The Impact of Fiscal Spending, Innovation Output on Economic Growth—Empirical Analysis Based on Mediating Effects Model

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Abstract. Based on panel data of 29 provinces from 2007 to 2016, this paper constructs an intermediary effect model to study the direct effect of fiscal expenditure on economic growth and the intermediary effect of fiscal expenditure on economic growth by promoting innovative output. The results show that fiscal expenditure on people's livelihood significantly promotes innovative output and economic growth, among which the effect of promoting The results show that fiscal expenditure on people's livelihood significantly promotes innovative output and economic growth, among which the effect of promoting innovative output is linear and the effect of promoting economic growth marginal decreases. Innovation output significantly promotes economic growth and marginal increases. The promotion effect of livelihood fiscal expenditure on economic growth includes the direct effect of promoting economic growth and the intermediary effect of promoting Although the part of direct effect and the total effect marginal decreases, the part of mediating effect increases.

Keywords: Fiscal expenditure · Innovation output · Economic growth · Mediation effect

1 Introduction

Fiscal spending has played an important role in the past economic development process and has had a significant impact on promoting economic growth and social welfare. Starting from 2007, the total fiscal expenditure of the Chinese government rose rapidly from 4978.135 billion yuan to 187,755.521 billion yuan in 2016, with an average annual growth rate of about 15.9%. Gross domestic product (GDP), on the other hand, has grown relatively slowly, from 2,702,232.3 billion yuan in 2007 to 7,435,858.5 billion yuan in 2016, with an average annual growth rate of about 11.9%. Fiscal expenditures have grown faster than GDP, while the share of total fiscal expenditures in GDP has gradually increased from 18.4% in 2007 to 25.2% in 2016. It is generally believed that government fiscal spending can have a catalytic effect on innovation output, which can contribute to economic growth, so fiscal spending is likely to contribute to economic growth by promoting innovation output. It is of great practical significance to study the effect of fiscal expenditure on innovation output and economic growth and to clarify the

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mechanism of fiscal expenditure for economic growth, in order to explore a new model of economic growth and build an innovative country.

But is the expansion of the size of government fiscal spending actually effective in promoting innovation and economic growth? When the scale of government fiscal spending is small, the expansion of government fiscal spending can improve the local investment environment, which in turn promotes regional economic growth. However, when the scale of government fiscal spending is large, excessive government spending will crowd out private investment, leading to distortion and inefficient allocation of social resources, increasing the tax burden on society and thus affecting economic growth. Therefore, the impact of fiscal spending on economic growth is likely to be inverted "U" shaped.

Among the studies related to financial subsidies and innovation, Yongze Yu (2009) divided the technological innovation process into two stages, technology development and technology achievement transformation, and conducted a study on the factors influencing innovation efficiency in high-tech industries using the DEA model, and the results showed that government support would promote the efficiency of technological innovation in high-tech industries [1]. Junhong Bai and Jing Li (2011) conducted a study based on data from Chinese industrial sectors, and the results supported the view that government R&D funding would promote innovation efficiency [2]. Gui Huangbao (2014) used a spatial econometric model to investigate the factors influencing R&D efficiency in high-tech industries, and the results showed that the effect of government funding on R&D efficiency was not significant [3]. Fang-Yuan Lu and Yan-Long Li (2016) constructed a stochastic frontier model (SFA) based on provincial panel data in China to study the impact of government financial subsidies on innovation efficiency in high-tech industries, and the results showed that government financial subsidies played a role in promoting innovation efficiency [4]. The vast majority of studies related to the impact of innovation output on economic growth also affirmed the role of innovation in promoting economic growth, and scholars such as Romer (1990), Aghion & Howitt (1992) introduced R&D into the endogenous growth model and proved that innovation can promote economic growth [5, 6]. Wang Zheng et al. (2018) simulated the impact of R&D inputs on economic growth based on the CGE model, and the results showed that R&D can significantly stimulate the overall economy of China. Therefore innovation is likely to be an important channel for fiscal spending to promote economic growth.

Among the studies on the relationship between fiscal spending and economic growth, Barro (1990) introduces government spending into an endogenous growth model and argues that government spending and economic growth have an inverted "U" shaped relationship and that there is a theoretically optimal size of government spending [7]. Vedder & Gallaway (1998) also argue that there is an inverted "U" shaped relationship between government spending and economic growth. Gallaway (1998) also argues that there is an inverted U-shaped relationship between government spending and economic growth [8]. Ma Sanyou (2000) estimated the optimal government expenditure size (as a share of GDP) to be 26.7% based on Chinese data from 1979 to 1998, and the expenditure size is smaller than the optimal size [9]. Pan, Wenqing et al. (2015) conducted an empirical study based on data from prefecture-level cities in China, and the findings

suggest that there is also an optimal size of consumer spending, and the current spending size is smaller than the optimal size, i.e., the expansion of fiscal spending size has contributed to economic growth overall [10]. Li Yanlong (2019) conducts an empirical study based on provincial panel data from 2007–2016 and shows that the relationship between livelihood fiscal spending and economic growth is inverted "U" shaped and most provinces are on the left side of the optimal size, but the impact of productive spending on economic growth is negative [11].

