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Financing Channels, Innovation Investment and Innovation Sustainability

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Abstract:

Innovation sustainability is of great significance for enterprises to build dynamic competitive advantages, but how to motivate enterprises to innovate continuously is still a key question that academic circles are eager to answer. Technological innovation largely depends on the amount of external financing that enterprises obtain, and maintaining innovation sustainability depends on the long-term investment of innovation funds. How to form a reasonable financing structure through the effective allocation of financial resources is not only related to the performance of financial functions, but also related to the sustainability of enterprise innovation. Therefore, it is of great significance to accurately identify the financing channels of innovation of Chinese enterprises for improving the financing environment and enhancing the innovation ability of enterprises. Based on the 2009-2019 panel data of listed companies in China's strategic emerging industries, I use the expansion model of Euler's equation to empirically study the relationship between financing channels, innovation investment and innovation sustainability. The study finds that internal cash flow and equity financing are the main financing channels for innovation investment in strategic emerging industries. Both commercial credit and informal channel funds have no impact on innovation investment. Debt financing has not only failed to promote technological innovation of enterprises, but on the contrary restricted the investment in technological innovation. When the main financing channels fluctuate, listed companies in strategic emerging industries maintain innovation sustainability through the smoothing effect of cash holdings. Through firm heterogeneity analysis, it is found that young companies and companies with severe financing constraints rely more on the smoothing effect of cash holdings than other firms.

Keywords*: Innovation Investment, Innovation Sustainability, Financing Channels, Euler Equation.*

I. INTRODUCTION

The innovation sustainability of an enterprise is inseparable from long-term innovation investment, and financing channels have a direct impact on innovation investment. Different financing structures have great differences in technological innovation of enterprises. Entering the stage of high-quality development, innovation is an inexhaustible motive force to achieve "high-quality development" and a source of motive force to promote high-quality development. Enhancing the ability of independent innovation and accelerating the construction of the national innovation system have become the key factors for the

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transformation and upgrading of China's manufacturing and the adjustment of industrial structure. The 2019 government work report clearly puts forward that it should insist on innovation to lead the development and foster new momentum. In fact, it emphasizes to seize the "key point" that affects the overall economic and social development through innovation. The development of strategic emerging industries is a strategic choice for China to enhance its independent innovation capability and seize the commanding heights of economic science and technology. However, most of the strategic emerging industries are small and medium-sized enterprises that are highly capital, knowledge and technology intensive. They focus on innovative activities in basic research, which are characterized by large capital investment, long duration and high risk. This characteristic determines that the development of strategic emerging industries needs financial system arrangements that can mobilize more capital and effectively spread risks [1].

The financial system plays an important role in allocating innovation resources and is an important part of the national innovation system. How to form a reasonable financial structure through the effective allocation of financial resources is not only related to the performance of financial functions, but also affects the innovation sustainability. Innovative enterprises are limited by their own production scale, business performance and other factors. The value of their own assets or the amount of funds accumulated in the process of production and operation are often limited. Generally, it is difficult to meet the development needs of the enterprise through internal financing, so external financing is needed. With the development of China's financial industry and the prosperity of the capital market, financial products and financing instruments are constantly being innovated, and enterprise financing methods are showing the characteristics of diversification. Enterprises have a wider range of external financing channels. Apart from the traditional bank loan financing methods, there are also equity financing, bond financing, commercial credit, bank off-balance-sheet financing and other methods. However, the impact of different financing structures on the technological innovation is very different. Brown et al. (2010), He and Wintoki (2016) all conducted research with U.S. enterprises as samples, and found that there is a strong positive correlation between research and development investment and cash flow, and research and development investment mainly relies on internal cash flow [2-3]; Hall (2016) believed that the difficulty of financing innovation investment from outside is the main reason why innovation relies on internal financing [4]. Brown and Petersen (2011) held that equity financing can enable shareholders to share the profits and growth of the enterprise. Without collateral requirements, the increase in equity will not cause problems related to the financial difficulties of the enterprise. Therefore, equity issuance has become the main external financing channel for technological innovation. With the increase in research and development intensity, research and development intensive companies increasingly rely on equity financing [5]; Yosha (1995) found that US research and development intensive companies mainly use equity financing, while Israeli research and development companies rely more on debt financing and government financing [6]. Aghion et al. (2004) found that companies engaged in research and development are more inclined to use debt financing than those that did not by using UK enterprise data, but the amount of debt financing decrease with the increase of R&D intensity, while the probability of issuing new stocks increase with R&D intensity [7].

