogeneity of innovation.

5.2. Selection effect

The financing effect has been verified above, but it does not entirely explain why land marketization promotes urban innovation. We argue that, in addition to the financing effect, the selection effect is also an important channel. This section further verifies the existence of the selection effect and identifies its mechanism from the dynamic perspective of heterogeneous firm entry and elimination.

5.2.1. Existence of selection effects

As predicted by the theoretical analysis, the increased level of land marketization facilitates the screening of innovative firms, leading to an increase in the proportion of high-innovation firms within the city. Accordingly, this section reveals the existence of selection effects by comparing the differences in the distribution of firm innovation capability under high and low levels of land marketization. Using the median land marketization level as the benchmark, the total sample was divided into two groups: high land marketization level and low land marketization level. Table 6 presents the mean values for firm innovation capability for the two groups of samples. In addition to the total sample, we also considered the heterogeneity at the firm, regional, and city levels.

The results in Table 6 show that the innovation capacity of firms is higher at high levels of land marketization, and the phenomenon is present across heterogeneous conditions, which provides direct evidence of the existence of selection effects. Further comparison also reveals that (1) at the same level of land marketization, the innovation capacity of state-owned enterprises is much higher than that of non-state-owned enterprises, because state-owned enterprises tend to have stronger capital. (2) The innovation capacity of start-up enterprises is generally lower than that of non-start-up enterprises, which indicates that the innovation capacity of enterprises is related to their growth stage. (3) The innovation capacity of enterprises becomes stronger as the size of the enterprise increases, and the innovation capacity of large enterprises is much higher than that of SMEs. (4) The innovation capability of enterprises in the eastern region is higher than that of those

Table 5
Spatial heterogeneity of the financing effect.

lnfina	Urban heterogeneity	Regional heterogeneity
land_1	1.521*** (0.132)	1.309*** (0.175)
*land_1*city*	0.782** (0.313)	
*land_1*region*		0.541** (0.230)
Control variable	YES	YES
VIF	1.10	1.18
Heteroscedasticity (P-Value)	0.00	0.00
Autocorrelation (P-Value)	0.00	0.00
F-statistic/Wald-statistic	245.60	243.16
R^2 (Within)	0.473	0.474
Observations	3966	3966

Note: ***, **, and * are significant at the 1%, 5%, and 10% level, respectively, and the brackets are the standard error of the coefficients.

[1] The empirical study of Tao et al. (2010) showed that market reforms can reduce the frequency of land violations. Therefore, land illegality is related to land marketization, but it has no obvious relationship with urban innovation capability. The number of land illegal cases as an instrumental variable is theoretically feasible and also passed the test. The data for the number of land illegal cases used in this study collected from the *China Land Resources Statistical Yearbook*.

[2] For time series and panel data, the lagged item of the independent variable as an instrumental variable is a common method for selecting the instrumental variable. In a continuous economic process, the second-order lag term of land marketization is strongly related to the current value but not related to the current error term because it has occurred.

Table 6
Existence of selection effects.

Heterogeneity conditions		High land marketization level	Low land marketization level
Total sample		0.865	0.527
Enterprise ownership	State-owned enterprises	2.153	1.019
	Non-state-owned enterprises	0.672	0.519
Startup or not	Startups	0.164	0.073
	Non-startups	0.881	0.540
Enterprise scale	Large enterprises	7.989	6.445
	Medium enterprises	1.028	0.856
	Small enterprises	0.154	0.099
Region	East	0.921	0.605
	Midwest	0.736	0.321
City levels	High-level	1.581	0.995
	Low- and medium-level	0.635	0.234

Note: the figures in the table are the mean values for enterprise innovation power.

in the central and western regions, which may be related to the location advantage. (5) The innovation capability of enterprises in high-level cities is much higher than that of those in low- and medium-level cities, because they are rich in innovation resources.

5.2.2. Identification of selection mechanisms

First, the selection effect is identified from the perspective of enterprise entry. Model 1 and model 2 in Table 7 show that land marketization is negatively correlated with the number of new enterprises because it increases the land price and thus increases the enterprise access threshold. Model 1 shows that the average marginal effect of land marketization on the number of newborn high-innovation enterprises is 0.017, which means that the number of newborn high-innovation enterprises will increase by 0.017% when the land marketization level increases by 1%. Model 2 shows that the marginal effect of land marketization on the establishment of newborn low-innovation enterprises is −0.196. This implies that a 1% increase in the level of land marketization will lead to a 0.196% decrease in the number of low-innovation firms. The above results suggest that the land marketization process promotes the start-up of high-innovation firms and discourages the start-up of low-innovation firms, which inevitably leads to an increase in the share of high-innovation firms at the city level, thus contributing to the improvement of the urban innovation capacity. To check the robustness of the conclusion, we replaced the measurement method for land marketization in model 3 and model 4. The regression results again support the original conclusion.