Compared with the existing studies, the contributions of this paper are: first, based on the mediating effect model, the mechanism of fiscal expenditure affecting economic growth by promoting innovation is studied, and the effect of fiscal expenditure on economic growth is decomposed into direct effect and indirect effect (or mediating effect); second, on the basis of the estimation of the mediating effect model, a counterfactual measurement method is used to quantitatively measure the contribution of fiscal expenditure on people's livelihood to the promotion of innovation output and economic growth, so as to more objectively understand the effect of fiscal expenditure on the economy. Second, based on the estimation of the mediating effect model, a counterfactual measurement method is used to quantitatively measure the contribution of livelihood fiscal expenditures to innovation output and economic growth, so as to more objectively understand the effect of fiscal expenditures on the economy; Third, in analyzing the effect of fiscal expenditures on innovation output and economic growth, the effects of livelihood fiscal expenditures and productive fiscal expenditures are studied separately, which is of great practical significance for optimizing the current fiscal expenditure structure.

2 Model Setup and Description

2.1 Mechanisms by Which Fiscal Spending Affects Innovation and Economic Growth

There are various types of fiscal expenditures in China, and various types of fiscal expenditures will bring different impacts on innovation and economic growth. The first is livelihood or welfare fiscal spending such as science, education, culture and health, social security and employment. Government spending on science and technology can directly alleviate the financing constraints of enterprises or institutions such as universities in terms of R&D funding, and most existing studies have shown that government funding for science and technology can improve the innovation efficiency and total factor productivity of enterprises. Government spending on education can improve the quality of education in all regions and improve the quality and competence of the employed population, which in turn will improve the innovation capacity of R&D personnel, which in turn will lead to higher innovation output and economic growth. Government spending on culture and health is also an important and necessary type of fiscal spending in China. The development of culture and health is directly related to the health and material culture of the employed population, which improves the productivity of the employed population and thus contributes to innovation output and economic growth. Social security and employment expenditures, on the other hand, are expenditures that provide basic security to the employed population and are important in motivating our employed population and thus increasing labor productivity.

In addition, although livelihood fiscal expenditures generally contribute to innovation output and economic growth, innovation output is also an important channel through which livelihood fiscal expenditures contribute to economic growth. However, not all livelihood fiscal expenditures promote economic growth through innovation. The improvement of innovation capacity is mainly due to the improvement of R&D personnel's quality, and the improvement of non-R&D personnel's quality also leads to labor productivity growth, but may not lead to economic growth by promoting innovation output. For example, education expenditure can improve not only the quality of R&D personnel but also the quality of non-R&D personnel, so education expenditure can promote innovation output for economic growth on the one hand, and on the other hand, it can also promote economic growth by promoting labor productivity of non-R&D employed personnel rather than innovation output. Thus livelihood fiscal expenditures can promote economic growth through innovation on the one hand, and also through other channels. The impact of livelihood fiscal expenditures on economic growth is manifested as a direct effect and an indirect effect through promoting innovation and thus economic growth.

Second, productive expenditure is also an important type of fiscal expenditure in China and has long been the most dominant type of expenditure, but in recent years, with the increase in the share of livelihood fiscal expenditure, the share of productive expenditure has decreased, but it is still an important type of fiscal expenditure. Capital expenditures such as transportation infrastructure investment expenditures can improve the local investment environment, reduce transportation costs for enterprises, promote R&D expenditures and innovation output of enterprises and thus drive economic growth. Fiscal expenditures on agriculture, forestry, and water affairs can alleviate the financing constraints in agricultural production, improve agricultural productivity and thus drive economic growth. However, since China has long had a larger share of productive fiscal expenditures and a higher bias towards productive expenditures, some studies have shown that the scale of productive expenditures in China is too high, which brings more "crowding out effect". For example, Fan Qingquan et al. (2015) conducted an empirical study based on panel data of prefecture-level cities in China from 2000 to 2012, and showed that there is an optimal fiscal expenditure scale for productive government spending, which has a positive impact on economic growth in 2000–2006, but has a suppressive effect on economic growth in 2009–2012. Had a depressive effect, and the productive fiscal spending since 2009 has been very close to the optimal size [12]. Thus the effects of productive and livelihood spending on innovation and economic growth are likely to be different, which also suggests the importance of analyzing the effects of productive and consumption spending separately.