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To maintain the innovation sustainability, it is inevitable to invest a large amount of long-term funds into R&D projects, which puts forward higher requirements for the allocation of financial resources. At present, China's economy is still in the transition period, and the development of capital market is still immature, with structural defects. Various laws, regulations and systems are still imperfect, resulting in unstable financing channels, high financing cost and low financing efficiency [8]. With the increasingly serious problem of corporate financing constraints in our country, domestic scholars began to study the sources of financing of our enterprises, but have not yet reached a consistent conclusion. Zhong (2016) thought that Chinese enterprises have equity financing preference [9]. Ju (2013) held that equity financing is not the main source of innovation investment for listed companies in China, and internal capital is the main financing channel for innovation investment [10]. Li et al. (2020) thought that equity financing contributes the most to enterprise innovation investment [11], and Lu (2013) found that the sources of funding for research and development of high-tech enterprises are internal cash flow and equity financing, and debt financing are not suitable for R&D investment [12]. Zhang and Yu (2018) believed that the effectiveness of equity financing and debt financing in promoting technological innovation is related to national conditions [13]. So, what is the financing structure for technological innovation in China's strategic emerging industries? Do they have a preference for equity financing? According to the characteristics of technological innovation, the adjustment cost of technological innovation is high. Once the main source of capital fluctuates, it will lead to the interruption of technological innovation. The cost of upfront investment cannot be recovered and becomes sunk cost, causing significant losses to the enterprise [5]. However, innovation projects in strategic emerging industries are generally heavily invested and require higher sustainability of funding. When the main financing channel of technological innovation fluctuates, how can enterprises don’t reduce their current innovation investment and maintain innovation sustainability? This is the main problem to be studied in this paper.

II. RESEARCH HYPOTHESES

According to MM theory, the information is completely symmetrical in a perfect capital market, there is no transaction cost and financing cost, and the investment decision of an enterprise has nothing to do with the financing method. However, the actual capital market often has information asymmetry, and the cost of external financing is obviously higher than that of internal financing. In the investment of technological innovation, the problem of information asymmetry is often more serious than ordinary investment, resulting in a higher premium on external financing, which makes the difference between internal and external financing costs larger. Information asymmetry in technological innovation refers to the fact that technological innovation enterprises often have a deeper understanding of the possibility and nature of success of innovation projects than potential investors, and there is a serious information asymmetry problem between the two parties, which results in the market for financing innovation projects looking like a "lemon" market. Arrow (1962) believed that moral hazard and adverse selection caused by information asymmetry hinder external financing of research and development investment [14]. China's capital market started relatively late, so its development scale and efficiency level lag behind those of western developed countries. The information asymmetry is even more serious, which results in higher external transaction costs. In addition, the high risk of technological innovation projects leads to an

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increase in the market necessary return corresponding to its risk, external investors require higher capital prices. The risk premium corresponding to the information asymmetry and the market necessary return corresponding to the project risk push up the external financing cost of technological innovation together. When strategic emerging enterprises make investment decisions, the cost of capital is a key factor that enterprises need to consider when raising and using capital. From the perspective of cost of capital, enterprise technological innovation will give priority to internal financing.

Hypothesis 1: Endogenous financing is the main financing channel for technological innovation in China's strategic emerging industries.

As most of the enterprises in strategic emerging industries are small and medium-sized entrepreneurial enterprises, their technological advantages have not yet been brought into play, market potential has not yet been released, economic benefits have yet to be released, resulting in insufficient accumulation of internal funds. In addition, and the profitability of emerging enterprises are unstable and vulnerable to the impact of economic cycles and external market demand. Especially when the economic growth rate slows down, the financial expenses of enterprises will increase significantly, and the profits of enterprises will be greatly affected, resulting in unstable internal cash flows. At the same time, the internal cash flow is not only used for research and development investment, but also to meet the capital requirements of daily operation, investment in fixed assets, distribution of dividends, payment of debts, etc. When the internal cash flow is limited, the enterprise will give priority to the internal cash flow for daily operation. When the internal capital is difficult to meet the capital demand for technological innovation, the technological innovation enterprise turns its financing direction to the external financing market. With the increasing investment in technological innovation, technological innovation activities are more dependent on external funds [15], and external financing has gradually become the main capital channel for enterprises to invest in technological innovation [16].

External financing mainly includes debt financing and equity financing. Most of the innovative enterprises are small and medium-sized enterprises, which have typical characteristics of light assets. They usually have less registered capital, low proportion of fixed assets and limited collateral. It is difficult to meet the strict credit requirements of banks, and it is difficult to finance creditor's rights. Hubbard and Kashyap (1992) point out that since most of the value of corporate innovation is embodied in growth opportunities and scientific knowledge, it is unable or difficult to obtain collateral value, and research and development investment may have little or no collateral value, while debt holders such as banks prefer physical assets or repayable assets as collateral for loans, such as fixed assets (plant and equipment) [17]. Qiu and Wan (2015) point out that the value of innovative companies like Samsung and Apple includes a large amount of intangible assets, such as intellectual property and human capital, which are difficult to commit as collateral for external borrowing, especially when competition is fierce [18]; Second, the long duration of investment in technological innovation in innovative enterprises means high uncertainty and high risks. These risks include not only traditional industry risks and business analysis, but also technological risks and sales risks in the process of developing new technologies into products. At the same time, they also face the risk that the value of existing technologies will decline due to the emergence