The second perspective for identifying the selection effect is the elimination of existing enterprises. Model 5 and model 6 in Table 7 show that land marketization has a significant positive effect on the elimination of enterprises. For every 1% increase in the land marketization level, the number of high-innovation enterprises eliminated increases by 0.136% and the number of low-innovation enterprises eliminated increases by 2.379%. This indicates that, with the improvement of land marketization, the elimination probability of low-innovation enterprises is higher than for high-innovation enterprises. In model 7 and model 8, re-regression based on different land marketization measurement methods was adopted to test the robustness of the original conclusions, and the results still showed that land marketization leads to a higher probability of elimination for low-innovation enterprises. The improvement of the urban land marketization level will therefore promote continuous progress of the overall innovation capability of existing enterprises, thus providing support for the improvement of urban innovation capability. The selection effect fully embodies the view of natural selection, and the market mechanism acts as the filter for the selection.

5.2.3. Mediation of selection effects

Based on Eqs. (8) and (9), we used the number of high-innovation firms as a mediating variable to check the mediating mechanism of the selection effect. The results are summarized in Table 8. Model 1

Table 8
Mediation of selection effects.

Model number	Model 1	Model 2	Model 3	Model 4
Dependent variable	*high*	*lninnov*	*high*	*lninnov*
land_1	1.712***	0.412***		
	(0.248)	(0.053)		
land_2			0.953***	0.156***
			(0.152)	(0.038)
High		0.246***		0.258***
		(0.028)		(0.029)
Control variable	YES	YES	YES	YES
VIF	1.49	1.56	1.49	1.56
Heteroscedasticity (P-Value)	0.00	0.00	0.00	0.00
Autocorrelation (P-Value)	0.00	0.00	0.00	0.00
F-statistic/Wald-statistic	18.25	124.50	16.49	115.59
R^2 (Within)	0.219	0.707	0.183	0.692
Observations	2769	2769	2769	2769

Note: ***, **, and * are significant at the 1%, 5%, and 10% level, respectively, and the brackets are the standard error of the coefficients.

Table 7
Selection effect.

	Enterprise entry perspective				Enterprise exit perspective			
Model number	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
Dependent variable	*new_high*	*new_low*	*new_high*	*new_low*	*closed_high*	*closed_low*	*closed_high*	*closed_low*
land_1	0.017***	−0.196***			0.136***	2.379***		
	(0.003)	(0.061)			(0.017)	(0.477)		
land_2			0.013***	−0.088**			0.113***	2.537***
			(0.002)	(0.040)			(0.015)	(0.680)
Control variable	YES	YES	YES	YES	YES	YES	YES	YES
VIF	1.20	1.20	1.20	1.20	1.21	1.21	1.21	1.21
Heteroscedasticity (P-Value)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Autocorrelation (P-Value)	0.033	0.014	0.031	0.011	0.203	0.375	0.197	0.403
F-statistic/Wald-statistic	12.93	5.66	13.71	4.86	20.89	8.32	19.97	6.23
R^2 (between)	0.128	0.137	0.229	0.137	0.053	0.153	0.029	0.150
Observations	3042	3042	3042	3042	2669	2669	2669	2669

Note: ***, **, and * are significant at the 1%, 5%, and 10% level, respectively, and the brackets are the standard error of the coefficients.

suggests that land marketization significantly contributes to the increase in the number of high-innovation firms at the city level, while model 2 suggests that the growth in the number of high-innovation firms also significantly contributes to the increase in urban innovation capacity. The intermediary effect of land marketization through the selection effect is approximately 0.421 (= 1.712 * 0.246), which accounts for 51% (= 0.421/(0.421 + 0.412)) of the total effect. In model 3 and model 4, we changed how land marketization was measured, and the selection effect remained significant. The above results suggest that the selection effect generated by land marketization at the micro-firm level can largely explain the increase in urban innovation capacity.