2.2 Intermediary Effect Model

This paper investigates the mechanism by which fiscal spending promotes innovation and thus economic growth based on a mediating effects model. Firstly, since fiscal spending affects economic growth, this paper sets up the following basic model.

$$\ln Y_{it} = \alpha_{1i} + \beta_1 Gov_{it} + \beta_2 Gov_{it}^2 + X_1 \psi_1 + u_{1it}; \tag{1}$$

The variable Y denotes total output, Gov denotes the size of fiscal expenditure, and the variable Gov^2 is introduced to test whether the effect of fiscal expenditure on economic growth is inverted "U", if it is inverted "U", then it indicates the existence of optimal fiscal expenditure size. X_1 is the control variable affecting X_i is the control variable for economic growth, and α is the regional fixed effect. Then the following model is set up.

$$\ln M_{1it} = \alpha_{2i} + \theta_1 Gov_{it} + \theta_2 Gov_{it}^2 + X_2\psi_2 + u_{2it}; \tag{2}$$

$$\ln Y_{it} = \alpha_{3i} + \lambda_1 Gov_{it} + \lambda_2 Gov_{it}^2 + \lambda_3 \ln M_{1it} + \lambda_4 \ln M_{it}^2 + X_1\psi_3 + u_{3it}; \tag{3}$$

where the variable M denotes regional innovation output and X_2 is the control variable affecting regional economic growth. In the setting of model (2) and model (3), the marginal impact of fiscal spending Gov on total output lnY can be expressed as

$$\frac{d \ln Y}{dGov} = \lambda_1 + 2\lambda_2 Gov + (\lambda_3 + 2\lambda_4 \ln M)(\theta_1 + 2\theta_2 Gov); \tag{4}$$

In model (4), the marginal effect of fiscal spending Gov on economic output lnY is decomposed into two parts, where $\lambda_1 + 2\lambda_2 Gov$ denotes the direct effect of fiscal spending affecting economic output lnY_2 and $(\lambda_3 + 2\lambda_4 \ln M)(\theta_1 + 2\theta_2 Gov)$ denotes the mediating effect of fiscal spending by promoting innovation output and thus economic output. In addition, the mediating effect of fiscal spending by affecting innovation and thus economic growth can be tested under the setting of model (1) to model (3). In this paper, we adopt the approach of Zhonglin Wen et al. (2004) to test [13]. The specific steps are as follows: the first step is to test whether fiscal spending affects firm output according to model (1), and if it is significant, go to the second step, and test whether fiscal spending affects innovation output according to model (2), and if it is significant, go to the third step, and test according to model (3), and if the effect of innovation on economic output is significant, see whether the effect of fiscal spending is significant at this time, and if it is significant, it is a partial mediating If it is significant, the effect is partially mediated, otherwise, the effect is fully mediated.

2.3 Variable Selection and Description

The output variable (Y) is the GDP of each province, but it needs to exclude the effect of price factors, which is discounted in this paper based on the GDP conversion index. The core explanatory variable is government expenditures (Gov). Consistent with most studies, this paper uses the fiscal expenditure of each region as a share of GDP in the current year to measure. This paper defines science, education, culture, health, and social security and employment as livelihood expenditures, and expenditures other than livelihood expenditures and general public service expenditures, national defense expenditures, and public security expenditures as productive expenditures. People's livelihood expenditures (Gov_1) and productive expenditures (Gov_2) are measured by the ratio of expenditure amount to the GDP of the year, respectively. The mediating variable (M) innovation output, the number of patents granted is used as a proxy variable in this paper, while another commonly used innovation output variable is the number of patent applications.

The selected control variables affecting total economic output GDP include (1) industrial structure (*ms*) measured using the sum of value added of secondary and tertiary industries in each province as a share of GDP, and (2) basic input variables (lnL_2 and lnK_2). Labor input L_2 is measured by the number of employed persons in each region, and capital input K_2 is measured by the method of perpetual inventory, whose specific measurement formula is: $K_{2it} = E_{it} + (1 - \delta)K_{2it-1}$, where K_{2it} is the capital stock of region i in period t, δ is the depreciation rate, and E_{it} is the amount of fixed asset investment in region i in period t. *The* base period capital stock is calculated as $K_{i0} = E_{i0}/(g_i + \delta_i)$, and g_i is the annual growth rate of fixed asset investment in region *i. The* depreciation rate δ *is* taken as 9.6% by referring to Zhang Jun et al. (2004) [14]. Before calculating the capital stock, the nominal fixed asset investment is converted to constant price level based on the fixed asset investment price index; (3) Human capital level (edu), measured by the average years of education of employed persons in the region; (4) Financial development level (fd), measured by the proportion of total deposits and loans of banking financial institutions in each region to GDP in that year.

