

Impact Mechanisms of Female Executives and Bank Loans on Technology Innovation: Evidence from Computer Enterprises

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Abstract. The paper investigates the forming mechanisms of R&D investment in the background of the Computer Enterprises in China from the perspectives of female executives, bank loans and the interaction between the two. The results of Multiple Linear Regression Model Based on OLS and rich robustness tests show that, for Computer Enterprises, female executives hold a strong negative attitude toward R&D activities, bank loans intensity does harm to the R&D investment, while the interaction between female executives and bank loans enhances R&D investment. Further empirical analysis reveals that, for Computer Enterprises, both female directors and female supervisors have a weaker negative effect on R&D investment, female executives still have negative effects on R&D performance.

Keywords: Female executive; bank loans; technology innovation; Computer Enterprises; China.

1. Introduction

Due to the long cycle and large demand for funds for R&D activities, it is difficult for internal financing to continuously support the development of enterprise R&D projects. Most companies have to obtain R&D funding through external sources to ensure the smooth implementation of corporate R&D. Bank loans is the most important external financing channel for Chinese enterprises. In fact, the impact of bank loans on R&D investment is more worth exploring in order to strengthen the bank-enterprise relationship. Theoretically, however, the relationship between bank loans and R&D investment is still controversial. The existing conclusions include the positive correlations[1], the negative correlations[2,3] and the contingency relationships[4]. Among them, more and more scholars have begun to agree that the relationship between bank loans and R&D investment should be explored from the perspective of contingency[5]. Therefore, it is of theoretical and practical importance to explore the relationship between bank loans and R&D investment from the perspective of contingency.

In addition, as more and more women break the "Career Ceiling" and enter the top management teams (TMTs) of the workplace, the impact of female executives on R&D investment has also received increasing attention. In terms of direct impact, the effect of female executives on R&D investment is positive[6], negative[7] and zero[8], respectively. From the perspective of moderating effects, female executives can also indirectly determine R&D investment decisions. Besides, existing research argues that female executives have distinctive performance consequences in traditional industries from those in high-tech and highly-competitive industries, e.g. the Computer Industries. Moreover, the research on the linkages between female executives and R&D investment has rarely been investigated in the Computer Industries. Based on this, the investigation into how female executives affect the R&D investment of enterprises in the computer industry, and how to determine R&D investment by adjusting the relationship between bank loans and R&D investment, which is of theoretical originality and practical necessity.

Based on the above discussion, the paper takes the Computer Industry as the research background, and integrates female executives, bank loans and R&D investment into the same research framework to explore the relationship among the three. The expected theoretical contributions are as follows: (1) to clarify the impact of bank loans on enterprise R&D investment in the Computer Industries, enriching the research on the determining mechanism of R&D investment; (2) to clarify the effect of female executives on enterprise R&D investment in the

Computer Industries, expanding the literature on the female executives' consequences; (3) to reveal the impact of the interaction between female executives and bank loans on R&D investment in the Computer Industries, expanding and deepening the literature of the forming mechanism of R&D investment under the contingency perspective.

2. Literature and hypotheses

From Information Asymmetry Theory, banks face obvious information asymmetry in their interaction with computer enterprises[9]. In the Computer Industries, enterprises are more familiar with the information of R&D activities than banks, including the probability of success. This includes the probability of success, the profit gained and the risk faced. Since Computer Industries are of longer reward cycles than other industries, when computer enterprises carry out R&D activities, the process is more risky and opaque to banks. Asymmetric information makes it difficult for banks, as the creditors, to distinguish the real quality of computer enterprises, thus increasing the difficulty of obtaining R&D funds. And more importantly, banks cannot enjoy the benefits of successful R&D activities, but need to bear the risk of R&D failure.

A hypothesis is proposed based on the above analysis:

H1: Bank loans negatively affect the R&D investment of computer enterprises.

