# Financial Constraints, Financing Channels and Corporations' R&D Investment

## —Based on Development Phase and Heterogeneity of Operating Cash Flow

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## Abstract

R&D investment is an important corporate data that government needs to pay attention to especially when Chinese economy is facing essential transition. Considering the diversity of R&D phase and cash flow condition, we divide the corporations listed in the growth enterprise market (GEM) into four types and discuss corporations' preferred channels to finance R&D investment and if each type of corporations faces identical financial constraints. Using panel data and q model, our analysis proves that listed corporations in GEM are facing financial constraints; operating cash flow is still the main capital source of R&D investment. If cash flow was favorable, corporations whose R&D project is in development phrase would prefer to finance R&D investment by debt and equity channels, bearing more loosely financial constraints. If cash flow was deficient, the channel of debt financing would no longer support R&D, and corporations in development phrase would more rely on equity financing, while corporations in research phrase would just maintain a low level of R&D investment by cash in hold.

## Keywords

## 1. Introduction

Since reform and opening up, our national economy has experienced thirty years of rapid growth. Although the old mode of economic growth, which depended on resource consumption and cheap labor force, had helped

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China achieve spectacular economic miracles, more and more problems and deficits are exposed with the development of economy and society. "The lateral reform for supply" and "the innovation-driven" have become the key words under our current economic conditions. Since China is in an important period of economic transition now, it is a great developing strategy for China to promote independent innovation and build an innovation-oriented country. Firms, as the most dynamic subject which is the closest to markets in business activities, are the main administrator in technology research and development and production innovation. Since a lot of R&D investment is needed during the process of technology research and development and product innovation, the R&D investment in corporation level could be concerned as one of the key factors that could improve technical innovation and macroeconomic growth. However, R&D investment has many disadvantages, such as longer cycle, bigger risks, higher adjustment cost, asymmetric information and a lack of collateral, leading to a more serious problem of financial constraints faced by innovative corporations. The corporations that are facing financial constraints could only make use of the cash flow which is internally generated and decide the scale of R&D investment by making ends meet, which will limit the development of various economic activities. What's more, corporations might miss many key occasions for product innovation, technological upgrading and strategic transformation, which will not only bring huge economy loss to corporations, but also might play a negative role at macro level on our transformation of economy growth pattern from "factor-driven" to "innovation-driven".

Recently, the problems of the functional mechanism and inner relation between financial factors and corporations' R&D investment have become an important perspective in the research for innovation theory. Foreign scholars also have all studied the mechanism of the inner relation between financial factors and corporations' R&D investment, providing support to the acceleration of corporations' R&D investment on financial development. Besides, there is some domestic literature which discussed the relation between financial factors and corporations' R&D investment. Among them, Chinese scholars have checked the sensitive problem between corporations' R&D investment and cash flow. Some specific literature also had discussed the influence of exogenous financing channels and cash in hold on corporations' R&D investment. However, most of the researches focused on checking the sensibility of corporations' R&D investment on cash flow and analyzing the influence of debt rights or equity financing on corporations' R&D investment. However, there are few literature systems analyzing the differences of contributions from different financing channels towards corporations' R&D investment. Besides, the current researches are classified by corporations' ownership nature, asset size and founded time so as to discuss different financial constraints faced by various types of corporations. But, there is no literature studying whether the corporations, which are in different development phases and different operating cash flow status, are faced with different financial constraints or whether the bias of different financing channels are existed. Thus, based on the listed corporations in GEM before 2011, this thesis empirically tested and analyzed the contributions of five financing channels (capital sources), namely operating cash flow, debt financing, equity financing, corporations' own cash flow and governmental subsidies on corporations' R&D investment through the sample data collected during 2011 to 2014. What's more, this thesis classified the sample corporations into four categories further based on development phases and corporations' cash flow status, empirically testing the contribution differences of different financing channels towards different corporations' R&D investment so as to provide theoretical support to the construction of policy systems to facilitate the development of independence innovation.

## 2. Literature Review and Research Hypothesis

### 1) The financial constraints and sensitivity of R&D investment on corporations internal cash flow

Myers & Majluff (1984) [1] put forward "the pecking order theory" of financing, which held the point that external creditors and equity investors would be faced with severe information asymmetry when evaluating corporations' investment projects, leading to a higher cost of external financing (debt financing and equity financing) than internal financing (operating cash flow and retained income). Thus, when making an investment, corporations will prefer to use internal cash flow and retained income to fund the investment projects. Only when internal financing could not meet the fund demands of investment projects will the corporations search for external financing. Faced with financial constraints, corporations could hardly raise sufficient capital through the external channels to support projects. As a result, corporations could only make decisions on investment scale within their means according to the current status of internal cash flow. Therefore, an increase in operating cash flow will provide corporations with more internal capitals to make the investment on a much grander scale, which results in an increase of sensitivity of enterprise investment on internal cash flow. Based on the above

analysis, Fazzari *et al.* (1988) [2] has been the first to judge whether corporations are faced with external financial constraints by checking the sensitivity between corporation investment and internal cash flow.