6. Conclusions and implications

In the wave of economic development based on science and technology, innovation capability has been regarded as the most important symbol of urban competitiveness and development prospects. Unlike countries or regions with mature market mechanisms, urban innovation capability in transitional economies not only comes from technological innovation, but also from improvements to the institutional environment. It is therefore very important to investigate the impact of the institutional environment on urban innovation capability, especially considering the institutional reform of resource allocation. This study sought to enhance the understanding of land marketization in contemporary China, with special attention to its impact on urban innovation capability.

Based on panel data and micro-industrial enterprise data of China, we verified the positive effect of land market allocation on the promotion of urban innovation capability. This promotion effect is significantly stronger in high-level cities than in other cities and also significantly stronger in the East than in the Midwest. Owing to the initiation of industrial land marketization, this effect also increased significantly after 2006. Furthermore, we proposed financing effect and selection effect to illustrate the intermediate mechanism. The financing effect implies that land marketization expands the financing scale, thus expanding investment in urban innovation activities. The selection effect implies that the competition mechanism introduced by land marketization promotes the technological innovation of enterprises.

This work represents the first step toward exploring the relationship between land marketization and urban innovation capability. It expands our understanding of the sources of urban innovation capability and enriches traditional research on land marketization. Although innovation capability has become a key factor influencing national competitiveness, determining how to improve regional innovation capability still challenges the central and local governments at all levels, especially in developing countries and transition economies. The present results provide some policy implications for other regions/countries. Unlike many proposals regarding government R&D policies (Feldman & Kelley, 2006), R&D subsidies (Lach, 2010; Zhang et al., 2011), the introduction of foreign investment (Fu et al., 2011), innovation networks (Li et al., 2015), and human capital (Winne & Sels, 2010), among others, we suggest that deepening market-oriented land resource allocation reforms may be an effective way to address the innovation development dilemma.

In many developing countries and transition economies, the market-oriented institutional environment is thin, with large amounts of planned allocations of land, vestigial land tenure, inadequate property rights protection, and illegal hidden markets (De Soto, 2000). These factors are not conducive to the competitive use of land resources, to the extent that the capital function of land is inhibited, thus greatly hamstringing the critical role of land in innovative development. Due to the differences in ideology, land ownership, and macro-institutions, China's experience in promoting innovative development through land marketization cannot be fully replicated in other developing countries, but the concept and reform strategy of using land for innovative development can provide a model for others. First, the state and government should play an active role in land market reform. The state needs to take the initiative in reducing restrictions on land rights and providing institutional provisions in land property rights protection, land market transactions, and land financing to facilitate land market development. The government can also channel land wealth toward innovation through appropriate institutional design. Second, market-oriented land system reform should be gradual. As a basic national system, governing land is often the most difficult to touch, and shocking changes to the land system will inevitably cause dramatic social unrest. A phased and gradual improvement of the land market mechanism is a desirable strategy. As the land market becomes increasingly open and competitive, micro market players such as enterprises will gradually adapt to acquiring land competitively, and land will naturally play a selective role in the process. In short, for central and local decision-makers who aim to support innovation, the results suggest that the establishment and improvement of land market competition and market transaction mechanisms are likely to yield valuable returns.

Although China's urban land marketization reform has supported great achievements, China's land market is still not sound due to administrative intervention and the dual system of urban and rural land, which often stifles market mechanisms (Yuan et al., 2019). In recent years, the lack of innovation has become one of the main challenges facing China's economy. How to further deepen reform to stimulate innovation has become an important issue for high-quality development. Given the findings of this study, it is necessary to further deepen the market-oriented reform of land factors for the construction of an innovative economic system. China must eliminate the price distortion and resource mismatch caused by administrative intervention in the supply of urban land—especially industrial land—to further improve the efficiency of urban land market operations. Second, farmers' collective land should be given equal market rights with state-owned land, and an integrated land market covering urban and rural areas should be constructed to expand the market scope.

For China, the push for land market reforms will pay off handsomely not only economically, but also as relates to climate change. China has made an ambitious commitment to reduce carbon emissions, and achieving that goal relies not only on direct technological innovation, but also on institutional innovation. This study suggests that deepening the reforms of the land system and promoting an innovative transformation of urban development patterns is a desirable development strategy for China to meet its carbon reduction commitments. Furthermore, in China's recent 14th Five-Year Development Plan, innovation has been placed at the heart of overall modernization. Methods for reforming the land system to support the innovation development strategy are an important issue that must be considered. China needs to pay attention to improving the land market to optimize the allocation of scientific and technological resources.