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of competitors. It is objectively difficult to meet the bank's requirements for risk control; Third, it is difficult for technological innovation activities to obtain stable cash flows. Most innovation projects cannot bring immediate returns and require a long recovery period to achieve revenue [19], while repayment of debts usually requires a stable source of cash flows, which makes the capital recovery period of enterprises inconsistent with the repayment period required by banks, making it more difficult for innovation projects to obtain financing from banks; Fourth, creditor's rights financing is easy to cause enterprises to face financial difficulties. For research and development intensive enterprises, such financial difficulties are often more serious [20]. The expected marginal cost of financial difficulties increases rapidly with the leverage ratio of young high-tech companies. If they face financial difficulties, the market value will depreciate rapidly. Therefore, Hypothesis 2 is put forward:

Hypothesis 2: Technological innovation depends on external financing as well as internal financing, and the main external financing source of technological innovation is equity financing.

Both internal cash flows and equity financing are highly volatile and unstable sources of funding. The main source of internal cash flows is net profit, which is susceptible to the operating risks of the enterprise. Brown et al. (2010) believe that the volatility of net profit is very large. Although labor costs are quasi-fixed in the short term, when other costs or income are impacted, net profit will fluctuate significantly, such as the increase in interest rates, the increase in tax rates, the appreciation of CNY, changes in macro policies and other factors [2]. For China, the volatility of equity financing is more obvious. Since the establishment of Shanghai Stock Exchange in 1990, the stock market has been accompanied by volatility. As the main financing method for technological innovation, when the economy is in a downward trend, it is more difficult for enterprises to finance through equity. From the characteristics of technological innovation, it can be seen that the adjustment cost of technological innovation is very high. Once the main source of funds fluctuates, it will lead to the interruption of technological innovation. High adjustment costs lead to financing constraints that are more binding on R&D-intensive firms [5]. For companies and industries with high R&D intensity and high R&D financing needs, the satisfaction of R&D financing needs will have a more obvious effect on the improvement of technological innovation [15]. When the main financing channel of technological innovation fluctuates, how can enterprises maintain the current investment in technological innovation and maintain the continuity of technological innovation?

One way in which liquidity can create value is to allow capital-constrained companies to manage their liquidity to offset most of the financial shocks when facing them, thus maintaining the stability of technology innovation spending and ultimately reducing adjustment costs [5]. As cash holdings can release liquidity in a short period of time and mitigate the impact of financial distress on R&D, the high adjustment costs associated with changing the investment path of research and development are partially avoided. In a good cash flow situation or a favorable period for issuing shares, an enterprise can establish a cash reserve to prevent the adverse impact of the negative impact of future financing on investment in technological innovation. When funds are in short supply, the enterprise can withdraw cash from the cash reserve, which can partially (or completely) offset the negative impact of cash flow or equity financing,

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and enable the company to better control the current and future adjustment costs of ongoing research and development projects. Therefore, companies facing financing constraints have a strong incentive to build and manage cash reserves to smooth R&D investments. Kim (1998) believed that the optimal cash holdings of an enterprise are the result of weighing the losses caused by low cash holdings against the gains from reducing the need for external capital with high financing costs [21]. Therefore, Hypothesis 3 is put forward:

Hypothesis 3: When the internal cash flow and equity financing of technological innovation fluctuate, the enterprise can maintain the sustainability of technological innovation through the smoothing effect of cash holdings.

A large number of literature shows that the age of the enterprise is an important factor that affects the external financing of the enterprise. Due to the information asymmetry, young enterprises need to pay a higher amount of "risk premium" to obtain external financing, which leads to high financing costs or lack of access to external financing. Therefore, in order to maintain the sustainability of technological innovation funds, the precautionary motivation of enterprises is more intense. On the one hand, young companies are constrained by their own accumulation and have limited internal cash flows. On the other hand, they have insufficient credit in the capital market and are difficult to raise funds. As a result, they may face more severe financing constraints than mature companies. In order to maintain the sustainability of internal innovation funds, young companies are more motivated to carry out cash management and establish cash reserves to buffer the problem of excessive adjustment costs caused by fluctuations in financing sources of technological innovation, so as to protect them from the impact of fluctuations in financing funds. Therefore, they are more dependent on cash holdings to maintain the sustainability of internal innovation funds. Considering the financing constraints, there are differences between mature enterprises and young enterprises in using cash holdings to maintain the sustainability of technological innovation. From this, we can infer the following:

Hypothesis 4: Young enterprises rely on the smoothing effect of cash holdings to maintain innovation sustainability greater than mature enterprises, and enterprises with severe financing constraints rely on the smoothing effect of cash holdings to maintain innovation sustainability greater than other enterprises.

