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The Effects of Fiscal and Tax Incentives on Regional Innovation Capability: Text Extraction Based on Python

Yawei Qi [1,*], **Wenxiang Peng** [1] and **Neal N. Xiong** [2]

[1] School of Information Management, Jiangxi University of Finance and Economics, Nanchang 330032, China; ivey09@163.com

[2] Department of Mathematics and Computer Science, Northeastern State University, Tahlequah, OK 74464, USA; xiongnaixue@gmail.com

[*] Correspondence: qiyawei@jxufe.edu.cn

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Abstract: The regulation of fiscal and tax policies is an imperative prerequisite for improving the regional innovation capability. In view of this, an attempt was made to select 31 provinces and cities in China as the research object from 2009 to 2018, to extract the fiscal and tax policy text encouraging innovation of the Chinese provinces and cities based on Python, and analyze their impact on regional innovation capability from both a text data and numerical data perspective. It is noteworthy that most of the provincial fiscal policies just follow the national fiscal policies. Each province does not formulate fiscal and tax policy according to its own unique characteristics. Fiscal policies and regional innovation capability exhibit significant spatial heterogeneity. Based on the results of the dynamic panel data model, it is seen that the R&D input and industrial structure are the main sources of improving innovation capability. The fiscal expenditure for science and technology, fiscal and tax policy text, macro tax burden, business tax (BT), and value-added tax (VAT) have a significant boosting effect on the regional innovation capability. However, the corporate income tax hinders the regional innovation capability. Finally, through the robustness test of invention patents, it is found that the fiscal and tax policy text, macro tax burden, and business tax still have a positive effect on invention patents, but the role of value-added tax has changed from promotion to obstruction, and the corporate income tax has become a significant obstacle on invention patents. This shows that China should build a tax system that promotes fair competition, reduce the tax burden of enterprises, encourage enterprises to conduct independent R&D, and guide enterprises in the evolution from the low-tech to high-tech innovation by improving the tax structure and fiscal technology expenditures.

Keywords: fiscal and tax policy; fiscal expenditure for science and technology; regional innovation capability; text mining

MSC: 91B64; 62P20; 62J05; 62H15

1. Introduction

China has made unprecedented economic progress during 40 years of reform and open-up. Such economic prosperity, with low factor costs and high capital investment at the expense of economic growth mode, has resulted in serious ecological environment problems and restricted the upgradation of the Chinese economy. According to the Porter's theory of the national innovation system, implementing an innovation-driven development strategy and vigorously advancing the scientific and technological innovation are strategic provisions for improving social productivity and overall national strength. Promoting innovative capability in firms should, therefore, become the cornerstone of economic

development policies. Drucker (1985) characterized innovation as a special entrepreneurship tool which contributes to the creation of wealth [1], and Gartner (1990) noted that innovation is one of the factors that constitute the nature of entrepreneurship [2]. Marx (1887) interpreted innovation as the result of companies' attempts to increase their profits [3]. Governments around the world are broadening and deepening their support for innovation in the private sector and the economy in general. The total global expenditure on R&D in 2017 was USD 2.2 trillion and continues to grow at a rate of 3.6% per year. The average share is typically much higher in advanced economies (2% of GDP) than in emerging market and middle-income economies (0.65% of GDP) or in low-income developing countries (0.15% of GDP). Israel and South Korea are the world's leading spenders on research and development (R&D), as a percentage of gross domestic product (GDP), according to the latest statistics from the Unesco Institute for Statistics. In pure dollar terms, however, the United States is consistently the largest spender on R&D, followed by China and Japan [4].

Regional economy has also become an important carrier for the economic development of the country. The development of the regional economy is an objective prerequisite for the comprehensive progress of society and the realization of a well-off society. Regional innovation capability determines the long-term competitiveness of the regional economy and is one of the driving forces for rapid, coordinated, and healthy development of the regional economy. The formation and development of innovation activities mainly rely on the regulations of both market mechanisms and government administrative intervention mechanisms. The first characteristic in innovation is information asymmetry and positive externalities. Because the private benefits or profits that the firm receives are only a portion of the overall social benefits, private firms in a market economy underinvest in research and technology. Market failures create suboptimal equilibria in the social optimum, which justifies state intervention. The second characteristic in innovation is the degree of uncertainty. The return on investment in innovation is more uncertain and exhibits longer periods of development, so private firms, especially in developing countries, have no incentive for R&D and innovation. The public policy is needed to stimulate company innovation. In addition, different regions will issue different policies to push dynamic innovation, and there are huge differences in conditions such as economic development, resource endowment, and industrial structure in different regions, which would result in the space difference of regional innovation.

Government is the maker and implementer of policy or institution. David et al. (2000) [5] affirmed the role of government on the allocation of national science and technology resources and believed that the government decided the speed and direction of technological progress. The government should stimulate the enthusiasm of the company for technological innovation, and the national innovation development strategy can be realized by stimulating the company's innovation vitality (Peng and Wang, 2018) [6]. The China Science and Technology Development Strategy Research Group (2003) believes that a regional innovation system is a regional network of institutional organizations that promotes innovation with characteristics that are related to regional resources. It aims to promote the generation, flow, update and conversion of new technology or new knowledge in the region [7]. Kyrgiafina and Sefertzi (2003) believed that new regional innovation policy should include the following: the practice of knowledge creation and technology transfer; nurturing an innovation culture; promoting funding sources for research and innovation; and fostering effective innovation management [8]. As a direct means for local governments to regulate economic operations, public policy has an important role to play in promoting research and development (R&D) the development, diffusion, and use of new knowledge and innovations. Public policies on fiscal incentives provide strong financial and policy support for regional innovation and promote regional innovation achievements into practical productive forces. Fiscal incentives, including tax policies, should be directed at specific barriers, impediments, or synergies, to facilitate the desired level of investment in R&D and innovations. Therefore, it is of great significance to study the impact of fiscal and tax policies on the enhancement of regional innovation capability.

The developing economies are at different stages of technological development and have different institutions and policy frameworks. Public policies on fiscal incentives fostering the increase of investment of financial resources for R&D projects are particularly needed in developing countries. Future studies should, therefore, be fine-tuned to the economic context of developing economies. China, being the top in 10 countries by GDP, provides an appropriate and unique setting for examining the fiscal policy effects on regional innovation capability. The Chinese government adopts various fiscal and tax reforms to encourage innovation in over two decades. The tax system underwent a major overhaul in 1994, as the value-added tax (VAT) was expanded to include the sale of goods, processing, and repair services, while directing more revenue to the central government. Hailed as China's most significant tax reform, the VAT was comprehensively implemented as the country's only indirect tax in 2016, effectively replacing the business tax (BT) that previously applied to a number of industries. The Chinese government envisions the VAT reform to further propel growth in services and consumption as the country pivots away from the low value-added industries. Although the tax rates faced by different regions in China are the same, the tax structure and macro tax burden of each region are different. One of the aims of this paper is to test whether different regions' fiscal and tax policies or fiscal and tax structures will affect regional innovation capability differently.