CRediT authorship contribution statement

Jian Cheng: Conceptualization, Methodology, Visualization, Writing – original draft, Writing – review & editing. Jiangmeng Zhao: Software, Formal analysis. Daolin Zhu: Funding acquisition, Supervision. Xin Jiang: Data curation, Validation. Hui Zhang: Writing – review & editing. Yuanjie Zhang: Data curation, Visualization.

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Appendix D. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.habitatint.2022.102540.

Appendix A. List of cities

Region	City
East	Sanya, Sanming, Shanghai, Dongguan, Dongying, Zhongshan, Linyi, Dandong, Lishui, Yunfu, Foshan, Baoding, Beijing, Nanjing, Nanping, Nantong, Xiamen, Taizhou, Tangshan, Jiaxing, Dalian, Tianjin, Weihai, Ningde, Ningbo, Suqian, Changzhou, Guangzhou, Langfang, Zhangjiakou, Xuzhou, Dezhou, Yangzhou, Chengde, Fushun, Jieyang, Wuxi, Rizhao, Chaoyang, Benxi, Hangzhou, Zaozhuang, Meizhou, Shantou, Shanwei, Jiangmen, Shenyang, Cangzhou, Heyuan, Quanzhou, Tai'an, Taizhou, Jinan, Jining, Haikou, Zibo, Huai'an, Shenzhen, Qingyuan, Wenzhou, Huzhou, Zhanjiang, Binzhou, Zhangzhou, Weifang, Chaozhou, Yantai, Zhuhai, Yancheng, Panjin, Shijiazhuang, Fuzhou, Qinhuangdao, Shaoxing, Liaocheng, Zhaoqing, Zhoushan, Suzhou, Maoming, Putian, Laiwu, Heze, Yingkou, Huludao, Hengshui, Quzhou, Liaoyang, Lianyungang, Xingtai, Handan, Jinhua, Tieling, Jinzhou, Zhenjiang, Fuxin, Yangjiang, Qingdao, Anshan, Shaoguan, Longyan
Central	Qitaihe, Sanmenxia, Shangrao, Linfen, Ulanqab, Wuhai, Jiujiang, Bozhou, Yichun, Jiamusi, Xinyang, Liuan, Xing'an, Baotou, Shiyan, Nanchang, Nanyang, Shuangyashan, Hefei, Ji'an, Jilin, Lvliang, Zhoukou, Hulunbeier, Hohhot, Xianning, Harbin, Shangqiu, Siping, Datong, Daqing, Taiyuan, Loudi, Xiaogan, Anqing, Anyang, Yichang, Yichun, Xuancheng, Suozhou Yueyang, Bayannur, Changde, Pingdingshan, Kaifeng, Zhangjiajie, Xinzhou, Huaihua, Fuzhou, Xinxiang, Xinyu, Jinzhong, Jincheng, Jingdezhen, Shuozhou, Songyuan, Zhuzhou, Wuhan, Yongzhou, Chizhou, Luoyang, Huabei, Huainan, Xiangtan, Chuzhou, Luohe, Puyang, Jiaozuo, Mudanjiang, Baicheng, Baishan, Yiyang, Suihua, Wuhu, Jingzhou, Jingmen, Pingxiang, Bengbu, Hengyang, Xiangyang, Xuchang Ganzhou, Chifeng, Liaoyuan, Yuncheng, Tonghua, Tongliao, Shaoyang, Zhengzhou, Chenzhou, Erdos, Ezhou, Tongling, Xilingole, Changchun, Changsha, Changzhi, Fuyang, Yangquan, Alashan, Suizhou, Maanshan, Zhumadian, Jixi, Hebi, Hegang, Yingtan, Huanggang, Huangshan, Huangshi, Heihe, Qiqihar
West	Zhongwei, Lincang, Lijiang, Urumqi, Leshan, Baoshan, Liupanshui, Lanzhou, Neijiang, Beihai, Nanchong, Nanning, Wuzhong, Xianyang, Shangluo, Jiayuguan, Guiyuan, Tianshui, Ankang, Anshun, Dingxi, Yibin, Baoji, Chongzuo, Bazhong, Pingliang, Guangyuan, Guang'an, Qingyang, Yan'an, Zhangye, Deyang, Chengdu, Lhasa, Panzhihua, Kunming, Zhaotong, Qujing, Laibin, Liuzhou, Guilin, Wuzhou Yulin, Wuwei, Bijie, Hanzhong, Hechi, Luzhou, Weinan, Yulin, Yuxi, Baiyin, Baise, Meishan, Shizuishan, Mianyang, Zigong, Xining, Xi'an, Guigang, Guiyang, Hezhou, Ziyang, Dazhou, Suining, Zunyi, Jiuquan, Chongqing, Jinchang, Qinzhou, Tongren, Tongchuan, Yinchuan, Fangchenggang, Longnan, Ya'an