III. Data and Methodology

3.1. Model specification

In order to test the effect of endogenous financing on innovation investment in strategic emerging industries, this paper mainly uses FHP model [22] and Euler equation [23] to test. The models used for the demonstration are as follows:

$$(RD/K)_{i,t} = \alpha_0 + \alpha_1(\mathrm{RD/K})_{i,t-1} + \alpha_2(\mathrm{RD/K})^2_{i,t-1} + \alpha_3(\mathrm{S/K})_{i,t-1} + \alpha_4(\mathrm{CF/K})_{i,t-1} \quad (1)$$

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$$(RD/K)_{\mathrm{i,,t}} = \alpha_1 + \alpha_2 Q_{i,t} + (\mathrm{CF/K})_{i,t} \quad (2)$$

$$(RD/K)_{\mathrm{i,t}} = \alpha_1 + \alpha_2 Q_{i,t} + (\mathrm{CF/K})_{i,t} + lev_{\mathrm{i,t}} + size_{i,t} \quad (3)$$

Formula (1) is the Euler equation model and formula (2) is the FHP basic model. Considering that the size and leverage level of an enterprise will also have an impact on the innovation investment, for example, whether a large-scale enterprise has more funds for innovation investment, and whether an enterprise with high leverage and poor financial position is not interested in innovation investment? Considering these factors, I add enterprise size and asset-liability ratio as control variables on the basis of FHP basic model, and obtains formula (3).

$(□□/□)_{it}$ is the proportion of Company i's innovation investment in Phase t in the beginning of the year. The innovation investment divided by the opening assets is used to eliminate the influence of the size of the enterprise. $(□/□)_{□,□-1}$ is the ratio of sales income to assets in Phase t-1 and $(□□/□)_{□,□}$ is ratio of cash flow to assets in Phase t, Where $(□□/□)_{□,□}$ is the cash flow of Company i in phase t, $Q_{i,t}$ is Tobin Q value in phase t, $□□□_{□,□}$ is the leverage ratio in phase t, $□□□□_{□,□}$ is the size of the Company in phase t, and is expressed by the natural logarithm of the assets at the end of the year.

Brown et al. (2010) extended Euler equation to study whether internal cash flow and equity financing have influence on technological innovation. He introduced the current value and lag period of internal cash flow and equity financing into Euler equation to test whether the technological innovation of enterprises depends on internal cash flow and equity financing [2]. In order to analyze the impact of various external financing channels on investment in technological innovation, I expand the Euler equation in accordance with the idea of Brown et al. (2010) [2]. On the basis of considering internal cash flows, four external financing channels, namely, stock financing, debt financing, commercial credit and informal channel funds, are gradually introduced into the Euler equation. The measurement model for empirical analysis is constructed as follows:

$$(RD/K)_{\mathrm{i,t}} = \alpha_1 (RD/K)_{i,t-1} + \alpha_2 (RD/K)^2_{i,t-1} + \alpha_3 (S/K)_{i,t} + \alpha_4 (S/K)_{i,t-1} + \alpha_5 (CF/K)_{i,t} + \alpha_6 (CF/K)_{i,t-1} + \alpha_7 (Exf)_{i,t} + \alpha_8 (EXF)_{i,t-1} + v_{i,t} \quad (4)$$

In the formula (4), the dependent variable $(□□/□)_{\mathrm{i,t}}$ is the innovation investment of Company i in Phase t, $(□/□)_{□,□}$ is the sales revenue of Company i in Phase t .$(□/□)_{□,□-1}$ is the sales revenue of Company i in Phase t-1, and $(\mathrm{Exf})_{□,□}$ is the external financing of Company i in Phase t, which are respectively the equity financing amount, debt financing amount, commercial credit financing amount and informal channel financing amount. As the paper is to study whether various external financing sources have an impact on innovation investment, the following analysis will focus on the size and significance of the regression coefficient of each financing variable.

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In order to test the smoothing effect of cash holdings in maintaining innovation continuity, the following model is obtained by adding the change amount of cash holdings to formula (4):

$$(RD/K)_{\mathrm{i,t}} = \alpha_1(RD/K)_{i,t-1} + \alpha_2(RD/K)_{i,t-1}^2 + \alpha_3(S/K)_{i,t} + \alpha_4(S/K)_{i,t-1} + \\ +\alpha_6(CF/K)_{i,t-1} + \alpha_7(Exf)_{i,t} + \alpha_8(EXF)_{i,t-1} + \alpha_9 \triangle \mathrm{CashH} + v_{i,t} \quad (5)$$

In formula (5) ΔcashH reflects the change in cash holdings, the coefficient of ΔCashH is negative for enterprises that rely on cash reserves to maintain the innovation sustainability. For those enterprises whose cash holdings do not play a role in maintaining innovation sustainability, the coefficient of ΔCashH should be significantly zero.

At the same time, considering the impact of industry and year, industry and time dummy variables are introduced into the above model to further mitigate the possible impact of missing variables. The industry classification is based on 19 broad categories according to the *Guidelines on Industry Classification of Listed Companies* (Revised in 2012) issued by the CSRC in 2012.