The control variables affecting regional innovation output include R&D labor input (lnL_1) and R&D capital input (lnK_1), in addition to industrial structure *ms*, human capital level *edu*, and financial development *fd.* Labor input L_1 is measured by the natural logarithm of the full-time equivalent of R&D personnel, and K_1 is also measured according to the perpetual inventory method, which is the same as the method of measuring fixed capital stock, but the difference lies in the choice of input flow variables and depreciation rate. lnL is the internal expenditure of R&D funds, and the depreciation rate is 15%. However, before calculating the R&D capital stock, the influence of price factors needs to be excluded, referring to Zhu Pingfang and Xu Weimin (2003) and Li Yanlong (2018), this paper uses 0.55 × consumer price index + 0.45 × fixed asset investment price index for calculation [15, 16].

2.4 Empirical Analysis

The data used in this paper are provincial panel data, and considering the uniformity of caliber and the availability of data, the panel data of the remaining 29 provinces and cities excluding Qinghai, Tibet and Hong Kong, Macao and Taiwan from 2007–2016 are finally selected in this paper. The data used are mainly from the China Statistical Yearbook. The number of employed persons in each region is obtained from the local statistical yearbooks, the share of educated persons in each stage is obtained from the China Labor Yearbook, the data on deposits and loans of regional banking financial institutions are obtained from the China Financial Yearbook, and the full-time equivalent of regional R&D personnel, internal expenditure on R&D funds and the number of patents are obtained from the China Science and Technology Statistical Yearbook.

3 Empirical Analysis

3.1 Fiscal Spending on PEople's Livelihood, Innovation Output and Economic Growth

This paper first analyzes the mediating effect of livelihood fiscal spending on innovation output and possibly through innovation output and thus economic growth, and the

estimation results are shown in Table 1. Where columns (1) and (2) of Table 1 show the estimated results of the impact of livelihood fiscal expenditures on regional innovation output, and columns (3) and (4) are used to test the mediating effect of livelihood fiscal expenditures on promoting economic growth.

As shown in column (1) of Table 1, the coefficient of the variable Gov1 is positive and significant at the 1% level of significance, which indicates that fiscal expenditures on people's livelihoods such as science, education, culture and health, and social security and employment play a significant role in promoting regional innovation output in general. For every 0.01 (1%) increase in the share of livelihood fiscal expenditures in GDP, the innovation output (number of patents granted) increases by about 5.32% on average. After adding the variable Gov12 in column (2), the variables of livelihood expenditure and its squared term are positive but do not pass the significance test, which indicates that the impact of livelihood expenditure on regional innovation output does not show an inverted "U" shape, further indicating the positive contribution of livelihood expenditure to innovation output.

As shown in column (3) of Table 1, the coefficient of variable Gov1 is positive and significant, and the coefficient of variable Gov12 is negative and significant, which indicates that the impact of fiscal expenditure on people's livelihood on economic growth shows an inverted "U" shape. The symmetric axis is about 12.4%, and most of the provinces are on the left side of the inverted "U" curve, which indicates that the impact of fiscal expenditures on economic growth is positive in general, but it shows a marginal decreasing feature, and when the fiscal expenditures on people's livelihood are too large, it will also have a certain degree of negative impact on economic growth.

As can be seen from column (4) of Table 1, the coefficient of the variable Gov1 is still positive and significant after the inclusion of the variable lnM, and the coefficient of the variable Gov12 is still negative and significant, but the coefficient (absolute value) is lower than before the inclusion of the variable lnM, and most of the provinces are still on the left side of the inverted "U" curve. The positive and significant coefficient of the variable lnM indicates that an increase in innovation output significantly contributes to economic growth. At this point, the third step of the mediating effect test has been completed, indicating that the effect of livelihood spending on innovation output and thus economic growth is a partial mediating effect, and that livelihood spending not only increases innovation output and thus economic growth, but also promotes economic growth through other channels such as increasing labor productivity.