Appendix B. Correlation matrix

	lninnov	land_1	land_2	Lnfina	indus	invest	finance	lncollege	science	lnfdi	lnpgdp
lninnov	1.000										
land_1	0.186***	1.000									
land_2	0.155***	0.684***	1.000								
lnfina	0.686***	0.401***	0.398***	1.000							
indus	0.056***	0.171***	0.124***	0.226***	1.000						
invest	0.141***	0.367***	0.298***	0.336***	0.084***	1.000					
finance	0.487***	−0.050***	−0.099***	0.277***	−0.199***	0.115***	1.000				
lncollege	0.706***	0.018	0.030**	0.603***	0.024	0.005	0.493***	1.000			
science	−0.017	0.122***	0.105***	0.032**	−0.094***	−0.125***	−0.162***	−0.122***	1.000		
lnfdi	0.650***	0.231***	0.231***	0.728***	0.225***	0.170***	0.243***	0.609***	−0.053***	1.000	
lnpgdp	0.650***	0.363***	0.324***	0.716***	0.453***	0.374***	0.254***	0.437***	−0.193***	0.677***	1.000

Note: ***, **, and * are significant at the 1%, 5%, and 10% level, respectively, and the brackets are the standard error of the coefficients.

Appendix C. Robustness test

Model number	Model 1	Model 2	Model 3	Model 4	Model 5
Different robustness situations	One-year lag	Changing the independent variable measure	Changing the dependent variable measure	Excluding provincial capitals and municipalities	Considering endogeneity
land	0.886*** (0.077)	0.215*** (0.057)	0.178*** (0.059)	0.606*** (0.082)	2.787*** (0.141)
Control variable	YES	YES	YES	YES	YES
F-statistic/Wald-statistic	75.73	54.47	31.93	57.34	303.68
VIF	1.43	1.40	4.24	1.23	1.44
Heteroscedasticity (P-Value)	0.00	0.00	0.00	0.00	0.00
Autocorrelation (P-Value)	0.00	0.00	0.00	0.00	0.00
Underidentification (P-Value)	–	–	–	–	0.00
Cragg-Donald Wald F statistic	–	–	–	–	410.583
Hansen (P-Value)	–	–	–	–	0.309
R^2 (Within)	0.525	0.465	0.035	0.463	–
Observations	3702	3702	4180	3297	3699

Note: ***, **, and * are significant at the 1%, 5%, and 10% level, respectively, and the brackets are the standard error of the coefficients.

References

Acemoglu, D., Akcigit, U., & Kerr, W. R. (2016). Innovation network. *Proceedings of the National Academy of Sciences, 113*(41), 11483–11488.

Acemoglu, D., Moscona, J., & Robinson, J. A. (2016). State capacity and American technology: Evidence from the nineteenth century. *The American Economic Review, 106*(5), 61–67.

Aghion, P., Bloom, N., Blundell, R., Griffith, R., & Howitt, P. (2005). Competition and innovation: An inverted-U relationship. *Quarterly Journal of Economics, 120*(2), 701–728.

Arqué-Castells, P. (2012). How venture capitalists spur invention in Spain: Evidence from patent trajectories. *Research Policy, 41*(5), 897–912.

Baron, R. M., & Kenny, D. A. (1987). The moderator-mediator variable distinction in social psychological research. *Journal of Personality and Social Psychology, 51*(6), 1173–1182.

Battese, G. E., & Coelli, T. J. (1992). Frontier production functions, technical efficiency and panel data: With application to paddy farmers in India. In *Working papers in econometrics and applied statistics, university of new England*.

Baum-Snow, N., & Pavan, R. (2012). Understanding the city size wage gap. *The Review of Economic Studies, 79*(1), 88–127.