3.2 The Data

This paper takes strategic emerging industries as the research sample. As there is no strategic emerging industry in the current industry classification of the CSRC, it is not possible to directly obtain a sample of listed companies in strategic emerging industries. In order to obtain a sample of listed companies in strategic emerging industries, this paper follows the following steps: the initial sample of this paper is selected from the sample of China Securities Index Company Limited and China Strategic Emerging Industries Composite Index (the "Emerging Composite Index") issued by Shanghai Stock Exchange in 2017, which covers a total of 1,117 companies in Shanghai and Shenzhen A-shares, small and medium-sized boards, GEM and New Third Board. As the data disclosed by New Third Board-listed companies are less and less comparable with other listed companies, it is removed from the sample box. Next, this paper sets some conditions for deletion in the sample database: First, the samples of ST and *ST listed companies in the sample period range are deleted; Second, the data of listed financial and insurance companies have been deleted; Third, delete the samples with missing values. After the above-mentioned deletion, the final sample is 773 listed companies of strategic emerging enterprise 2009-2019.

3.3 Variable

The definitions and descriptions of each variable involved in this paper are shown in Table I:

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TABLE I. Definition and Description of Variables

Variable name	Variable code	Variable dataset description
Technical Innovation	RD/K	Current year research and development expenditure/Total assets at the beginning of the period
Sales Revenue	S/K	Revenue from sales for the current year/total assets at the beginning of the period, of which revenue from sales is derived from the principal business in the profit statement.
Internal Cash Flow	CFK	(net profit for the current period+ depreciation charge for the current period)/assets at the beginning of the period, where depreciation charge for the current period = accumulated depreciation for the current period– accumulated depreciation for the previous period
Stock Financing	Stk	During the current period, the enterprise discovers the funds raised by the shares/assets at the beginning of the period, among which the funds raised by the shares are found to be "cash received from absorbing equity investments" in the cash flow statement.
Debt Financing	Debt	New loans of assets at the beginning of the period/assets at the beginning of the period, among which the new loans are from "cash received from borrowing" in the cash flow statement.
Mercantile Credit	Cred	(accounts payable+ bills payable+ receivables in advance)/assets at the beginning of the period
Informal Capital	Infm	The enterprise's current informal financing funds/assets at the beginning of the period, which are derived from "other cash received in relation to financing activities" in the cash flow statement.
Changes In Cash Holdings	ΔcashH	The net increase in cash and cash equivalents in the statement of cash flows is measured
Company Size	Size	Logarithm of current assets of an enterprise
Asset-Liability Ratio	Lev	The current asset-liability ratio of the enterprise

IV. EMPIRICAL RESULTS AND DISCUSSIONS

4.1 The impact of Endogenous Financing on Innovation Investment

For the FHP model, this paper estimates according to the model (1) and model (2) set up above. Model (1) is the FHP basic model and model (2) is the FHP model with relevant control variables. In order to determine the type of panel model, the above two models are tested by F test and Hausman test. From the F test results, it can be seen that the F statistic of the basic model is 12.25, the corresponding P value is

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0.0000, and the F statistic of the FHP model with relevant control variables is 12.5, the corresponding P value is 0.0000. The two models reject the original assumption of mixed regression, that is, the panel model is considered to have individual effect. According to the results of Hausman test, the corresponding P values of the two models are 0.0000, which strongly rejects the original assumption of random effect, so the individual fixed effect model is chosen. The specific estimation results are as follows:

TABLE II. Regression results of FHP model

Variable	Model 1	Model 2
CFK	0.035***(0.008)	0.044***(0.008)
TobinQ	0.001***(0.000)	0.0013***(0.000)
size		0.004***(0.001)
lev		0.006*(0.003)
Constant	0.027***(0.001)	-0.065***(0.013)
R-squared	0.031	0.048
Sample size	773	773

Notes: ***, ** and * mean significant at the significance level of 1%, 5% and 10%, respectively; The figures in brackets are standard errors, the same as below.

The regression results in Table II show that, whether it is the FHP basic model or the FHP model with relevant control variables, the regression coefficients of Tobin Q value and cash flow are significant positive at the significance level of 1%, which indicates that the market value and cash flow of an enterprise positively affect the innovation investment. The higher the market value of an enterprise, the greater its investment in technological innovation, the greater its cash flow, and the higher its innovation investment, indicating that investment in l innovation investment in China's strategic emerging industries generally depends on internal cash flow.

For the investment model of Euler equation, since the explanatory variables contain the lag term of the explained variables, a dynamic panel model is formed. There is an endogenous relationship between the explanatory variables and the explained variables, which leads to the gradual correlation between the lag variable that changes within the group and the error term that changes within the group. If the parameter is still estimated by using the estimation method of the ordinary panel model, a "dynamic panel deviation" will appear. Therefore, the tool variable method is needed to overcome the parameter estimation problem caused by the model's endogeneity. As the systematic GMM method increases the number of moment constraints, the problem of validity of GMM estimators arises. However, the limited information maximum likelihood estimation method is not sensitive to weak instrumental variables, which can avoid the problem of weak instrumental variables. In this paper, both systematic GMM and limited information maximum likelihood estimation are used to estimate the investment model of Euler equation.