However, the effect of innovation on economic growth may be non-linear, and column (5) of Table 1 shows the estimation results with the inclusion of the variable lnM2. From column (5) of Table 1, the coefficient of the variable lnM is negative and significant, while the coefficient of the variable lnM2 is positive and significant, indicating that the effect of innovation output on economic growth is non-linear (positive "U" shape). It is calculated that the level of innovation output in the majority of provinces lies on the right side of the positive "U" curve, which indicates that innovation output contributes to economic growth in general and shows a marginal incremental character, which is consistent with the findings of Jia, J. et al. (2017) [17].

In columns (1) and (2) of Table 1, the coefficient of the variable lnK1 is positive and significant, the coefficient of the variable lnL1 is positive but does not pass the

significance test, and the coefficient of the variable lnK1 is significantly larger than the coefficient of lnL1, which indicates that both R&D labor input and R&D capital input promote the increase of innovation output, but the promotion effect of R&D capital input is more obvious. The output elasticity of R&D capital input is greater relative to R&D labor input, i.e., R&D capital is relatively more scarce. In addition, the sum of the two coefficients is less than one, indicating that the R&D side exhibits a decreasing scale characteristic. The coefficients of the variables lnK2 and lnL2 in columns (3)–(5) are positive and pass the significance test, and the coefficients are less different and the sum of the coefficients is also less than 1. This indicates that both labor and capital inputs are important factors for economic growth, and the current overall performance is also characterized by diminishing returns to scale.

The coefficients of the other control variables show that the coefficients of the variables ms in columns (1)–(5) are negative and significant, and the coefficients of the variable ms2 are positive and significant, and most of the provinces are located on the right side of the U-shaped curve, which indicates that the upgrading of industrial structure brings a significant contribution to both regional innovation output and economic growth. In addition, the coefficients of variables fd and edu in columns (1)–(5) are positive and significant, which indicate that the improvement of both financial development level and human capital level will significantly contribute to innovation output and economic growth.

Further, following the steps of the test for mediating effects also reveals that financial development, human capital, and industrial structure all bring about significant promotional effects on innovation output and economic growth, and all show partial mediating effects. Comparing the estimated coefficients of column (5) and column (3), the coefficient of the variable Gov1 in column (5) decreases to 60.8% and the coefficient of the variable Gov12 decreases to 52.1%, so it can be seen that the mediating effect of financial expenditure on people's livelihood through promoting innovation and thus economic growth accounts for about 40%-48% of the total effect. According to the coefficient changes of other variables, the mediating effect of industrial structure upgrading to promote innovation and thus economic growth accounts for about 25% ~ 45%, the mediating effect of financial development to promote economic growth accounts for about 30%, and the mediating effect of human capital to promote economic growth accounts for about 8%. From the above comparison, we can see that the mediating effect of people's livelihood expenditure on promoting innovation and thus economic growth is larger than the mediating effect of industrial structure, financial development and human capital on promoting innovation and thus economic growth.

3.2 Productive Fiscal Spending, Innovation Output, and Economic Growth

This part of the paper analyzes the mediating effects of productive fiscal spending on innovation output and possibly through innovation output and thus economic growth, and the estimated results are shown in Table 2. Where columns (1) and (2) of Table 2 show the estimated results of the impact of productive fiscal spending on regional innovation output, and columns (3) and (4) are used for possible mediating effects.

Table 1. Fiscal spending on people's livelihood, innovation output and economic growth

	(1)	(2)	(3)	(4)	(5)
	lnM	*lnM*	*lnY*	*lnY*	*lnY*
Gov_1	5.324***	3.925	3.506***	3.276***	2.131***
	(2.97)	(0.85)	(5.27)	(4.93)	(3.07)
${Gov_1}^2$		5.112	−14.119***	−13.181***	−7.357***
		(0.33)	(−6.38)	(−5.94)	(−2.91)
lnM				0.028**	−0.133***
				(2.58)	(−3.46)
lnM^2					0.008***
					(4.37)
lnK_1	0.892***	0.902***			
	(8.19)	(7.97)			
lnL_1	0.009	0.014			
	(0.07)	(0.11)			
lnK_2			0.429***	0.403***	0.418***
			(37.74)	(26.62)	(27.84)
lnL_2			0.382***	0.383***	0.424***
			(8.56)	(8.68)	(9.71)
ms	−66.315***	−67.503***	−28.001***	−27.264***	−21.049***
	(−3.37)	(−3.37)	(−8.87)	(−8.70)	(−6.29)
ms^2	39.222***	39.916***	16.887***	16.443***	12.843***
	(3.34)	(3.34)	(8.94)	(8.77)	(6.45)
fd	0.154**	0.152**	0.048***	0.042***	0.033***
	(2.58)	(2.53)	(5.11)	(4.33)	(3.41)
edu	0.110***	0.109***	0.036***	0.032***	0.033***
	(3.03)	(2.99)	(6.51)	(5.70)	(5.97)
Constant term	21.451**	21.837**	12.709***	12.465***	10.197***
	(2.55)	(2.57)	(9.48)	(9.38)	(7.36)
Number of samples	290	290	290	290	290
Adjust R^2	0.890	0.889	0.986	0.987	0.988