Meanwhile, the characteristics of research, such as longer cycle, bigger risks, higher adjustment cost, asymmetric information and a lack of collateral, make it difficult for corporations which are faced with financial constraints to raise fund through the channels of debt financing and equity financing when investing in research and development projects. Therefore, there is a significant positive correlation between the financial constraints of corporations' R&D investment and operating cash flow. Based on the above analysis, many scholars have applied the method proposed by Fazzari *et al.* (1988) into the theoretical research of R&D innovation of corporations afterward. Hall (1992) [3] has empirically tested the positive correlation between R&D investment and operating cash flow based on the data of manufacturing corporations in America from 1973-1987. According to the related data of 179 new & high-tech small-sized corporations in America, Himmelberg and Petersen (1994) have found that internal finance is the main capital source of corporations' research and development activities since new & high-tech corporations are seriously restricted by external financial constraints. Besides the research on American corporations, some scholars also have studied the corporations in many other countries, such as Japan, Germany, Belgium, Denmark and so on, the result of which has proved that there is a significant sensitivity from the R&D investment of the corporations faced with financial constraints to their internal cash flow (Mulkay, 2001 [4]; Bond, 2003 [5]). In the domestic area, Liu Li (2003) [6] has proposed in his research that corporations' R&D investment would be restricted when there is a lack of internal capital. However, the increase of operating cash flow has a positive effect on the conduct of research and development activities. Tang Qingquan (2010) [7] has found that it is the characteristics of R&D activities that lead to a serious condition of information asymmetry with external investors during the course of R&D based on the relationship of corporations' R&D investment and internal cash flow. Thus, it is difficult for corporations to raise R&D fund through debt financing and equity financing; instead, they could only rely on the internal cash flow in corporations, which prove the existence of cash flow within the corporations. Taking Chinese listed manufacturing corporations as the research subject, Guo Xinwei (2014) has supported the above view by GMM method that R&D investment of the corporations which are faced with financial constraints relies on internal cash flow. Thus, this thesis put forward the hypothesis as following:

H1: The R&D activities of our listed corporations in GEM might be faced with external financial constraints to a certain extent, that is to say, there's a significant positive correlation between R&D investment and operating cash flow.

**2) The promotion of external financing channels on corporations' R&D investment**

Debt financing and equity financing are the traditional external financing channels. The existing researches have confirmed that equity financing plays a positive role on corporations' R&D investment. However, whether debt financing would promote efficiently the R&D investment of corporations remains controversial in the academic field. For example, Liu Zhen (2009) [8] has found in his research that internal financing and equity financing are the main capital sources for new high-tech corporations, but the capitals raised by debt financing do not apply to R&D investment. What's more, Xiao Hailian (2014) [8] has proposed in her research that there is a negative correlation between R&D investment and corporations' financing leverage, that is to say, corporations would not provide capital support for R&D projects through the way of increasing debts. Besides, Lu Xin and Zhen Yangfei (2013) [8] had also empirically tested the relationship among R&D investment, internal cash flow, external debt rights and equity financing based on the samples of new high-tech corporations listed on the main board during 2007-2009. The result shows that it is difficult for Chinese high-tech listed corporations to obtain equity financing since the main capital sources of R&D are internal operating cash flow and equity financing. However, there are other research results which are different from the above one in this field. For example, based on Chinese manufacturing listed corporations, Guo Xinwei and Wang Xi (2014) have found in their empirical test that equity financing has a significant positive effect on the R&D investment of large scale corporations and state-controlled corporations. This thesis held the view that a proper increase in debt level could optimize capital structure and could enhance the use of capital efficiently without significant increase of operational risks since the launch of Growth Enterprise Market (GEM) was relatively late and the assets liabilities ratio of most sample corporations remained in a relative low level during the studying period. On the other hand, with the rapid development of our bond market and the continuously reform and improvement of the banking system recently, it is more easy and convenient for listed corporations in GEM to raise more fund on the operational activities through debt. Thus, to some extent, debt financing could promote corporations' R&D investment, but the

high risk of R&D activities and the lack of mortgages make corporations more apt to the channel of equity to raise fund for R&D activities. Based on the above results, this thesis proposed the following hypothesis:

H2: As the main external financing channels for listed corporations in GEM, both equity financing and debt financing could efficiently promote corporations' R&D activities. However, the promotion effect of equity financing is fairly larger.

**3) Cash smoothing, governmental subsidies and R&D investment**

Besides corporations' own channels as operating cash flow and external financing, corporations could provide fund for R&D projects through the opening cash and special subsidies from government.

By studying the cash management and debt policies of corporations, Acharya *et al.* (2007) [8] has proved that corporations prefer to use cash resources rather than increasing debt to relieve the impact of cash flow on investment in corporations. Brown and Peterson (2011) [9] had proved that whether corporations would choose cash resources to smooth R&D investment or not, the result would show that corporations faced with financial constraints would commonly use the cash in hold to smooth R&D investment. The research result of GuoXinwei (2014) also proved that the cash held by corporations faced with financial constraints has a smoothing effect on R&D investment.

Besides, most of Chinese listed corporations in GEM are growth-type high-tech corporations, which could obtain considerable subsidies from government. For example, in 2014, the cash inflow of sample enterprise driven by governmental subsidies was over 10 million CNY, making governmental subsidies as one of the available capital sources for the R&D activities by listed corporations in GEM. A lot of domestic researches (such as Huang Yixiang and Yao Zheng, 2015 [10]) have also confirmed that the governmental subsidies have a significant impact on corporations' R&D investment. Based on the above research results, this thesis raised the following hypothesis:

H3: Corporations faced with financial constraints would use the cash in hold to smooth R&D investment.