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TABLE III. Regression results of Euler equation investment model

Variable	System GMM Estimation	Likelihood Estimation
L.RK	1.202***(0.032)	1.109***(0.0435)
$(L.RK)^2$	-2.377***(0.088)	-1.757***(0.301)
L.(CF/K)	0.075***(0.008)	0.022**(0.009)
L.(S/K)	-0.017***(0.001)	-0.005***(0.002)
Constant	0.005***(0.001)	0.003***(0.001)
Sample size	757	757
AR(1)	-4.1011	
AR(1) P value	0.0000	
AR(2)	-0.2836	
AR(2) P value	0.7768	

The premise of the system GMM estimation method is that there is no autocorrelation for the perturbation term and it can be seen from Table III that the value of AR (1) of the system GMM is -4.1011, the corresponding P value is 0.0000, the value of AR(2) is -0.2836, and the corresponding P value is 0.7768, which indicates that at the significance level of 5%, there is a first-order autocorrelation for the difference of the perturbation term, but there is no second-order autocorrelation. The original assumption that "there is no autocorrelation for the perturbation term" is accepted. The result of Saran test is $P<0.1$, indicating that the original assumption that the tool variables are valid cannot be rejected at the significance level of 10%, That is to say, the tool variables are all valid, indicating that the setting of the model is reasonable. When estimating the model, the variables on the right side of the model are regarded as endogenous variables according to the estimation method of Brown [2].

From the regression results in Table III, it can be seen that the coefficient estimates of the limited information maximum likelihood estimation and the system GMM estimation are very close. The coefficient of cash flow lag period is both positive and significant at the significance level of 5%, indicating that the cash flows of listed companies in strategic emerging industries in China have obvious promotion effect on innovation investment and the innovation investment has obvious dependence on internal cash flows. The coefficient of the lag period of innovation investment in GMM estimation method and likelihood estimation method is significantly positive, indicating that the innovation investment in the previous period has a significant positive impact on the innovation investment in the current period, which is closely related to the long investment cycle and sustainability characteristics of innovation project. In addition, in both models, the square term of the lag period of innovation investment is negative at the significance level of 1%, which confirms the expectation of Bond and Meghir (1994) when deducing the Euler equation investment model [24].

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From the analysis results of the FHP model and the Euler equation investment model, it can be seen that the regression coefficient of cash flow in the two models is significantly positive, indicating that the innovation investment is obviously positively affected by the internal cash flow of the enterprise, that is to say, endogenous financing is the main financing channel for technological innovation in China's strategic emerging industries, which verifies Hypothesis 1.

4.2 The Impact of External Financing on Innovation Investment

As the model (4) not only involves the current value of each financing channel variable, but also involves the lag term, when the impact directions of the two variables on innovation investment are inconsistent, it is difficult to directly analyze the impact of this explanatory variable on the explained variable. This paper explains the regression coefficient in the model referring to the method of Brown et al. (2010), through the chi-square test to illustrate the impact of various financing channels on innovation investment [2]. The original assumption of Chi-square test is that the sum of regression coefficients of current term and lagging term of financing channel is zero. If Chi-square test rejects the original assumption, it indicates that the impact of financing channel on innovation investment is significant. When the sum of regression coefficients of current term and lagging term is positive, it indicates that the impact of financing channel on technological innovation is positive; otherwise, it is negative.

TABLE IV. Regression results of External Financing on Technological Innovation Investment

Variable	Model 1	Model 2	Model 3	Model 4
	equity financing	debt financing	credit	informal channel funds
L.RK	1.050***	1.102***	1.221***	1.172***
	(0.020)	(0.019)	(0.020)	(0.018)
$(L.RK)^2$	-1.753***	-1.917***	-2.420***	-2.085***
	(0.056)	(0.052)	(0.055)	(0.040)
CFK	-0.049***	-0.065***	-0.081***	-0.063***
	(0.009)	(0.007)	(0.007)	(0.005)
L.CFK	0.083***	0.080***	0.107***	0.098***
	(0.006)	(0.005)	(0.004)	(0.004)
S/K	0.024***	0.022***	0.019***	0.027***
	(0.001)	(0.001)	(0.001)	(0.001)
L.S/K	-0.024***	-0.022***	-0.016***	-0.031***
	(0.001)	(0.001)	(0.001)	(0.001)
Exf	0.011***	0.001	0.023***	-0.001
	(0.001)	(0.001)	(0.003)	(0.003)
L.Exf	-0.009***	-0.011***	-0.026***	-0.008***
	(0.001)	(0.000)	(0.001)	(0.002)
Constant	0.001	0.002***	-0.005***	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)

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Sample size	757	721	757	691
AR (1)	-6.258	-4.916	-5.424	-5.156
AR (1) P value	0.000	0.000	0.000	0.000
AR (2)	-0.418	-0.763	-0.703	-0.981
AR (2) P value	0.676	0.445	0.482	0.326
Sargan value	0.163	0.089	0.277	0.119