It has experienced a great boom in R&D input and output in the past decades. The impact of government policies on the innovation boom remains under-examined. Thus, one of the marginal contributions of this paper is that, this paper, by taking 31 provinces of China as a sample, constructs a dynamic panel data model to empirically analyze the influence of tax arrangement on regional innovation capability from the angle of macro tax burden, tax structure, and fiscal and tax incentive policies. In the connotation definition and index selection of innovation and fiscal policy, the existing literature is based more on numerical data, lacking examination of the text data, which otherwise would make evaluation of innovation effect of fiscal and tax policy rather uncomprehensive. To draw robust conclusions, more evidence is needed. Therefore, another marginal contribution of this paper is that it uses Python to extract the fiscal and tax incentive policies for R&D and innovation issued by the Chinese government, describes the spatial differences of fiscal and tax incentive policies for innovation in China, and examines the incentive effect of fiscal and tax policies on innovation from the perspective of both numerical data and text data. Moreover, the panel data analysis employed in the paper overcomes common methodological problems (such as autocorrelation, heteroscedasticity, and lagged dependent variable) and makes robustness tests on empirical results, ensuring the reliability of empirical results and the estimation of unbiased and efficient estimators.

The remainder of this paper is structured as follows. In the following section, we explore the research literature review, analyze the role of fiscal and tax policies on innovation, and propose the related hypothesis. Section 3 takes the 31 provinces and cities in China as examples and analyzes the spatial difference of fiscal and tax policies and regional innovation capability. Section 4 takes 31 provinces and cities in China as an example, to analyze the empirical results of fiscal and tax policy affecting regional innovation capability. Section 5 presents conclusions and discusses future work.

2. Materials and Methods

2.1. Literature Review

In the last decade, China's innovation capability has been markedly improved. Xi Jinping, who has served as General Secretary of the Communist Party of China, clearly stated that some major disruptive technological innovations were creating new industries or new business model, and that information technology, biotechnology, manufacturing technology, and new material technology had penetrated into almost all fields at the 2016 National Science and Technology Innovation Conference. The pace of the integration of next-generation information technologies, such as big data, cloud computing, and mobile internet with robotics and intelligent manufacturing technologies, has accelerated. Investment in education and research has strengthened the knowledge bases. However, the government's worry is that,

because of the public good aspects of knowledge and market imperfections, adequate resources are not being devoted to knowledge accumulation, resulting in an undersupply of innovation and suboptimal growth of productivity. The desire to remain at the leading edge of technological development or to move to the technological forefront in selected areas has spurred a "technical arms race" and concentrated attention on rankings of technological capability and preparedness. Drawing upon an unusually rich dataset spanning 9752 digitized archival documents, Eriksson et al. (2019) found that successful innovation policies in mature economies largely involve dealing strategically with resourceful vested interests, adjusting expectations, and removing obstacles to industrial renewal [9]. Ho et al. (2005), using a sample of US firms for an over-40-year period from 1962 to 2001, investigated whether the future share price returns of a firm were positively related to a firm's R&D intensity and showed that R&D investment creates value for firms over one-year and three-year horizons [10]. Kalantonis et al. (2020) empirically investigated the effect of R&D disclosed information in firms' financial statements on the value relevance of the reported accounting, and found that R&D reporting has a significant effect on the association of equity price with accounting data [11]. They highlight the necessity of an improvement of the legal framework in the direction of an obligatory reporting of capitalized R&D information, which could be more attractive to the investors and shareholders.

What are important tax, legal, and fiscal considerations for a government in fostering business and technological innovation? Fiscal policy is one way how Congress and other elected officials influence the economy by using spending and taxation. The objective of fiscal policy is to create healthy economic growth. Mamuneas and Ishaq (1996) found that fiscal policy can reduce the risk of innovation investment and increase investment income, thereby stimulating enterprises to increase R&D funding [12]. Liu et al. (2011) found that the government tax, fiscal, and other policies are increasingly important to improve and stimulate technological innovation [13]. Herbig (1994) believed that reducing the macro tax burden is not necessary to promote regional innovation, because the reduction of taxes will lead to a decline in government fiscal expenditure, which is not conducive to the government's regulation of regional innovation; the tax burden must be maintained at a reasonable level which can ensure good public services without creating bad incentives for innovation [14]. Zhou (2012) believed that the macro tax burden on regional innovation did not have a significant impact, while fiscal income per capita showed a significant positive impact on regional innovation [15]. Chen et al. (2019) believed that the scientific and technological achievements of research institutes and enterprises in the region are of practical significance only when they are transformed into new technologies and achievements that can be used by the market. Therefore, how should fiscal and tax incentive policies focus on promoting the transformation of scientific and technological achievements [16]? Based on data from 24 manufacturing sectors in Brazil from 2001 to 2008, Gramkow and Angerkraavi (2018) explored the extent to which fiscal policies could contribute to Brazilian green innovation. They found that fiscal instruments such as low-cost (subsidy) financing for innovation and fiscal incentives for sustainable practices were effective in inducing green innovation [17]. Fiscal policy can play an important role in stimulating innovation through its effects on R&D, entrepreneurship, and technology transfer. However, some scholars showed that excessive government financial intervention will "crowd out" the technical input and output of the enterprises (Busom, 2000; Klette and Jarle, 2012) [18,19]. Zhang et al. (2017) found that enterprise income tax inhibits innovation investment enterprises in the eastern region; the tax burden of enterprises in the eastern region is higher than that of the central and western enterprises, but enterprises in the eastern region attract more innovative investment [20]. The varying results of effectiveness of R&D tax incentives do not provide a justifiable ground for dismissing the effectiveness of R&D tax incentives. A successful R&D fiscal incentive strategy, to a large degree, depends on understanding the advantages of different policy tools.

Government fiscal subsidies and tax incentives are the two most important policy tools for the government to support business innovation (Lee, 1996; Aghion et al., 2012) [21,22]. In many economies, fiscal subsidies and tax incentives have become an integral part of a broader strategy to increase investment in R&D and promote innovation. Tax incentives and direct subsidies have different roles

within a policy mix for business R&D and are complementary to each other. The fiscal incentive policy includes R&D tax incentives, such as tax credits, enhanced allowances, accelerated depreciation, and special deductions for labor taxes or social security contributions. Hall (2019) presents the policy rationale for tax incentives, discusses their design and potential effectiveness, and reviews the empirical evidence on their actual effectiveness. The focus is on the two most important and most studied incentives: R&D tax credits and super deductions, and IP boxes (reduced corporate taxes in income from patents and other intellectual property). Taxes provide the income that funds the government [23]. Chang (2018) estimates the causal effect of R&D tax incentives on R&D expenditures using new data on US states. Identifying tax variation comes from changes in federal corporate tax laws that heterogeneously and, due to the simultaneity of state and federal corporate taxes, automatically affect state-level tax laws. The results show that R&D tax incentives significantly increases firms' innovative input and output, a 1% increase in R&D tax incentives causes a statistically significant 2.8–3.8% increase in R&D. Scholars currently have a limited understanding of the role of R&D tax incentives in developing countries [24]. Based on the panel data of 59 listed high-tech enterprises in Western China, from 2014 to 2018, Li et al. (2020) constructed a fixed effect model to study whether enterprise innovation performance would be affected under the interaction of fiscal and tax incentives and R&D investment. It is found that both tax incentives and financial subsidies have a significant impact on the innovation performance of manufacturing enterprises through the intermediary variable of R&D input, but private enterprises enjoying tax incentives have a crowding out effect on the improvement of innovation performance by R&D input. At the same time, the interaction between tax incentives and enterprises' expensed R&D investment is more conducive to the improvement of enterprises' innovation performance, while the combination of financial subsidies and capitalization R&D investment also has a positive impact on the improvement of innovation performance [25]. Cao and Chen et al. (2018) studied the impact of tax incentives on corporate innovation efficiency. The stimulation effect of R&D tax incentives may be heterogeneous across industries, enterprise scale and tax type [26]. Wang and Kesan (2020) found a stringent corporate tax policy with narrowly tailored R&D thresholds for tax credits can positively incentivize R&D and patent applications by small and medium enterprises (SMEs) and value-added tax credits cannot induce R&D when they do not confer subsidies or a competitive advantage on SMEs [27]. After the introduction of the personal income tax and income tax withholding, the value-added tax stands out as one of the most important tax policy innovations. In many cases, the VAT was accompanied by a reduction in customs duties and tariffs tax policy in developing countries. Alavuotunki, Haapanen, and Pirttilä (2019) examined the impact of the introduction of the value-added tax on inequality and government revenues, using newly released macro data, and found income-based inequality has increased due to the VAT adoption, whereas consumption inequality has remained unaffected [28].