H4: Governmental subsidies could promote R&D investment to a certain extent.

**4) The influence of the heterogeneity of corporations' R&D phase and operating cash flow condition on financial constraints and the preferences of financing channels**

According to the studies on large-scale manufacturing corporations in Britain and Germany, Bond *et al.* (1999) [11] has found that the sensibility of internal cash flow, R&D investment and fixed investments in these two countries has significant differences. Taking the large-scale manufacturing corporations in France and America as examples, Mulkay *et al.* (2001) has found that the operating cash flow of American corporations plays a much bigger role on their R&D investment. Some domestic researches studied by Tang Qingquan and Xiao Hailian (2012, 2014) [12] had also confirmed that different R&D investments make different degrees of sensibility in cash flow and different influences from debt to different R&D investments. The above researches showed that different types of corporations, faced with different degree of financial constraints, would have different preferences on financing channels.

People usually divide R&D activities into two phases as Research & Development, or R & D. The research phase, a feasible exploratory stage, is aimed at obtaining new scientific or technical knowledge. Whether it is possible to bring economic benefits to corporations is great variability. However, the development phase is a stage that applies the existing research results into practice and changes technical transformation into products, which have a relatively high certainty on getting economic benefits. According to "the sixth part of ASBE (Accounting Standards for Business Corporations)-intangible assets (2006)", the expense of the research phase and the development phase incorporations' internal R&D projects should be separated. Among them, all the expense in research phase should be counted into the R&D expenditure (R), and the eligible expense in development phase could be capitalized and then counted into the development expenditure (D). Besides, according to the condition of corporations' operating cash flow, this thesis has divided the corporations into two categories: the corporations with sound and unsound condition of cash flow. Thus, based on the condition of operating cash flow in the R&D phase, we finally classified corporations into four categories and put forward the following hypothesis:

H5: When cash flow is in favorable condition, the corporations in development phase would prefer to fund R&D projects through the channels of debt financing and equity financing since they face relatively fewer constraints.

H6: When cash flow is in deficient condition, corporations would not like to finance R&D projects through the channels of debt financing no matter in what phases.

## 3. Research Design

### 1) Data sources and sample selection

Taken the corporations listed in Shengzhen GEM before 2011 as examples, this thesis set the time span of samples from 2011 to 2014. It collected some relative data by consulting the annual reports of sample corporations published in Shenzhen Stock Exchange and collecting R&D investment and governmental subsidies by hand. Other financial data and specifications of listed corporations were all from the data base of CSMAR.

The ASBE (Accounting Standards for Business Enterprises, 2006) of China has clearly required corporations to disclose the expenditure in research phase (R) and in development phase (D) separately when disclosing the information of R&D expenditure. This thesis assumes that the listed corporations consume development expenditure more than two years during sample period, that is to say, when the development expenditure in balance sheet is greater than zero (D > 0), this corporation is considered in development phase; on the contrary, the corporation is in exploratory (research) phase[1]. Similarly, if the operating cash flow of listed corporations is more than zero more than two years during sample period (CF > 0), then the cash flow would be considered in favorable condition; on the contrary, these corporations are considered in deficient condition of cash flow. Thus, as talked above, this thesis has divided these sample corporations into four categories: the exploratory phase with deficient condition of cash flow, the exploratory phase with favorable condition of cash flow, the development phase with deficient condition of cash flow, and the development phase with favorable condition of cash flow. The distribution of various sample corporations is as following: (see **Table 1**)

In order to improve the quality of sample data, the sample data has been filtered in this thesis. The following data has been removed from: 1) the data of corporations whose main business or operating industry has been changed since major assets restructurings; 2) the IPO data of listed corporations for the current year; 3) the industries with extremely low R&D investment, such as culture and entertainment, farming and mining; 4) the accounting data of corporations with inconsistent research expenditure and development expenditure or the data is not disclosed separately, and the data of corporations whose R&D investment is zero (both the development and research expenditure are zero) during the span of sample period. After selection, finally 729 unbalanced panel data from 204 listed corporations in GEM was obtained. In the end, in order to further avoid the interference of extreme values in the data, all the variables in this thesis have been dealt with Winsorization around the level of plus or minus 5%.

### 2) The model design and variable definition

Consulting to the demonstration analysis model of FHP (1988) from Tang Qingquan and Xu Xin (2010), this thesis has established the below regression equation based on Tobin's q model of investment to check the sensibility of corporations' R&D investment on cash flow:

$$R\&D_{i,t} = \beta_0 + \beta_1 CF_{i,t} + \beta_2 Q_{i,t-1} + \beta_3 S_{i,t} + \beta_4 Lev_{i,t} + \varepsilon_{i,t} \tag{1}$$

See **Table 2** the explanation of each variable in the model. If the coefficient $\beta_1$ of variable $CF_t$ in an empirical test is significantly positive, then the R&D investment has significant positive correlation with operating cash flow. It shows that the R&D activities of corporations face external financing constraints to a certain extent.