Bettencourt, L., Lobo, J., & Strumsky, D. (2007). Invention in the city: Increasing returns to patenting as a scaling function of metropolitan size. *Research Policy, 36*(1), 107–120.

Boyer, T., & Blazy, R. (2014). Born to be alive? The survival of innovative and non-innovative French micro-start-ups. *Small Business Economics, 42*(4), 669–683.

Brandt, L., Biesebroeck, J. V., & Zhang, Y. (2012). Creative accounting or creative destruction? Firm-level productivity growth in Chinese manufacturing. *Journal of Development Economics, 97*(2), 339–351.

Brunow, S., Birkeneder, A., & Rodriguez-Pose, A. (2018). Creative and science-oriented employees and firm-level innovation. *Cities, 78*(8), 27–38.

Cai, H., Henderson, J. V., & Zhang, Q. (2013). China's land market auctions: Evidence of corruption. *The RAND Journal of Economics, 44*(3), 488–521.

Cao, G. Z., Feng, C. C., & Tao, R. (2008). Local land finance in China's urban expansion: Challenges and solutions. *China and World Economy, 16*(2), 19–30.

Castaldi, C., Frenken, K., & Los, B. (2015). Related variety, unrelated variety and technological breakthroughs: An analysis of us state-level patenting. *Regional Studies, 49*(5), 767–781.

Chaney, T., Sraer, D., & Thesmar, D. (2012). The collateral channel: How real estate shocks affect corporate investment. *The American Economic Review, 102*(6), 2381–2409.

Cheng, J., Zhu, D. L., Zhang, H., & Hu, B. W. (2020). Research on the dynamic inefficiency of China's economy from the perspective of land capitalization. *China Land Science, 34*(3), 31–38 (in Chinese).

Coase, R., & Wang, N. (2012). *How China became capitalist*. Palgrave Macmillan.

Cvijanović, D. (2014). Real estate prices and firm capital structure. *Review of Financial Studies, 27*(9), 2690–2735.

Czarnitzki, D., Ebersberger, B., & Fier, A. (2007). The relationship between R&D collaboration, subsidies and R&D performance: Empirical evidence from Finland and Germany. *Journal of Applied Econometrics, 22*(7), 1347–1366.

De Soto, H. (2000). *The mystery of capital*. London: Bantam Press/Random House.

Ding, C. R. (2003). Land policy reform in China: Assessment and prospects. *Land Use Policy, 20*, 109–120.

Du, J., Thill, J. C., Peiser, R. B., & Feng, C. (2014). Urban land market and land-use changes in post-reform China: A case study of Beijing. *Landscape and Urban Planning, 124*, 118–128.

Feldman, M. P., & Kelley, M. R. (2006). The ex ante assessment of knowledge spillovers: Government R&D policy, economic incentives and private firm behavior. *Research Policy, 35*(10), 1509–1521.

Feng, L., Wei, L., & Jiang, Y. (2008). Study on the contribution of land element to economic growth in China. *China Land Science, 22*(12), 4–10 (in Chinese).

Florida, R. (2002). *The rise of the creative class*. New York: Basic Books.

Florida, R., Adler, P., & Mellander, C. (2017). The city as innovation machine. *Regional Studies, 51*, 86–96.

Friedrich, P., & Nam, C. W. (2013). Innovation-oriented land-use policy at the sub-national level: Case study from Germany. *Studies in Regional Science, 43*(2), 223–240.

Fu, X., Pietrobelli, C., & Soete, L. (2011). The role of foreign technology and indigenous innovation in the emerging economies: Technological change and catching-up. *World Development, 39*(7), 1204–1212.

Furman, J. L., Porter, M. E., & Stern, S. (2002). The determinants of national innovative capacity. *Research Policy, 31*(6), 899–933.

Glaeser, E. L., Kallal, H. D., Scheinkman, J. A., & Shleifer, A. (1992). *Growth in cities* (p. 3451309). Scholarly Articles.

Griliches, Z. (1990). Patent statistics as economic indicators: A survey. *Journal of Economic Literature, 28*(4), 1661–1707.

Hall, R. E. (1988). The relation between price and marginal cost in US industry. *Journal of Political Economy, 96*(5), 921–947.

Howell, S. T. (2017). Financing innovation: Evidence from R&D grants. *The American Economic Review, 107*(4), 1136–1164.