The second tool is government spending—which includes subsidies, welfare programs, public works projects, and government salaries. Based on the sample data of Chinese manufacturing enterprises, Yang and Liu (2019) used the method of propensity score matching and quantile regression analysis to explore the impact of fiscal and tax incentive policies on the substantive innovation of manufacturing enterprises from two perspectives. They found that fiscal R&D subsidy and tax incentive promoted the substantial innovation activities of Chinese manufacturing enterprises, but their effects were different. The incentive effect of fiscal R&D subsidy was obviously better than that of tax incentive policy. Compared with state-owned enterprises, non-state-owned enterprises' substantive innovation behavior is more sensitive to the stimulus feedback of fiscal R&D subsidy and tax incentive. However, state-owned enterprises based on institutional arrangement are closely connected with government politics, which weakens the effect of fiscal and tax policies. State-owned enterprises prefer the strategic innovation of "seeking support". From the perspective of fiscal and tax incentives, the effect of R&D fiscal subsidies with "exclusivity" on innovative heterogeneous enterprises shows a trend of "monotonicity increasing", while the effect of tax incentives shows a trend of "monotonicity decreasing" [29]. Wang et al. (2017) analyzed the impact of R&D subsidies on corporate innovation

and found that different fiscal and tax policies (fiscal subsidies and tax incentives) have different incentive effects on the innovation of enterprises [30]. Specifically, some scholars (Zhang and Du, 2019; Ning and Li, 2019) believe that, in the innovation input stage, the incentive effect of fiscal subsidies is more significant. In the output stage, the incentive effect of tax incentives is more significant [31,32]. Tax incentives are usually available to all firms that invest in R&D and have a larger effect in industries characterized by high R&D thrust and for small firms (those with less than 50 employees). Meanwhile, subsidies increase innovation more in industries that are highly dependent on external finance (where R&D cannot be accommodated by current cash flow), mainly the information technology sector. Some studies suggest that R&D tax incentives stimulated the development of new products and innovation (Czarnitzki et al., 2011, Ernst and Spengel, 2011, and Westmore, 2013) [33–35]. However, R&D tax incentives appear to be effective in increasing incremental innovations, but they might not result in more radical innovations, as shown by Cappelen et al. (2012) and Ernst et al. (2014) [36,37].

Most of the previous literature analyzes the construction and determinants of a regional innovation system, or directly link the tax, fiscal expenditure, and economic growth, to analyze tax burden and fiscal science and technology expenditure on macroeconomic development. However, the empirical results are not uniform. The existing literature rarely studies the impact of different tax structures and R&D fiscal incentives on regional innovation capability.

2.2. The Influence Mechanism of Fiscal and Tax Policies on Stimulating Innovation

Tax and fiscal incentives have become the common policy tools in encouraging firms to spend more on R&D, and the recession has further raised interest in the effectiveness of these policies thereby, serving the following purposes.

(1) Increasing the overall level of R&D spending throughout the economy. Businesses have long considered tax incentives as important and sometimes necessary relief in lieu of high R&D costs. Fiscal investment or tax incentives can effectively offset the funding gap of regional innovation systems and form a significant leverage-driven effect (Xie, Tang, and Lu, 2009) [38].

(2) Affecting the distribution of R&D among sectors to favor more promising sectors and to loosen the constraints, such as the supply of S&T workers. Most of the R&D outlay across countries is in IT, hardware, automotive industries, and pharmaceuticals. Fiscal and tax policy have an obvious guiding role and present the government's macroeconomic control of the entire country or the region (Guo and Luo, 2015) [39]. According to the national industry or the sector development strategy, the fiscal policy determines the direction of technological innovation and production. At the same time, the government has introduced tax reduction and exemption incentives for specific industries to optimize the technical structure.

(3) Reduce the innovation risk of the enterprises. R&D has the characteristics of a large-scale investment, long investment cycle, and high risk, which determine the existence of large uncertainties in independent innovation activities. The government can implement fiscal subsidies for innovative enterprises through fiscal technology expenditures, and accelerate tax depreciation, tax deductions, and other preferential tax policies to help the enterprises avoid innovation risks and thereby motivate enterprises. However, the enterprises will only be profitable if the innovation achievements are recognized. The government procurement system can increase the social demand for innovative products and reduce the market operating risks of such enterprises.

(4) Reduce R&D costs of the firms. Fiscal subsidies or tax benefits can effectively reduce the cost of innovation of economic individuals in the region, bridge the gap between the private benefits and social benefits of economic individual innovation activities, and reduce external disturbances. The introduction of "Pre-Tax Deduction of Enterprise Research and Development Expenses", at the end of 2008, is an important way to encourage technological innovation in China in terms of taxation. This policy reduces the income tax base payable by the technological innovation enterprises by doubling the cost of technological innovation and reducing the cost of capital for technological innovation. IT outsourcing, business process outsourcing, and knowledge process outsourcing companies in

designated cities, which are granted Advanced and New Technology Service Enterprise (ATSE) status, pay a reduced corporate income tax rate of 15% instead of 25%.

(5) Permission of FDI into selected industrial sectors to serve as a conduit for new technologies and possibly also as an axe for cluster development in urban technology zones and parks. China's tax system reform in 1994 abolished the progressive income tax system for non-state-owned enterprises, reduced the nominal tax rate for state-owned enterprises to 33%, but still gave foreign companies a low tax rate (25%). Input value-added tax (VAT) on domestically manufactured equipment purchased by qualified native R&D institutes and foreign invested R&D centers is refundable. The comparative advantage of tax has set off an investment trend in which foreign capital has flooded into China. As a result, foreign mature technology is introduced and digested with the introduction of capital. Business tax exemption on revenue is derived from offshore outsourcing services and the transfer of trusted qualified technology. The option of incorporating and being taxed at a lower marginal corporate rate subsidizes risk-taking, thereby inducing the formation of new businesses (Cullen and Gordon, 2007; Russo, 2004) [40,41].

(6) Promoting the rational allocation of the limited regional innovation resources, to avoid vicious inter-regional competition, by adopting the attitude of "competitive cooperation". Reasonable fiscal and tax policies are conducive to the flow of innovation elements between regions and cross-regional innovation cooperation activities; if the innovation capability of different regions is greatly diverse, it will not be conducive to the improvement of innovation capability in the backward regions and the entire country. The government can realize the spatially balanced development of regional innovation capability through transfer payment policies.

Based on these arguments, we propose Hypothesis 1, as follows.