This thesis considers that besides the cash flow generated from self-operating activities, the corporations' R&D capital sources also include: the subsidies of corporations and government, debt financing, equity financing, and the cash in hold. However, in the cash flow statement, the governmental subsidies have been included in the cash flow produced during operating activities. Thus, in the new model, it is necessary to replace the cash flow of governmental subsidies ($CF\_G_t$) which is eliminated with the operating cash flow variable ($CF_t$) in

**Table 1.** The distribution of four categories of sample corporations.

| | Whole samples | Exploratory phase | | Development phase | |
|---|---|---|---|---|---|
| | | Deficient cash flow | Favorable cash flow | Deficient cash flow | Favorable cash flow |
| Sample size | 729 | 113 | 331 | 78 | 207 |

[1]The sample period span for the listed sample corporations before 2010 is 4 years; and 3 years for the listed corporations in 2011. Thus, this thesis has made the hypothesis that the sample corporations are in the development phase if they had development expenditure more than two years (or two year); on the contrary, they are in the exploratory phase. The classification of cash flow conditions shares the same principle of classification.

**Table 2.** The variable definition and explanation.

| Variable types | The name of variables | Variable symbols | Variable definition and explanation |
|---|---|---|---|
| The explained variables | R&D investment | R&D | (R&D expenditure + development expenditure)/total assets at the beginning period |
| The explaining variables | Operating cash flow | CF | (The net cash inflows produced by operating activities)/total assets at the beginning period |
| | Internal operating cash flow (governmental subsidies has been eliminated) | CF_G | (The net cash inflows produced by operating activities-the cash inflows produced by governmental subsidies)/total assets at the beginning period |
| | Governmental subsidies | Gov | (The cash inflows produced by governmental subsidies)/total assets at the beginning period |
| | Debt financing | Debt | (The short-term debt variation amount + the variation amount of bonds payable)/total assets at the beginning period |
| | Equity financing | Equ | The cash received by absorbing equity investment/total assets at the beginning period |
| | The variation of cash in hold. | Cashch | The variation amount of monetary capital/total assets at the beginning period |
| Control variables | corporations' investment chances | Q | The current Tobin Q value of corporations = (stake market capitalization in the end of period + total assets in the end of period)/total assets in the end of period. Among them, the net asset value per share of market capitalization of non-circulating stocks in the end of period should be multiplied by the amount of non-circulating stocks in the end of period |
| | growth | S | increase rate of business revenue = (the current business revenue - the business revenue of last period)/the business revenue of last period |
| | Debt to asset ratio | Lev | total liability in the end of period/total assets in the end of period |

mode (1). In the meantime, the variables, such as $Gov_t, Debt_t, Equ_t, Cashch_t$, should be explained to check the contribution of various financing channels on R&D investment. The final regression equation is as following:

$$R\&D_{i,t} = \beta_0 + \beta_1 CF\_G_{i,t} + \beta_2 Gov_{i,t} + \beta_3 Debt_{i,t} + \beta_4 Equ_{i,t} + \beta_5 Cashch_{i,t} + \beta_6 Q_{i,t-1} + S_{i,t} + \varepsilon_{i,t} \qquad (2)$$

Compared the regression Equation (2) with Equation (1), the variable $Lev_t$ in control variables is eliminated, because the problem of multiple co-linear relation is found between the current assets liabilities ratio ($Lev_t$) and debt financing ($Debt_t$) after analyzing the covariance matrix and testing the variable VIF. As a result, the current asset ratio and debt financing could not be introduced into a model at the same time.

This thesis has further divided these sample corporations into four categories based on the two dimensions as R&D phase and cash flow condition for empirical tests. Adopting the equation (2) to carry out regression analysis on these four categories, this thesis also studied whether there are differences in the contribution of various financing channels on R&D investment of different types of corporations. Since the data collected in this thesis is unbalanced panel data, we should use the fixed effects regression model of panel data as the analysis method after referring to the methods of some related literature. Besides, explaining variables and explained variables with absolute amount should be divided by total assets of the beginning period. The definition of each variable is showed in the following **Table 2**.

## 4. Empirical Analysis

### 1) Descriptive Statistics

All the samples and the main average values of four categories of corporation could be seen in **Table 3**. Compare the average values of each group by t-test, the following results could be achieved after the analysis: 1) The R&D investment scale of corporations in the development phase is significantly larger than the ones in exploratory phase. However, the R&D investment of corporations with favorable cash flow condition is a little more than the ones with deficient cash flow condition. The result shows that, compared with cash flow condition,