From the perspective of the Risk Aversion Theory, female executives in the TMTs show great differences from male executives in terms of thinking patterns and risk preferences, which are reflected in that male executives are usually willing to change, and dare to take risks and innovate, while female executives show more risk aversion, fear of innovation and resistance to change. Therefore, compared with male executives, female executives are more prudent, caution and conservative in their investment strategies when faced with risky decisions such as R&D investment, and their competitive tendencies and risk preferences are lower[10]. They show resistance to change, uncertainty and setbacks, which are associated with R&D activities closely, and thus they are vulnerable to attack, so they are more risk-averse and unwilling to take radical investment strategies[11].

A hypothesis is proposed based on the above analysis:

H2: Female executives negatively affect the R&D investment of computer enterprises.

The Signal Theory predicts that when banks face a higher participation degree of female executives, they would feel the conservative and stable characteristics of the enterprises in innovation investment decisions, and further feel that the need to strictly control R&D investment by the banks themselves is reduced. Meanwhile, when female executives face a higher proportion of bank loans, they will feel the negative strong tendency of banks to make innovation decisions, which will reduce their sensed need of exerting negative control over innovation investment. Because if both sides try their best to control the investment in innovation, computer enterprises will face a greater innovation crisis, which is more detrimental to reducing the risk of computer enterprise development. Hence, even from the perspective of the Risk Aversion Theory, in cases where there is a clear tendency to invest negatively in innovation, both parties will appropriately curb their negative investment tendencies, so as to maintain the basic R&D investment and low-risk operation of the computer enterprises.

A hypothesis is proposed based on the above analysis:

H3: The interaction of female executives and bank loans has a positive effect on the R&D investment of computer enterprises.

3. Methodology

3.1 Sample and Data

The paper takes the computer enterprises that disclosed R&D investment data in A-share listed companies from 2009 to 2018 in China as the initial sample, and follows these steps for processing:

(1) to eliminate the listed companies marked with ST, * ST, or PT in the sampling year; (2) to exclude the listed companies with singularity data in the sampling year; (3) to exclude the listed companies whose data required by the research cannot be completely obtained in the sampling year.

The data required in this paper mainly come from the CSMAR database, and a few data are collected manually from the annual report of enterprises. After the above steps of sample screening and data processing, a research sample consisting of 2973 unbalanced panel observations from the Computer Industries were finally reached. To avoid the distortion effect of outliers on the final empirical results, the main continuous variables were Winsorized with 1% quantile and 99% quantile.

3.2 Variables

3.1.1 Dependent Variable: R&D Intensity

Referring to existing literature[12], the ratio of R&D expenditures to total sales is used as a measure. R&D expenditures with a one-year lag (i.e., RDE_{t+1}) were used as a proxy for robustness testing.

3.1.2 Explanatory Variables

Referring to the existing literature on capital structure and corporate finance[13], bank loan intensity (BLI) is measured by the ratio of bank loans to total assets.

Referring to the existing literature, female executives' participation degree (FEPD) is measured by the proportion of female executives to the size of the TMT. And the number of female executives (FEPD_N) is used as the alternative measure for the robustness test.

Besides, the interaction of female executives and bank loans (INTERACTION_BF) is measured by the product of ZBLI and ZFEPD, i.e., $ZBLI * ZFEPD$.

3.1.3 Control Variable

Referring to the relevant literature[14], the following variables are chosen as the control variables: firm size(FSIZE, the logarithm of total assets), the ratio of independent directors(RID), the ratio of the largest shareholder's shareholdings(RLSS), listing age(LAGE), CEO duality(CEODUAL), return on equity(ROE), sales expense rate(SER), the proportion of fixed assets(PFA), the logarithm of top executives' shareholdings(LNTES), the logarithm of the top three executives' cash compensation(LTTECC), and Tobin's Q(TQ).

Moreover, nine-year dummy variables and six regional dummy variables are designed to control the fixed-year effects and regional effects.

3.3 Descriptions

Table 1 shows the descriptive statistical results. In Computer Industries, the average bank loan intensity is 8%, the average female executives' ratio is 20.1%, the average R&D intensity is 8.65%.