Hypothesis 1 (H1): *Fiscal and tax policies can stimulate innovation.*

The fiscal policies relating to R&D can take many different forms, including tax allowances, tax deductions, super deductions, tax exemptions, and tax credits. If the government's objective is to increase R&D intensity among firms from a relatively low level, tax incentives may be the most sensible approach. Meanwhile, direct subsidies are better suited to encourage higher-risk projects and to meet specific policy goals. If the government's objective is to enlarge the R&D capability within certain fields or R&D milieus, in this case, subsidies would be the natural choice, since it is more difficult to target specific fields or areas of R&D activities through tax incentives. At the same time, due to the complex tax structure, there are many types of taxes, including VAT, consumption tax, income tax, and so on. Different types of taxes may have different effects on innovation. Therefore, it is necessary to test whether Hypothesis 2 holds.

Hypothesis 2 (H2): *Different tax structures have different effects on innovation.*

3. Measurement of Fiscal Policies and Regional Innovation Capability

3.1. Measurement of Fiscal Policy

Due to the large differences in local economic foundations, natural endowments, development needs, and cultural characteristics, details of the fiscal and tax support policies supporting innovation in different provinces and cities in China are not the same. In order to characterize the differences in fiscal and tax incentive innovation policies in China's provinces and cities and analyze their implementation effects, this paper uses Python and other software to crawl the policy texts in the official websites of the central and local government, the Ministry of Finance, the State Taxation Administration of 31 provinces and cities in mainland China (not including Hong Kong, Macau, and Taiwan), from 2009 to 2018. We obtained more than 10,000 policy text data and then extracted the fiscal and tax policies related to innovation and remove the fiscal and tax policies that are not

related to technological innovation. The local governments adopt various policy tools and design them to best suit the regional innovation capability and economic development. Gong (2003) [42] believed that, according to the characteristics of underdeveloped regions, the choice of government policy tools in the regional innovation system should focus on the following aspects: fiscal and tax incentives, financial and credit policies, talent incentives, intermediary service system development policies, SME development policy, government procurement policy, etc. Combining the classification of science and technology policies by Xu and Li (2017) [43], this paper divides the fiscal and tax policies supporting technological innovation into two dimensions: policy objectives and policy tools. The classification criteria are shown in Table 1.

Table 1. Classification of fiscal and tax policies to stimulate innovation.

Dimension	Category	Aspect
Policy objectives	Encourage basic research	Patent system; government funding; government procurement
	Encourage the transformation of technological achievements	Control; technical standards; R&D investment; Subsidies; foreign investment and technology introduction; digestion and absorption; industrialization
	Encourage the improvement of innovation systems	Cooperative research programs; enterprise innovation capability
Policy tools	Demand policy	Trade control; outsourcing
	Supply policy	Public services, education, and training; personnel measures; science and technology infrastructure; science and technology information support; science and technology funds
	Environmental policies	Tax incentives; finance; intellectual property; administrative measures; target planning

From Table 1, it is evident that, from the perspective of policy objectives or policy tools, most of the China's current science and technology innovation are closely related to fiscal benefits, such as tax incentives, tax exemption lists, and fund management. The endogenous driving force of innovation in China can further be stimulated by adopting innovation-related financial tools, such as income tax exemption for scientific enterprises, protection of the patent system, and tax exemption for R&D equipment for scientific research. Therefore, this paper uses the content of policy tools and policy objectives as keywords to crawl policies related to innovation from the general fiscal and tax policy text. The process of web crawling for R&D fiscal and tax incentive policy based on Python is as follows:

The first step: download the requests package, re package (also known as regular expression matching operations), json package, pandas package in Python.

The second step: use the requests instruction to crawl all the policy data of the central and local government, the Ministry of Finance, the State Taxation Administration official website in China. Take the policy data as source data to be matched.

The Third step: use the re instruction to match the required policies. That is, use the contents of policy tools and policy objectives as keywords to search and match tax incentive policies text form the source data, and at the same time, extract policy-related text (including title, document number, topic type, time, publishing unit, and website address).

The fourth step: crawl and match all the R&D tax incentive policies through a loop statement. The core algorithm is re (regular expression) matching in greedy matching algorithm, based on NFA (non-deterministic finite automata) and DFA (deterministic finite automata) regular expression engines.

The fifth step: use the pandas package to export the entire data into a csv format file.

Only the provincial government documents published on the official websites or documents of central government forwarded to the regional official websites are included in the statistics. If the

policy-release section is directly connected to the central government's official website, it will not be included in the statistics. According to the crawled policy text data, most provinces and cities in China directly forward the notices or announcements of the relevant fiscal and tax policies of the State Taxation Administration and the Ministry of Finance. However, each province rarely issues fiscal and tax policies to encourage innovation according to its own characteristics; instead, each just closely follows China's innovation-driven development strategy at a macro level, without analysis and refinement.

From the spatial distribution of fiscal and tax policies that stimulate innovation, Beijing, Tianjin, Shanghai, Guangdong, and Jiangsu provinces publish or forward fiscal and taxation policies almost every year, indicating that these provinces use fiscal and taxation policies as the main incentive tool for regional innovation. While Inner Mongolia, Hainan, Henan, Qinghai, Xinjiang, and other provinces and cities released a few fiscal and tax incentive policies. Guizhou, Shaanxi, and Yunnan did not released or forwarded fiscal or tax incentives policies before 2014, but released more fiscal and tax policies to support innovation in the past four years, indicating these provinces change their attitude toward innovative fiscal and taxation policies, and recognize the incentives of fiscal and tax policies for regional innovation activities.

3.2. Measurement of Regional Innovation Capability and Spatial Heterogeneity

There are many descriptions of regional innovation performance in existing research, and in order to ensure the accuracy of the research results, this paper used the regional innovation index in the "China Regional Innovation Capability Report", because the data can be obtained directly, without complicated calculation, thus reducing the possible errors in the calculation process. This report is undertaken by the China Science and Technology Development Strategy Group. The data have a certain amount of authority and can better explain the innovation capability of each region. The innovation indexes of 31 provinces and cities in mainland China are shown in Table 2.

Table 2 reveals that Beijing, Tianjin, Jiangsu, Guangdong, Shanghai, and Zhejiang have been leading regions for innovation capability, and the top three have been Beijing, Jiangsu, and Guangdong, indicating that these three provinces are leaders in regional innovation capability. Xinjiang, Qinghai, and Ningxia have been in the last echelon of innovation capability. At the same time, the innovation capability of Inner Mongolia, Liaoning, Heilongjiang, and other provinces has shown a downward trend from the perspective of time trends. According to the standard deviation and coefficient of variation, there is a significant spatial difference in China's regional innovation capability. The spatial differences of regional innovation capability continue to rise, except the decline in spatial difference in 2012. Specifically, it can be divided into north–south differences and east–west differences.

According to the regional division standards set by the *National Bureau of Statistics of China*, China's provinces and cities are divided into the three regions, according to geographical location: eastern region, central region, and western region. The eastern region includes Beijing, Tianjin, Hebei, Shanghai, Jiangsu, Zhejiang, Fujian, Shandong, Liaoning, Guangdong, and Hainan; the central region includes Shanxi, Jilin, Heilongjiang, Anhui, Jiangxi, Henan, Hubei, and Hunan; the western region includes Inner Mongolia, Guangxi, Chongqing, Sichuan, Guizhou, Yunnan, Tibet, Shaanxi, Gansu, Qinghai, Ningxia, and Xinjiang. If China's provinces and cities are divided into the northern and southern region, the northern region includes Beijing, Tianjin, Hebei, Henan, Shandong, Shanxi, Liaoning, Jilin, Heilongjiang, Mongolia, Anhui, Shaanxi, Gansu, Ningxia, and Xinjiang; the southern region includes Shanghai, Jiangsu, Zhejiang, Fujian, Jiangxi, Hubei, Hunan, Guangdong, Guangxi, Hainan, Chongqing, Sichuan, Guizhou, Yunnan, Qinghai, and Tibet. It can be seen that the average innovation capability of the southern region is higher than that of the northern region. The average innovation capability of the eastern region has always been higher than that of the central and western regions, but the gap is slowly narrowing. Overall, the innovation capability of Southeast China is the strongest.