**Table 3.** Descriptive statistics of the mean of variables.

| variables | complete sample | exploratory phase | | development phase | |
|---|---|---|---|---|---|
| | | deficient cash flow | favorable cash flow | deficient cash flow | favorable cash flow |
| $R\&D_t$ | 0.0303 | 0.0213 | 0.0267 | 0.0379 | 0.0420 |
| $CF_t$ | 0.0371 | −0.0417 | 0.0689 | −0.0430 | 0.0594 |
| $CF\_G_t$ | 0.0295 | −0.0485 | 0.0617 | −0.0505 | 0.0509 |
| $Gov_t$ | 0.0075 | 0.0068 | 0.0072 | 0.0074 | 0.0085 |
| $Debt_t$ | 0.0303 | 0.0489 | 0.0227 | 0.0583 | 0.0217 |
| $Equ_t$ | 0.0071 | 0.0077 | 0.0057 | 0.0075 | 0.0087 |
| $Cashch_t$ | −0.0551 | −0.0734 | −0.0520 | −0.0688 | −0.0448 |
| $Q_{t-1}$ | 1.7422 | 1.6173 | 1.6900 | 1.7591 | 1.8873 |
| $S_t$ | 0.2416 | 0.2450 | 0.2306 | 0.1949 | 0.2750 |
| $Lev_t$ | 0.2284 | 0.2476 | 0.2310 | 0.2812 | 0.1938 |
| Sample amount | 729 | 113 | 331 | 78 | 207 |

Note: the table only shows the mean of variables.

the R&D phases play a more important role than cash flow condition on the influence of R&D investment decisions. 2) For the whole samples, governmental subsidies take up an appropriate proportion (about 20.21%) in the operating net cash inflow of corporations. The governmental subsidies of the corporations in the development phase are proved to be significantly larger than the ones in the exploratory phase after t-test. However, the average value of governmental subsidies in the corporations with different cash flow conditions has no significant differences. It shows that government would adjust its special subsidies based on what R&D phases that corporations are in. 3) On the aspect of external financing, the annual capitals financed through debt financing channel by corporations in GEM is larger than the one through the channel of equity financing. After a larger scale of debt financing, the annual debt financing scale of the corporations with deficient cash flow condition is twice bigger than the ones with favorable cash flow condition. 4) In the sample period, if the variation of average value of various corporations' cash in hold is less than 0, the scale of cash held by corporations in GEM is generally decreasing gradually. 5) On the aspect of control variables, the assets liabilities ratio of listed corporations in GEM is in a low level (the average value is 22.84% in the sample period), relatively, the corporations in the development phase with deficient cash flow condition have a higher ratio of debt assets (about 28.12%). On the other hand, the corporations, whose R&D activities are in development phase and in favorable cash flow condition, have a higher investment value (Tobin Q) and growth (S).

**2) Correlation analysis**

**Table 4** is about the correlation coefficient matrix. The result shows that: the current operating cash flow, governmental subsidies, the equity financing and corporations' investment value and growth have positive correlation with R&D investment at 1% significance level. Thus, it could be judged initially that corporations' operating cash flow, the governmental subsidies corporations received and the equity financing have played a positive role in R&D investment. Since the correlation coefficient between assets liabilities ratio in the end period and the current debt financing is over 0.5. Besides, assets liabilities ratio in the end period and the current debt financing has positive correlation at 1% significance level. Thus, there is reason to doubt that a relatively serious problem of multiple mutual linear is existed between these two variables. After regression analysis, when $Lev_t$ and $Debt_t$ have been taken as model explaining variables at the same time, the coefficient of the two variables is not significant. However, when eliminating one of the above two variables independently, the coefficient of the two variables are significant in the regression analysis. What's more, the calculation of VIF value also proves that there is a serious problem of multiple mutual linear in these two variables. As a result, the variable of $Lev_t$ has been eliminated in Equation (2).

**3) Regression analysis**

*a) The regression of complete samples*

At first, this thesis makes a regression analysis on whole samples. The empirical test results are showed on

**Table 4.** The correlation coefficient matrix of variables.

|  | R&D$_t$ | CF$_t$ | Gov$_t$ | Debt$_t$ | Equ$_t$ | Cashch$_t$ | Lev$_t$ | Q$_{t-1}$ | S$_t$ |
|---|---|---|---|---|---|---|---|---|---|
| R&D$_t$ | 1 | | | | | | | | |
| CF$_t$ | 0.1416* | 1 | | | | | | | |
| Gov$_t$ | 0.1638* | 0.0575 | 1 | | | | | | |
| Debt$_t$ | 0.0097 | −0.2190* | −0.0042 | 1 | | | | | |
| Equ$_t$ | 0.2094* | 0.0117 | 0.0816 | 0.1067* | 1 | | | | |
| Cashch$_t$ | 0.0376 | 0.1261* | −0.0080 | −0.0427 | 0.0672 | 1 | | | |
| Lev$_t$ | −0.0518 | −0.0898 | 0.0066 | 0.5680* | 0.1295* | −0.0236 | 1 | | |
| Q$_{t-1}$ | 0.2973* | 0.1717* | 0.0968* | 0.0874 | 0.2076* | −0.0061 | 0.0435 | 1 | |
| S$_t$ | 0.2058* | 0.1304* | −0.0092 | 0.1524* | 0.2064* | 0.0702 | 0.1986* | 0.1892* | 1 |

Note: *means at 1% significance level.

**Table 5**. Among them, model (1) makes a regression analysis on the whole samples through the regression equation (1). The result shows that corporations' R&D investment has a positive correlation with operating cash flow $CF_t$, and the increase of assets liabilities ratio plays a significant positive role in R&D investment.

Model (2), Model (3) and Model (4) have been added the following variables as explaining variables in order on the basis of Model (1). Considering the problem of multiple mutual linear mentioned above, variable $Lev_t$ has been eliminated from the models. Finally, Model (5) separated governmental subsidies from operating cash flow to test whether the cash flow produced by governmental special subsidies will have significant effect on R&D investment.