Note: ***, **, * indicate significant at 1%, 5%, and 10% significance levels, respectively, and t-statistic values. Are in parentheses

As can be seen from column (1) of Table 2, the coefficient of the variable Gov_2 is positive, but does not pass the significance test, which indicates that productive spending has a positive effect on innovation to some extent, but this negative effect is not

Table 2. Productive fiscal spending, innovation output and economic growth

	(1)	(2)	(3)	(4)
	lnM	*lnY*	*lnY*	*lnY*
Gov_2	0.696	−0.295	−0.300	0.006
	(0.47)	(−1.19)	(−1.23)	(0.03)
lnM			0.035***	−0.157***
			(2.98)	(−3.99)
lnM^2				0.009***
				(5.08)
lnK_1	1.061***			
	(10.58)			
lnL_1	−0.106			
	(−0.83)			
lnK_2		0.443***	0.410***	0.431***
		(46.27)	(28.20)	(29.85)
lnL_2		0.452***	0.449***	0.456***
		(8.99)	(9.09)	(9.70)
ms	−54.466***	−33.133***	−31.650***	−20.712***
	(−2.77)	(−10.58)	(−10.14)	(−5.65)
ms^2	32.176***	19.998***	19.099***	12.639***
	(2.74)	(10.70)	(10.25)	(5.79)
fd	0.177***	0.061***	0.053***	0.043***
	(2.74)	(6.16)	(5.27)	(4.33)
edu	0.137***	0.036***	0.031***	0.032***
	(3.74)	(6.20)	(5.23)	(5.80)
Constant term	15.257*	14.339***	13.828***	9.911***
	(1.83)	(10.70)	(10.40)	(6.69)
Number of samples	273	273	273	273
Adjust R^2	0.886	0.985	0.986	0.987

Note: ***, **, * indicate significant at 1%, 5%, and 10% significance levels, respectively, and t-statistic values. Parentheses

significant, so the mediating effect through innovation and thus economic growth does not exist statistically. As can be seen from column (2), the coefficient of the variable Gov_2 is negative, but it does not pass the significance test, which indicates that productive fiscal spending shows some degree of negative effect on economic growth, but the effect is small and still statistically insignificant. From column (3), the coefficient of the variable *lnM is* positive and significant, indicating that an increase in innovation output

significantly contributes to economic growth, the same conclusion as in Table 1, and at this point the coefficient of the variable Gov_2 still does not pass the significance test. After adding the variable lnM^2 in column (4), the coefficient of the variable Gov_2 is still insignificant, the coefficient of the variable *lnM is negative and significant, and the coefficient of the variable* lnM^2 is negative and significant, which is still consistent with the findings in Table 1.

The above findings indicate that although innovation output has a significant contribution to economic growth, there is a significant difference between the effects of productive fiscal spending and livelihood fiscal spending on innovation output and economic growth, and the effect of productive spending on innovation output and economic growth is not significant, which can also be considered that the mediating effect of productive spending through affecting innovation and thus economic growth does not exist. In addition, according to the sign and significance of the coefficients of the control variables, it can be seen that the coefficients of the control variables in Tables 2 and 1 obtain basically the same conclusions. All of the above indicate that the upgrading of industrial structure, the level of financial development and the level of human capital promote innovation and economic growth, and show a partial mediating effect.

3.3 Robustness Tests

The above analyses are all based on the estimation of the innovation output variable as the number of patents granted, however, the innovation output variable used in most studies is the number of patent applications. On the one hand, the number of patent applications can contribute to economic growth even if the patents applied for are not granted, and on the other hand, the number of patent applications will not be granted until some time in the future, so the number of patent applications may be a more reasonable variable to measure innovation output. In this section, the above innovation output variables are replaced by the number of patent applications for estimation, and the estimation results are shown in Table 3.

As can be seen from Table 3, the conclusions obtained after replacing the innovation output variable from the number of patents granted to the number of patent applications are basically the same as those in Tables 1 and 2, which further indicates that the findings of this paper are robust to a certain extent. Comparing the results of Table 3 with those of Tables 1 and 2, it can be seen that there are some differences in the coefficient magnitudes of the effects of fiscal expenditures on regional innovation output and the effects of innovation output on economic growth in the results of Table 3. The coefficient of the livelihood fiscal expenditure variable in Table 3 is about twice as large as that in Table 1, which indicates that the marginal impact of livelihood fiscal expenditure on the number of patent applications is larger than the marginal impact on the number of patents granted. The coefficients (absolute values) of variable lnM and variable lnM2 are larger compared to the previous ones, which indicates the relatively larger contribution of innovation output to economic growth when the number of patent applications is used as the innovation output variable. In addition, the coefficients of the variable productive fiscal spending are slightly different compared to before, but still do not pass the test of significance.