Table 2. Regional innovation index of provinces and cities in China.

	2009	2010	2012	2013	2014	2015	2016	2017	2018
Beijing	53.19	47.92	46.11	50.73	50.11	50.45	52.61	52.56	54.3
Tianjin	37.44	35.89	34.09	36.13	36.11	36.49	34.15	33.71	32.14
Hebei	25.2	23.26	22.67	23.02	20.88	21.14	20.89	20.05	21.97
Shanxi	24.69	23.83	20.68	21.68	21.2	20.61	18.17	17.93	19.14
Inner Mongolia	21.87	20.46	26.18	23.73	19.23	21.44	18.22	18.32	19.11
Liaoning	33.03	28.93	31.28	28.85	27.19	26.88	24.46	22.26	22.44
Jilin	24.37	22.2	20.76	22.64	20.69	18.95	18.53	19	20.48
Heilongjiang	27.67	22.84	24.61	23.55	21.22	20.65	21.16	19.51	19.19
Shanghai	52.44	46.23	42.28	47.18	46.59	45.62	46.04	44.81	46
Jiangsu	55.63	52.27	53.84	57.58	58.86	58.01	57.2	53.3	51.73
Zhejiang	44.61	41.23	38.48	42.4	41.46	42.05	37.94	37.66	38.88
Anhui	31.92	28.56	30.08	29.75	30.47	29.86	30.02	28.36	28.72
Fujian	29.86	24.16	26.48	29.33	28.8	29.25	27.2	25.77	26.3
Jiangxi	25.82	22.07	24.32	23.53	21.86	23.34	21.85	22.04	21.61
Shandong	40.41	37.34	36.71	37.73	37.93	37.49	36.29	33.77	33.64
Henan	28.4	25.96	25.26	26.21	24.33	25.9	26.44	24.23	24.91
Hubei	32.76	30.61	28.35	28.71	28.82	28.59	29.07	29.35	29.45
Hunan	28.94	29.79	28.45	28.25	28.59	29.01	27.77	26.63	26.59
Guangdong	53.65	51.89	49.38	53	52.44	52.71	53.62	55.24	59.55
Guangxi	22.7	22.56	22.67	23.06	22.3	23.62	22.81	21.19	21.87
Hainan	21.31	21.95	23.3	24.1	26.79	28.03	25.68	22.49	22.79
Chongqing	29.53	29.85	28.08	33.88	32.9	32.99	32.04	30.05	30.3
Sichuan	33.61	29.95	28.35	27.16	26.98	26.39	29.08	27.52	27.04
Guizhou	23.31	19	20.77	22.6	20.41	21.22	25.64	22.19	22.27
Yunnan	24.32	20.74	19.37	21.32	21.13	20.3	19.72	20.43	21.48
Tibet	18.13	18.43	17.43	17.39	17.77	17.09	17.16	17.7	16.4
Shaanxi	29.12	27.79	27.84	27.68	26.86	27.14	29.29	36.05	26.49
Gansu	20.93	19.83	19.7	22.2	23.58	21.68	22.06	20.82	20.05
Qinghai	18.99	16.3	17.62	17.65	16.19	17.71	15.78	18.13	20.97
Ningxia	20.16	20.89	16.8	20.32	17.64	18.52	20.04	20.68	19.45
Xinjiang	23.93	20.38	20.32	20.39	18.49	18.04	19.86	20.04	19.93
Average	30.90	28.49	28.14	29.41	28.64	28.75	28.41	27.80	27.91
Standard deviation	10.81	10.07	9.52	10.60	11.07	10.94	11.01	10.86	11.09
Average of the East	40.62	37.37	36.78	39.10	38.83	38.92	37.83	36.51	37.25
Average of the Central	28.07	25.73	25.31	25.54	24.65	24.61	24.13	23.38	23.76
Average of the West	23.88	22.18	22.09	23.12	21.96	22.18	22.64	22.76	22.11
Average of the North	29.49	27.07	26.87	27.64	26.40	26.35	26.15	25.82	25.39
Average of the South	32.23	29.81	29.32	31.07	30.74	31.00	30.54	29.66	30.20
Coefficient of variation	0.35	0.35	0.34	0.36	0.39	0.38	0.39	0.39	0.40

4. Empirical Study

4.1. Data

This paper selects panel data from 31 provinces and cities in China (not including Hong Kong, Macau, and Taiwan), from 2009 to 2018, and constructs a panel data model to test the incentive effect of variables such as regional, fiscal, and tax policies on innovation capability.

4.2. Model Set

Fiscal and tax policies relating to R&D incentives and subsidies, while being important, are not the sole factors influencing regional innovation capability. According to the knowledge production function, regional innovation activities follow an input–output process. The focus of this paper is on the role of fiscal and tax policies in promoting R&D investment, which is viewed as one of the important inputs of innovative outcomes, and innovation as output also requires input of basic elements such as R&D personnel and R&D capital. Drawing on the analysis of factors affecting innovation output

by Furman et al. (2002) and Wei et al. (2010) [44,45], regional innovation output is also related to the innovation environment created by the government, and fiscal and tax policies relating to R&D incentives as a major part of the innovation environment. Therefore, the knowledge production function is constructed based on the Cobb–Douglas production function:

$$Innovation_{it} = A_{it} K^a_{it} L^\beta_{it} X^r_{it} e^{\varepsilon_{it}} \tag{1}$$

where the explained variable *Innovation*$_{it}$ is the regional innovation capability of the region *i* in the *t* year, which is measured by the Innovation Index of each province and city, published by China Science and Technology Development Strategy Group. K_{it} indicates R&D capital input of the region *i* in the *t* year, L_{it} is R&D personnel input of the region *i* in the *t* year, and A_{it} indicates financial factors of the region *i* in the *t* year related to the regional innovation environment, which mainly include the released fiscal policy, government financial investment in science and technology, tax structure, etc. X_{it} indicates other control factors of the region *i* in the *t* year. Therefore, Equation (1) can be extended to the following:

$$Innovation_{it} = Ce^{Policy^{d1}_{it} + Gov^{d2}_{it} + Tax^{d3}_{it}} K^a_{it} L^\beta_{it} X^r_{it} e^{\varepsilon_{it}} \tag{2}$$

The logarithm of both sides of the Equation (2) can be obtained as follows:

$$\ln Innovation_{it} = C + d_1 Policy_{it} + d_2 Tax_{it} + d_3 Gov_{it} + a \ln K_{it} + \beta \ln L_{it} + r \ln X_{it} + \varepsilon_{it}$$

$d_1, d_2, \alpha, \beta, \gamma$ indicate regression coefficient. ε_{it} indicates residual of the region *i* in the *t* year.