The coefficient of variable $CF_t$ from Model (1) to Model (4) is over zero at the 1% significant level. This means that the R&D activities of our listed corporations in GEM still rely on corporations' operating cash flow, that is to say, they still face financing constraints to a relative extent, which is consistent with the research result of previous literature at home and abroad, demonstrating the hypothesis of H1 as well. On the aspect of traditional external financing channels, the coefficient of debt financing and equity financing from Model (3) to Model (5) is all over zero at 1% significant level. However, the coefficient of equity financing is much bigger than the ones in debt financing and operating cash flow. It explains that a bigger proportion of capitals absorbed by equity financing channel is used for R&D, while the capitals financed by debt financing channel or self-operating activities are more often used in daily operating activities. Thus, equity financing channel has a positive effect on R&D investment, which demonstrates the hypothesis of H2. On the aspect of other capital sources, the variation of cash in hold in the end period and beginning period in Model (4) and Model (5) has a negative correlation with R&D investment, which explains that corporations' cash in hold has a certain smoothing effect on R&D investment, which demonstrates the hypothesis of H3. However, compared with the above explaining variables which are at 1% significant level, this variable is only at 10% significant level, which is much less than other financing channels. It shows that the influence of the smoothing effect of cash in hold on corporations' R&D investment is very limited. On the other hand, Model (5) has separated governmental subsidies from operating cash flow on the basis of Model (4) to test influence of cash flow and governmental subsidies produced by corporations' internal operating activities on R&D investment. The regression result shows that the corporations' R&D investment still has a significant positive correlation with the cash flow produced by internal operating activities even after eliminating governmental subsidies. However, the governmental subsidies have no significant influence on R&D investment, which is not consistent with the hypothesis of H4.

Finally, the analysis on the coefficient of control variables and significance level shows that: the bigger the Tobin Q of corporations is, the more identification the corporations would receive from external investors, the higher the willing of corporations to increase R&D investment; besides, a proper debt on one hand could enhance financial leverage, on the other hand, it plays a positive role in improving corporations' ability of R&D investment to a certain extent. Meanwhile, after adding new explaining variables into the Models in order from Model (2) to Model (5), the significance level of each variable almost remains the same. While the adjustment value of R2 is gradually increasing, the empirical models and results are showed relatively stable.

**Table 5.** The regression result for full samples.

| variables | R&D investment | | | | |
|---|---|---|---|---|---|
| | Model (1) | Model (2) | Model (3) | Model (4) | Model (5) |
| $CF_t$ | 0.0177*** | 0.0251*** | 0.0245*** | 0.0239*** | |
| | (2.62) | (3.64) | (3.61) | (3.52) | |
| $CF\_G_t$ | | | | | 0.0237*** |
| | | | | | (3.50) |
| $Debt_t$ | | 0.0216*** | 0.0206*** | 0.0200*** | 0.0199*** |
| | | (3.29) | (3.18) | (3.09) | (3.08) |
| $Equ_t$ | | | 0.1133*** | 0.1153*** | 0.1144*** |
| | | | (4.25) | (4.33) | (4.29) |
| $Cashch_t$ | | | | −0.0074* | −0.0075* |
| | | | | (−1.79) | (−1.82) |
| $Gov_t$ | | | | | 0.1032 |
| | | | | | (1.63) |
| $Q_{t-1}$ | 0.0027*** | 0.0030*** | 0.0026*** | 0.0023*** | 0.0024*** |
| | (3.53) | (3.96) | (3.46) | (3.07) | (3.16) |
| $S_t$ | 0.0015 | 0.0017 | 0.0009 | 0.0011 | 0.0012 |
| | (1.05) | (1.19) | (0.66) | (0.79) | (0.87) |
| $Lev_t$ | 0.0179*** | | | | |
| | (3.88) | | | | |
| $Cons$ | 0.0205*** | 0.0231*** | 0.0232*** | 0.0233*** | 0.0225*** |
| | (13.37) | (16.78) | (17.15) | (17.20) | (15.23) |
| Sample amount | 729 | 729 | 729 | 729 | 729 |
| Adjustment value $R^2$ | 0.0850 | 0.0777 | 0.1086 | 0.1141 | 0.1168 |

Note: ***, **, * means respectively the significant level at 1%, 5% and 10%. The values in parentheses mean the t value of each variable.

*b) Categorical regression of samples*

**Table 6** is about the empirical test result of categorical regression of samples. The result shows that: if cash flow is in favorable condition, no matter what phases the corporations are in, the coefficient of variables of $Debt_r$ and $Equ_t$ are significantly over zero, which means that both debt financing and equity financing play a significant positive role in R&D investment. And at that time, the sensibility of corporations' R&D investment in development phases is not significant on internal operating cash flow while the coefficient $CF\_G_t$ of the corporations in exploratory phase is still over zero, which proves the hypothesis H5 to a certain extent. Meanwhile, we found that, although corporations which are in favorable operating cash flow condition are easily access to external credit resources, the annual debt financing scale and assets liabilities ratio of corporations which has a favorable cash flow condition is significantly less than the corporations which are in deficient cash flow condition (through the method of t-test on average value in groups). The above result shows that no matter in the exploratory phase or the development phase, corporations which are in favorable cash flow condition could get more credit capitals without serious debt financing constraints. However, when corporations are making debt financing, the risk-reward characteristics are not match to the R&D investment especially the one in exploratory phase, which leads to the fact that corporations would try to avoid the debt financing channel when financing R&D projects. Why R&D investment relies on internal operating cash flow only when corporations are in exploratory phase but not development phase? This thesis holds the view that there are two main reasons that lead to the phenomenon: subjectively, corporations in development phase are more willing to invest based on their actual