Correlation analysis shows that bank loans and female executives are negatively correlated with R&D investment intensity, with correlation coefficients of -0.259 ($P < 0.01$) and -0.342 ($P < 0.01$) respectively; There is a weak and positive correlation between bank loans and female executives, with a correlation coefficient of 0.040 ($P < 0.05$); Except for ROE, there is a significant correlation between R&D investment intensity and all other control variables. The VIF test results show that the multicollinearity problem in this study is acceptable and will not harm the reliability of the empirical analysis results. The detailed results of correlation analysis are available on request.

3.4 Models

To test H1, H2 and H3, Model (1) is built as follows. If α_1 is statistically negative, H1 holds. If α_2 is statistically negative, H2 holds. If α_3 is statistically positive, H3 holds.

$$RDI_{it} = \alpha_{it} + \alpha_1 BLI_{it} + \alpha_2 FEPD_{it} + \alpha_3 ZBLI_{it} * ZFEPD_{it} + \alpha_4 CONTROL_{it} + \sum REGION + \sum YEAR + \varepsilon_{it}$$

(1)

Table 1. Descriptive statistics results.

Variables	Range	Minimum	Maximum	Mean	Standardized Deviation	Skewness	Kurtosis
BLI	0.472	0	0.472	0.08	0.097	1.368	1.371
FEPD	0.476	0	0.476	0.201	0.108	0.315	-0.351
RDI	0.253	0.06	0.253	0.087	0.0619	1.268	0.811
FSIZE	5.878	19.76	25.638	21.54	1.058	0.816	0.893
RID	0.222	0.333	0.556	0.382	0.053	0.875	0.321
RLSS	64.29	8.77	73.06	31.152	13.44	0.654	0.005
LAGE	24	2	26	10.564	5.831	0.956	0.445
CEODUAL	1	0	1	0.39	0.487	0.459	-1.79
ROE	0.749	-0.442	0.307	0.07	0.094	-2.087	10.124
SER	0.428	0.011	0.439	0.078	0.074	2.117	5.422
PFA	0.604	0.007	0.611	0.144	0.125	1.215	0.936
LNTES	19.84	0	19.84	13.848	6.215	-1.513	0.822
LTTECC	3.4	11.59	14.99	13.284	0.633	0.301	0.107
TQ	8.772	0.843	9.614	2.454	1.535	2.232	6.13

4. Results

4.1 Main Results

Column I of Table 2 reports the regression results of Model (1). The coefficient of BLI on RDI is significantly negative ($B=-7.735$, $P=0.000$), indicating the existence of a negative effect of bank loans on R&D investment. H1 holds. The coefficient of FEPD on RDI is significantly negative ($B=-6.680$, $P=0.000$), indicating that female executives have a negative effect on R&D investment. H2 holds. The coefficient of $ZBLI*ZFEPD$ on RDI is significantly positive ($B=0.270$, $P=0.000$), indicating that the interaction between female executives and bank loans would enhance R&D investment. H3 holds.

4.2 Robustness Test

Three robustness tests have been executed to ensure the empirical results' validity. First, by replacing FEPD in Model (1) with $FEPD_N$, Model (2) has been built. Column II of Table 1 reports the regression results of Model (2). Second, by replacing RDI in Model (1) with $RDEt+1$, Model (3) has been built. Column III of Table 1 reports the regression results of Model (3). Third, by replacing FEPD in Model (1) with the logarithm of bank loans ($LNBL$), Model (4) has been built. Column IV of Table 1 reports the results of Model (4). All the robustness test results confirm H1, H2 and H3.

4.3 Further Exploration

To further investigate the effect of female directors on R&D investment, the study replaces FEPD in Model (1) with the number of female directors ($FDPD_N$), and Model (5) is built. The regression results of Model (5) are shown in Column I of Table 3, indicating that female directors have a weaker negative effect on R&D investment than female executives, while the interaction between female directors and bank loans has no effect on R&D activities.

To further investigate the effect of female supervisors on R&D investment, the study replaces FEPD in Model (1) with the number of female supervisors ($FSPD_N$), and Model (6) is built. The regression results of Model (6) are shown in Column II of Table 3, indicating that female supervisors have a weaker negative effect on R&D investment than female executives and female directors, while the interaction between female supervisors and bank loans has no effect on R&D activities.