Table IV examines the impact of various external financing channels on innovation investment. Items (2) to (5) are models added with equity financing, debt financing, commercial credit and informal financing respectively on the basis of internal cash flows. From the perspective of model setting, the differences of the disturbance terms of the four models all have first-order autocorrelation, but there is no second-order autocorrelation. The original assumption that "the disturbance terms have no autocorrelation" and the Sargan value cannot reject the original assumption that "all tool variables are valid" at the significance level of 5% are accepted, indicating that the model setting is reasonable. According to the internal cash flow coefficients, the sums of current and lag period coefficients of cash flow in model 1, model 2, model 3 and model 4 are all significantly positive at the 1% significance level. Chi-square test is performed on the sum of the current and lag period coefficients, and the original assumption that the sum of the coefficients of cash flow is 0 is rejected in all four models, which shows that the positive effect of cash flows on innovation investment remains unchanged regardless of which external financing channel in the models. This conclusion is consistent with the result obtained by the Euler equation investment model, and once again shows that innovation investment in China's strategic emerging industries is dependent on internal cash flows. Judging from the coefficients of various financing channels, the current and lag coefficients of equity financing in Model 1 are significantly positive and negative respectively, and the sum of the two is 0.002 (the P value of Chi-square test is 0.0095, and the original assumption that the sum of the coefficients is 0 is rejected), indicating that equity financing has a positive role in promoting China's innovation investment in strategic emerging industries, and equity financing is the main financing source of China's innovation investment in strategic emerging industries. From the test results of model 2, it can be seen that the current value coefficient of debt financing is not significant, while the lag period coefficient is significantly negative, indicating that debt financing is not the main financing channel for innovation investment, but has restricted the innovation investment. The test results of model 3 show that the coefficients of current period and lag period of commercial credit are significantly positive and negative respectively, and the sum of the two coefficients is -0.0031, but the chi-square test accepts the original assumption of 0 (the p value of chi-square test is 0.2174), which indicates that commercial credit is not the main financing source for innovation investment. The test results of model 4 report that the current coefficient of informal channel financing is not significant, while the lag coefficient is significantly negative, indicating that informal channel financing is also not the financing source of innovation investment.

The above test results show that for listed companies in China's strategic emerging industries, internal cash flow and equity financing are the main financing channels for innovation investment. Neither commercial credit nor informal channel funds have an impact on innovation investment. Debt financing

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not only does not promote innovation investment, but also restricts innovation investment of enterprises and is not a main financing source for innovation investment. Therefore, equity financing is the main channel of external financing for China's strategic emerging industries, which verifies hypothesis 2.

4.3 The Smoothing Effect of Cash Holdings on Innovation Sustainability

TABLE V. Regression results of the smoothing effect of cash holdings on innovation persistence

variable	Model 1	Model 2	Model 3	Model 4	Model 5
	overall sample	young enterprises	mature enterprises	enterprises with lower financing constraints	enterprises with higher financing constraints
L.RK	1.063***	1.203***	0.804***	1.282***	0.815***
	(0.018)	(0.020)	(0.010)	(0.008)	(0.008)
$(L.RK)^2$	-1.743***	-1.812***	-1.330***	-2.036***	-1.500***
	(0.049)	(0.096)	(0.025)	(0.033)	(0.021)
CFK	-0.042***	-0.013***	-0.034***	-0.023***	-0.028***
	(0.008)	(0.005)	(0.004)	(0.002)	(0.003)
L.CFK	0.077***	0.083***	0.042***	0.038***	0.0411***
	(0.006)	(0.002)	(0.004)	(0.001)	(0.003)
S/K	0.024***	0.013***	0.027***	0.025***	0.014***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)
L.S/K	-0.025***	-0.024***	-0.023***	-0.023***	-0.015***
	(0.001)	(0.001)	(0.000)	(0.000)	(0.004)
Stk	0.018***	0.012***	0.031***	-0.009***	0.053***
	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
L.Stk	-0.010***	-0.011***	-0.005***	-0.017***	-0.003***
	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)
ΔCashH	-0.015***	-0.013***	-0.002***	0.008***	-0.020***
	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
Constant	0.000	0.001*	0.004***	-0.006***	0.005***
	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)
Sample size	757	479	579	381	376

Model 1 in Table V reports the effect of the smoothing effect of cash holdings on the innovation sustainability. The regression results show that the coefficient of ΔcashH is all significantly negative at the significance level of 1%, indicating that innovation investment increases with the decrease in cash holdings. The coefficient of ΔcashH -0.0146 indicates that if an enterprise reduces its cash holdings by one unit, the technological innovation investment will increase by 0.0146 units. This means that the larger the decrease in the current cash holdings level of an enterprise, the more liquidity released through the change in cash holdings, and the stronger the effect of cash holdings on maintaining the sustainability of internal innovation funds. The empirical results show that the smoothing effect of cash holdings is common in

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China's strategic emerging industries to maintain the sustainability of internal innovation funds, which verifies hypothesis 3. In addition, the coefficient of equity financing and cash flow are basically consistent with the previous estimation results, indicating that the estimation results are robust.