**Table 6.** The result of categorical regression.

| Important explaining variables | Complete sample | Exploratory phase | | Development phase | |
|---|---|---|---|---|---|
| | | Deficient cash flow | Favorable cash flow | Deficient cash flow | Favorable cash flow |
| $CF\_G_t$ | 0.0237*** | −0.0043 | 0.0504*** | 0.0959* | 0.0104 |
| | (3.50) | (−0.10) | (3.94) | (1.78) | (0.47) |
| $Gov_t$ | 0.1032 | 0.1123 | 0.0591 | 0.2767 | 0.0882 |
| | (1.63) | (0.43) | (0.58) | (0.87) | (0.81) |
| $Debt_t$ | 0.0199*** | −0.0197 | 0.0215** | −0.0067 | 0.0294** |
| | (3.08) | (−0.98) | (2.06) | (−0.28) | (2.00) |
| $Equ_t$ | 0.1144*** | 0.0157 | 0.1026** | 0.2320* | 0.1637*** |
| | (4.29) | (0.25) | (2.46) | (1.98) | (3.16) |
| $Cashch_t$ | −0.0075* | −0.0227* | −0.0019 | −0.0278 | −0.0063 |
| | (−1.82) | (−1.66) | (−0.28) | (−1.30) | (−0.74) |
| Sample amount | 729 | 113 | 331 | 78 | 207 |
| Adjustment $R^2$ | 0.1168 | 0.1478 | 0.1638 | 0.3027 | 0.1849 |

Note: ***, **, * mean respectively the significant level of 1%, 5% and 10%. The values in parentheses mean the t value of each variable.

demands. The cash flow condition of the current year is no longer considered as the main factors. What's more, corporations are more likely to support R&D investment through external capitals. If debt rights are not used, equity financing would be adopted more frequently. The regression coefficient of $Debt_r$ and $Equ_t$ of corporations in development phase is bigger than the ones in the exploratory phase (but the coefficient differences among groups do not pass Chow Test). However, the corporations in the exploratory phase are not willing to enlarge R&D investment blindly since their R&D is still in the exploratory phase. The investment strategies are of course based on the cash flow principle of "make ends meet" to control risks. On the other hand, subjectively, the R&D projects in development phase are surer to get benefits since the external equity funders face relatively minor. Thus when corporations make equity financing, they meet less financial constraints. While corporations in the exploratory phase are more difficult to get the support from equity financing. This is mainly because the corporations at that time face equity financing constraints.

When facing a deficient cash flow, if corporations' R&D activities are in development phase, the R&D investment has a positive correlation with internal operating cash flow at 10% significant level. We can see from **Table 3** that, in the development phase, the corporations which are in deficient condition of cash flow have the biggest average value of the variables as $Lev_t$ and $Debt_t$ in the four categories, which shows that this type of corporations has got more credit resources. However, **Table 6** shows that the R&D investment of this type of corporations has no significant correlation with debt financing amount, which indicates that the capitals financed by debt financing do not have a significant positive effect on R&D investment. The reason is that this type of corporations have faced cash flow difficulties and borrowed a lot of money to support production operation, to expand business channels and so on. At that time, the high assets liabilities ratio has made corporations face a higher operating risk, as a result, they are not willing to invest the funds from debt financing to R&D activities (which might further increase operation risks and enhance the uncertainty of corporate income). This type of corporations is more inclined to use equity financing to push the development of R&D projects. The coefficient of variable $Equ_t$ in this type of corporations through Chow Test is significantly bigger than the other two categories of corporations in the exploratory phase. However, compared with the corporations with favorable cash flow, this type of corporations faces equity financing constraints, leading to an insufficient of external financing and a significant positive correlation between R&D investment and internal operating cash inflow. If the R&D activities are still in exploratory phase, the internal operating cash flow, governmental subsidies, debt financing, equity financing of corporations have no significant influence on R&D investment, but the variation of cash in hold at 10% level has a significant negative correlation with R&D investment. It might be because the type of

corporations neither is willing to use external capitals to expand R&D investment when facing a relatively serious operational risk, nor increase R&D investment when the condition of operating cash flow improves. Under this circumstance, corporations usually have to use their existing cash to maintain the low level of R&D investment, and their scale of annual R&D investment is the lowest among the four categories of corporations (see Table 3). All in all, when facing a deficient condition of cash flow, corporations both in the exploratory phase and the development phase would not adopt debt financing channel to expand R&D investment (all the regression coefficient of $Debt_t$ is not significant), which proves the hypothesis of H6.