Table 3. Fiscal spending, innovation output and economic growth

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	lnM	*lnY*	*lnY*	*lnY*	*lnM*	*lnY*	*lnY*	*lnY*
	Gov_1	Gov_1	Gov_1	Gov_1	Gov_2	Gov_2	Gov_2	Gov_2
Gov	6.736	3.506***	3.294***	2.076***	−0.418	−0.295	−0.279	0.081
	(1.47)	(5.27)	(4.89)	(3.03)	(−0.27)	(−1.19)	(−1.14)	(0.34)
Gov^2	15.881	−14.119***	−13.790***	−6.601***				
	(1.03)	(−6.38)	(−6.23)	(−2.61)				
lnM			0.019*	−0.170***			0.021*	−0.194***
			(1.73)	(−4.47)			(1.88)	(−5.27)
lnM^2				0.009***				0.011***
				(5.15)				(6.10)
lnK_1	1.086***				1.413***			
	(9.67)				(13.66)			
lnL_1	−0.343***				−0.573***			
	(−2.67)				(−4.34)			
lnK_2		0.429***	0.413***	0.417***		0.443***	0.420***	0.429***
		(37.74)	(27.99)	(29.63)		(46.27)	(27.82)	(30.34)
lnL_2		0.382***	0.386***	0.440***		0.452***	0.455***	0.462***

(*continued*)

Table 3. (*continued*)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
		(8.56)	(8.67)	(10.06)		(8.99)	(9.10)	(9.92)
ms	−86.746***	−28.001***	−26.862***	−21.690***	−49.083**	−33.133***	−32.105***	−20.657***
	(−4.37)	(−8.87)	(−8.37)	(−6.74)	(−2.42)	(−10.58)	(−10.15)	(−5.92)
ms^2	51.724***	16.887***	16.200***	13.218***	28.971**	19.998***	19.379***	12.582***
	(4.37)	(8.94)	(8.43)	(6.88)	(2.39)	(10.70)	(10.26)	(6.04)
fd	−0.024	0.048***	0.047***	0.032***	0.079	0.061***	0.058***	0.044***
	(−0.41)	(5.11)	(4.97)	(3.46)	(1.19)	(6.16)	(5.71)	(4.59)
edu	0.065*	0.036***	0.035***	0.035***	0.126***	0.036***	0.033***	0.035***
	(1.81)	(6.51)	(6.21)	(6.47)	(3.33)	(6.20)	(5.67)	(6.39)
Constant term	31.810***	12.709***	12.230***	10.572***	13.825	14.339***	13.935***	10.079***
	(3.77)	(9.48)	(8.97)	(7.90)	(1.61)	(10.70)	(10.32)	(7.16)
Number of samples	290	290	290	290	273	273	273	273
Adjust R^2	0.896	0.986	0.986	0.988	0.882	0.985	0.986	0.987

Note: ***, **, * indicate significant at 1%, 5%, and 10% significance levels, respectively, and t-statistic values are in parentheses

3.4 Nonlinear Decomposition of the Impact of Fiscal Spending on PEople's Livelihood on Economic Growth

From the estimation results in column (5) in Table 1, it is clear that although the direct effect of livelihood fiscal expenditures on economic growth is marginal decreasing, since innovation output significantly promotes economic growth with increasing marginal impact, and livelihood fiscal expenditures significantly promote innovation output, this indicates that the direct effect of livelihood fiscal expenditures on economic growth and the mediating effect of promoting economic growth by promoting innovation and thus economic growth are This suggests that there is a significant difference between the direct effect of livelihood spending on economic growth and the mediating effect of promoting innovation and thus economic growth. Substituting the estimated coefficients in column (5) of Table 1 into Eq. (4) yields.