4.3. Explanatory Variables

Drawing on the research of Hu (2005) [46] and Zhang et al. (2014) [47], the core explanatory variables selected in this paper are as follows:

R&D capital input (RDK): The capital investment of regional innovation activities can be expressed by the intensity of R&D expenditure, that is, the ratio of R&D expenditure to GDP.

R&D personnel input (RDL): The personnel investment of regional innovation activities can be measured by the full-time equivalent of R&D personnel and take the natural logarithm.

Fiscal and tax policy text (Policy): This variable can be measured by number of fiscal and tax policies issued by the provinces or forwarded from the central government to stimulate innovation, reflecting the extent to which the government uses fiscal and tax policies as a tool to stimulate innovation. The data was obtained by the author, using the Python technology on the official websites of each provincial government department.

Government fiscal expenditure for science and technology (GOV): This variable can be measured by the share of local fiscal science and technology expenditure in total fiscal expenditure. Generally speaking, the higher the level of government spending on science and technology, the better the basic environment for scientific and technological innovation and more is the innovation output.

Tax Arrangement (Tax): This indicator mainly includes two aspects of macro tax burden and tax structure. Among them, the macro tax burden (Taxtot) is expressed by the proportion of regional taxes (including local tax and national tax revenue) to local GDP. Regarding the tax structure, considering that VAT, business tax and corporate income tax are the three types of taxes that account for the largest proportion of total tax revenue, VAT, BT, and IT are used to represent the ratio of valued-added tax, business tax, and corporate income tax to the total tax, respectively.

4.4. Control Variables

The control variable X mainly includes the following variables:

Regional traffic infrastructure density (Inf): It is mainly expressed in terms of railway mileage and highway mileage per unit area.

Level of Openness (Open): It is expressed by the proportion of total import and export to GDP in terms of the location of the business unit. The greater the degree of regional economic openness, the greater the degree of technological spillovers, the better the local conditions for absorbing external technology, and the more it contributes to the formation of regional innovation capability.

Industry Structure (Str): In general, the industrial structure is closely related to the local innovation condition. The greater the proportion of the tertiary industry that is dominated by services, the more likely it is to promote regional innovation capability. To measure the state of the local industrial structure, this paper uses the ratio of the industrial added value of the secondary industry to the industrial added value of the tertiary industry.

Regional economic development (PGDP): The local economic development status is an important foundation for innovation and determines the market size of innovative products. This paper uses the natural logarithm of GDP per capita to measure the level of economic development.

The data are procured from the *China Science and Technology Statistics Yearbook*, *China Financial Statistics Yearbook*, and *China Statistical Yearbook* over the years. The statistical results of the main variables are shown in Table 3.

Table 3. Descriptive statistical analysis of variables.

Variables	Definition (Unit)	Average	SD	Min	Max	Observations
Innovation	Innovation index (null)	28.83	10.56	15.78	59.55	310
Patent	Invention Patent (pieces)	6072	9239	7	53,259	310
Policy	Fiscal and tax policies (items)	2.116	2.494	0	14	310
Fiscal	Fiscal expenditure for science and technology (%)	1.941	1.443	0.293	7.202	310
Taxtot	Total taxes/local GDP (%)	8.235	2.957	4.193	19.965	310
VAT	VAT/total taxes (%)	22.11	11.41	5.915	64.34	310
BT	Business tax/total taxes (%)	31.61	7.418	11.634	54.402	248
IT	Income tax/total taxes (%)	13.98	3.688	3.162	26.30	310
RDL	R&D personnel (person years)	10.95	1.341	6.986	13.54	310
RDK	R&D intensity (%)	1.522	1.090	0.190	6.014	310
PGDP	GDP per capita (yuan)	10.65	0.492	9.241	11.94	310
Str	Industry Structure (null)	1.068	0.355	0.199	2.002	310
Open	Level of Openness (%)	2.816	0.958	0.523	5.043	310
Inf	Traffic infrastructure density (km/km^2)	0.934	0.544	0.045	2.379	310

4.5. Empirical Results

In general, the panel data model is mainly divided into three types: mixed model, fixed effect model, and random effect model. This paper first determined whether to use a fixed-effect model or a random-effect model based on the Hausman test. The test result was 83.32. The null hypothesis was rejected at a significance level of 1%, so the fixed-effect model was more appropriate. At the same time, the Wooldridge test for autocorrelation in panel data was used, and the F test result was 1.679. At a significance level of 10%, the null hypothesis cannot be rejected, that is, the model did not have a serious autocorrelation. The Modified Wald test for heteroscedasticity in the fixed effect regression model was used. The chi-square test results showed that the null hypothesis was rejected at a significance level of 1%, that is, the model had serious heteroscedasticity. Thus, the xtgls model was finally selected to correct heteroscedasticity. The empirical results are shown in Table 4.

Table 4. The results of empirical test.

	Innovation			Ln(Patent)		
Fiscal	0.910 ***	0.507 *	1.093 ***	0.010	−0.034	0.016
	(0287)	(0.307)	(0.290)	(0.020)	(0.025)	(0.021)
Policy	0.360 ***	0.370 ***	0.311 ***	0.014 ***	0.020 **	0.019 ***
	(0.065)	(0.0873)	(0.070)	(0.004)	(0.006)	(0.004)
VAT	12.18 ***			−1.675 ***		
	(4.751)			(0.330)		
BT		−25.22 ***			0.204	
		(4.782)			(0.376)	
IT			−21.33 **			−1.301 ***
			(8.055)			(0.614)
Tax	0.054	0.346 ***	0.164	0.045 ***	0.060 ***	0.039 ***
	(0.106)	(0.123)	(0.118)	(0.009)	(0.011)	(0.010)
RDL	1.990 ***	3.389 ***	2.117 ***	1.084 ***	1.123 ***	1.062 ***
	(0.253)	(0.369)	(0.281)	(0.026)	(0.031)	(0.027)
RDK	1.452 ***	0.780 **	1.668 ***	0.071 **	0.055 ***	0.111 ***
	(0.368)	(0.381)	(0.375)	(0.023)	(0.026)	(0.026)
Open	1.727 ***	1.806 ***	1.665 ***	0.034	0.041	0.044
	(0.286)	(0.361)	(0.313)	(0.027)	(0.031)	(0.029)
Inf	2.324 ***	1.759 ***	2.282 ***	0.051	0.003	0.007
	(0.457)	(0.488)	(0.456)	(0.037)	(0.042)	(0.038)
Str	−3.023 ***	−1.667 **	−2.715 ***	−0.257 ***	−0.327 ***	−0.322 ***
	(0.786)	(0.816)	(0.803)	(0.069)	(0.076)	(0.072)
PGDP	3.414 ***	3.792 ***	3.526 ***	−0.241 ***	−0.294 ***	−0.268 ***
	(0.590)	(0.706)	(0.667)	(0.067)	(0.073)	(0.070)
Constant	−36.79 ***	−62.69 ***	−34.66 ***	−2.415 **	−2.678 *	−2.056 *
	(5.923)	(9.104)	(6.792)	(0.662)	(0.799)	(0.693)
Time effect	Yes	Yes	Yes	Yes	Yes	Yes
Individual effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	310	248	310	310	248	310
Wald	15,523.74	15,472.39	13,327.00	58,231.44	57,348.86	59,728.20

Note: ***, **, and * respectively indicate that the regression coefficient is significant at the statistical level of 1%, 5%, and 10%, with standard deviation in brackets. Ln(Patent) is the natural logarithmic form of variable Patent.