Huang, X. J., Chen, Z. G., Yu, R., & Li, L. L. (2013). The performance and suggestion of Chinese land transfer system since 1980s. *Modern Urban Research*, (9), 15–21 (in Chinese).

Huber, F. (2012). Do clusters really matter for innovation practices in information technology? Questioning the significance of technological knowledge spillovers. *Journal of Economic Geography, 12*(1), 107–126.

Ju, X. S., Lu, D., & Yu, Y. H. (2013). Financing constraints, working capital management and the persistence of firm innovation. *Economic Research Journal, 48*(1), 4–16 (in Chinese).

Klette, T. J. (1999). Market power, scale economies and productivity: Estimates from a panel of establishment data. *The Journal of Industrial Economics, 47*(4), 451–476.

Klette, T. J., & Griliches, Z. (1996). The inconsistency of common scale estimators when output prices are unobserved and endogenous. *Journal of Applied Econometrics, 11*(4), 343–361.

Kou, Z. L., & Liu, X. Y. (2017). *Find report on city and industrial innovation in China 2017*. Fudan Institute of Industrial Development (in Chinese).

Lach, S. (2010). Do R&D subsidies stimulate or displace private R&D? Evidence from Israel. *The Journal of Industrial Economics, 50*(4), 369–390.

Lin, G. C. S., & Ho, S. P. S. (2005). The state, land system, and land development processes in contemporary China. *Annals of the Association of American Geographers, 95*(2), 411–436.

Lin, G. C. S., & Yi, F. (2011). Urbanization of capital or capitalization on urban land? Land development and local public finance in urbanizing China. *Urban Geography, 32*(1), 50–79.

Liu, G. C. (2017). Financial asset allocations and the firms' R&D activity in China: Crowding-out or crowding-in? *Statistical Research, 34*(7), 49–61 (in Chinese).

Liu, T., Cao, G., Yan, Y., & Wang, R. Y. (2016). Urban land marketization in China: Central policy, local initiative, and market mechanism. *Land Use Policy, 57*, 265–276.

Liu, T., & Lin, G. C. S. (2014). New geography of land commodification in Chinese cities: Uneven landscape of urban land development under market reforms and globalization. *Applied Geography, 51*(7), 118–130.

Liu, S. Y., Wang, Z. F., & Zhang, W. F. (2020). The exhaustion of China's land-driven development mode: An analysis based on threshold regression. *Management World, 36*(6), 80–92 (in Chinese).

Li, D., Wei, Y. D., & Wang, T. (2015). Spatial and temporal evolution of urban innovation network in China. *Habitat International, 49*, 484–496.

Lu, X. H., Jiang, X., & Gong, M. Q. (2020). *How land transfer marketization influence on green total factor productivity from the approach of industrial structure? Evidence from China* (Vol. 95). Land Use Policy.

Lu, M., Zhang, H., & Liang, W. Q. (2015). How the bias toward central/western land supplies boosts wages in the east. *Social Sciences in China, 36*(5), 59–83 (in Chinese).

Niebuhr, A. (2009). Migration and innovation: Do cultural diversity matter for regional R&D activity? *Papers in Regional Science, 89*(3), 563–585.

Niosi, J. (2010). Rethinking science, technology and innovation (STI) institutions in developing countries. *Innovation: Management, Policy & Practice, 12*, 250–268.

Paik, W. (2014). Land developers, states, and collusive clientelism in marketizing China. *Pacific Focus, 29*(1), 68–91.

Pakes, A., & Schankerman, M. (1984). *The rate of obsolescence of patents, research gestation lags, and the private rate of return to research resources, R&D, patents, and productivity*. Chicago: University of Chicago Press.

Qian, Z. H., & Mou, Y. (2012). *The level of land marketization in China: Measurement and analysis*. Management World (in Chinese).

Qin, Y., Zhu, H., & Zhu, R. (2016). Changes in the distribution of land prices in urban China during 2007-2012. *Regional Science and Urban Economics, 57*, 77–90.

Rosenbusch, N., Brinckmann, J., & Bausch, A. (2011). Is innovation always beneficial? A meta-analysis of the relationship between innovation and performance in smes. *Journal of Business Venturing, 26*(4), 441–457.

Schumpeter, J. (1936). *The theory of economic development*. Cambridge: Harvard University Press.

Sedgley, N., & Elmslie, B. (2011). Do we still need cities? Evidence on rates of innovation from count data models of metropolitan statistical area patents. *The American Journal of Economics and Sociology, 70*(1), 86–108.