Table 2. Main results and robustness test results.

Variables	I	II	III	IV
	Model (1)	Model (2)	Model (3)	Model (4)
	RDI	RDI	RDEt+1	RDI
BLI	-7.735*** (-7.182)	-8.158*** (-7.451)	-8.516*** (-6.796)	-6.713*** (-19.074)
FEPD	-6.680*** (-18.993)		-6.482*** (-15.834)	
ZBLI*FEPD	.270*** (2.796)		.265** (2.305)	
FEPD_N		-.996*** (-16.115)		
ZBLI*FEPD_N		.308*** (3.225)		
LNBL				-.081*** (-6.632)
ZLNBL*FEPD				.216*** (2.407)
CONTROL	YES	YES	YES	YES
YEAR/INDUSTRY	YES	YES	YES	YES
(Constants)	7.618** (2.518)	-.761 (-.255)	1.165 (.188)	8.073*** (2.672)
F	60.769	55.949	46.908	60.434
Adj.R2	.375	.355	.364	.373
N	2973	2973	2411	2973

Table 3. Further exploration results

Variables	I	II	III	IV
	Model (5)	Model (6)	Model (7)	Model (8)
	RDI	RDI	ERIP	EIIP
BLI	-8.910*** (-7.862)	-8.833*** (-7.777)	-.677** (-2.468)	.011 (.039)
FEPD			-.810*** (-9.053)	-.556*** (-5.960)
ZBLI*FEPD			.014 (.583)	.003 (.104)
FDPD_N	-.517*** (-5.267)			
ZBLI*FDPD_N	.126 (1.225)			
FSPD_N		-.457*** (-4.246)		
ZBLI*FSPD_N		-.054 (-.542)		
CONTROL	YES	YES	YES	YES
YEAR/INDUSTRY	YES	YES	YES	YES
(Constants)	-5.581* (-1.802)	-7.028** (-2.273)	-17.356*** (-22.537)	-13.401*** (-16.709)
F	43.903	43.346	62.819	57.133
Adj.R2	.302	.299	.382	.360
N	2973	2973	2973	2973

To further investigate the effect of female executives on R&D performance, the study constructs Model (7) by replacing RDI in Model (1) with the exploratory innovation performance (ERIP),

measured by the logarithm of the number of invention patents. The regression results of Model (7) are shown in Column III of Table 3, indicating that female executives and bank loans both have negative effects on exploratory innovation performance, while the interaction between female executives and bank loans has no effect on exploratory innovation performance.

In addition, the study constructs Model (8) by replacing RDI in Model (1) with the exploitative innovation performance (EIIP), which is measured by the logarithm of the patents number of industrial designs and utility models. The regression results of Model (8) are shown in Column IV of Table 3, indicating that female executives have a negative effect on exploitative innovation performance, bank loans and the interaction between the two have no effect on exploitative innovation performance.

5. Conclusion

This paper seeks to examine how female executives, bank loans and their interaction change R&D in Chinese Computer Enterprises. It was found that in Computer Enterprises, (1) female executives hold a strong negative attitude toward R&D activities, (2) bank loan intensity does harm to the R&D investment, (3) the interaction between female executives and bank loans enhances R&D investment.

Further exploration reveals that in Computer Enterprises, (1) female directors have a weaker negative effect on R&D investment, (2) female supervisors have the weakest negative effect on R&D investment among the top female leaders, (3) bank loans has a zero effect on exploitative innovation performance and a negative effect on exploratory innovation performance, and (4) female executives have negative effects on exploitative innovation performance and exploratory innovation performance.

In terms of theoretical contributions, this study enriches the determining mechanisms of R&D activities from the perspectives of female executives, bank loans and their interaction in the backgrounds of the Computer Industries, and extends the research boundaries of gender diversity, debt structure and technology innovation by integrating female executives, bank loans and especially their interaction into a whole research framework. In addition, this study enriches the application context of the upper echelons theory, information asymmetry theory, signaling theory and gender diversity perspectives by using listed Computer Companies in China as the research sample.

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