$dlnY/dGov_1 = \lambda_1 + 2\lambda_2\ Gov_1 + (\lambda_3 + 2\lambda_4\ lnM)(\theta 1 + 2\theta_2\ Gov_1) = (3.506–28.119Gov_1) + (0.0852\text{lnM-}0.708)$, where the first bracket is the direct effect part and the second bracket is the intermediary effect part. It can be found that the direct effect part shows a marginal decreasing characteristic with the expansion of the scale of livelihood financial expenditure, while the intermediary effect part shows a marginal increasing characteristic with the expansion of the scale of livelihood financial expenditure. The second order derivative is less than 0. This indicates that the total effect is marginal decreasing as the scale of fiscal expenditure increases, but the intermediary effect is marginal increasing. This indicates that investing more fiscal expenditure on people's livelihood to promote the increase of innovation output (manifested as increasing the proportion of intermediary effect) can improve the effect of fiscal expenditure on people's livelihood to promote economic growth, although the direct effect is also partially positive, but the direct effect of fiscal expenditure on people's livelihood to promote economic growth will show a marginal decreasing feature as the scale of fiscal expenditure on people's livelihood expands, which is important for optimizing the current fiscal expenditure structure and This is of great practical significance for optimizing the current fiscal expenditure structure and improving the efficiency of fiscal expenditure to better promote economic growth.

4 Conclusions

Based on the panel data of 29 provinces and cities in China from 2007 to 2016, this paper constructs a mediated effects model to investigate the direct effect of livelihood fiscal spending and productive fiscal spending to promote economic growth and the indirect effect of promoting economic growth by promoting innovation respectively, and then conducts a robustness test based on the innovation output index of the number of patent applications, which illustrates that the results of this paper have a certain degree of robustness. Finally, the non-linear effects of livelihood fiscal spending to promote economic growth were decomposed, and the main conclusions obtained in this paper are as follows:

At this stage, the impact of productive fiscal expenditure on innovation output and economic growth is not significant, while the people's livelihood fiscal expenditure significantly promotes innovative output and economic growth, of which the effect of

people's livelihood fiscal expenditure on promoting innovative output is linear, and the effect of promoting economic growth is inverted "U", that is, with the expansion of the scale of people's livelihood fiscal expenditure, it is characterized by marginal decline.

Whether the number of patent applications or the number of patents granted are used as the variable of innovation output, the results show that innovation output also significantly contributes to economic growth, and is characterized by marginal increases as the level of innovation output increases.

The role of people's livelihood fiscal expenditure on economic growth includes the direct effect of promoting economic growth and the intermediary effect of promoting economic growth by promoting innovative output, although the partial and total effects of direct effects are characterized by marginal decline, but the intermediary effect is characterized by marginal increase.

In addition, the study also shows that the output elasticity of R&D capital input is greater than that of R&D labor input, which indicates that R&D capital input is more scarce in China at present. The effects of industrial structure upgrading, financial development and human capital on economic growth are divided into the direct effect of promoting economic growth and the mediating effect of promoting innovation and thus economic growth, but the mediating effect of promoting innovation and thus economic growth is more obvious in the case of livelihood expenditure. However, the mediating effect of livelihood expenditure on innovation output and thus economic growth is more obvious.

Based on the above findings, this paper proposes the following policy recommendations: (1) Expand the scale of fiscal expenditures on people's livelihood such as science, education, culture and health, and appropriately reduce the scale of productive fiscal expenditures such as capital construction. Because the impact of productive fiscal expenditure on innovation output and economic growth is not significant, and the financial expenditure on people's livelihood significantly promotes innovation output and economic growth, the scale of productive fiscal expenditure has now reached near the optimal scale, and the scale of fiscal expenditure on people's livelihood There is still room for expansion, so fiscal expenditures for people's livelihood should be appropriately expanded and productive fiscal expenditures should be moderately reduced; (2)Invest more fiscal expenditures on people's livelihood for promoting the increase of innovation output. However, as the scale of fiscal expenditures on people's livelihood increases, the direct effect of fiscal expenditures on people's livelihood on economic growth will show a marginal decreasing effect, while the intermediary effect of promoting innovation and thus economic growth will show a marginal increasing effect. (Increase the proportion of intermediation effect) can improve the effect of livelihood expenditure on economic growth; (3) Increase the relative proportion of R&D capital investment. At present, the output elasticity of R&D capital input is greater than that of R&D labor input, which is caused by the relative scarcity of R&D capital input in China, while the relative proportion of R&D personnel input is larger, so increasing the relative proportion of R&D capital input can more effectively promote the increase of innovation output and thus economic growth; (4)Promote the upgrading of industrial structure, human capital and financial development level to better promote the growth of innovation output. The impact of industrial structure upgrading, financial development

and human capital on economic growth is also divided into direct effect of promoting economic growth and intermediary effect of promoting innovation and thus economic growth, where the intermediary effect is also marginal increasing, so promoting such factors such as increasing financial support to science and technology and vigorously developing science and technology finance can better promote innovation output and economic growth.

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