Model 2 and Model 3 in Table V are the test results of the cash holdings of young enterprises and mature enterprises in maintaining the innovation sustainability respectively and the sample is divided based on the age of the enterprises (A company whose age is older than the average is a mature company, and a company whose age is younger than the average is a young company). The purpose of dividing the sample into mature enterprises and young enterprises is to examine whether there is a significant difference in the role of cash holdings in maintaining innovation sustainability in the two types of samples. Therefore, the focus of this study is on the magnitude and significance of the change coefficient of cash holdings in the two types of samples. In the young sample, the coefficient of ΔcashH is -0.013, and in the mature sample, the coefficient of ΔcashH is -0.0022. Both coefficients are significantly negative at the significance level of 1%. From the comparison of the two sets of coefficients, it can be seen that the absolute value of ΔcashH coefficient of the young sample is significantly greater than that of the mature sample, indicating that the young enterprises rely more on the smoothing effect of cash holdings to maintain innovation sustainability, which verifies hypothesis 4.

In order to verify whether the role of cash holdings in maintaining the innovation sustainability is related to the degree of financing constraints of the enterprise, the sample is divided into two groups based on the degree of financing constraints (enterprises with more severe financing constraints than the average and enterprises with lower financing constraints than the average). Model 4 and Model 5 in Table V are the test results of cash holdings with lower financing constraints and enterprises with more severe financing constraints in maintaining innovation sustainability, respectively. The test results report that in the more severe financing constraint sample, the coefficient of ΔcashH is -0.0202, and in the lower financing constraint sample, the coefficient of ΔcashH is -0.0081, and both coefficients are significant at the significance level of 1%. It can been seen that the absolute value of the coefficient of ΔcashH of the more severe financing constraint sample is significantly greater than that of the lower financing constraint sample, indicating that the smoothing effect of cash holdings is more obvious in the enterprises with severe financing constraints, specifically as follows: the more severe financing constraints the enterprises rely on the smoothing effect of cash holdings to maintain the innovation sustainability, which verifies hypothesis 4.

In principle, the company should hold an appropriate amount of cash by the operating and competitive environment. As early as Keynes's literature (1936), it was shown that companies with financial constraints were more likely to hoard cash, that is to say, enterprise characteristics largely determine the optimal level of enterprise cash holdings, but many factors of research and development companies may increase the tendency to hold cash, such as fluctuations in cash flows, fluctuations in stock issuance, competition and financial constraints [3]. Bates (2009) points out that external financing costs for R&D expenditures are more expensive than ordinary capital, so research and development expenditure will be more inclined to use cash holdings to deal with the impact of future cash flows [25]. The importance of cash holdings to

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research and development intensive companies is maintaining the continuity of internal innovation funds and ensuring the smooth progress of innovation activities. Therefore, for enterprises facing financing constraints, in order to maintain the sustainability of internal innovation funds, cash reserves must be made to avoid the adverse impact of capital fluctuations on innovation.

V. CONCLUSION

Based on the panel data of listed companies in China's strategic emerging industries from 2009 to 2019, I empirically study the relationship between financing channels, innovation investment and innovation sustainability in strategic emerging industries by using the extended model of Euler equation. The study finds that, firstly, China's strategic emerging industries mainly rely on internal cash flow and equity financing for innovation investment. Both commercial credit and informal channel funds have no impact on investment in innovation investment. Debt financing does not promote technological innovation of enterprises, but restricts investment in technological innovation of enterprises. Second, when major financing channels fluctuate, listed companies in strategic emerging industries maintain the innovation sustainability through the smoothing effect of cash holdings. Young enterprises and enterprises with severe financing constraints rely more on the smoothing effect of cash holdings.

The research conclusion of this paper has strong enlightenment significance. On the whole, the development and growth of strategic emerging industries cannot be separated from the support of capital. The government should focus on optimizing the external environment for investment and financing of innovation, and build a sound financial system to support technological innovation of strategic emerging industries. The main external financing channel for China's strategic emerging industries' innovation is equity financing. However, at present, China's direct financing market is still underdeveloped, the scale of direct financing is insufficient, and indirect financing is still the main financing method for enterprises, which causes the problems of difficult and expensive financing for enterprises. Therefore, on the one hand, there is an urgent need to expand financing channels, vigorously develop direct financing, and promote the reform of the stock and bond markets, so that direct financing methods have a corresponding scale and diversified structure; On the other hand, it is necessary to improve the service efficiency and service experience of the financial industry, form financing platforms and tools specifically for research and development intensive industries such as strategic emerging industries. The government should guide and encourage venture capital and long-term capital to invest in technological innovation projects, and finally a technological innovation financing system is formed, based on market mechanism, guided by government investment and widely participated by social capital so that more financial resources can flow to innovation projects and innovation enterprises.

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