The regional innovation index involves five aspects: knowledge creation, knowledge acquisition, enterprise innovation, innovation environment, and innovation performance. Innovation is a high-input and high-risk activity. As the backbone of regional innovation activities, enterprises not only face huge risks from technology, markets, management, and finance, but also often meet problems such as low internal management, no profit, and difficulty in financing during the R&D stage. Therefore, on the one hand, the government can supplement R&D capital input through fiscal technology expenditure; on the other hand, the government is the creator of the innovation environment and the publisher of the fiscal and tax policies. The government can support innovation activities in the region through fiscal and tax policy tools, create a good environment for innovation, and reduce the risks of enterprise innovation. According to Table 4, regional fiscal science and technology expenditure can promote the improvement of regional innovation capability. The greater the local fiscal science and technology expenditure, the greater is the government's support for R&D investment, which can improve local innovation capability. The fiscal and tax policies issued by the government play a significant role on promoting regional innovation capability. The more the government attaches importance to the incentive role of fiscal and tax policies on innovation, the more preferential policies rolled out, and the creation of innovation environment is more conducive to stimulate enterprises innovation. From the perspective of tax burden, the tax burden can promote regional innovation capability. Reasonable macro tax burden is an important factor for stimulating innovation. The government uses tax revenue to improve regional innovation infrastructure, develop science and technology education, and create a good regional innovation environment by adjusting fiscal policies to promote regional innovation capability. Nordic countries such as Sweden and the Netherlands are typically high-tax-burdened

countries, with taxes accounting for more than 40% of GDP. However, the Nordic countries' tax structure is more reasonable, not based on income tax, but mainly on value-added tax. Taxation can provide superior and affordable medical and social security for domestic residents, increase investment on education and innovation, and give policy and financing tilt to R&D innovation and entrepreneurship, thus eliminating the worries of SMEs and effectively reducing the risk of corporate innovation, which has greatly stimulated the innovation power of enterprises. From the perspective of tax structure, the ratio of value-added tax and corporate income tax to total tax is positively associated with the current regional innovation capability, while the ratio of business tax to total tax is negatively associated with current regional innovation capability. The regions with higher value-added tax, corporate income tax, and lower business tax have stronger current innovation capability. The reform to replace the business tax (BT) with the value-added tax (VAT) in 2016 is the largest tax reform initiative in China since 1994. Prior to the reform, BT was levied on gross turnover with no deduction permitted for tax paid when purchasing other goods or services, which severely restricts the development of the tertiary industry and hinders the sustainable economic development and the improvement of regional innovation capability. Replacing BT with VAT will increase the VAT deduction chain, expand the scope of corporate deductions, avoid double taxation of income, ease the pressure on outsourcing costs, reduce the tax burden, increase the internal cash flow, and thereby promote corporate technological innovation. VAT is also designed to encourage low-end manufacturers to upgrade their technology and capability, and to invest in research and development to move up the value chain. Thus, VAT has a positive impact on regional innovation capability. As the second largest tax, the corporate income tax in china plays a negative role in regional innovation capability. The higher corporate income tax rate causes greater corporate burden, the greater the chance of a company failing financially. The Chinese government offers preferential tax treatment for corporate income that does not have an incentive effect on regional innovation. In addition, the higher corporate income tax rates has adverse effect on growth and employment, and that is associated with higher tax evasion. Thus, corporate income tax is not conducive to R&D investment and innovation. Our empirical results verify the role of higher corporate taxes in reducing innovator incentives and discouraging risk-taking (Mukherjee, et al., 2017) [48].

The invention patent is the best indicator reflecting the regional innovation quality. Therefore, the invention patent grants are used as a substitute variable for regional innovation index. Fiscal policy texts and burden tax still have a significant role in promoting the regional invention patents, indicating that the local fiscal expenditure and fiscal preferential policies are the main means for the government to stimulate innovation. Fiscal technological expenditures and business tax has not played a significant role in invention patents. VAT and corporate income tax have a negative effect on stimulating invention patents. Because the tax incentive policies do not place requirements on the quality of technological innovation, invention patents in China are generally of the highest quality; therefore, tax incentive policies stimulate enterprises to imitation innovation rather than original innovation, thus weakening the incentive effect of tax policies on invention patents. At the same time, in the context of the immature development of China's capital market, the tax regulation on independent innovation is not perfect, and fiscal subsidies have also caused market distortions, unfairness, and rent-seeking to some extent. Therefore, VAT and corporate income tax have a negative impact on invention patents.

Considering the lag of regional innovation output, this paper considers the impact of variables such as fiscal and tax policies on regional innovation capability in the lag period (see Table 5). By comparing the effect of coefficients of various taxes in the current period and the lagging period, we find that the positive impact of macro tax burden on regional innovation capability becomes insignificant, and business tax has a significant role in promoting regional innovation capability. It can be seen that, in the long run, value-added tax and business tax will have a greater effect on promoting regional innovation capability, while corporate income tax will increase the burden and restrain corporate passion for innovation and regional innovation ability. The business tax increases the burden of the enterprise in the short-term, but with the implementation of the reform of BT to VAT, business tax

has been reduced year by year, and the taxation system is more perfect. Thus, business tax has a positive effect on regional innovation capability. At the same time, value-added tax and business tax as regressive turnover taxes will promote the innovation of traditional enterprises and provide a stronger incentive to earn more money than the income tax does. The invention patent grants with lag of one year used as a substitute variable were also introduced. The results show that the promotion effect of business tax on invention patents is significant. Although value-added tax has a promoting effect on the overall regional innovation capability, it has a blocking effect on invention patents; the corporate income tax also has a significant negative effect on invention patents in the long-term. High-tech enterprises and service sectors are the main creators of invention patents. Prior to VAT reform, only industrial businesses and manufacturers operate under the VAT regime, whereas service sectors are subject to pay Chinese business tax. Consequently, service sectors have to pay higher revenue-based taxes and are not able to benefit from VAT deductions. Although enterprises no longer pay business tax after VAT reform, an increase in the value-added tax will increase the burden of high-tech enterprises and service sectors and will have a negative effect on the revenue, weakening innovation motivation accordingly. The preferential policies for value-added tax and corporate income tax are still not perfect. Traditional enterprises in industrial businesses can benefit from the VAT reform. Value-added tax and corporate income tax incentive policies will not stimulate original innovation of the high-tech enterprises. To sum up, value-added tax and corporate income tax have a negative effect on high value patents, while business tax has a positive effect on high-value patents.

Table 5. Robustness test of results.