Shang, W. (2020). Effects of new infrastructure investment on labor productivity based on producer services perspective. *Nankai Economic Studies*, (6), 181–200 (in Chinese).

Su, Y. S., & Hung, L. C. (2009). Spontaneous vs. policy-driven: The origin and evolution of the biotechnology cluster. *Technological Forecasting and Social Change, 76*(5), 608–619.

Tao, R., Lu, X., Su, F. B., & Wang, H. (2009). China's transition and development model under evolving regional competition patterns. *Economic Research Journal, 44*(7), 21–33 (in Chinese).

Tao, K. Y., Zhang, M., & Li, L. X. (2010). Market reform and illegal action: Evidence from China's land lawbreaking. *Nankai Economic Studies*, (2), 28–43 (in Chinese).

Thompson, P., & Fox-Kean, M. (2005). Patent citations and geographic spillovers: A reassessment. *The American Economic Review, 95*(1), 450–460.

Wang, L. (2014). Forging growth by governing the market in reform-era urban China. *Cities, 41*(12), 187–193.

Wang, Q., Chen, Z. G., Ye, Y. G., & Huang, X. J. (2007). Spatio-temporal pattern of land marketization in China. *Resources Science*, (1), 43–47 (in Chinese).

Winne, S. D., & Sels, L. (2010). Interrelationships between human capital, HRM and innovation in Belgian start-ups aiming at an innovation strategy. *International Journal of Human Resource Management, 21*(11), 1863–1883.

Wu, F. L. (2019). *Land financialisation and the financing of urban development in China*. Land Use Policy.

Wu, Y. P., & Li, L. (2017). Performance evaluation of special economic zones in China: From the perspective of firm innovation capacity. *Journal of Financial Research*, (6), 126–141 (in Chinese).

Xi, Q., & Mei, L. (2019). Industrial land price, selection effect and industrial efficiency. *Economic Research Journal, 54*(2), 102–118 (in Chinese).

Xu, J., Anthony, Y., & Wu, F. L. (2009). Land commodification: New land development and politics in China since the late 1990s. *International Journal of Urban and Regional Research, 33*(4), 890–913.

Xu, S. Y., Chen, J., & Zhao, G. (2018). How does the land leasing marketization affect the economic growth? *China Industrial Economics*, (3), 44–61 (in Chinese).

Yuan, F., Wei, Y. D., & Xiao, W. (2019). Land marketization, fiscal decentralization, and the dynamics of urban land prices in transitional China. *Land Use Policy, 89*(12), 104208.

Yu, M. G., Zhong, H. J., & Fan, R. (2016). Do the new performance appraisals (EVA) promote innovation of central government-owned enterprises (CGOEs)? *Economic Research Journal, 51*(12), 104–117 (in Chinese).

Zhang, F., Cooke, P., & Wu, F. (2011). State-sponsored research and development: A case study of China's biotechnology. *Regional Studies, 45*(5), 575–595.

Zhang, L., Wei, H., & Ou, D. (2019). Land Financing Local Debt and Leverage: Analysis of the land mortgage behavior of local government financing platforms. *Journal of Financial Research*, (3), 92–110 (in Chinese).
Zhang, F., & Wu, F. (2019). Rethinking the city and innovation: A political economic view from China's biotech. *Cities, 85*(2), 150–155.
Zhao, Y. J., & Song, T. (2019). From land finance to land revenue. *Finance and Accounting Monthly*, (8), 155–161 (in Chinese).
Zheng, S. Q., Sun, W., Wu, J., & Wu, Y. (2014). Infrastructure investment, land leasing and real estate price: A unique financing and investment channel for urban development in Chinese cities. *Economic Research Journal, 49*(8), 14–27 (in Chinese).
Zhou, Y., Zong, Q., & Chen, X. (2013). Yardstick competition among local municipal governments over the education expenditure under decentralized fiscal system. *Economic Research Journal, 11*, 127–160 (in Chinese).
Zhu, J. (2005). A transitional institution for the emerging land market in urban China. *Urban Studies, 42*(8), 1369–1390.
Zhu, F., & Zhu, X. (2020). Research on the estimation of China's infrastructure net capital stock and fixed capital consumption. *The Journal of Quantitative & Technical Economics, 37*(6), 70–88 (in Chinese).