Finally, for the four categories of corporations, although governmental subsidies have positive but not significant correlation with R&D investment since their regression result of complete samples are the same. This might because: innovative R&D is an investment activity with long cycle, big risks and high benefits, but general corporations could not predict the exact amount and duration of governmental subsidies. If corporations expand their R&D investment rashly just because the temporary governmental subsidies, they might not only encounter a higher adjustment cost, but also increase the operational risks.

**4) Robustness Test**

In order to control the relative problems of existing potential heteroscedasticity and sequence, the standard error of all the regression coefficients has been dealt with Cluster processing at a company level. Empirical test results about complete samples and categorical samples are shown on Table 7. After comparison, we found that the significant level of the important explaining variables in Table 7 is the same as Table 6. The test result shows that even though the problems of the existing potential heteroscedasticity and sequence have been considered, the regression results are still relatively robust.

Since both the coefficient and significant level of the explaining variable $Cashch_t$ are far lower than other explaining variables and only the sample corporations which are in the exploratory phase with a deficient cash flow are showed significantly, this factor is considered to have very limited influence on R&D investment. Thus, if we eliminate this explaining variable in the robustness test and make a regression analysis on the total samples and various sample corporations based on the previous method of empirical test, the coefficient and significant level of other explaining variables in the regression result would not be changed remarkably. Besides, in the robustness test, we also add $Lev_{t-1}$ instead of $Lev_t$ into the regression equation (2) to avoid the problem of multiple mutual linear with the variable $Debt_t$. The empirical result and the conclusion are the same as the ones mentioned above completely, and the coefficient of the variable $Lev_{t-1}$ is not significant, the above result shows that the estimated result of the model is relatively robust. Limited by thesis length, the procedure of robustness test mentioned above is not listed in this thesis.

**Table 7.** Robust regression result of Cluster.

| Important explaining variables | Complete samples | Exploratory phase | | Development phase | |
|---|---|---|---|---|---|
| | | Deficient cash flow | Favorable cash flow | Deficient cash flow | Favorable cash flow |
| $CF\_G_t$ | 0.0237*** | −0.0043 | 0.0504*** | 0.0959* | 0.0104 |
| | (3.03) | (−0.11) | (3.16) | (1.78) | (0.40) |
| $Gov_t$ | 0.1032 | 0.1123 | 0.0591 | 0.2767 | 0.0882 |
| | (1.56) | (0.57) | (0.69) | (1.05) | (0.69) |
| $Debt_t$ | 0.0199*** | −0.0197 | 0.0215** | −0.0067 | 0.0294** |
| | (3.50) | (−1.50) | (2.43) | (−0.25) | (2.56) |
| $Equ_t$ | 0.1144*** | 0.0157 | 0.1026** | 02320*** | 0.1637** |
| | (3.50) | (0.32) | (2.22) | (2.88) | (2.27) |
| $Cashch_t$ | −0.0075* | −0.0227** | −0.0019 | −0.0278 | −0.0063 |
| | (−1.81) | (−2.53) | (−0.24) | (−1.44) | (−0.82) |
| Sample amount | 729 | 113 | 331 | 78 | 207 |
| Adjustment $R^2$ | 0.1168 | 0.1478 | 0.1638 | 0.3027 | 0.1849 |

Note: ***, **, * mean respectively the significant level of 1%, 5% and 10%. The values in parentheses mean the t value of each variable.

## 5. Conclusions and Inspiration

The aim for China in this key period is to pursue economic transformation and build an innovation-oriented country, and the key to success is whether a set of policies and systems could be established with a view to carrying out so as to guide, stimulate and support corporations to consolidate the independent innovation and increase R&D investment. In this respect, the result of this thesis has some policy implications: firstly, the research result of this thesis proves that the influence of debt financing and government subsidies is limited on the R&D investment of innovative corporations. This is because the scale and duration of governmental subsidies are difficult to predict, while the characteristics of risks and revenues of debt financing and R&D activities are not matched. Especially when corporations face deficient cash flow, they would not put their money on R&D activities though they obtained relatively more credit resources. On the contrary, the capitals obtained through equity financing channel are more often used in R&D activities. Thus it could be pre-judged that one of the important reasons for the insufficient R&D investment of our innovative corporations is that they face relatively serious financing constraints, which are characterized by the blocked channel of equity financing. So, in order to support innovative R&D activities of corporations, a stock and equity exchange market, which has sound financing and investment functions and fits to sustainable development, should be established to improve financing and refinancing regulations and to encourage the development of the industries as risk investment and private venture, creating a better environment of equity financing for corporations. Besides, although innovative corporations could fund a part of capitals through debt financing channel, they are not willing to spend a vast sum of money on R&D investment. This is because the revenues of R&D investment are not sure and have a long cycle while the traditional credit mode is difficult to match the above characteristics of R&D investment. As a result, government could guide commercial banks and other financing institutions to explore more creative credit modes, such as a combination of investment and credit, convertible bond and so on. Finally, when making special subsidies and policy supports on corporations' innovative R&D activities, local government should pay more attention to the corporations whose R&D activities are in development phase and in a deficient cash flow. Because this type of corporations should strengthen their willing and motivations to expand R&D investment, but they do not try to invest the money from debt financing channel to R&D investment even though their self-operating activities will produce an insufficient cash inflow. At that time, government should give some special subsidies properly to push the innovative activities of corporations accurately and efficiently.

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