	Innovation			Ln(Patent)		
	Lag of 1 Year	Lag of 1 Year	Lag of 1 Year	Lag of 1 Year	Lag of 1 Year	Lag of 1 Year
Fiscal	1.091 ***	0.710 **	1.223 ***	0.025	−0.002	0.026
	(0.322)	(0.342)	(0.326)	(0.020)	(0.025)	(0.022)
Policy	0.204 ***	0.257 ***	0.176 **	0.014 ***	0.014 **	0.015 ***
	(0.071)	(0.0761)	(0.072)	(0.004)	(0.006)	(0.005)
VAT	9.482 *			−1.972 ***		
	(5.019)			(0.313)		
BT		29.89 ***			0.217 ***	
		(4.827)			(0.345)	
IT			−27.26 ***			−1.557 ***
			(8.443)			(0.588)
Tax	−0.115	0.181	0.063	0.043 ***	0.049 ***	0.041 ***
	(0.112)	(0.122)	(0.124)	(0.009)	(0.0102)	(0.010)
RDL	1.942 ***	3.081 ***	2.114 ***	1.083 ***	1.107 ***	1.066 ***
	(0.277)	(0.362)	(0.292)	(0.025)	(0.0285)	(0.026)
RDK	1.555 ***	1.040 **	1.825 ***	0.073 **	0.077 ***	0.115 ***
	(0.407)	(0.447)	(0.409)	(0.022)	(0.024)	(0.024)
Open	1.603 ***	1.548 ***	1.567 ***	0.040	0.040	0.048
	(0.306)	(0.361)	(0.323)	(0.027)	(0.031)	(0.030)
Inf	2.473 ***	2.151 ***	2.509 ***	−0.032	0.002	0.006
	(0.485)	(0.515)	(0.484)	(0.037)	(0.040)	(0.038)
Str	−4.369 ***	−2.863 ***	−3.913 ***	−0.190 ***	−0.257 ***	−0.250 ***
	(0.833)	(0.852)	(0.829)	(0.065)	(0.075)	(0.071)
PGDP	3.184 ***	3.741 ***	3.263 ***	−0.319 ***	−0.364 ***	−0.342 ***
	(0.611)	(0.721)	(0.678)	(0.066)	(0.072)	(0.070)
C	−30.93 ***	−59.88 ***	−30.59 ***	−1.374 **	−1.560 *	−1.121 *
	(6.242)	(8.989)	(6.987)	(0.649)	(0.764)	(0.691)
Time effect	Yes	Yes	Yes	Yes	Yes	Yes
Individual effect	Yes	Yes	Yes	Yes	Yes	Yes
Obs.	279	217	279	279	217	279
Wald	11,496.48	16,469.02	11,402.89	61,501.28	63,030.67	69,007.03

Note: ***, **, and * respectively indicate that the regression coefficient is significant at the statistical level of 1%, 5%, and 10%, with standard deviation in brackets.

Regardless of the regional innovation capability or the invention patents, R&D personnel and capital input have a significant promotion effect, indicating that R&D input is the main source of enhancing innovation output. Opening up to the outside world and transportation infrastructure have a significant role in promoting overall regional innovation capability, but their impact on invention patents is not significant, indicating that technology spillovers and infrastructure can promote innovation synergies, strengthen innovation information sharing, and improve the regional innovation capability, while invention patents with higher technical value rely more on independent innovation. There is a significantly negative association between industrial structure and regional innovation capability. This is because the industrial structure index is measured by the ratio of the secondary industry to the tertiary industry. The larger the proportion of the main tertiary industry is, the smaller the industrial structure index is, and the more obvious the upgrading of industrial structure is; moreover, further industrial structure will stimulate the improvement of regional innovation capability and invention patents. The degree of regional economic development has a significantly positive association with the overall regional innovation capability, but a significantly negative association with the invention patents. The more advanced the regional economy, the greater the market demand for innovative product, the more perfect the innovation environment, which will improve the regional innovation capability. However, the higher regional economic development may make enterprises pay more attention to incremental innovation, and then inhibit the original innovation and invention patents.

5. Conclusions and Future Work

The core of high-quality development is to transform the economic growth mode from factor-driven to innovation-driven economy, making innovation the main driving force for the economic development. Given the benefits of innovation in improving the competitiveness and advancing economic growth, many economies have recently begun to formulate conducive policies to boost innovation. However, in the process of independent innovation development, the externality, uncertainty, and high risk of innovation make companies often experience market failures. Therefore, the government departments must adopt reasonable fiscal and tax tools to guide and intervene innovation activities. This paper first uses Python to extract the fiscal and tax policy texts issued by selected provinces in China. Based on the sample of 31 provinces and cities in mainland China from 2009 to 2018, a panel data model was constructed to analyze the impact of the fiscal and tax policies on regional innovation capability. It is found that most of China's provinces and cities are only following the innovation-driven development strategy of China at a macro level and seldom issue the fiscal and tax policies to suit the exigencies of the region. There is greater spatial heterogeneity in policies and regional innovation capability. The results show that fiscal technology expenditures and fiscal policy texts play a significant role in promoting overall regional innovation capability. The impact of different types of taxes on the overall regional innovation capability is different. Value-added tax and corporation income tax have promoted the current regional innovation capability, whereas the business tax has hindered the same. However, in the long run, business tax has promoted, whereas corporation income tax has hindered, the lagging regional innovation capability. In general, value-added tax and business tax promote the overall regional innovation capability. The increase of corporation income tax hinders the improvement of the overall regional innovation capability. The release of suitable fiscal and tax policies helps to stimulate invention patents, and local fiscal technology expenditure does not significantly promote invention patents. Value-added tax and corporation income tax hinder the promotion of invention patents, while business tax promotes the regional invention patents. R&D personnel, R&D capital, and upgradation of industrialized structure are the main factors that promote the overall regional innovation capability and invention patents. Openness, transportation infrastructure, and economic development levels enhance the overall regional innovation capability by improving the innovation environment and increasing the innovation potential. However, the effect of openness, transportation infrastructure and economic development levels is not significant and even has an inhibitory effect on invention patents.

In order to make better use of the incentive effect of fiscal and tax policies on innovation, the government must lay a solid foundation for the steady growth of fiscal investment in science and technology by increasing the fiscal expenditure. At the same time, increasing the support of fiscal technology expenditure for high-tech innovation, reducing the financial science and technology investment's preference for low-tech innovation will render more funds for corporation innovation and basic research to create a conducive environment for independent innovation. For regions with poor economic development levels, fiscal investment in science and technology should pay more attention to investment in innovation infrastructure and gradually adjust the regional innovation orientation from low-tech to high-tech. In regard to the selection of financial subsidy objects, a consumption-oriented financial subsidy mechanism needs to be established. Essentially, a market-consumption-demand-oriented production mechanism has to be established to promote the supply-side structural reforms. At the same time, efforts are to be made to comprehensively promote the reform of value-added tax, improve the tax structure, eliminate double taxation, reduce the burden on enterprises, promote industrial transformation, and service industry development to stimulate corporate innovation vitality.

Although this paper considers the impact of fiscal and tax policy texts (quantity), tax structure, and other factors on regional innovation capability, it does not consider the content and quality of fiscal and tax policies suit to the region. Local governments formulating preferential tax policies on their own can easily lead to vicious competition and disrupt the investment environment, making it impossible for all regions to compete fairly. Therefore, the central government restricted local governments from being able to formulate preferential tax policies at will, and each region faced many restrictions when formulating fiscal and tax policies. To encourage local governments to formulate appropriate fiscal and tax policies according to local conditions, future research may be carried out from the following aspects: use spatial econometric or statistical models to analyze the spatial correlation of regional innovation capability and the spatial spillover effect of regional fiscal and tax incentive policies on regional innovation capability; taking enterprises as research objects, comparatively analyze the impact of direct fiscal subsidies and indirect R&D tax incentive policies on R&D input and output, and heterogeneity of stimulating effect across industries and scale; in addition to enterprises, universities, scientific research institutions, and government agencies (including regional technology transfer networks) are important innovation subjects. Industry–university research cooperation innovation is an important way to accelerate innovation and promote original innovation. The stimulating effects of fiscal and tax policies on technological innovation at different stages may be different. A comparative analysis of the incentive effects of fiscal and tax policies on the innovation R&D stage, the transformation of scientific achievements, and the mass production stage is needed to provide policy advice for formulating appropriate fiscal and tax incentive policies.

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